



**DOE**

**MARKET RESEARCH STUDY  
MAPPING THE SOLAR  
INVESTMENT**

**PUBLIC**

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## 1.0 INTRODUCTION

This report explores early-stage investments in solar technologies by the private sector. Of specific interest are investments in emerging solar technologies by business angels and venture capitalists, as well as corporations and utilities in the energy sector and Fortune 500 companies. As the Federal government often steps in when private sector investments are low, a key goal of this report is to map the solar investment space and determine where different types of investments are being made. The report is divided into two main sections – the first focused on venture capital and the second on commercial firms (energy companies, utilities, fortune 500 firms, and green banks). Excluded from this report is funding provided by the Department of Energy in emerging solar technologies and self-funded initiatives by small business.

## 2.0 ANGEL AND VENTURE CAPITAL INVESTMENT

Early-stage investment, also known as seed capital, provides start-up companies with enough funding to launch. If the business venture proves viable, investors will move into further rounds of funding such as series A, B, C, and so on.<sup>1</sup> According to *The Hartford*, “angel investors” are defined as “wealthy private investors focused on financing small business ventures in exchange for equity.” Venture capital (VC) firms, on the other hand, use an investment fund and invest “other people’s money”.<sup>2</sup>

This section explores angel and venture capital investment in early-stage solar opportunities. To surface relevant firms an open-source search was performed utilizing combinations of key terms relevant to angel and venture capital investments in solar technologies. Results containing technologies, companies, and investment firms were then further explored to ascertain the depth of interest in solar technologies within these organizations. Recipients of investment funds were also reviewed in order to define the technology area and surface any technical specifications which might be available. Reviewing company websites facilitated further expansion of the listing of venture capital/angel firms.

Table 1 contains a summary of the early-stage investments in solar technologies that are explored in this document. Each of the investment firms presented in Table 1 are subsequently profiled with a brief description provided of the technologies in which they invest and Points of Contact. Hyperlinks to the companies in which they have invested (domestic and foreign) are included in Table 1 for further exploration.

**Table 1:** Angel Investment Summary Table

Firm	Solar Investment Activity
<a href="#">Active Impact Investments</a>	<p><a href="#">Clir</a>, software to optimize wind and solar asset performance.<sup>3</sup></p> <p><a href="#">Jaza</a>, distributed solar energy and lighting made affordable in Africa.<sup>4</sup></p> <p><a href="#">Solstice</a>, a community-based solar initiative that seeks to increase access to residential rooftop solar and uses a first-of-kind solar qualification metric.<sup>5</sup></p>
<a href="#">American Family Insurance Institute for Corporate and Social Impact</a>	<p><a href="#">Solstice</a>, a community-based solar initiative that seeks to increase access to residential rooftop solar and uses a first-of-kind solar qualification metric.<sup>6</sup></p>
<a href="#">Blackhorn Ventures</a>	<p><a href="#">Swift Solar</a>, a startup manufacturing lightweight solar panels that are more efficient than conventional panels through the use of perovskite materials.<sup>7</sup></p> <p><a href="#">Wunder Capital</a>, a technology company that develops software and partners with leading solar organizations and financial institutions to build large-scale solar projects across the U.S.<sup>8</sup></p>
<a href="#">Blue Bear Capital</a>	<p><a href="#">Raptor Maps</a>,<sup>9</sup> a Machine Learning-powered software solution specifically intended to help solar companies reduce costs and increase energy production. Raptor Solar processes thermal and color imagery generated from aerial solar site inspections with drones and/or manned aircraft to detect, classify, and localize anomalies.<sup>10</sup></p> <p><a href="#">Omnidian</a>, an O&amp;M and insurance provider for distributed solar.<sup>11</sup></p>
<a href="#">Breakthrough Energy Ventures</a>	<p><a href="#">Arnergy</a>, providing African communities with modular solar solutions for residential and enterprise energy as well as power supply for rural telecommunications.<sup>12</sup></p> <p><a href="#">CubicPV</a>, offering Direct Wafer™ manufacturing and durable perovskite materials for powerful tandem modules.<sup>13</sup></p> <p><a href="#">Terabase</a>, a company developing an interconnected digital and automation platform to reduce the cost and increase the scalability of utility-scale solar.<sup>14</sup></p>

<p><a href="#">Buoyant Ventures</a></p>	<p><a href="#">Raptor Maps</a>,<sup>15</sup> a Machine Learning-powered software solution specifically intended to help solar companies reduce costs and increase energy production. Raptor Solar processes thermal and color imagery generated from aerial solar site inspections with drones and/or manned aircraft to detect, classify, and localize anomalies.<sup>16</sup></p>
<p><a href="#">City Light Capital</a></p>	<p><a href="#">Optivolt Labs</a>,<sup>17</sup> which has developed shade-tolerant solar panel technology that delivers up to 25x more power in shade when compared to conventional solar.<sup>18</sup></p> <p><a href="#">Terabase</a>, a company developing an interconnected digital and automation platform to reduce the cost and increase the scalability of utility-scale solar.<sup>19</sup></p> <p><a href="#">Sunfolding</a>,<sup>20</sup> a company developing a modular, single-axis tracker system powered by air pressure in polymer bellows that has the flexibility and installation simplicity of a fixed-tilt system.<sup>21</sup> This new tracker will allow for solar installation in complex terrain environments.<sup>22</sup></p>
<p><a href="#">Climate Capital</a></p>	<p><a href="#">Mosaic</a> (Solar financing)  <a href="#">Bright</a> (Residential solar for Mexico)  <a href="#">Lumen Energy</a> (Solar financing)<sup>23</sup>  <a href="#">Swift Solar</a>, a startup manufacturing lightweight solar panels that are more efficient than conventional panels through the use of perovskite materials.<sup>24</sup></p>
<p><a href="#">Congruent Ventures</a></p>	<p><a href="#">Raptor Maps</a>,<sup>25</sup> a Machine Learning-powered software solution specifically intended to help solar companies reduce costs and increase energy production. Raptor Solar processes thermal and color imagery generated from aerial solar site inspections with drones and/or manned aircraft to detect, classify, and localize anomalies.<sup>26</sup></p> <p><a href="#">Omnidian</a>, an O&amp;M and insurance provider for distributed solar.<sup>27</sup></p>
<p><a href="#">Data Point Capital</a></p>	<p><a href="#">Raptor Maps</a>,<sup>28</sup> a Machine Learning-powered software solution specifically intended to help solar companies reduce costs and increase energy production. Raptor Solar processes thermal and color imagery generated from aerial solar site inspections with drones and/or manned aircraft to detect, classify, and localize anomalies.<sup>29</sup></p>
<p><a href="#">Energize Ventures</a></p>	<p><a href="#">Aurora Solar</a>, which has developed software to address scalable solar design and sales. According to the company, to date, Aurora software has been used to design over 5 million solar installations.<sup>30</sup></p>

<a href="#">Fifth Wall</a>	<a href="#">Aurora Solar</a> , which has developed software to address scalable solar design and sales. According to the company, to date, Aurora software has been used to design over 5 million solar installations. <sup>31</sup>
<a href="#">Gaingels</a>	<p><a href="#">Palmetto</a>, end-to-end solar solutions.<sup>32</sup></p> <p><a href="#">SmartHelio</a>, focused on “making solar plants greener” using proprietary edge sensor and intelligent software.<sup>33</sup></p> <p><a href="#">WildGrid</a>, providing a service to make converting to solar technology simple.<sup>34</sup></p>
<a href="#">Good Growth Capital</a>	<a href="#">Swift Solar</a> , a company developing metal halide perovskite for solar PV applications.
<a href="#">Gratitude Railroad</a>	<a href="#">Solstice</a> , a community-based solar initiative that seeks to increase access to residential rooftop solar and uses a first-of-kind solar qualification metric. <sup>35</sup>
<a href="#">The Lightsmith Group</a>	<a href="#">SOURCE Global</a> , offering solar-powered hydropanels that pull moisture from the air to produce renewable drinking water. <sup>36</sup>
<a href="#">Next Wave Impact</a>	<a href="#">Solstice</a> , a community-based solar initiative that seeks to increase access to residential rooftop solar and uses a first-of-kind solar qualification metric. <sup>37</sup>
<a href="#">Powerhouse Ventures</a>	<p><a href="#">Raptor Maps</a>,<sup>38</sup> a Machine Learning-powered software solution specifically intended to help solar companies reduce costs and increase energy production. Raptor Solar processes thermal and color imagery generated from aerial solar site inspections with drones and/or manned aircraft to detect, classify, and localize anomalies.<sup>39</sup></p> <p><a href="#">Solstice</a>, a community-based solar initiative that seeks to increase access to residential rooftop solar and uses a first-of-kind solar qualification metric.<sup>40</sup></p> <p><a href="#">Terabase</a>, a company developing an interconnected digital and automation platform to reduce the cost and increase the scalability of utility-scale solar.<sup>41</sup></p>

<p><a href="#">Safar Partners</a></p>	<p><a href="#">Swift Solar</a>, a company developing metal halide perovskite for solar PV applications.</p> <p><a href="#">Ubiquitous Energy</a>/MIT for development of transparent solar panels.<sup>42</sup></p>
<p><a href="#">SustainVC</a></p>	<p><a href="#">EnergySage</a>, the leading online comparison-shopping marketplace for rooftop solar, community solar, and financing.<sup>43</sup></p> <p><a href="#">Locus Energy</a>, a solar monitoring and data analytics platform provider for the residential, commercial, and utility solar PV market sectors, with over 80,000 systems deployed across North America.<sup>44</sup></p> <p><a href="#">Scanify</a>, a solar software platform that incorporates drones and 3D modeling technology to improve solar contractor surveying, design and installation of residential and commercial projects.<sup>45</sup> Scanify's software "improves system accuracy and enhances worker safety, reducing onsite survey and design time by up to 90%, and lowering the cost of solar installations."<sup>46</sup></p> <p><a href="#">Solmetric</a>, a test and measurement company that designs and manufactures tools for the solar installation industry. Solmetric was acquired by Vivint Solar in 2014.<sup>47</sup></p> <p><a href="#">Solstice</a>, a community-based solar initiative that seeks to increase access to residential rooftop solar and uses a first-of-kind solar qualification metric.<sup>48</sup></p>
<p><a href="#">Village Capital (ViCap)</a></p>	<p><a href="#">e-Chromic Technologies</a>, developing an innovative reflective electrochromic thin film that enables users to control light and solar heat transmission through windows.<sup>49</sup></p> <p><a href="#">Solar SiteDesign</a>, offering a solar marketplace platform for commercial and residential properties intended to streamline the process of sharing information with all project stakeholders and help to reduce expensive soft costs.<sup>50</sup></p>
<p><a href="#">VoLo Earth Ventures</a></p>	<p><a href="#">Blue Dot Photonics</a>, using quantum-cutting technology to improve silicon solar panels providing 16% more energy and lowering the cost of solar power by 10%.<sup>51</sup></p> <p><a href="#">Solar Inventions</a>, created with a mission to accelerate the pace of innovation in solar and other clean energy solutions, with benefits including increased power, improved shading tolerance, and reduced hotspot risk.<sup>52</sup></p> <p><a href="#">Wattch</a>, a next-generation data analytics platform for solar energy.<sup>53</sup></p>

## 2.1 Active Impact Investments

Based in Manhattan Beach, California, [Active Impact Investments](#) invests in climate tech start-ups to “support environmental resiliency through profitable investment.”<sup>54</sup> Active Impact Investments’ Fund II offering is focused on four areas:

- Clean energy & transportation
- Smart infrastructure
- Sustainable food & water
- Circular & sharing economy.<sup>55</sup>

Active Impact’s Investment Criteria include:

- Early-stage private company with a climate tech solution
- Exceptional leadership team
- Generating revenues between \$200K and \$3M
- 5-50 employees
- Interested in growth and willing to accept help from outsiders<sup>56</sup>

Entrepreneurs are invited to submit their venture via an [online form](#).

**Active Impact Investments has invested in:**

- [Clir](#), software to optimize wind and solar asset performance<sup>57</sup>
- [Jaza](#), distributed solar energy and lighting made affordable in Africa<sup>58</sup>
- [Solstice](#), a community-based solar initiative that seeks to increase access to residential rooftop solar and uses a first-of-kind solar qualification metric.<sup>59</sup>

Contact Information	
<b>Organization</b>	Active Impact Investments
<b>Address</b>	805 Manhattan Ave, Suite 201 Manhattan Beach, CA 90266
<b>Website</b>	<a href="https://www.activeimpactinvestments.com/">https://www.activeimpactinvestments.com/</a>

## 2.2 American Family Insurance Institute for Corporate and Social Impact

Based in Madison, Wisconsin, [American Family Insurance Institute for Corporate and Social Impact](#) seeks to invest in “visionary entrepreneurs who are building scalable social enterprises”<sup>60</sup> in the following focus areas:

- Economic opportunity for all
- Healthy youth development
- Equity in education
- Resilient communities.<sup>61</sup>

American Family Insurance Institute invests in Seed and Series A stages. The firm’s focus is on promoting climate justice, as it invests in startups that “increase access to clean energy, promote strong infrastructure, and build climate adaptation strategies for communities that face the most adverse climate impacts.”<sup>62</sup>

American Family Insurance Institute does not provide a vehicle for venture submission, and instead invites entrepreneurs to contact the investment team directly via an [online form submission](#).

**American Family Insurance has invested in:**

- [Solstice](#), a community-based solar initiative that seeks to increase access to residential rooftop solar and uses a first-of-kind solar qualification metric.<sup>63</sup>

Contact Information	
Organization	American Family Insurance
Address	821 E. Washington Ave. Madison, WI 53703
Website	<a href="https://www.amfaminstitute.com/">https://www.amfaminstitute.com/</a>

### 2.3 Blackhorn Ventures

Based in Colorado, [Blackhorn Ventures](#) funds companies that are “using technology to create unprecedented resource productivity.”<sup>64</sup> The firm’s industry focus areas include construction, manufacturing, healthcare, agriculture, transportation, water, and energy.<sup>65</sup>

Entrepreneurs are invited to pitch an opportunity to Blackhorn Ventures via an [online form submission](#).

**Blackhorn Ventures has invested in:**

- [Swift Solar](#), a startup manufacturing lightweight solar panels that are more efficient than conventional panels through the use of perovskite materials.<sup>66</sup>
- [Wunder Capital](#), a technology company that develops software and partners with leading solar organizations and financial institutions to build large-scale solar projects across the U.S.<sup>67</sup>

Contact Information	
<b>Organization</b>	Blackhorn Ventures
<b>Address</b>	1023 Walnut St #100 Boulder, CO 80302
<b>Website</b>	<a href="https://blackhornvc.com/">https://blackhornvc.com/</a>

## 2.4 Blue Bear Capital

With locations in Los Angeles, California; San Francisco, California; Jackson, Wyoming; Houston, Texas; and London, United Kingdom, [Blue Bear Capital](#) invests in high-growth technology companies across the energy, infrastructure, and climate industries.<sup>68</sup>

According to Blue Bear Capital, “macro factors are forcing the energy supply chain to get smarter and more efficient. Meanwhile, breakthrough technologies like machine learning, industrial internet, and cloud computing have reached commercial scale. But there is often a gap between Tech VC and the energy industry. Blue Bear Capital exists to fill that gap.”<sup>69</sup>

Blue Bear’s key energy industry investment themes include:

- Digitization of traditional supply chain work
- The industrialization of renewables
- Data-driven grids.<sup>70</sup>

Key technology investment themes include:

- Wide learning as the next deep learning
- Integration as the next Interface
- The digital operating system for energy.<sup>71</sup>

Blue Bear Capital does not provide information on applying for funding, but does include a general contact email, [info@bluebearcap.com](mailto:info@bluebearcap.com). Blue Bear Capital also provides direct contact information for each member of its investment team.

### Blue Bear Capital has invested in:

- [Raptor Maps](#),<sup>72</sup> a Machine Learning-powered software solution specifically intended to help solar companies reduce costs and increase energy production. Raptor Solar processes thermal and color imagery generated from aerial solar site inspections with drones and/or manned aircraft to detect, classify, and localize anomalies.<sup>73</sup>
- [Omnidian](#), an O&M and insurance provider for distributed solar.<sup>74</sup>

Contact Information	
<b>Organization</b>	Blue Bear Capital
<b>Address</b>	9171 Wilshire Boulevard, Suite 500 Los Angeles, CA 90210
<b>Website</b>	<a href="https://bluebearcap.com/">https://bluebearcap.com/</a>

## 2.5 Breakthrough Energy Ventures

[Breakthrough Energy Ventures](#) (BEV) was established in 2015 by Bill Gates and a team of private investors to “support innovations that will lead the world to net-zero emissions.”<sup>75</sup>

BEV describes itself as a “network of entities and initiatives, including investment funds, nonprofit and philanthropic programs, and policy efforts linked by a common commitment to scale the technologies we need to achieve a path to net zero emissions by 2050.”<sup>76</sup>

BEV has raised over \$2 billion in committed capital to support emerging companies focused on significantly reducing emissions from the agriculture, buildings, electricity, manufacturing, and transportation sectors.<sup>77</sup>

Investment criteria is summarized below:

- **“Climate Impact:** Due to the magnitude of human energy consumption, progress in small increments isn’t enough. We will only invest in technologies with the potential, at scale, to reduce greenhouse gases by at least half a gigaton every year, about 1 percent of global emissions.”
- **“Scientific Possibility:** Because the time it takes to get to market for clean technologies is so long, it is important to vet projects carefully early on. We will only invest in projects that our technologists deem scientifically feasible at scale.”
- **“Other Investors:** We do not have the resources to solve the entire global energy challenge on our own. We will only invest in companies that we believe can ultimately attract additional investment from others.”
- **“Filling the Gaps:** Some aspects of clean tech have attracted more investor interest than others. We will focus our resources on neglected areas and enterprises we believe are critical to explore.”

Further, BEV does not limit investment based on early- or late-stage, size, geographic location, or technology.

### Breakthrough Energy Ventures has invested in:

- [Arnergy](#), providing African communities with modular solar solutions for residential and enterprise energy as well as power supply for rural telecommunications<sup>78</sup>

- [CubicPV](#), offering Direct Wafer™ manufacturing and durable perovskite materials for powerful tandem modules<sup>79</sup>
- [Terabase](#), a company developing an interconnected digital and automation platform to reduce the cost and increase the scalability of utility-scale solar.<sup>80</sup>

Contact Information	
<b>Organization</b>	Breakthrough Energy Ventures
<b>Address</b>	4110 Carillon Point Kirkland, WA 98033
<b>Website</b>	<a href="https://www.breakthroughenergy.org/">https://www.breakthroughenergy.org/</a>

## 2.6 Buoyant Ventures

[Buoyant Ventures](#) invests in digital solutions for climate risk, with a focus on 3 areas:

- Adaptation - adapt to risk
- Mitigation - meet climate goals
- Digital foundation - enable the future.<sup>81</sup>

Buoyant invests in early-stage ventures with seed and series A funding across the following industries:

- Energy
- Mobility
- Built environment
- Agriculture & water.<sup>82</sup>

Buoyant Invests in the following areas:

- Digital technologies:  
including software, analytics, sensors, platforms, etc.
- Seed & series A:  
Also seeks to build relationships with pre-seed companies
- Growth startups:  
Specifically, companies that “can rapidly scale to meet the urgency of climate change”
- Climate impact:  
Companies that help companies and communities solve for and adapt to climate change and risk.<sup>83</sup>

Buoyant Ventures invites entrepreneurs to apply for investment consideration via an [online form](#).

## Buoyant Ventures has invested in:

- [Raptor Maps](#),<sup>84</sup> a Machine Learning-powered software solution specifically intended to help solar companies reduce costs and increase energy production.

Contact Information	
Organization	Buoyant Ventures
Address	1322 West Deerpath Road Lake Forest, IL 60045
Website	<a href="https://www.buoyant.vc/">https://www.buoyant.vc/</a>

## 2.7 City Light Capital

Headquartered in New York, New York, [City Light Capital](#) “only invests in companies where there is a direct relationship between financial outcomes and measurable social impact.”<sup>85</sup> The firm supports companies at seed stage and beyond:

- [City Spark Investments](#):  
Seed and pre-seed companies
- [City Light Investments](#):  
Companies with at least \$1 million in revenue, an exponential growth path, and measurable social impact<sup>86</sup>

City Light invites entrepreneurs to fill out an [online form](#) for investment consideration.

Specific to City Spark funding, entrepreneurs are invited to submit several items via an [online portal](#) in order to be considered for seed funding, including:

- Investment deck
- Management team bios
- Path to measuring impact

## City Light has invested in:

- [Optivolt Labs](#),<sup>87</sup> which has developed shade-tolerant solar panel technology that delivers up to 25x more power in shade when compared to conventional solar.<sup>88</sup>
- [Terabase](#) a company developing an interconnected digital and automation platform to reduce the cost and increase the scalability of utility-scale solar.<sup>89</sup>
- [Sunfolding](#),<sup>90</sup> a company developing a modular, single-axis tracker system powered by air pressure in polymer bellows that has the flexibility and installation simplicity of a fixed-tilt system.<sup>91</sup> This new tracker will allow for solar installation in complex terrain environments.<sup>92</sup>

Contact Information	
<b>Organization</b>	City Light Capital
<b>Address</b>	335 Madison Ave, 4th Floor New York, NY 10017
<b>Website</b>	<a href="https://citylight.vc/">https://citylight.vc/</a>

## 2.8 Climate Capital

Headquartered in San Francisco, California, [Climate Capital](#) makes initial investments of \$10k - \$500k+.<sup>93</sup>

Climate Capital does not provide information on how to apply for funding.

**Climate Capital has invested in:**

- [Swift Solar](#) a startup manufacturing lightweight solar panels that are more efficient than conventional panels through the use of perovskite materials.<sup>94</sup>

Contact Information	
<b>Organization</b>	Climate Capital
<b>Website</b>	<a href="https://www.climatecapital.co/">https://www.climatecapital.co/</a>

## 2.9 Congruent Ventures

[Congruent Ventures'](#) focus is on addressing sustainability challenges with respect to the following focus areas:

- Mobility and urbanization
- Energy transition
- Food and agriculture
- Sustainable production and consumption.<sup>95</sup>

Congruent seeks to invest early in the following areas:

- Hardware
- Software
- Enterprise
- Consumer
- Deep technology
- Fin-tech
- Business model innovation<sup>96</sup>

Entrepreneurs are invited to send deal submissions via email: [investors@congruentvc.com](mailto:investors@congruentvc.com)

**Congruent Ventures has invested in:**

- [Raptor Maps](#) a Machine Learning-powered software solution specifically intended to help solar companies reduce costs and increase energy production.
- [Omnidian](#) an O&M and insurance provider for distributed solar.<sup>97</sup>

Contact Information	
<b>Organization</b>	Data Point Capital
<b>Address</b>	<i>Office Address:</i> 201 Mission St, Suite 650, San Francisco, CA 94105 <i>Mailing Address:</i> 6114 La Salle Avenue #443, Oakland, CA 94611
<b>Website</b>	<a href="https://congruentvc.com/">https://congruentvc.com/</a>

**2.10 Data Point Capital**

Located in Boston, Massachusetts, [Data Point Capital](#) invests in data-driven businesses in several categories of interest, including the consumer Internet (e-commerce, mobile, media), cloud-based enterprise software, and the industrial Internet of Things.<sup>98</sup>

Data Point Capital does not provide information on how to apply for funding but does include [general contact information](#) on their website.

**Data Point Capital has invested in:**

- [Raptor Maps](#) a Machine Learning-powered software solution specifically intended to help solar companies reduce costs and increase energy production.<sup>99</sup>

Contact Information	
<b>Organization</b>	Data Point Capital
<b>Address</b>	341 Newbury Street, 6th Floor Boston, MA 02115
<b>Website</b>	<a href="https://datapointcapital.com/">https://datapointcapital.com/</a>

## 2.11 Energize Ventures

[Energize Ventures](#) describes itself as “a leading global alternative investment manager focused on the digitization of energy and sustainable industry,” with the mission to “accelerate the sustainable energy transition by partnering with the best companies at the intersection of energy and technology to provide financial capital, industry expertise and commercialization support.”<sup>100</sup> Energize invests in software-based solutions across industries including renewable energy, critical infrastructure, climate resiliency, cybersecurity and mobility.<sup>101</sup>

According to *Solar Power Investor*, Energize “has close ties with Invenergy and thus leverages the partnership to quickly scale and commercialize its portfolio.”<sup>102</sup> The group also has key partnerships with [Schneider Electric](#), [WEC Energy Group](#), and [GE](#). Energize prefers to lead Series A-C rounds with initial investments between \$10-20 million.<sup>103</sup>

Energize Ventures does not provide information on how to apply for funding and does not provide contact information online.

### Energize Ventures has invested in:

- [Aurora Solar](#), which has developed software to address scalable solar design and sales. According to the company, to date, Aurora software has been used to design over 5 million solar installations.<sup>104</sup> Energize first partnered with Aurora Solar by leading their Series A in 2019. In 2021, Energize continued their investment in Aurora through its growth fund, Energize Growth Fund I<sup>105</sup>, participating in Aurora’s \$250 million Series C funding round led by [Coatue](#), with follow-on participation from existing investors [ICONIQ Capital](#), [Energize Ventures](#), and [Fifth Wall](#). In just over two years, Aurora Solar has raised more than \$320 million.<sup>106</sup>

Contact Information	
Organization	Energize Ventures
Address	1 South Wacker Drive, Suite 1120 Chicago, IL 60606
Website	<a href="https://www.energize.vc/">https://www.energize.vc/</a>

## 2.12 Fifth Wall

Located in Marina Del Rey, California, [Fifth Wall](#) describes itself as “pioneering an advisory-based approach to venture capital” with a full-service, integrated, operationally aligned approach, as the “first and largest venture capital firm advising corporates on and investing in Built World technology.”<sup>107</sup> Fifth Wall invests in climate technology, real estate, and retail

Entrepreneurs are invited to pitch ideas via email: [ideas@fifthwall.com](mailto:ideas@fifthwall.com)

### Fifth Wall has invested in:

- [Aurora Solar](#) has developed software to address scalable solar design and sales.<sup>108</sup>

Contact Information	
<b>Organization</b>	Fifth Wall
<b>Address</b>	13160 Mindanao Way Suite 100B Marina Del Rey, CA 90292
<b>Website</b>	<a href="https://fifthwall.com/">https://fifthwall.com/</a>

### 2.13 Gaingels

Founded in 2014 and headquartered in New York City, New York, [Gaingels](#) is a LGBTQIA+/Allies investment syndicate, describing itself as “one of the largest and most active private investors in North America dedicated to supporting diversity in leadership at all levels within the venture capital ecosystem.”<sup>109</sup>

- As of January 2022, Gaingels projects close to \$600M+ in investments for the year
- The Gaingels portfolio counts over 1000+ companies<sup>110</sup>

### Gaingels has invested in:

- [Palmetto](#), end-to-end solar solutions.<sup>111</sup>
- [SmartHelio](#), focused on “making solar plants greener” using proprietary edge sensor and intelligent software.<sup>112</sup>
- [WildGrid](#), providing a service to make converting to solar technology simple.<sup>113</sup>

Contact Information	
<b>Organization</b>	Gaingels, Inc
<b>Address</b>	43 West 23rd 2nd Floor New York, NY 10010
<b>Website</b>	<a href="https://gaingels.com/">https://gaingels.com/</a>

### 2.14 Good Growth Capital

Located in both Charleston, South Carolina and Boston, Massachusetts, [Good Growth Capital](#) claims a diverse scouting pool in the Southeast as well as early-stage technology accelerators at MIT and throughout Research Triangle.<sup>114</sup> The firm invests in the following areas:

- Health tech
- Data science
- Green tech (including renewables)
- Hard science<sup>115</sup>

Good Growth Capital provides an [online form](#) for companies seeking investment.

**Good Growth Capital has invested in:**

- [Swift Solar](#) – a company developing metal halide perovskite for solar PV applications. According to Good Growth Capital, first uses for Swift Solar’s technology will be satellites which require lightweight, with the future goal to expand to all rooftops.<sup>116</sup> Good Growth Capital does not appear to have other investments in solar technology startups as of the time of this report (July 2022).

Contact Information	
<b>Organization</b>	Good Growth Capital
<b>Address</b>	182 Beacon St. Unit 14 Boston, MA 02116
<b>Website</b>	<a href="https://www.goodgrowthvc.com/">https://www.goodgrowthvc.com/</a>

**2.15 Gratitude Railroad**

Located in Los Angeles, California, [Gratitude Railroad](#) is a community of investors focused on solving environmental and social problems through investor education, gatherings, incubation of impact infrastructure, and early-stage direct venture capital.<sup>117</sup>

We do not invest from a traditional fund, but rather work closely with all our investors to identify opportunities and syndicate capital on a deal-by-deal basis. We take a long-term view on our investments and partner with entrepreneurs and investment managers to create enduring businesses that benefit humankind.<sup>118</sup>

Gratitude Railroad primarily invests in early-stage growth companies at the seed and series A level with revenues of ~\$1M. Gratitude Railroad is self-described as sector and issue-area agnostic, and focuses on U.S.-based businesses, with a typical investment size of \$250,000 - \$2 million.<sup>119</sup>

Gratitude Railroad does not provide a specific means of applying for funding, and instead directs interested entrepreneurs to contact directly.<sup>120</sup>

**Gratitude Railroad has invested in:**

- [Solstice](#) a community-based solar initiative that seeks to increase access to residential rooftop solar and uses a first-of-kind solar qualification metric.

Contact Information	
<b>Organization</b>	Gratitude Railroad LLC
<b>Address</b>	5651 Aspenleaf Dr Park City, UT 84098
<b>Website</b>	<a href="https://gratituderailroad.com/">https://gratituderailroad.com/</a>

**2.16 Lightsmith Group**

Founded in 2019 and headquartered in New York City, New York, [The Lightsmith Group’s](#) focus areas include “technology-enabled business services and solutions in the areas of energy, water, food and agriculture, and climate resilience solutions.”<sup>121</sup>

Lightsmith’s investment criteria includes:

- Companies providing technology enabled business services and solutions that address critical societal needs, including in the areas of energy, water, food and agriculture, and climate resilience solutions
- Established business, ready to scale: Have proven technologies and business models with significant revenues and demonstrated customer validation in existing markets
- Attractive Economics: Attractive gross margins and ability to grow profitably
- Leading market position: Established a top market position within its sub-sector or market segment
- Persistent advantage: Will be able to sustain its market position and profitability in future through a durable differentiation or competitive advantage
- Superior management: Talented management teams with proven ability to scale businesses
- ESG & Metrics: Have or can put Environmental Social and Governance (ESG) processes in place and can apply key performance indicators to assess social and environmental impacts.<sup>122</sup>

Lightsmith Group does not provide information on how to apply for funding.

**The Lightsmith Group has invested in:**

- [SOURCE Global](#) in Malaysia. SOURCE Global offers solar-powered hydropanels that pull moisture from the air to produce renewable drinking

water. These standalone hydropanels measure 1m x 2m and can function well in dry climates, including the Sonoran Desert – where SOURCE Global is headquartered.<sup>123</sup>

Contact Information	
<b>Organization</b>	The Lightsmith Group
<b>Address</b>	11 East 44th Street, Suite 1502 New York, NY 10017
<b>Website</b>	<a href="https://lightsmithgp.com/">https://lightsmithgp.com/</a>

## 2.17 Next Wave Impact

Located in Denver, Colorado, [Next Wave Impact](#) is focused on increasing diversity, inclusion, and impact in early-stage investing and the entrepreneurial ecosystem, through their “innovative learning-by-doing progressive fund model.”<sup>124</sup>

Next Wave provides the following investment criteria for its U.S. Impact Fund I:

The Next Wave US Impact Fund I seeks to demonstrate that impact investing can provide attractive financial returns. We will build a diversified portfolio with a goal of maximizing both social and financial returns. The fund will follow a triple-bottom-line model of investing (people, planet, prosperity).

We will seek a portfolio that is **more angel investments (early stage) than venture (later stage)**. On the early side, we want to see both proof of concept and some market traction. Investments at the pre-revenue stage would be an exception and would require a proven entrepreneur, amazing idea, and/or incredible backers. The fund will emphasize diversity by investing not only against stage, but also industry and geography, and a diverse set of underrepresented entrepreneurs.<sup>125</sup>

Portfolio Company Characteristics sought by Next Wave include:

- **Sustainable Competitive Advantage:** Competitive advantages can include high barriers to entry (if no IP, then trade secrets that can allow a reasonable amount of time to become market leader), disruptive technology, etc. Company should foresee creating some type of unique marketing position.
- **Strong, Well-Balanced Management Team:** Should include knowledge of the industry, their product and competitor’s product as well as an understanding of where their product fits in the future trending of their industry. Should have enthusiasm and ability to execute their plan.
- **Strong preference for serial entrepreneurs** who have successfully exited in the past, are coachable, and communicate well with their investors.
- **Market Opportunity:** The market ideally would have room for growth and offer opportunity to capitalize on attractive industry trends.
- **Balanced and diverse growth strategy** which addresses both vertical as well as horizontal growth.
- **Product/Service Differentiation** (No “Me-too” companies)

- **Has a Plan B as well as Plan A**, in addition to a clear exit strategy (or, in cases of alternative financing vehicles, a clear path to repayment of investment + return).<sup>126</sup>

Further, Next Wave's fund investments focus on firms that the company believes will have a significant positive impact on people, communities, and the planet. Further:

We are interested in companies that have shown traction in solving a large-scale problem in education, health, food sustainability, and opportunities in clean / energy saving technology, as well as companies that are focused on the aging population.

We will not invest in pharma and medical devices that include FDA approval unless the approval is imminent.

We should have geographic diversity and a portfolio weighted more heavily to women entrepreneurs, but not necessarily exclusively women-led companies. We'd like to see women and/or minorities on the founding team.<sup>127</sup>

Financial Considerations for investment by Next Wave include:

- Valuations: Reasonable valuation for the stage of the entity > should be comparable to market median prices. **Unless at a later stage, valuations above \$6M should be thoroughly reviewed and have disruptive technology; most early-stage company valuations should be between \$2 – 4M.**
- Funding Ask: Should be in line with their stage of growth. Our aim is to have • **of \$100K to \$250K per company in the first two years of the fund and follow-on investments of \$250-\$500K in years three and four.** We may ask for a board seat. Observer status at a minimum.
- Number of expected funding rounds: the company should have looked at this and provided their answer, which we can then evaluate as to what amounts of money have to be put aside for follow-on round investing.
- Diversity in terms of Stage of Company – at a minimum, company should have proof of concept. Most companies should be already in the market and earning some revenue. Some investments should be later stage so exits are possible in the near term. Some companies should be quick to cash flow break even, not requiring multiple funding rounds. To achieve diversity, we plan to invest in 6- 8 companies each year for the first two years. **Our typical first investment size will be 100K-150K.**
- We plan to syndicate all deals and not be the sole funder. Ideally, we should invest no more than 30% of the round. We will aim to syndicate deals with our networks including: Toniic, Investors Circle, Golden Seeds, Astia Angels, Pipeline Angels, 37 Angels, Blue Tree Angels, Portfolia, and other angel and early stage and impact VC firms.
- A 'quick' win or 2 relatively early would help to grow the reputation of the fund. We plan to make follow on investments in a subset of our portfolio companies in years 3-4, as well as possibly a few more seed investments. Our follow-on investments will be in the 200K-\$500K range.
- Our due diligence will focus on ensuring the social/environmental impact is core to the companies' business models and clearly define it for each company. Early screening can ensure the impact isn't, but detailed due diligence will need to prove out how the impact mission is core to the company, so ideally that is preserved post-exit. The fund will follow a triple-bottom-line model of investing (people, planet, prosperity).<sup>128</sup>

Focus Areas include:

- Education
- Health
- Water
- Fintech
- Financial access/inclusion/security
- Green technology/cleantech
- Agriculture & food, including Agtech
- Sustainable consumer products including food products/organics & green consumer products/services
- Employment generation
- Aging and longevity
- New social enterprise business models
- Other screens/thresholds<sup>129</sup>

Entrepreneurs seeking capital from Next Wave, it is noted that they should be referred by one of the members of Next Wave’s investment committee or one of their limited partners (LPs).<sup>130</sup> Next Wave is not accepting applications for new funding at the time of this report (July 2022).<sup>131</sup>

**Next Wave Impact has invested in:**

- [Solstice](#) a community-based solar initiative that seeks to increase access to residential rooftop solar and uses a first-of-kind solar qualification metric.<sup>132</sup>

Contact Information	
<b>Organization</b>	Next Wave Impact
<b>Address</b>	1031 33rd St Denver, CO 80205
<b>Website</b>	<a href="https://nextwaveimpact.com/">https://nextwaveimpact.com/</a>

**2.18 Powerhouse Ventures**

[Powerhouse Ventures](#) “backs entrepreneurs building the digital infrastructure for rapid decarbonization.” In March 2022, the firm launched its \$70 million second fund.<sup>133</sup>

According to the firm, its investors represent some of the world’s largest corporations in energy, utilities, mobility, financial services, and tech:

- Credit Suisse
- Constellation
- Toyota Ventures

- Energy Impact Partners
- American Electric Power
- TotalEnergies
- Microsoft<sup>134</sup>

Entrepreneurs are invited to submit a [startup inquiry](#).

**Powerhouse Ventures has invested in:**

- [Solstice](#) a community-based solar initiative that seeks to increase access to residential rooftop solar and uses a first-of-kind solar qualification metric.<sup>135</sup>
- [Terabase](#) a company developing an interconnected digital and automation platform to reduce the cost and increase the scalability of utility-scale solar
- [Raptor Maps](#) a Machine Learning-powered software solution specifically intended to help solar companies reduce costs and increase energy production.<sup>136</sup>

Contact Information	
<b>Organization</b>	Powerhouse Ventures
<b>Address</b>	1528 Webster St #11 Oakland, CA 94612
<b>Website</b>	<a href="https://www.powerhouse.fund/">https://www.powerhouse.fund/</a>

**2.19 Safar Partners**

Headquartered in Cambridge, Massachusetts, [Safar Partners](#) “takes advantage of its deep connections at world-class universities – primarily, MIT, Harvard, and the University of Rochester – to invest in the commercial potential of technology startups originating there.”<sup>137</sup> Safar’s investment areas include:

- Cleantech and advanced materials
- AI/IT and robotics
- Life sciences<sup>138</sup>

According to Safar, the firm targets a return multiple of over 4x on invested capital and a net IRR of over 20%.<sup>139</sup>

Safar Partners provides an online [contact form](#).

**Safar Partners has invested in:**

- [Swift Solar](#) – a company developing metal halide perovskite for solar PV applications.

- [Ubiquitous Energy](#)/MIT for development of transparent solar panels.<sup>140</sup>

Contact Information	
<b>Organization</b>	Safar Partners
<b>Address</b>	One Broadway, 14th floor, Cambridge, MA 02142
<b>Phone</b>	<a href="https://www.safar.partners/">https://www.safar.partners/</a>

## 2.20 SustainVC

With locations in Boston, Massachusetts, Durham, North Carolina, and Philadelphia, Pennsylvania, [SustainVC](#) invests in early-stage, high-impact companies with \$500,000 to \$1 million in funds.<sup>141</sup>

SustainVC's focus areas include:

- Climate & sustainability
  - o Energy & environment, transportation efficiency, sustainable agriculture & food systems
- Equality & empowerment
  - o Work force development, accessibility technology, financial mobility & inclusion
- Health & Education
  - o Healthcare & medical technology, personal wellness, education technology.<sup>142</sup>

Investment criteria include:

- Early-stage, for-profit ventures domiciled in North America, actively raising Series Seed - Series A rounds with capital needs between \$500,000 - \$5,000,000
- Strong, diverse, and passionate management teams with proven industry experience and expertise
- Post proof-of-concept with clear market traction in the form of revenues (\$100K-\$5M), contracts, strategic partnerships, users, etc.
- Scalable business models and large addressable markets, with plans to ultimately pursue an exit strategy
- Strong IP, clear barriers to entry, and competitive advantage
- Dedication and commitment to social and/or environmental impact<sup>143</sup>

SustainVC is specifically interested in “innovative entrepreneurs that are building highly-scalable, impactful companies with early-stage capital needs,” and directs those interested in funding to contact via email at [info@SustainVC.com](mailto:info@SustainVC.com).

## SustainVC has invested in:

- [Solstice](#) a community-based solar initiative that seeks to increase access to residential rooftop solar and uses a first-of-kind solar qualification metric.<sup>144</sup>
- [EnergySage](#), the leading online comparison-shopping marketplace for rooftop •, community solar, and financing.<sup>145</sup>
- [Locus Energy](#), a solar monitoring and data analytics platform provider for the residential, commercial, and utility solar PV market sectors, with over 80,000 systems deployed across North America.<sup>146</sup>
- [Scanifly](#), a solar software platform that incorporates drones and 3D modeling technology to improve solar contractor surveying, design, and installation of residential and commercial projects.<sup>147</sup> Scanifly’s software “improves system accuracy and enhances worker safety, reducing onsite survey and design time by up to 90%, and lowering the cost of solar installations.”<sup>148</sup>
- [Solmetric](#), a test and measurement company that designs and manufactures tools for the solar installation industry. Solmetric was acquired by Vivint Solar in 2014<sup>149</sup>

Contact Information	
Organization	SustainVC
Address	1150 Main Street Unit 9 Concord, MA 01742
Phone	<a href="https://sustainvc.com/">https://sustainvc.com/</a>

## 2.21 Village Capital

Founded in 2009 and headquartered in Washington, DC, Village Capital (VilCap) describes itself as “the largest organization in the world supporting impact-driven, seed-stage startups.”<sup>150</sup> Further, “Since 2009 our team has directly worked with more than 1,100 entrepreneurs in 28 countries, and our affiliated fund, [VilCap Investments](#), has invested in 110 startups that have gone on to raise more than \$4 billion in follow-on capital.”<sup>151</sup>

VilCap offers a range of accelerator programs for start-ups that provide support via training curriculum. As part of its accelerator initiative, VilCap includes \$300,000 in grant funding for a subset of cohort companies in the accelerator programs, with each company eligible to receive grant funding of up to \$75,000, directed through a peer selection process.

VilCap’s current [Greentech Europe 2022](#) accelerator eligibility requirements include:

- Must be a for-profit market-based solution that tackles a sustainability challenge in Europe, especially Southern Europe

- Must have operations in (or have the ability to expand business to) the EMEAA or European market
- Must have a minimum viable product (MVP), and raised less than \$3M in equity
- Must have at least one full-time founder based in EMEAA or Europe, and Co-Founders to have 50%+ female representation or more than 25% of senior leadership team to be female
- Must have meaningful customer or business validation (not limited to revenue, can also be successful pilot studies, number of users, and/or strategic partnerships)

Headquartered in San Francisco, California, [VilCap Investments](#) invests in early-stage companies with social and environmental impact.<sup>152</sup>

VilCap does not provide information on how to apply for funding.

**VilCap has invested in:**

- [e-Chromic Technologies](#), developing an innovative reflective electrochromic thin film that enables users to control light and solar heat transmission through windows.<sup>153</sup>
- [Solar SiteDesign](#), offering a solar marketplace platform for commercial and residential properties intended to streamline the process of sharing information with all project stakeholders and help to reduce expensive soft costs.<sup>154</sup>

Contact Information	
<b>Organization</b>	VilCap Investments
<b>Address</b>	29 Rivoli Street San Francisco, CA 94117
<b>Website</b>	<a href="https://www.vilcapinvestments.com/">https://www.vilcapinvestments.com/</a>

## 2.22 [VoLo Earth Ventures](#)

Headquartered in Snowmass Village, Colorado, [VoLo Earth Ventures](#) provides first-in funding and hands-on leadership to early-stage climate tech companies.<sup>155</sup>

VoLo Earth does not provide information on investment criteria or an application process.

The firm has invested in the following solar technologies:

- [Blue Dot Photonics](#), using quantum-cutting technology to improve silicon

solar panels providing 16% more energy and lowering the cost of solar power by 10%.<sup>156</sup>

- [Solar Inventions](#), created with a mission to accelerate the pace of innovation in solar and other clean energy solutions, with benefits including increased power, improved shading tolerance, and reduced hotspot risk.<sup>157</sup>
- [Wattch](#), a next-generation data analytics platform for solar energy.<sup>158</sup>

## 2.3 Summary

The preceding section reviewed investments made in early-stage solar technologies by 22 business angel/venture groups. These investors provided funding to 26 different companies, with most of the apparent investment going to five firms:

- Aurora Solar
- Raptor Maps
- Solstice
- Swift Solar
- Terabase

In a February 2022 article **Aurora Solar** was cited as having a \$4 billion dollar valuation after a \$200 million investment from numerous venture capital firms. Their product is “a digital platform that streamlines sales and design processes for the solar industry to help speed up adoption. About 4% of U.S. homes use solar panels, with growth constrained by often lengthy processes needed to design, sell, permit and connect projects.”<sup>159</sup>

**Raptor Maps** received a \$22 million Series B investment in February, 2022 – bringing the total number of investors to 15. “Raptor Solar is an advanced software-as-a-service platform for the entire solar lifecycle – from financing and development through operations. Raptor Solar lets utility-scale and C&I solar companies standardize and analyze data, collaborate, optimize PV assets, reduce risk and ultimately lift financial return. The SaaS platform serves as an auditable system of record featuring state-of-the-art digital twins of solar assets. An industry first, users can scan in module serial numbers to streamline warranty claims and verify supply chains. Subscribers benefit from inspection analytics, productivity tools and ability to quantify financial loss and even benchmark portfolios against Raptor Maps’ global database. The software solves major growing pains across solar finance, development and asset management.”<sup>160</sup>

According to Crunchbase [Solstice](#) has received a total of \$4.7M in eight rounds of investment, from 19 investors.<sup>161</sup> In a 2021 press release which post-dates the Crunchbase information, Solstice reports raising \$3.1 million for community solar and other affordable renewable energy projects.<sup>162</sup> According to Solstice “One of these innovations is Solstice’s new community solar qualification metric, the EnergyScore. Leveraging data from nearly 875,000 customer records, the EnergyScore is projected to predict future payment behavior more accurately than FICO credit scores, while simultaneously including a larger proportion of qualified low-to-moderate income customers.”

Founded in 2017, [SwiftSolar](#) has raised \$15.4M in five rounds of funding from nine investors.<sup>163</sup> The company develops photovoltaics cells designed to build the next generation of solar technology. “The company’s cells are made of ultra-thin perovskite films and are engineered to absorb different parts of the solar spectrum to provide high-efficiency tandem solar cells that achieve weight ratios due to their strong light absorption and high efficiency, enabling clients to produce efficient, lightweight and low-cost photovoltaics.”

[Terabase](#) has built the first digital platform for managing the full project life cycle of utility-scale solar and combined it with a construction automation system to transform the way solar power plants are deployed. According to an August 2, 2022 press release, Terabase recently raised a \$44M series B co-led by Bill Gates’ Breakthrough Energy Ventures and Prelude Ventures. This is the third round of funding.<sup>164</sup> Terabase’s automated field-factory, capable of 24/7 operations, can significantly compress construction schedules and reduce costs while ensuring higher build quality. The robotics-assisted workflow will also improve worker health and safety by eliminating manual lifting of heavy panels and steel components under often difficult outdoor weather conditions.

These investments reveal that what is of interest to this pool of early-stage investors are technologies that expedite the installation of solar. Only one of the preceding five companies was funded for innovations in the solar technology itself – SwiftSolar.

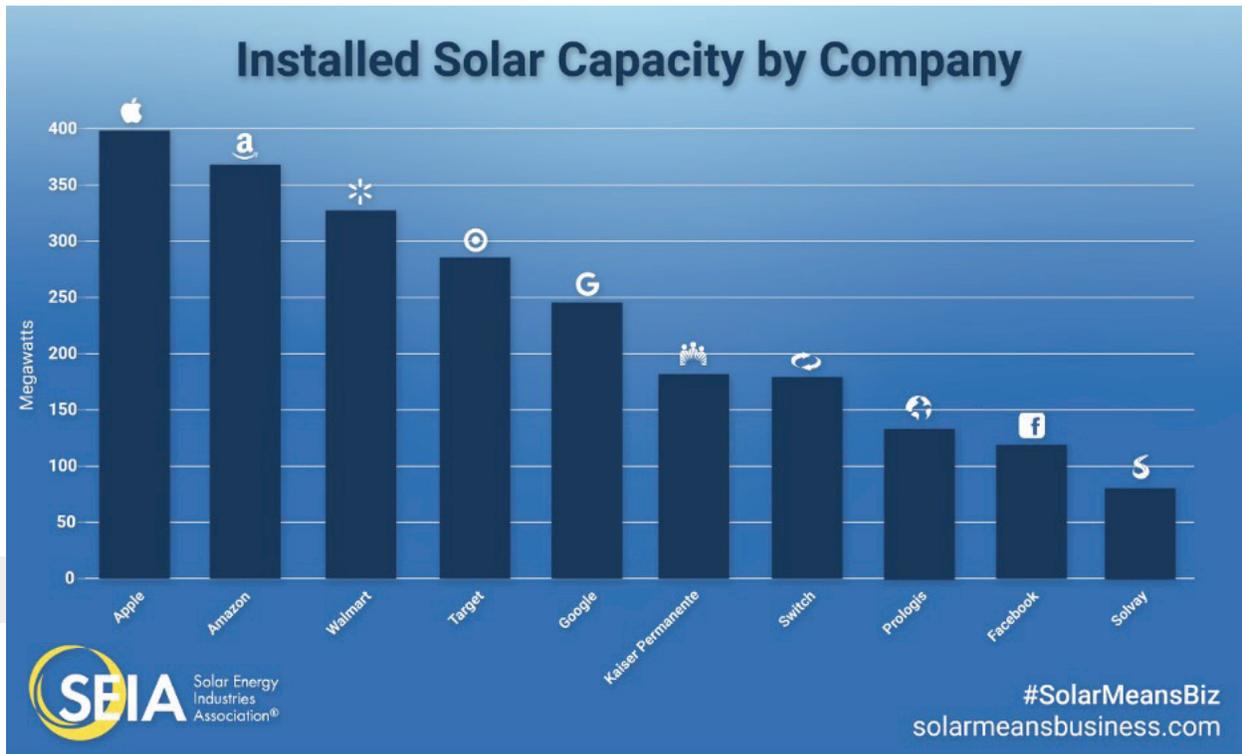
### 3.0 CORPORATE INVESTMENTS

In the balance of this report, focus shifts to corporate investments. When seeking to understand the role of commercial companies’ investments in early-stage solar technologies, corporate use of solar technologies is nearly impossible to ignore. While many sources provide information on the use of solar energy by these firms, they do not often provide information on funding for external technology development or venture capital for solar projects. The Solar Energy Industries Association (SEIA) *Solar Means Business* [report](#) provides information on U.S. corporations investing in solar and renewable energy, however it is focused on installed capacity as opposed to investments in early-stage technology. Nevertheless, it is important to understand the trends in Fortune 500 capacity over the past few years as it provides some context for the overall interest in and acceptance of solar energy. The most recently available figures report that through 2019, the top corporate solar users in America have installed more than 8,300 MW of capacity across more than 38,000 different facilities across the country.<sup>165</sup>

The key takeaways from the SEIA *Solar Means Business* report are listed below:

- Corporate solar adoption has expanded rapidly over the past several years, with two thirds of all capacity installed since 2015.
- The 1,286 MW installed in 2019 represents a 10% increase from 2018 and is second to 2017 for annual commercial deployment.

- The surge in on-site commercial solar continued in 2019, with a record 844 MW installed, while 441 MW of off-site projects were completed.
- The systems tracked in this report generate enough electricity each year to power 1.6 million U.S. homes.<sup>166</sup>



**Figure 1:** Installed Solar Capacity by Company, 2019

Source: SEIA<sup>167</sup>

**Power Purchase Agreements (PPAs)** are a commonly used mechanism for Fortune 500 solar energy use. Corporate solar purchases represent \$22 billion in investment nationally over the last 10 years. Additionally, the increase in third-party financing has given companies more financial flexibility to make larger solar investments with less upfront capital.<sup>168</sup> In terms of their applicability to Fortune 500 solar investment, PPAs are arrangements in which a third-party developer installs, owns, and operates an energy system on a customer’s property, enabling the customer to purchase the system’s electric output for a predetermined period. This provides the customer with stable and often low-cost electricity with no upfront cost, while also enabling the owner of the system to take advantage of tax credits and receive income from the sale of electricity.<sup>169</sup> PPAs typically range from 10 to 25 years and the developer remains responsible for the operation and maintenance of the system for the duration of the agreement.<sup>170</sup> Several examples of these agreements are included throughout this report.

In a 2021 book by Jonas Nahm, *Collaborative Advantage: Forging Green Industries in the New Global Economy*, provides a chapter titled, “[Wind and Solar Invention in the United States](#),” which sheds some light on the role of private investment in early-stage solar and

wind technology in the United States and abroad. The chapter notes that this sector has primarily benefited from policy support that pushed private investment in this space.

“US renewable energy firms used broad institutional support for high-technology research, including a legal framework that facilitated spinoffs (and licensing of the results of federally funded research) and a large venture capital community willing to invest in high-risk technology projects. These resources allowed for large numbers of high-technology start-ups, the majority of which focused on the development of disruptive renewable energy technologies that had originated in federally funded research programs.”<sup>171</sup>

Nahm goes on to note that federal and state-level policies co-created large markets for wind turbines and solar PV technologies, but U.S. start-up firms were not accompanied by comprehensive domestic supply chains focused on scale-up and manufacturing. Therefore, a lacking supplier base diminished the number of firms that could enter wind and solar supply chains, and the presence of collaborative advantage allowed firms to look for partners with complementary skills outside the United States causing many American firms to rely on global partners to commercialize their technologies. These global arrangements were easier for large, multinational corporations than for the high-tech start-ups that spun off universities and research institutes to maintain and use.<sup>172</sup>

Firms like GE and Applied Materials, which could quickly enter new industrial sectors through the acquisition of start-up firms, systematically matched their own capabilities with complementary skills in global supply chains. For smaller start-up firms, finding such partners required considerably more effort. With limited financial and human resources, such global collaborations were equally hard to maintain over time. Governments around the world have attempted to replicate American strength in technological innovation. Despite outsized public investments in renewable energy research and development, however, the US specialization in invention has not generated vertically integrated domestic industries.<sup>173</sup>

The findings included in this report mirror the ideas introduced by Nahm in that the investments by Fortune 500 companies in early-stage solar technology development are not easily identifiable; as the following sections will reveal. The search for corporate investment started with the energy sector and then migrates to utilities, Fortune 500 companies and Green banks<sup>1</sup>.

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1 “A **Green Bank** is a publicly capitalized entity established specifically to facilitate private investment into domestic low carbon, climate resilient (LCR) infrastructure and other green sectors such as water and waste management. These dedicated green investment entities have been established at the national level (Australia, Japan, Malaysia, Switzerland, United Kingdom), state level (California, Connecticut, Hawaii, New Jersey, New York and Rhode Island in the United States), county level (Montgomery County, Maryland, United States) and city level (Masdar, United Arab Emirates.” <https://greenbanknetwork.org>

## 4.0 ENERGY SECTOR INVESTMENT

This section profiles the top energy companies in the United States that are investing in solar energy. These entities have been selected based upon evidence of investment in the development of individual technologies, long-range plans to expand the use of solar energy, and the current use of solar energy for various aspects of the business. While this listing represents the top U.S. players, it does not include European or other international players such as Shell or BP despite their large U.S. presence.

The table below summarizes solar energy technology investment efforts by leaders in the U.S. energy sector. These efforts include the use of solar energy PPAs, internally developing solar technologies, and externally funding or developing solar technologies through various mechanisms such as partnerships or venture capital. These efforts are expanded upon in subsequent sections of this report. The large number of investments in PPAs by this sector reflects the desire of fossil fuel companies to eliminate emissions on a large enough scale to demonstrate that they are moving toward sustainable approaches to energy generation.

**Table 2:** Energy Sector Investment in Solar Energy

Solar Technology Development			
Company	Solar PPA	Internal	External
<a href="#">Baker Hughes</a>	X	X	
<a href="#">Chevron</a>	X		X
<a href="#">Exxonmobile</a>	X		
<a href="#">Halliburton</a>	X	X	X
<a href="#">Kinder Morgan</a>	X		X
<a href="#">Occidental</a>	X	X	
<a href="#">Phillips 66</a>		X	
<a href="#">Schlumberger</a>			X
<a href="#">Williams Companies</a>		X	
<b>Totals</b>	<b>6</b>	<b>5</b>	<b>4</b>

### 4.1 Baker Hughes Company

Baker Hughes entered into a long-term power purchase agreement with EDF Energy Services in 2020 that resulted in a reduction of 1.2 million metric tons of CO<sub>2</sub> eq. emissions over the term of the agreement, which is a 10-year PPA for 25 MWs of wind and 30 MWs of solar energy.<sup>174</sup>

In February 2022 Baker Hughes joined a strategic partnership with and invested in [NET Power](#) to advance the technical and commercial deployment of NET Power’s low-cost, electric power system that generates no atmospheric emissions and inherently captures all carbon dioxide (CO<sub>2</sub>). The partnership, which brings together industry expertise to enable the global deployment of NET Power’s technology solution, already includes McDermott; Constellation; Oxy Low Carbon Ventures, a subsidiary of Occidental; and 8 Rivers Capital. To rapidly deploy this solution, NET Power will license its technology to global customers seeking to decarbonize the energy and industrial sectors. NET Power’s zero-emission, flexible and rapidly dispatchable energy can also help balance variable power sources like solar and wind, helping the world decarbonize faster and with lower cost.<sup>175</sup>

**Baker Hughes is working to advance solar technology is by contributing its centrifugal compressor technologies and auxiliary systems specifically designed for Supercritical carbon dioxide (sCO<sub>2</sub>).**

The company’s [Bently Nevada](#) (parent company Baker Hughes) Minden, Nevada headquarters is powered by more than 50% renewable energy, including a solar field installed in 2016 that saves 1,100 metric tons of carbon emissions per year. Baker Hughes has made a commitment to reduce CO<sub>2</sub> equivalent emissions by 50 percent by 2030 and achieve net zero by 2050.<sup>176</sup>

Another way that Baker Hughes is working to advance solar technology is by contributing its centrifugal compressor technologies and auxiliary systems specifically designed for Supercritical carbon dioxide (sCO<sub>2</sub>). sCO<sub>2</sub> has been studied as enabling technology to promote widespread adoption of concentrating solar power (CSP), and sCO<sub>2</sub> has recently been attracting increasing industrial interest. The company is involved with the European Union H2020-funded “SOLARSCO2OL” project, which is developing innovative, economically viable, and easily replicable sCO<sub>2</sub> power block technology to increase the flexibility of CSP plants—and facilitate wider deployment of CSP across Europe.<sup>177</sup>

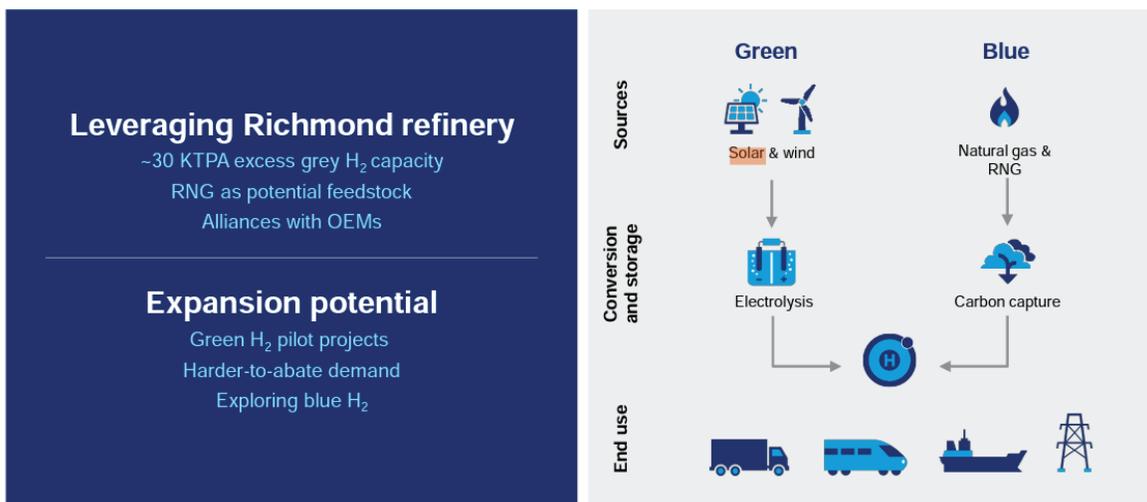
The project focuses on small and medium sized, medium temperature (max 550°C) plants. The solution will reduce plant levelized cost of electricity (LCOE) to under 10 c€/kWh in Europe, and promote a power plant cycle layout that requires no water. In doing so, SOLARSCO2OL will strengthen the EU’s industrial leadership in both CSP and turbomachinery sectors. It’s an important project for the European Strategic Energy Technology (SET) Plan, but also for clean power generation overall—as what’s accomplished here will enable greater solar viability and flexibility all around the world.<sup>178</sup>

## 4.2 Chevron

The company is seeking to reduce emissions using a multi-pronged strategy that includes the use of solar technologies as both an energy source and as an enabling technology for reduction efforts. Chevron announced that it is working toward a \$10 billion lower carbon capital allocation between 2021 and 2028, and in 2019 the company began procuring renewable power for its operations in the Permian Basin. These efforts are expected to reduce emissions by 300,000 tons per year, and 70% of its Permian demand can be met with renewable power.

Hydrogen appears to be the focus of the company’s work in this area, this work is exemplified through the company’s work at its Richmond facility where Chevron is building a hydrogen hub that relies on several enabling technologies.

## Building a California hydrogen hub



### Leveraging Richmond refinery

~30 KTPA excess grey H<sub>2</sub> capacity  
RNG as potential feedstock  
Alliances with OEMs

### Expansion potential

Green H<sub>2</sub> pilot projects  
Harder-to-abate demand  
Exploring blue H<sub>2</sub>

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The company recently initiated two green hydrogen pilot projects –one utilizing a gasified waste stream and another a solar powered electrolyzer. Chevron is also providing access to 49 acres of refinery land for the [Marin Clean Energy Solar One project](#), which generates 10.5 megawatts of renewable energy annually, or enough to power 3,900 U.S. homes.<sup>179</sup> In July 2021, the Chevron Products Company division (Chevron), and Cummins Inc. announced a memorandum of understanding (MOU) to explore a strategic alliance to develop commercially viable business opportunities in hydrogen and other alternative energy sources. The MOU provides the framework for Chevron and Cummins to initially collaborate on four main objectives: advancing public policy that promotes hydrogen as a decarbonizing solution for transportation and industry; building market demand for commercial vehicles and industrial applications powered by hydrogen; developing infrastructure to support the use of hydrogen for industry and fuel cell vehicles; and exploring opportunities to leverage Cummins electrolyzer and fuel cell technologies at one or more of Chevron’s domestic refineries.<sup>180</sup>

**Power Purchase Agreements (PPAs) are arrangements in which a third-party developer installs, owns, and operates an energy system on a customer’s property, enabling the customer to purchase the system’s electric output for a predetermined period.**

Also in 2021, Chevron planned to acquire an equity interest in the **Advanced Clean Energy Storage (ACES) project**, a 2019-formed joint venture between Mitsubishi Power Americas

and Magnum Development, which was a developing green hydrogen hub that could support more than 1 GW of electrolysis facilities and store 5,500 metric tons of their produced green hydrogen in salt caverns near Delta, Utah. Chevron, Magnum, and Mitsubishi Power were negotiating definitive documentation outlining Chevron's participation in the joint venture, but in 2022 the company changed its plans, and in June 2022 Chevron announced that it was pulling out of the Utah green hydrogen energy storage project.<sup>181</sup>

In terms of investment in specific technologies or companies, Chevron invested in several companies, including [Starfire Energy](#) through Chevron Technology Ventures (CTV). CTV does not appear to have invested in solar companies, but Starfire's technology is complementary to solar and other renewable energy sources such as wind. The company is developing modular systems to produce carbon-free ammonia that allows for direct use of renewable energy sources such as wind, solar and hydro. Overall, these efforts are part of a new \$300 million **Future Energy Fund II**, which will focus on industrial decarbonization, emerging mobility, energy decentralization, and the growing circular carbon economy."<sup>182</sup>

The overarching mission of CTV is to pursue and invest in externally developed technologies and new business solutions that have the potential to enhance the way Chevron produces and delivers affordable, reliable, and ever-cleaner energy. While solar does not appear to be key investment area at present, CTV works with a range of startup companies, investors, incubators and accelerators to access technology that can be used across the company to operate more efficiently, at a lower carbon intensity and launch viable new businesses.<sup>183</sup>

### 4.3 [ExxonMobil](#)

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Exxon can trace its involvement with solar energy back to the 1970s when it internally developed and championed solar cells during the energy crisis, however, those efforts ceased in the 1980s as oil process fell.<sup>184</sup> More recently, in 2019, the company began purchasing wind and solar power in West Texas as part of a 12-year agreement with the Danish energy company [Orsted](#). The plan is to use low cost, clean electricity to power Exxon Mobil's expanding operations in one of the world's most productive oil fields known as the Permian Basin. In addition to the use of solar, the company is interested in wind, biofuels, and carbon capture technology to further its renewables profile.<sup>185</sup>

While there is no mention of solar or renewable energy in the company's most recent [sustainability report](#), it does mention broad efforts to reduce emissions. In late 2020 the company announced a five-year program that committed to cut the intensity of CO2 emissions from its upstream production by 15-20% by 2025, and decrease the intensity of methane, a far more potent greenhouse gas, by 40-50%.<sup>186</sup>

### 4.4 [Halliburton Company](#)

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[Halliburton Labs](#), a division of the company launched in 2020, is focused on the science and evolution of sustainable, reliable energy through a collaborative, accelerator-like environment offering access to facilities and mentors.<sup>187</sup> In November 2021 four companies were selected to participate in the Halliburton Labs program, including, [Icarus RT](#). Icarus

RT is working to improve system performance and return on investment in commercial and utility scale solar photovoltaic systems by developing a power boosting and energy storage technology. The [technology](#) is designed to cool the solar panels, collect rejected heat, and convert the heat into additional power to improve system efficiency and output.<sup>188</sup>

Additionally, the company has an ongoing rooftop solar initiative that includes four major projects in Singapore, India, and California, Halliburton commissioned two new solar projects in Malaysia and Colombia in 2021. The company has executed several solar PPAs in recent years and plans for more in 2022.<sup>189</sup>

#### 4.5 [Kinder Morgan, Inc.](#)

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In February 2021 [Kinder Morgan Inc.](#) formed a new [Energy Transition Ventures](#) group to identify and pursue commercial opportunities within the low-carbon sector. The in-house group's mission is to identify, analyze and pursue commercial opportunities emerging from the transition to lower carbon energy by focusing on customer outreach and business development activities in pursuit of those new ventures, including services like carbon capture and sequestration, RNG capture, blue and green hydrogen production, *renewable power generation*, electric transmission, and renewable diesel production. The group's first acquisition was **Kinetrex Energy**, a company that specializes in natural gas production, storage, liquefaction, and transportation.<sup>190</sup>

Additionally, some of the equipment at the company's facilities is powered through solar panels installed on-site, and in 2021, the company consumed approximately 1,058 MWh of renewable energy from the solar panels it operates, which is equivalent to approximately 749 metric tons of CO2 avoided.<sup>191</sup>

**Table 3: Potential Opportunities for Energy Transition Ventures Group**

Climate-related Opportunities	Potential Financial Impact	Available Strategy and Enhancement Measures
<b>Resource Efficiency</b>		
<ul style="list-style-type: none"> <li>– Using more efficient equipment</li> <li>– Using more efficient production and distribution processes</li> </ul>	<ul style="list-style-type: none"> <li>– Reduced operating costs through efficiency gains and cost reductions</li> <li>– Increased production capacity, resulting in increased revenues</li> </ul>	<ul style="list-style-type: none"> <li>– Increasing use of our existing assets</li> <li>– Leveraging economies of scale from incremental acquisitions and expansions of assets</li> </ul>
<b>Energy Source</b>		
<ul style="list-style-type: none"> <li>– Using lower-emission sources of energy</li> <li>– Using supportive policy incentives</li> <li>– Using new technologies</li> <li>– Participating in the carbon markets</li> <li>– Shifting toward decentralized energy generation</li> </ul>	<ul style="list-style-type: none"> <li>– Attractive returns on investment in lower carbon natural gas infrastructure</li> <li>– Increased capital availability as more investors favor lower-emission products</li> <li>– Reputational benefits resulting in increased demand for services</li> <li>– Increased value of fixed assets</li> </ul>	<ul style="list-style-type: none"> <li>– Allocating the largest portion of our capital to lower carbon natural gas infrastructure</li> <li>– Developing new services including storage / transportation of lower-emission energy sources</li> <li>– Expanding and developing lower carbon business activities</li> </ul>
<b>Products and Services</b>		
<ul style="list-style-type: none"> <li>– Developing and/or expanding lower emission goods and services</li> <li>– Diversifying business activities</li> <li>– Responding to shifting consumer preferences</li> </ul>	<ul style="list-style-type: none"> <li>– Increased revenue through demand for lower emission products and services</li> <li>– Increased revenue from our competitive position and asset flexibility to respond to shifting consumer preferences</li> </ul>	<ul style="list-style-type: none"> <li>– Allocating the largest portion of our capital to lower carbon natural gas infrastructure</li> <li>– Developing new services</li> <li>– Expanding and developing lower carbon business activities</li> </ul>
<b>Markets</b>		
<ul style="list-style-type: none"> <li>– Increased demand for natural gas services</li> <li>– Increased demand for natural gas storage and pipeline services to backstop intermittent renewable power supply</li> <li>– Using public-sector incentives for carbon transportation and sequestration</li> <li>– Increased demand for reliable fuel for power generation</li> </ul>	<ul style="list-style-type: none"> <li>– Increased revenue from increased demand for natural gas gathering, processing, transportation, storage, and distribution</li> <li>– Increased revenue through access to new and emerging carbon transportation and sequestration markets</li> </ul>	<ul style="list-style-type: none"> <li>– Allocating the largest portion of our capital to lower carbon natural gas infrastructure</li> <li>– Pursuing carbon sequestration opportunities</li> <li>– Developing new services focused on deliverability and unconventional energy storage</li> </ul>
<b>Resiliency</b>		
<ul style="list-style-type: none"> <li>– Responding quickly to market changes resulting from natural disasters</li> <li>– Participating in renewable energy programs and adopting energy efficiency measures</li> </ul>	<ul style="list-style-type: none"> <li>– Increased market valuation through resilience planning</li> <li>– Increased reliability of supply chain and ability to operate under various conditions</li> </ul>	<ul style="list-style-type: none"> <li>– Business continuity planning</li> <li>– Continuing to innovate and improve our energy management programs</li> <li>– Evaluating new ways to reduce our emissions by increasing equipment efficiency</li> </ul>

Source: Kinder Morgan<sup>192</sup>

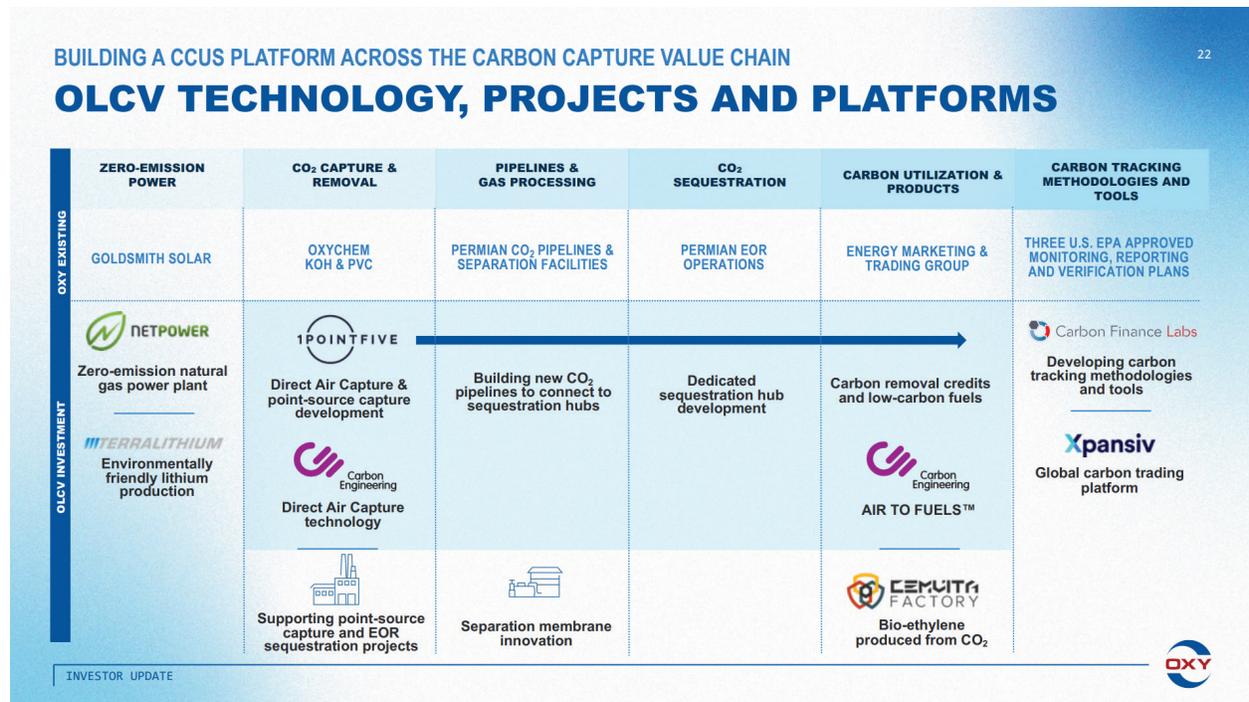
#### 4.6 Occidental Petroleum Corporation

Occidental is an international oil and gas exploration and production company with operations in the United States, Middle East, and Latin America, headquartered in Houston, Texas. [Oxy Low Carbon Ventures, LLC](#) (OLCV) is a subsidiary of Occidental – its global strategy includes active investment in carbon dioxide enhanced oil recovery (CO2-EOR) and carbon capture, utilization, and storage (CCUS), as well as other emissions reducing technologies.

In 2019 Occidental's Oxy Low Carbon Ventures (OLCV) subsidiary announced that it had signed a long-term power purchase agreement for 109 MW of solar energy, beginning in 2021, for use in its Permian operations.<sup>193</sup> The solar facility was built by Occidental in Ector County, near Odessa, Texas on 120 acres and features 174,000 photovoltaic panels, with a total capacity of 16 megawatts. OLCV also signed a long-term purchase agreement of 109 megawatts of solar energy, for use at its Goldsmith field in the Permian Basin in early 2021 through a 12-year agreement OLCV and the infrastructure investment and management firm Macquarie's Green Investment Group, and solar plant developer Core Solar LLC.<sup>194</sup>

**Chevron has raised its 2022 production forecast in the Permian Basin to between 700,000 and 750,000 barrels of oil-equivalent per day, a more than 15% year-over-year increase. The basin is a vast oil and gas region spanning parts of the west Texas and southeastern New Mexico.**

The Goldsmith field solar operations are part of the company's overarching net zero strategy that largely focuses on carbon capture technologies and methods. The company expects to have three sequestration hubs online by 2025 and to build seventy 1 MTPA Direct Air Capture Facilities by 2035.<sup>195</sup>



**Figure 2: OlcV Technology, Projects, and Platforms**  
Source: Oxy, March 2022<sup>196</sup>

An example of internal solar technology development is Project AVOID, which is a device that can seamlessly perform all aspects of an in-person Audio, Visual and Olfactory (AVO) inspection remotely. AVOID was conceptualized Senior Automation Engineer, [Andrew Pruet](#), and is by powered by solar panels. AVOID device collects data including

methane levels, temperature, and humidity as well as live audio and video making 24/7 AVO monitoring possible. Additionally, Oxy was an early investor in NET Power, whose technology generates zero-emissions electricity while utilizing and capturing CO2 that can be deployed alongside other CO2 reduction technologies as a strong complement to renewables like wind and solar.<sup>197</sup>

#### 4.7 Phillips 66

Future Energy Fund II is a \$300 million investment fund launched by Chevron Technology Ventures in 2021. Chevron Technology Ventures (CTV) pursues externally developed technologies and new business solutions that have the potential to enhance the way Chevron produces and delivers affordable, reliable, and ever-cleaner energy.

Phillips 66's Energy Research & Innovation organization operates in Bartlesville, Oklahoma at the 440-acre Phillips 66 Research Center, and the [organic photovoltaics \(OPV\)](#) program at Phillips 66 develops the next generation of solar cell technology. Phillips 66 broke the OPV world record for converting light to electricity three times: in 2012, 2016 and 2017, the company is now working to further improve the power density, lifetime, cost and scalability of the Phillips 66 ShieldPower™ brand of OPV materials.<sup>198</sup> Very little information is

available on these materials, however, Dr. Reed Eisenhart, the Director of Solar Energy for Phillips 66 has [presented](#) on the topic.



**Figure 3:** ShieldPower™ Challenges to Address

Source: Phillips66 via YouTube.<sup>199</sup>

The company's Emerging Energies group is focused on commercializing and implementing emerging energy technology within Phillips 66's operations and portfolio of assets through its core focus areas of renewable fuels, batteries, carbon capture, and low-carbon hydrogen – it does not appear to be focusing on solar technologies in this area. The company recently announced that it will be building a large volume [renewable fuels plant](#).

#### 4.8 Schlumberger

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In early 2020 the company announced the formation of [Schlumberger New Energy](#) as a mechanism to expand beyond oil and gas and participate in the low-carbon economy with a focus on energy efficiency, energy storage, and renewable energy production. Schlumberger invests in new energy technology ventures and innovative partnerships in strategic sectors, the Schlumberger New Energy ventures sectors include:

- Carbon Capture and Sequestration
  - o Emissions-reduction technology
  - o Remove CO2 and achieve negative emissions, even in hard-to-abate sectors
- Geoenery for Heating and Cooling
  - o Powered by the Earth
  - o Heat and cool buildings while reducing CO2 emissions by up to 90%
- Geothermal Power
  - o Differentiated, well-established source of renewable energy
  - o Use the heat of the Earth to generate electricity by tapping into hot water and steam zones
- Hydrogen as an Energy Carrier
  - o Clean, safe solution for global decarbonization
  - o Unlock affordable hydrogen production, energy storage, and fuel applications at scale

- Sustainable Battery-Grade Lithium
  - o Technology-driven approach to a responsible supply ecosystem
  - o Explore new ways to produce and process high-purity lithium with the entire production ecosystem in mind<sup>200</sup>

The company is a [Solar Impulse Foundation partner](#), however, investment in specific solar technologies was not uncovered.

#### 4.9 [The Williams Companies, Inc.](#)

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The company launched [Williams New Energy Ventures](#) in 2021 as a business development group focused on commercializing innovative technologies, markets, and business models. Solar efforts include this group and others throughout the company. Its solar team is currently developing 16 solar projects totaling approximately 375 megawatts (MW) of solar capacity that would offset approximately 16% of Williams facilities' total estimated annual energy demand. The first projects are expected to go in-service in 2023 generating renewable energy credits that can either be sold into the market or retired to offset Scope 2 emissions. Initial sites identified are in Alabama, Colorado, Georgia, Louisiana, New Jersey, North Carolina, Ohio, Pennsylvania, and Virginia.

New Energy Ventures collaborates with groups and individual across Williams to evaluate and implement projects to grow its clean energy business based on the following guiding principles:

- **Achieve carbon reductions for ourselves, our customers, and partners** – We are focused on reducing emissions across our assets. Since 2005, we have reduced our emissions by 44% and are on our way to meeting our 2030 goal of a 56% reduction. To achieve our low-carbon aspirations, we will collaborate with our current customers and new partners to reduce emissions. Our relationships across the natural gas supply chain provide opportunities to work with industry to achieve emissions reductions and build new sustainable business for a low-carbon future.
- **Create economic value with actionable investments** – We are starting with projects such as solar installations adjacent to our operations to reduce emissions and deliver economic benefits. We will expand these opportunities while looking to invest in future clean energy projects and carbon abatement instruments. Many future opportunities that can deliver scalable emissions reductions are not economically feasible today. We will work to enable the required technology, regulatory and market innovations to deliver financial returns from these emerging opportunities. As we see technology and market mechanisms mature, we will expand our investments to grow our economic value.
- **Target opportunities where our midstream competencies and infrastructure provide strong competitive advantages** – As a premier energy infrastructure company, we have experience building, operating, and maintaining major infrastructure to move, store and deliver energy on demand. We will use our natural gas-focused strategy, our infrastructure capabilities, technical competencies, project capabilities, financial depth, and relationships to accelerate the clean energy future. We are a credible partner with the structure, processes, and people to put new energy ideas into practical application, and then deploy at scale.

- **Provide scalable options for the future** – To match the size of the challenge and opportunity our clean energy future presents, we must focus on scalable opportunities. We will scope a wide range of opportunities to create options for our larger ambition for the future. We will structure our participation so that we can start with smaller investments and then scale into future growth.<sup>201</sup>

Presently, New Energy Ventures is developing 16 solar projects totaling approximately 375 MW with ten initial projects targeting in-service in 2023 and 2024. Additionally, the company is exploring concepts including a Williams Wyoming Energy Hub to integrate renewable power, hydrogen, captured CO<sub>2</sub> and methanation into its existing assets where wind and solar power can drive electrolysis and green hydrogen production in combination with captured CO<sub>2</sub> to create synthetic methane.<sup>202</sup> In September 2021 Williams and Ørsted, a company that develops, constructs, and operates offshore and onshore wind farms, solar farms, energy storage facilities, and bioenergy plants signed a memorandum of understanding (MOU) to explore potential jointly developed Power-to-X projects in the U.S. Through this MOU, the two companies are identifying ways to leverage Ørsted's renewables and hydrogen expertise with Williams' natural gas infrastructure and processing experience to co-develop hydrogen or synthetic natural gas facilities powered by renewable energy.<sup>203</sup>

#### 4.10 Others

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In early 2021 [EOG Resources announced](#) it would use solar arrays to operate compressors that would typically be powered by natural gas throughout southern New Mexico using 24,000 solar panels on 70 acres to provide up to eight megawatts for the compressors with no combustion.

[ConocoPhillips](#), like many of its peers, is using some solar power in its Permian Basin operations through a feasibility study.

[Enterprise Products Partners L. P.](#) has more than 16,200 solar powered metering stations generating approximately 7 megawatt hours of power generation per day across the United States. These solar operated stations are used to run natural gas chromatographs, measurement, controls, and communications equipment, as well as to generate power to certain cathodic protection system installations for the purpose of corrosion prevention across our liquid and gas pipelines. The company is also looking to expanded solar power purchasing and/or installations across its systems.<sup>204</sup>

In 2012 [Marathon Petroleum Corporation](#) built a solar farm on 6 acres of city-owned property in Findlay, Ohio to test various types of solar panels and study the viability and feasibility of solar as an economical source of electricity. The research is now concluded, and Marathon donated the solar farm to the city of Findlay,<sup>205</sup> but the company continues to power dozens of pipeline components in remote areas with solar-powered units.

[Devon Energy Corporation](#) announced a development agreement in February 2022 to integrate renewable energy into the operations of the company's Stateline field located in Oklahoma. Devon worked with Omnia Midstream Partners, LLC, an Oklahoma based energy solutions developer and advisor - the project design incorporates American made solar panels, inverters, and battery storage to support dynamic power demand on the company's private electric grid.<sup>206</sup>

## Summary

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In this section, solar initiatives of nine leaders from the energy sector were reviewed with an emphasis on the engagement of their venture arms. Unlike the private equity investment firms discussed in the previous section, the leaders in the energy sector appear to have more of an interest in solar technology per se, rather than funding research to accelerate adoption of solar technologies.

- Baker Hughes, an early and consistent adopter of solar technology, is involved with the SOLARSCO20L project to increase the flexibility of CSP plants.
- Chevron has made \$300M available through its Future Energy Fund II and its Technology Venture arm actively works with a range of start-ups, incubators and investors.
- Halliburton Labs is focused on the science and evolution of sustainable, reliable energy and is working to improve system performance and return on investment in commercial and utility scale solar photovoltaic systems by developing a power boosting and energy storage technology.
- Phillips 66 Energy Research & Innovation organization is responsible for developing the next generation of solar cell technology. Phillips 66 broke the OPV world record for converting light to electricity three times: in 2012, 2016 and 2017, the company is now working to further improve the power density, lifetime, cost and scalability of the Phillips 66 ShieldPower.

Although not all the companies profiled in the energy sector are actively engaged with improving solar technologies, as a group – they appear to be more focused on advancing technologies, rather than accelerating the rate of adoption.

## 5.0 UTILITIES

The utility scale solar market faced many challenges in 2021 as supply chain issues and labor availability pushed prices to their highest levels in three years. These challenges and others resulted in a 19% reduction in utility-scale deployment forecasts in 2021-2022, however, demand for utility-scale solar remains strong as increasing numbers of states, utilities and corporations seek to fulfill their clean energy goals.<sup>207</sup>

The role of utility companies in the solar energy space is unique – these companies may act as suppliers for renewable energy, be partners in PPAs, and may also be engaged in internal and external technology development. Additionally, the utilities companies tend to have more direct relationships with groups engaged in community solar, and the utilities are often the beneficiaries or end users of new solar technologies. The table below summarizes these effort areas and are then profiled in greater detail further in the report.

**Table 3:** Solar Technology Development Effort Areas

Solar Technology Development			
Company	Solar PPA	Internal	External
<a href="#">Nextera Energy</a>	X	X	
<a href="#">Duke Energy</a>	X	X	X
<a href="#">Southern Company</a>	X		
<a href="#">Dominion Energy</a>	X	X	X
<a href="#">Exelon</a>	X	X	X
<a href="#">Xcel Energy</a>	X	X	X
<b>Totals</b>	<b>6</b>	<b>5</b>	<b>4</b>

### 5.1 [Dominion Energy](#)

[Dominion Energy](#) currently has solar energy services in five states with plans to expand. In September 2021 the Nature Conservancy and Dominion Energy Virginia announced a [collaborative effort](#) to develop a utility-scale solar project on former surface mines in the coalfields of Southwest Virginia, which is expected to generate approximately 50 megawatts of solar energy. The company will jointly develop the project with ANTARES Group, which will serve as the owner’s engineer with plans to begin construction in 2024 or 2025.<sup>208</sup> Additionally, the company’s Solar for Students program provides a hands-on educational opportunity for students to learn about solar energy from a solar array – participants receive a 1.2-kilowatt solar system with educational materials and training for educators.<sup>209</sup>

### 5.2 [Duke Energy](#)

[Duke Energy Sustainable Solutions](#) is expanding its use of renewable power going from almost 8,800 MWs of wind and solar at the end of 2020 to just over 10,500 MWs by the end of 2021. As part of this expansion, the company launched a sustainable financing framework to help *attract* investments in eligible green and social projects to the company.<sup>210</sup> The company’s Commercial Renewables acquires, develops, builds, and operates wind and solar renewable generation throughout the U.S. The group’s portfolio consists of nonregulated renewable energy and energy storage businesses. Commercial Renewables also enters strategic partnerships including minority ownership and tax equity structures in wind and solar generation. Duke Energy’s electric utilities also buy power through purchased power agreements (PPAs) from solar, wind, hydroelectric and biomass (including waste to energy) resources.<sup>211</sup>

### 5.3 Exelon

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[Exelon](#) operates a venture arm, [Constellation Technology Ventures \(CTV\)](#), that supports growth-stage technology companies that could complement the company's core businesses or dramatically change the energy industry. [PosiGen](#) is an active participant in CTV's portfolio, PosiGen's business model features standardized, kitted solar installations and marketing strategies, that provide low customer acquisition costs and hardware installation costs. Past CTV company, [Astrum Solar](#) a residential solar installer was acquired by Direct Energy in July 2014 and SolarBridge, a power electronics company and CTV participant was acquired by SunPower in November 2014. [The Exelon Foundation](#) focuses on funding community, education, and workforce development programs in core areas – its efforts have including funding for start-ups through the company's Climate Change Investment Initiative (2c2i). Amidus Resilience's distributed solar installation in Washington, D.C. received funding through this effort.

### 5.4 Nextera Energy

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While [NextEra Energy](#) is a leader in solar and is one of America's largest capital investors in infrastructure with the world's leading wind, solar, and battery storage portfolio, it does not appear to be funding the development of individual technologies. The company does operate solar subsidiaries such as [Florida Power and Light \(FPL\)](#) and SolarTogether, the largest community solar program in U.S. – these groups have benefitted from extensive internal research, development, and investment. For example, FPL installed the first battery modules for world's largest solar-powered battery in 2021.<sup>212</sup>

### 5.5 Southern Company

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[Southern Company](#) boasts an internal research and development (R&D) organization that uses strategic partnerships with companies, government organizations, universities and research institutes to develop low and no-carbon generation technologies, to move renewables, energy storage and distributed generation solutions, and grid modernization forward.<sup>213</sup> In addition to its internal R&D and other efforts to expand its technical capabilities it does appear to be investing in other companies, but not currently for solar technology. Southern Company is a founding partner and the chair of [Energy Impact Partners](#), which is a utility-backed venture capital fund with over \$2 billion in assets under management.<sup>214</sup> The overarching focus of Southern Company's R&D efforts as well as Energy Impact partners seems to be energy storage, transmission, and other enabling technologies for solar and wind that address the issue of intermittency with these energy sources.

### 5.6 Xcel Energy

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[Xcel Energy](#)'s Renewable Development Fund promotes the startup, expansion, and attraction of renewable energy projects and companies in states where the company operates, including solar technology. Xcel Energy participates in other collaborative innovation efforts such as [EPRI's Incubatenergy Labs](#) that offers early-stage companies the opportunity to pitch their concepts to a group of leading energy providers, it was a founding participant in Energy Impact Partners, it committed \$15 million to Energize

Ventures, a leading global investment manager in 2021, it joined MSP Equity Fund in early 2022, committing to invest \$2.5 million, and Xcel Energy participates in the Low-Carbon Resources Initiative led by the Electric Power Research Institute (EPRI). The company has also invested in the [Solar Technology Acceleration Center \(SolarTAC\)](#) in Aurora, Colorado.<sup>215</sup> A detailed look at these and many other investment efforts may be seen [here](#).

## 6.0 FORTUNE 500 INVESTMENT

The U.S. Environmental Protection Agency (EPA) established the [Green Power Partnership \(GPP\)](#) in 2001 to encourage organizations to use green power voluntarily to protect human health and the environment. EPA's Partners include a wide variety of organizations, including large corporations; small and medium-sized businesses; local, state, and federal governments; non-profit institutions; and colleges and universities.

As of April 25, 2022, the combined annual green power use of EPA's Top Fortune 500 Partners amounts to nearly 64 billion kilowatt-hours of green power, which is equivalent to the annual electricity use of more than 5.9 million average American homes. Companies from the EPA GPP list that were identified as using solar energy have been researched and profiled in this section.

The following table summarizes research findings on solar investment by Fortune 500 firms. The metrics considered below include whether the companies are using power purchase agreements (PPAs) for solar energy, and whether they are funding the development of solar technologies, either through internal technology development, or funding solar technology development by external players. More comprehensive profiles on these companies and their efforts are found in subsequent sections of this report.

**Table 4:** Fortune 500 Investment in Solar Energy

Solar Technology Development			
Company	Solar PPA	Internal	External
<a href="#">Apple</a>	X		
<a href="#">Applied Materials</a>		X	
<a href="#">Biogen</a>	X		
<a href="#">Cisco</a>	X		X
<a href="#">Dell</a>	X	X	
<a href="#">Dow</a>	X	X	X
<a href="#">Equinix</a>	X		

<a href="#">GM</a>	X	X	X
<a href="#">Google</a>	X		X
<a href="#">HP</a>	X		X
<a href="#">IBM</a>	X	X	X
<a href="#">Intel</a>	X		X
<a href="#">Jacobs Engineering</a>		X	
<a href="#">KC</a>	X		
<a href="#">Lockheed Martin</a>	X	X	X
<a href="#">Microsoft</a>	X		X
<a href="#">Boeing</a>	X	X	X
<a href="#">P&amp;G</a>	X		
<a href="#">T-Mobile</a>	X		X
<b>Totals</b>	<b>17</b>	<b>8</b>	<b>11</b>

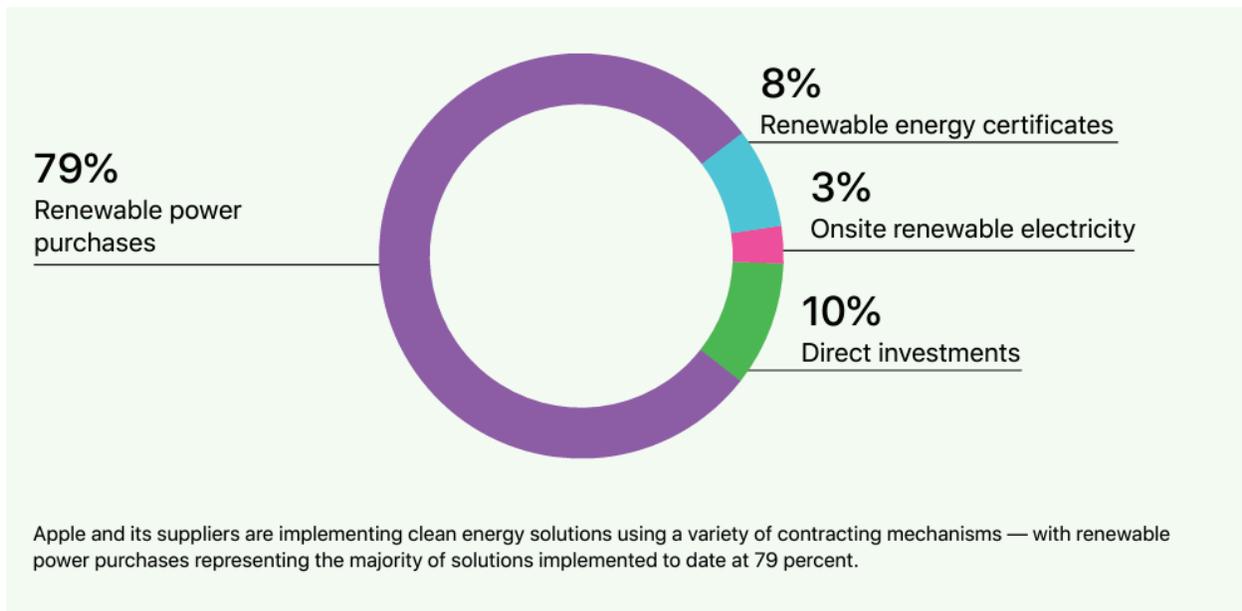
## 6.1 EPA Green Power Partners (GPP)

This list of companies serves as the basis for Fortune 500 companies explored in this report. Searches were carried out on these companies to gain a better understanding of their individual efforts in funding the development of early-stage solar technology innovation and noting their use of solar energy for individual sustainability initiatives.

### 6.1.1 Apple Inc.

Apple's [Supplier Clean Energy Program](#) was launched in October 2015 to advance clean energy through its manufacturing supply chain. In 2020 Apple announced a plan to transition its entire manufacturing supply chain, including material extraction, component manufacturing, and final product assembly to 100 percent renewable electricity. The program is focused on increasing energy efficiency at supplier facilities and transitioning suppliers to clean, renewable electricity.<sup>216</sup>

Apple has made several investments in solar energy through power purchase agreements, and by providing development funding for solar power plants, but it did not appear to fund the technology development used in these plants.<sup>217</sup> The following Figure shows the type of contracting mechanisms and technologies suppliers have identified to help meet their commitments. Among these, 18% of these supplier renewable energy technology solutions were solar in FY2021.<sup>218</sup>



**Figure 6:** Supplier renewable energy procurement mechanisms (FY2021)

**Source:** Apple 2022.<sup>219</sup>

It is important to note how the process of investing in the supplier program is working. For example, in China - Apple is investing directly in the associated projects through a \$300 million fund that includes investments from companies that hope to benefit from the power and [DWS Group](#), a Deutsche Bank subsidiary that will manage the fund.<sup>220</sup>

### 6.1.2 *Applied Materials, Inc.*

In terms of solar technology [offerings](#), Applied Materials provides wafer inspection, metrology, and screen printing for solar applications. [Applied Ventures, LLC](#) is the venture capital arm of Applied Materials, Inc. and invests in early-stage technology companies that, “promise to deliver high growth and exceptional returns,” at any stage, and invests up to \$50M per year globally. Startups can access new materials engineering and semiconductor technology innovations and leverage the company’s global fab infrastructure to validate high-performance devices and scale more quickly. The group offer startups atomic-level engineering capabilities on 200mm/300mm silicon wafers, glass substrates, and roll-to-roll substrates. To date, Applied Ventures has invested in over 80 companies across 13 countries. In reviewing the company’s [press releases](#) it does not appear that solar technologies have been funded.

### 6.1.3 *Biogen*

In 2020 Biogen announced its Healthy Climate, Healthy Lives™ initiative, which is a \$250 million, 20-year initiative to eliminate fossil fuels across its operations and collaborate with others to improve health, especially for the world’s most vulnerable populations. As part of this effort the company said that it will actively support other institutions in their efforts to combat climate change by increasing investments in high-performing ESG

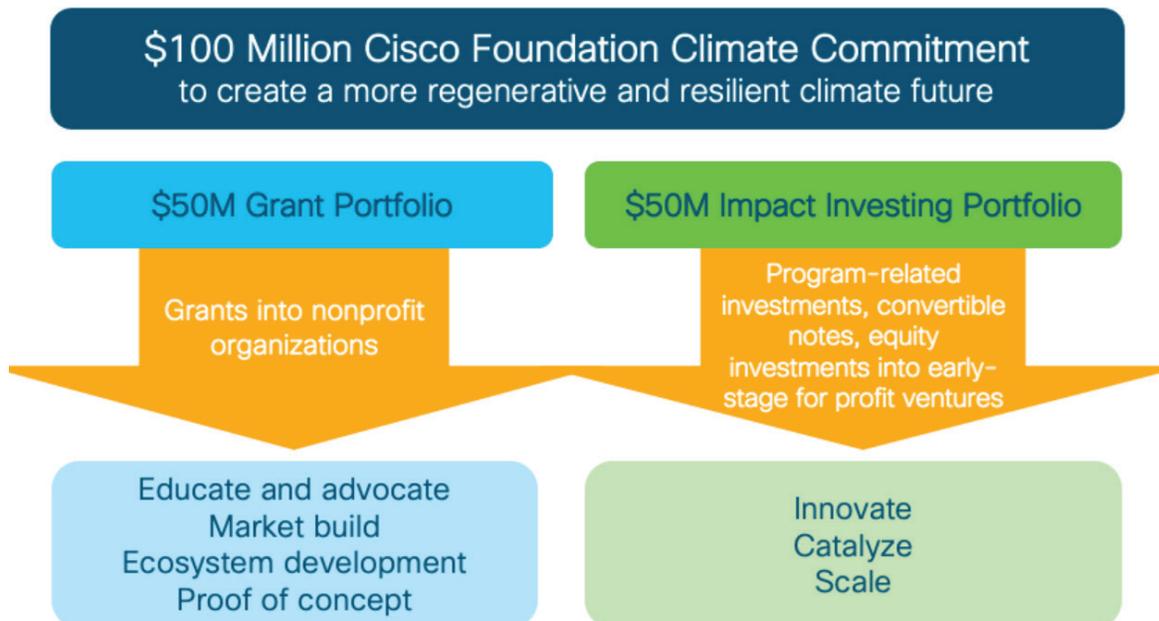
(environmental, social and governance) companies and investment funds.<sup>221</sup> Additionally, this initiative is providing US-based Biogen employees access to 100% renewable energy in their homes by fully covering Arcadia, a monthly subscription service that connects renters and homeowners across the US to wind and solar energy through their utility accounts.<sup>222</sup> Given the company's focus on healthcare, it appears unlikely that the funding will support solar technology development. However, in terms of energy use, the company's operations in Mexico are matched with 100% renewable electricity through the purchase and retirement of I-RECs from the [Aura Solar I project](#).<sup>223</sup>

#### 6.1.4 Cisco Systems, Inc.

The Cisco Foundation was established in 1997 by a gift from Cisco to partner with nonprofits, non-governmental organizations (NGOs), and community-based organizations to carry out many of the company's Corporate Social Responsibility programs. [The Cisco Foundation](#) works with nonprofit and non-governmental organizations around the world to develop technology-based solutions in its investment areas, and in April 2021 it announced a commitment to granting and investing \$100 million over ten years for innovative solutions that could reduce carbon emissions that lead to global warming.

The Foundation's strategy for investing in promising climate solutions is based on the following principles:

- Focus on early-stage solutions
- Diversified, blended finance approach
- Respect for natural systems and an emphasis on regeneration



**Figure 7:** Cisco Foundation Climate Commitment Fund

Source: Cisco<sup>224</sup>

The Cisco Foundation recognized a gap for early-stage funding and within 20 minutes of announcing its \$100 million commitment in April 2021, it had a LinkedIn connection request from an interested party. To date, the Foundation has held hundreds of meetings with organizations working in this area and already funded one solar technology solution. These solutions and organizations include international groups, not-for-profit organizations, and more.

Nia Tero is a nonprofit grantee that exists to ensure that Indigenous peoples have the economic power and cultural independence to steward and protect their livelihoods and the territories they call home. We partnered to fund Kara Solar, a community enterprise initiative that trains Indigenous community members as technicians who build, operate, and maintain solar electric shuttle boats in rainforest communities. These boats reduce deforestation by removing the need for roads to be created, linking numerous communities across various Indigenous territories, all while creating economic opportunity for the community members. Its current phase of deployment encompasses 70 villages. In the first six months of our grant partnership, Kara Solar trained 13 Achuar technicians in the Ecuadorian Amazon and 13 Tumucumaque technicians in the Brazilian Amazon. Finally, Cisco's support enables Nia Tero, Conservation Strategy Fund, and Kara Solar to conduct an analysis on the impact of electric river transportation on the incursion of new roads and deforestation.<sup>225</sup>

In addition to its funding for solar solutions the company also uses PPAs for solar energy to power its facilities and opened a solar farm in California in 2017.

### 6.1.5 Dell Technologies

In addition to using solar energy to power Dell facilities the company has recently worked on a new approach to using solar technology to benefit others through its [Solar Learning Labs](#). The Solar Learning Labs are made from refurbished shipping containers, powered by the sun, and are then used as classrooms or workstations in remote areas with plans to expand these units into community hubs offering a variety of services in addition to learning. These expansion plans are being carried out through a partnership with Computer Aid, Intel and Microsoft. The hubs were built with Dell technology and do not appear to have been developed with externally sourced or funded early-stage technologies.

In terms of the company's overarching investments in early-stage technologies, [Dell Technologies Capital](#) invests in startups in enterprise and cloud infrastructure, its current areas of focus are Apps & Services, Infrastructure, Data & DevOps, Security, and Silicon. The company does not appear to have funded solar technologies.

### 6.1.6 Dow

Dow has been a contributor to the growth of solar energy technologies through internal [technology development](#) and using sustainability targets involving solar energy and [PPAs](#). Additionally, the company's solar technology portfolio has grown through strategic acquisitions of companies such as [NuvoSun](#) and strategic alliances and partnerships with other [firms](#). In terms of investment, [Dow Venture Capital](#) works exclusively on strategic investments in start-up companies around the world that could add value to Dow's overall business. The company does not provide information on the portfolio of companies

represented in its Dow Venture Capital effort and the most recently available annual report 10-K SEC filings do not provide information on the amount or recipients of this venture funding.

### **6.1.7 Equinix, Inc.**

Equinix, a digital infrastructure company, applies a multifaceted approach to meeting its renewable energy targets based on the following principles:

- Utilize renewable and low carbon energy
- Secure local sources of renewable energy where possible
- Seek new or recently built generation sources
- Advocate for favorable renewable energy policies and consider renewable energy availability when locating new data centers<sup>226</sup>

While the majority of its strategy relies on power purchase agreements the company does note that, “Beyond our renewable energy strategy, we continue to evaluate for onsite solar opportunities, onsite generation from fuel cells, and any other distributed low-carbon technology that fits with our overall strategy.”<sup>227</sup>

### **6.1.8 General Motors, LLC**

General Motors has worked on solar technology development in a variety of ways over the past few years – these methods range from [equity investment](#) in energy companies to partnerships, PPAs, and internal technology development.

Examples of the company’s large-scale solar efforts, it executed its largest solar project of 300 megawatts in Michigan through a green tariff agreement, making all GM sites in Southeast Michigan served by DTE on renewable power, including its global headquarters in Detroit and Warren Technical Center, and as part of [DTE’s MIGreenPower program](#) and will source 500 megawatts of solar energy. Additionally, GM will source 180 MW of solar power from a new project in Arkansas, its first project to source panels from First Solar in Ohio. The 180 megawatts of solar power will source power for 100 percent of GM’s Wentzville Assembly and Lansing Delta Township Assembly, with the remaining power allocated to Lansing Grand River Assembly. By late 2022, the company’s largest facility in North America, Spring Hill Manufacturing, is expected to be powered by 100 percent solar energy through a green tariff agreement with the Tennessee Valley Authority, which is expected to supply up to 100 megawatts of solar energy per year.<sup>228</sup> In early 2022 GM made a 20-year agreement with Consumers Energy to use clean energy at its Flint Assembly Plant, Parts Processing Center in Burton and GM Components Holdings Plant in Wyoming, which will support approximately 70 MW of emission-free renewable energy in Michigan.<sup>229</sup>

### 6.1.9 Google LLC (Alphabet)

Google launched its Renewable Energy Cheaper than Coal (RE<C) initiative in 2007, which was halted in 2011. Following this change, Google shifted its investment focus from R&D for renewable technologies to implementation.<sup>230</sup> However, despite focusing on power purchase agreements and broad sustainability initiatives there are examples on investments in individual technology firms.

A UK software start-up, Open Climate Fix, was awarded more than £500,000 (\$690,000) to advance its open-source solar forecasting offering. The solution from Open Climate Fix uses images taken on 5-minute timescales from a geostationary satellite to monitor the changing patterns and movements of clouds over time and a machine learning algorithm uses the recent history of the cloud images to determine and improve how they are moving and changing over time.<sup>231</sup> The funding was awarded as part of [Google.org's Impact Challenge On Climate](#), which innovative ideas that seek to use technology to accelerate Europe's progress toward a greener, more resilient future. Each selected organization receives funding (possible range between €500,000 and €2,000,000) and an invitation to participate in a Google for Startups Accelerator.

Another example of early-stage funding from Google is LevelTen Energy from Seattle, WA which raised \$35 million in a Series C round led by NGP Energy Capital, with participation from Google and others in 2021. LevelTen operates a marketplace that allows corporations, utilities, universities and others to sign on to power purchase agreements with renewable sources such as wind and solar energy.<sup>232</sup> While Google is listed in the funding notices it is not clear exactly how much of the \$35 million raised came from each source.

### 6.1.10 HP Inc.

[HP Tech Ventures](#) is HP's corporate venture arm, that typically invests at Seed to Series B and collaborates with startups at all stages for strategic partnerships. Its current areas of focus include advanced manufacturing, artificial intelligence, device security, digital health, edge computing, gaming and eSports, virtual and augmented reality, and 3D printing.<sup>233</sup> While HP Ventures does not appear to have recently funded solar technologies, [HP's Girls Save the World challenge](#) did awarded the grand prize to the development and implementation of: Etana, a low-cost, solar-powered fingerprint scanner that provides women in developing nations with a digital proof of identity even if they don't have access to the Internet or electricity.<sup>234</sup> The company has also been using solar PPAs for several years.<sup>235</sup>

### 6.1.11 IBM

IBM has developed solar technologies internally over the years, used solar energy to power its facilities and engaged in PPAs, and has also provided funding and collaborative efforts to technology companies and universities working on solar solutions. One current example of IBM's efforts in collaborative solar development is through its work with [Raise Green](#), an inclusive impact investment marketplace for climate solutions. The approach taken by Raise Green is to combine equity crowdfunding with community solar to make impact investing accessible to everyone where investors can buy in for as little as \$100.00 to get started. Raise Green came to IBM Global Business Services (GBS) with a need that the parties developed into the [Originator Engine](#), and in 2021 Raise Green announced their

collaboration to develop its software solution deployed using Red Hat OpenShift on IBM Cloud. As part of this effort, a team of IBM design and technology specialists worked with Raise Green to co-create, develop and deploy a proof-of-concept for the Originator Engine in just eight weeks through the [IBM Garage](#).<sup>236</sup>

IBM has several mechanisms for funding new and innovative solutions, IBM Ventures is IBM’s corporate venture investment arm that has several affiliated groups for development efforts and also has identified [energy technology](#) as an overarching area of interest for the company.

**Table 5:** IBM Venture Groups

Group	Description
<b>Partner-World</b>	<p>PartnerWorld is made up of over 55,000 partners focusing on in three core concepts:</p> <p>“Partnership: Together we can go further.</p> <p>Investments: The resources, programs, and tools that we offer help you to train your team and generate demand to your innovative solutions.</p> <p>Your Growth: By accessing a variety of products and services, you can create your own value add solution and be supported in the market by our technology.”</p> <p>Link: <a href="https://www.ibm.com/partnerworld/public">https://www.ibm.com/partnerworld/public</a></p>
<b>Startup with IBM</b>	<p>This IBM program is focused on helping B2B scaleups navigate the challenges and opportunities of growth and getting companies to market faster. After applying and being accepted, participants receive monthly IBM Cloud credits to spend on over 100 services on IBM Cloud®, access to Integrated technologies from IBM, and the opportunity to get offerings in front of nearly 25 million IBM customers, visitors, partners, and developers.</p> <p>Applicants must meet the following requirements:</p> <ul style="list-style-type: none"> <li>• Your revenue in the last 12 months is less than USD 15 million.</li> <li>• Your startup is privately held and has been in business for less than 10 years.</li> <li>• You have not been a paying customer of IBM Cloud.</li> <li>• You are a verifiable entity with a website and dedicated email server.</li> </ul> <p>Link: <a href="https://developer.ibm.com/startups/">https://developer.ibm.com/startups/</a></p>

<b>IBM Garage™</b>	<p>IBM Garage™ is accelerator for digital transformation. It helps participants generate innovative ideas and equips them with experts, practices, and technologies to rapidly turn those ideas into business value.</p> <p>Link: <a href="https://www.ibm.com/garage">https://www.ibm.com/garage</a></p>
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Source: IBM Ventures<sup>237</sup>

### 6.1.12 Intel Corporation

Intel's investments in solar technology development funding date back to 2008 when it announced that it was leading a \$50 million [investment round](#) in a new start-up and spinning off solar technology that it had developed. The divested assets from Intel became part of an independent company, SpectraWatt Inc, that was focused on improving solar cell manufacturing, however, the company closed in 2011. Intel Capital invested in a few other solar companies that have since closed. More recently, the company has been focused on PPAs with solar energy companies as opposed to funding individual technologies or technology development companies.

[Intel Capital](#) appears to have shifted its focus to four core areas of computing, Cloud, Devices, Frontier and Silicon and does not appear to be funding solar technology at this point.<sup>238</sup> However, the company is an active user of solar energy as it works to meet sustainability targets – Intel has installed solar farms at many locations to power the company's operations. Despite the use of solar panels, Intel does not appear to have invested in the development of the systems and panels it uses.

### 6.1.13 Jacobs Engineering Group

Jacobs Engineering Group is a leader in the development of solar photovoltaic (PV) facilities around the world and works with clients developing bifacial single-axis tracking solar projects integrated with agricultural facilities (agrivoltaics).<sup>239</sup> While the company's efforts as a whole are focused on technology development and planning it does not appear that they are providing funding for outside development of solar technologies at this time.

### 6.1.14 Kimberly-Clark Corporation

Kimberly-Clark Corporation has work to meet its renewable energy targets through PPAs and adding solar panels to its facilities. One recent example of a collaborative effort and investment in solar energy is through the company's facility in LaGrange, Georgia which now houses a 3MW solar project with over 8,600 solar panels. Kimberly-Clark leased the land to United Renewable Energy for the project - United Renewable Energy develops, designs, builds and maintains solar photovoltaic and energy storage systems for utilities, industrial and commercial companies, Independent Power Producers, and Electrical Membership Co-operatives. The 3MW project was the result of collaboration between Kimberly-Clark's facility, United Renewable Energy LLC as the project developer and builder, and NextEra Energy Resources, LLC through a subsidiary, which is the long-term project owner. With the work completed, the output from the solar facility and the

renewable energy credits (RECs) will be sold to Georgia Power as part of Georgia Power's Renewable Energy Development Initiative, and the associated RECs will be retired on behalf of all of Georgia Power's customers. Furthermore, Kimberly-Clark entered into a separate agreement to purchase RECs from NextEra Energy Resources, which allows Kimberly-Clark to offset its greenhouse gas emissions<sup>240</sup>.

#### 6.1.15 Lockheed Martin

Lockheed Martin Ventures is based in Silicon Valley and is focused on investing in startup companies that are developing the next generation of disruptive, cutting-edge commercial technology. The group doubled the size of its technology investment fund from \$100 million to \$200 million in 2018, its focus areas are:

- Artificial intelligence
- AR / VR / MR
- Autonomy & robotics
- Blockchain
- Advanced communications
- Cybersecurity
- Data & analytics
- Digital transformation
- NextGen electronics
- Hypersonics
- IoT / Edge computing
- Advanced materials
- Advanced manufacturing
- Quantum
- Sensors
- Space tech<sup>241</sup>

In 2018 Lockheed Martin Ventures and Energy Innovation Capital (EIC) offered Ocean Aero a Series B funding round worth several million dollars.<sup>242</sup> Ocean Aero's signature product at the time of funding was the Submaran, which was the first hybrid wind and solar-powered surface and subsurface vehicle designed for extended ocean observation and data collection. Today, its [TRITON](#) platform is fully wind and solar powered. Another example of funding for an external solar project is through a 2014 effort in which Lockheed Martin contracted Advanced Green Technologies (AGT) to design and build a 2.25-megawatt solar carport at their Mission Systems and Training facility in Oldsmar, Florida. The project uses 7260 solar modules mounted on a 151,400 square foot area that is 24' in height, which provides clean energy to the facility and protected parking for 534 vehicles.<sup>243</sup> Also, while not early-stage, Lockheed directed \$9 million U.S. dollars toward TC Energy's Saddlebrook Solar + Storage Project (Alberta, Canada) in 2021.<sup>244</sup>

The company has also leveraged [PPAs](#) for solar energy for the past several years.

### 6.1.16 Microsoft Corporation

In January 2020, Microsoft announced its commitment to becoming carbon negative by 2030, meaning that by the end of this decade, it will remove more carbon from the environment than it emits. By 2050, the company's goal is to remove all the carbon it has ever emitted in its 46-year history. Also in 2020, Sol Systems, a national solar energy finance and development firm, and Microsoft announced plans to invest at least \$50 million for community-led grants and investments that support educational programs, job and career training, habitat restoration, and programs that support access to clean energy and energy efficiency. The first awards for the Sol/Microsoft funds were announced in 2022.

**[Energy Impact Partners LP \(EIP\)](#), a venture capital firm backed by Microsoft and Duke Energy**, has raised \$200 million to fund clean energy and sustainable manufacturing technology. The Deep Decarbonization Frontier Fund will provide capital for high-risk ventures aiming to provide green energy or low-carbon industrial processes. It will be funded by utilities and oil and gas companies and plans to pair up its successes with these sponsors when their technology is ready to go into production. While its [portfolio](#) includes solar companies, these companies appear to be focused on community solar, solar financing, and solar development as opposed to technology development.

Microsoft has also been using power purchase agreements (PPAs) for solar energy and has noted its interest in investing in minority-owned energy companies. For example, Microsoft announced a solar energy partnership with Volt Energy, a Black-owned solar energy development firm, in July 2021 to supply Microsoft with 250 megawatts of solar power. The company has indicated that it is interested in community-based solar efforts with diverse partners, including those from rural areas. However, information on specific solar technologies or technology companies was not widely noted.<sup>245</sup>

### 6.1.17 The Boeing Company

Boeing's internal solartech efforts date back to the 1980s and in mid-2021 Boeing and AeroEquity Industrial Partners announced a new partnership to expand Boeing's venture capital investments called [AEI HorizonX](#). Among the group's investments are Redwire Corporation, a leader in space infrastructure for the next generation space economy, with *valuable IP for solar power generation and in-space 3D printing and manufacturing*.<sup>246</sup>



**Figure 8:** AEI HorizonX Target Themes for Investment  
**Source:** AEI HorizonX<sup>247</sup>

The group focuses on early-stage equity investments in transformative technologies and businesses that will define the future of aerospace, defense, enterprise and industrial markets. AEI HorizonX invests in the earliest stages (Series A, B) and continues to work with these companies and their founders at every stage of growth.<sup>248</sup>

### 6.1.18 The Procter & Gamble Company

P&G has signed solar PPAs and invested in solar panels and technology for its manufacturing facilities at various locations across the globe, however, it does not appear to provide funding for the development of solar technologies. [P&G Ventures](#) is an early-stage startup studio within Procter & Gamble that partners with entrepreneurs to accelerate solutions in eight core areas but this does not include solar technology.

### 6.1.19 T-Mobile

In 2018 T-Mobile announced a plan to source 100% of its total electricity usage with renewable energy by the end of 2021 and was able to meet this goal. The strategy includes eight virtual power agreements, 19 retail agreements, one Green Direct program, and unbundled Renewable Energy Certificates that support projects across the country as well as 37 community solar projects.<sup>249</sup>

T-Mobile's investments appear to be primarily focused on community solar efforts in support of its broader sustainability goals and not on developing individual technologies to deploy these solutions. In early 2022 T-Mobile announced a partnership with Nexamp in its community solar program. T-Mobile now has subscriptions to ten separate Nexamp solar farms representing more than 50 MW of total project capacity across Maine, Massachusetts and New York, and local electric customers interested in participating in clean energy can subscribe to these projects and receive discounts on their bill from T-Mobile. However, it does not appear that T-Mobile provided any funding for the development of Nexamp's early-stage work.

Another effort in early 2022 from the company focuses on community solar in New York state, DSD Renewables and T-Mobile entered into a partnership to develop and construct three community solar projects. The partnership between DSD and T-Mobile came from a T-Mobile request for proposals (RFP). DSD was selected on the strength of its community solar portfolio and will be the long-term owner of the projects. The partnership between DSD and T-Mobile is expected to continue into the future, however, it does not appear that this partnership is funding technology development.<sup>250</sup>

In mid-2022 T-Mobile subscribed to 14 of U.S. Solar's new 1-MW community solar gardens, which will provide energy cost savings to T-Mobile locations across seven Minnesota counties. Presently, 11 of the 14 gardens are in various stages of construction and development, these subscriptions allow companies and individuals to benefit from local solar without any upfront costs or equipment on their property.<sup>251</sup>

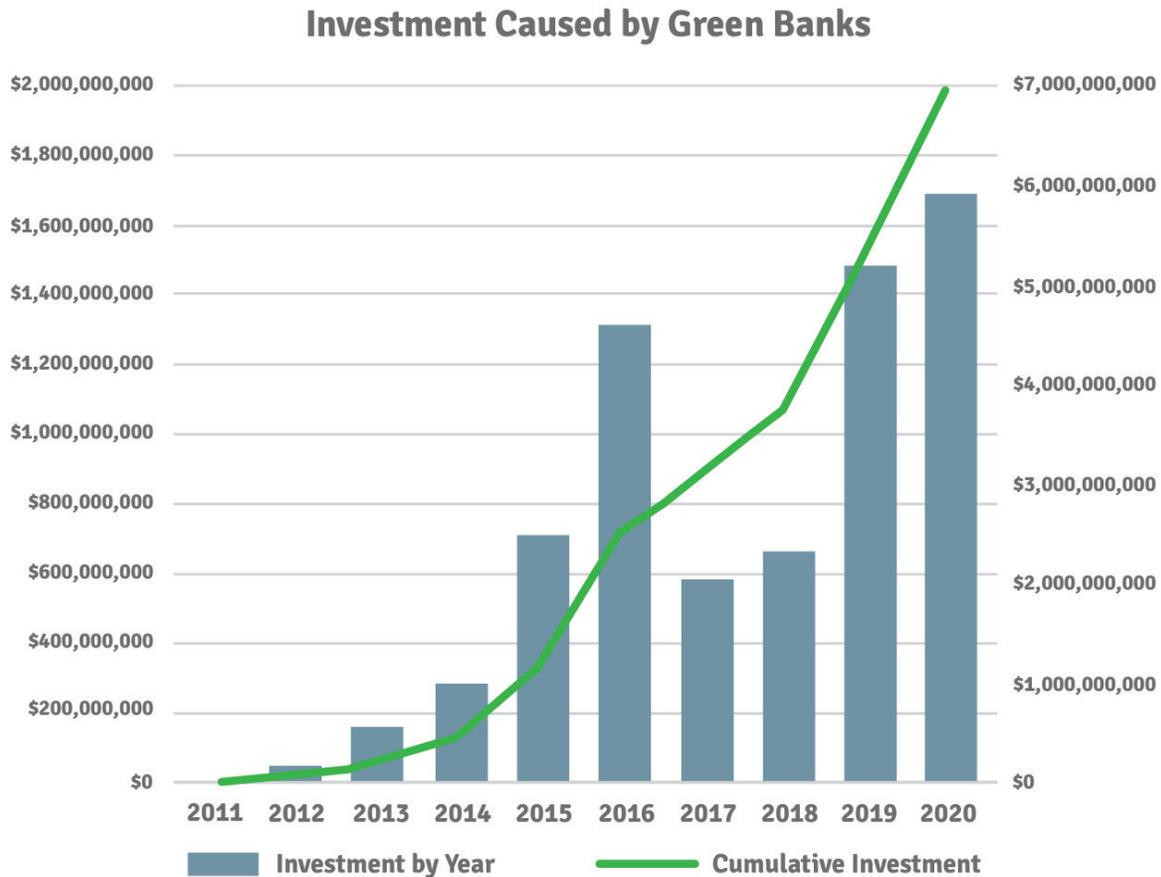
## 7.0 GREEN BANKS

As defined by the National Renewable Energy Laboratory (NREL), "Green Banks help secure low-cost capital for clean energy projects including solar at favorable rates and terms to both traditional and otherwise challenging market segments."<sup>252</sup> More specifically, green banks use public capital to mobilize more private investment into green and resilient financing markets to fill gaps with the ultimate goal of enabling private capital partners to enter clean energy markets at scale without green bank assistance. The concept of green banks was initially proposed in 2009, and there are now 21 green banks in the U.S., with more in development.<sup>253</sup>



**Figure 4:** Green Banks in the U.S., 2021  
**Source:** Coalition for Green Capital<sup>254</sup>

In May 2021 the American Green Bank Consortium and the Coalition for Green Capital published a [report](#) outlining the state of green banks in the United States. At the time of publication (May 2021) American Green Banks have caused \$7.0 billion in clean energy investment since 2011, with \$1.69 billion of this investment taking place in calendar year 2020.<sup>255</sup>



**Figure 5:** Investment Caused by Green Banks 2011-2021  
**Source:** American Green Bank Consortium & Coalition for Green Capital<sup>256</sup>

The concept of a National Green Bank was first introduced in 2009 and on August 7, 2022 the Senate passed the [Inflation Reduction Act](#) that includes \$27 billion for a National Climate Bank intended to spur investment in clean technologies. The National Climate Bank is described further in a companion piece of [legislation](#), and would focus on investments in nine key areas:

- Renewable energy;
- Energy storage;
- Clean transportation;
- Transmission (for clean energy);
- Climate resiliency measures;
- Energy and water efficiency;
- Reforestation of degraded land;
- Agricultural projects; and

- electrification and decarbonization of industrial processes.<sup>257</sup>

The Green Bank Network [database](#) contains information compiled by the group from publicly available information, a search was carried out for solar projects funded in the U.S. and yielded [53 results](#). However, of the 53 results none were funding technology development, instead the projects being financed tended to fall into a few broad categories including distributed solar, community solar, PPAs, and construction of new facilities.

## 8.0 CONCLUSION

This report explores early-stage investments in solar technologies by the private sector. As the Federal government often steps in when private sector investments are low, a key goal of this report is to map the solar investment space and determine where different types of investments are being made. The report is divided into two main sections – the first focused on venture capital and the second on commercial firms (energy companies, utilities, fortune 500 firms, and green banks). The equity investment community as well as utilities appear to be focused on technologies that will accelerate the rate of adoption of solar in the residential sector. Companies that were profiled in the energy sector have committed to carbon reduction throughout their plants, while their venture arms appear to have an interest in advancing the performance of solar technologies. The picture with the Fortune 500 companies profiled in this report is mixed with fewer specifically focused on solar.

## 9.0 APPENDIX

The following sections contain background information used throughout the research process.

### 9.1 Fortune 500

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The U.S. Environmental Protection Agency (EPA) established the Green Power Partnership (GPP) in 2001 to encourage organizations to use green power voluntarily to protect human health and the environment. EPA's Partners include a wide variety of organizations, including large corporations; small and medium-sized businesses; local, state, and federal governments; non-profit institutions; and colleges and universities.

As of April 25, 2022, the combined annual green power use of EPA's Top Fortune 500 Partners amounts to nearly 64 billion kilowatt-hours of green power, which is equivalent to the annual electricity use of more than 5.9 million average American homes.

**Table 6:** Green Power Partnership Fortune 500® Partners List

Partner Name	Annual Green Power Usage (kWh)	GP % of Total Electricity Use*	Industry	Green Power Resources
1. <a href="#">Microsoft Corporation</a>	8,324,914,969	100%	Technology & Telecom	Various
2. <a href="#">Google LLC (Alphabet)</a>	7,914,747,101	93%	Technology & Telecom	Solar, Wind
3. <a href="#">T-Mobile</a>	7,806,076,868	100%	Technology & Telecom	Various
4. <a href="#">Intel Corporation</a>	5,022,773,872	100%	Technology & Telecom	Various
5. <a href="#">The Procter &amp; Gamble Company</a>	2,594,266,946	100%	Consumer Products	Various
7. <a href="#">Equinix, Inc.</a>	2,458,915,894	100%	Technology & Telecom	Various
9. <a href="#">Apple Inc.</a>	2,202,581,271	101%	Technology & Telecom	Biogas, Biomass, Small-hydro, Solar, Wind
11. <a href="#">PepsiCo</a>	1,711,233,504	100%	Food & Beverage	Solar, Wind
12. <a href="#">Kimberly-Clark Corporation</a>	1,645,259,000	55%	Consumer Products	Solar, Wind
13. <a href="#">Wells Fargo</a>	1,611,074,372	100%	Banking & Fin. Svcs.	Solar, Wind
14. <a href="#">Target Corporation</a>	1,280,653,824	33%	Retail	Solar, Wind
15. <a href="#">General Motors, LLC</a>	1,207,062,040	38%	Automotive	Biogas, Solar, Wind
17. <a href="#">Owens Corning</a>	1,083,288,025	62%	Industrial Goods & Svcs.	Solar, Wind
18. <a href="#">Cisco Systems, Inc.</a>	1,063,237,505	100%	Technology & Telecom	Solar, Wind
21. <a href="#">salesforce.com</a>	543,792,117	73%	Technology & Telecom	Solar, Wind
22. <a href="#">Johnson &amp; Johnson</a>	456,736,383	77%	Health Care	Solar, Wind
24. <a href="#">Dell Technologies</a>	404,054,000	61%	Technology & Telecom	Solar, Wind
26. <a href="#">The Boeing Company</a>	391,087,669	20%	Industrial Goods & Svcs.	Biomass, Small-hydro, Solar, Wind
27. <a href="#">Best Buy</a>	374,264,000	56%	Retail	Solar, Wind
28. <a href="#">The Clorox Company</a>	371,787,000	100%	Consumer Products	Solar, Wind

29. <a href="#">Lockheed Martin</a>	322,000,000	22%	Industrial Goods & Srvcs.	Biomass, Solar, Wind
31. <a href="#">eBay Inc.</a>	275,608,040	82%	Technology & Telecom	Solar, Wind
34. <a href="#">Cummins, Inc.</a>	231,336,076	48%	Industrial Goods & Srvcs.	Solar, Wind
36. <a href="#">JPMorgan Chase &amp; Co.</a>	213,953,094	14%	Banking & Fin. Srvcs.	Solar, Wind
38. <a href="#">PayPal, Inc. / U.S. Data Centers</a>	203,891,990	100%	Banking & Fin. Srvcs.	Solar, Wind
39. <a href="#">HP Inc.</a>	188,160,273	100%	Technology & Telecom	Various
41. <a href="#">IBM</a>	174,191,810	12%	Technology & Telecom	Solar, Wind
42. <a href="#">American Express</a>	167,364,195	100%	Banking & Fin. Srvcs.	Solar, Wind
43. <a href="#">State Street Corporation</a>	158,991,503	104%	Banking & Fin. Srvcs.	Solar, Wind
44. <a href="#">Fifth Third Bank</a>	153,164,000	100%	Banking & Fin. Srvcs.	Solar, Wind
45. <a href="#">DaVita Kidney Care</a>	144,202,000	24%	Health Care	Solar, Wind
47. <a href="#">Applied Materials, Inc.</a>	113,897,687	41%	Technology & Telecom	Biogas, Biomass, Geothermal, Small-hydro, Solar, Wind
49. <a href="#">Kohl's, Inc.</a>	85,308,921	9%	Retail	Solar, Wind
50. <a href="#">Jacobs Engineering Group</a>	68,323,101	100%	Constr. & Eng. Srvcs.	Small-hydro, Solar, Wind
51. <a href="#">The Estee Lauder Companies Inc.</a>	66,935,219	104%	Consumer Products	Solar, Wind
52. <a href="#">Netflix, Inc.</a>	65,639,739	100%	Media & Publishing	Biomass, Geothermal, Small-hydro, Solar, Wind
53. <a href="#">Tractor Supply Company</a>	61,422,766	15%	Retail	Solar, Wind
54. <a href="#">The Hartford Financial Services Group Inc.</a>	59,490,000	106%	Insurance	Solar, Wind
57. <a href="#">Hormel Foods Corporation</a>	53,128,842	7%	Food & Beverage	Solar, Wind
62. <a href="#">United Services Automobile Association (USAA)</a>	34,438,069	22%	Insurance	Solar, Wind
66. <a href="#">Albertsons Companies, Inc. / Select Locations</a>	8,661,840	13%	Retail	Solar, Wind

73. <a href="#">Macy's, Inc. / 8 California Stores</a>	1,870,679	25%	Retail	Solar
74. <a href="#">FedEx Express / Oakland Hub Facility</a>	1,034,772	10%	Shipping	Solar

\* Reflects the amount of green power as a percentage of total electricity use. Partners choosing to purchase green power in an amount exceeding 100 percent of their U.S. organization-wide electricity use are listed as such.

° Indicates Provider is selling Partner a third-party certified green power product. Get more information on third-party certification.

Source: U.S. EPA<sup>258</sup>

## 9.2 ENERGY SECTOR

The following the list covers the largest public companies in the Energy sector in the United States by market capitalization, this was used to determine what the U.S. energy sector is doing in terms of investment in the solar technology space.

**Table 7:** Top Energy Companies from the United States as of Apr. 01, 2022

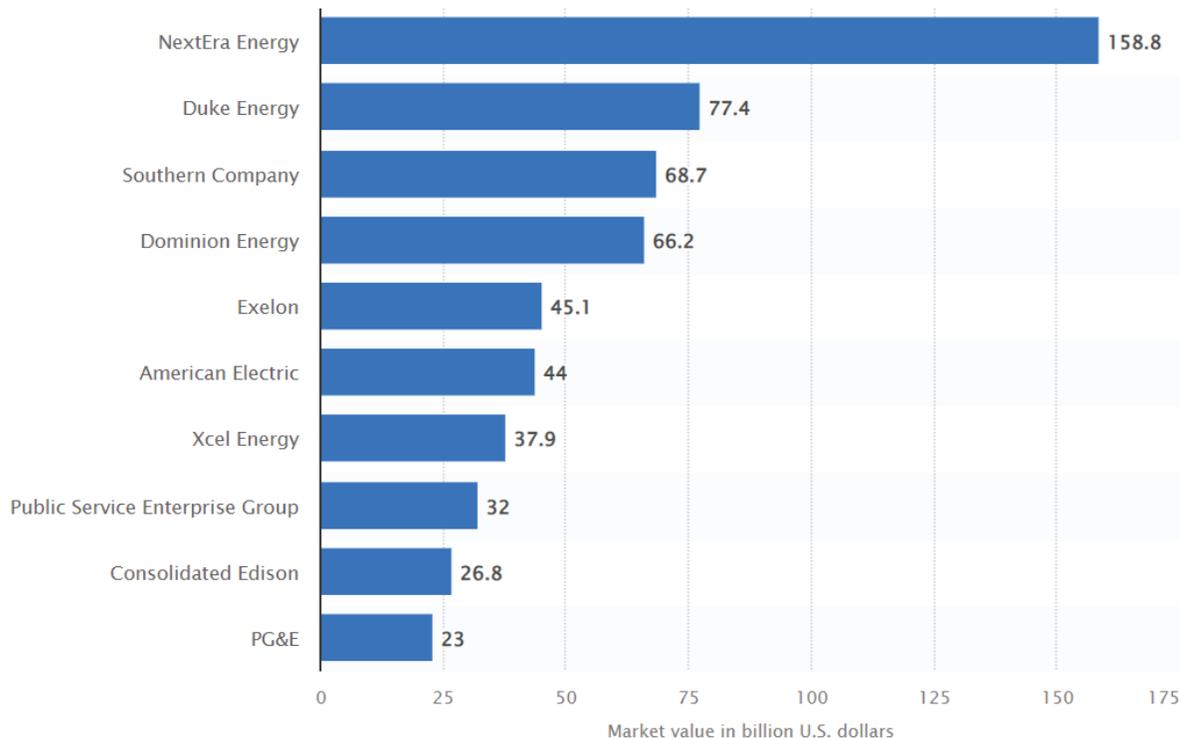
Ranking	Company	Market Cap (USD)
1	<a href="#">Exxon Mobil Corporation</a>	\$348.72 B
2	<a href="#">Chevron Corporation</a>	\$315.13 B
3	<a href="#">ConocoPhillips</a>	\$136.32 B
4	<a href="#">EOG Resources, Inc.</a>	\$71.90 B
5	<a href="#">Pioneer Natural Resources Company</a>	\$62.19 B
6	<a href="#">Schlumberger Limited</a>	\$57.63 B
7	<a href="#">Enterprise Products Partners L.P.</a>	\$57.43 B
8	<a href="#">Marathon Petroleum Corporation</a>	\$54.54 B
9	<a href="#">Occidental Petroleum Corporation</a>	\$52.30 B
10	<a href="#">Kinder Morgan, Inc.</a>	\$43.38 B
11	<a href="#">Devon Energy Corporation</a>	\$41.82 B
12	<a href="#">The Williams Companies, Inc.</a>	\$41.60 B
13	<a href="#">Valero Energy Corporation</a>	\$41.27 B
14	<a href="#">Baker Hughes Company</a>	\$38.39 B
15	<a href="#">Phillips 66</a>	\$37.51 B

16	<a href="#">MPLX LP</a>	<a href="#">\$35.27 B</a>
17	<a href="#">Cheniere Energy, Inc.</a>	<a href="#">\$34.92 B</a>
18	<a href="#">Halliburton Company</a>	<a href="#">\$33.95 B</a>
19	<a href="#">Hess Corporation</a>	<a href="#">\$32.81 B</a>
20	<a href="#">ONEOK, Inc.</a>	<a href="#">\$31.66 B</a>

Source: Disfold, April 2022<sup>259</sup>

### 9.3 UTILITIES

In terms of utilities, the largest electric utilities based on market value in the United States as of April 2021 include the following companies.



**Figure 9:** Largest electric utilities based on market value in the United States as of April 2021 (in billion U.S. dollars)

Source: Statista, April 2021<sup>260</sup>

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