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Footfall and Social Media v. Concentrated Solar Power: When the Power of a Choice in a Behavior-Based Economy can be More Powerful than the Power of the Sun

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FOOTFALL AND SOCIAL MEDIA v. CONCENTRATED SOLAR POWER: WHEN THE POWER OF CHOICE IN A BEHAVIOR-BASED ECONOMY CAN BE MORE POWERFUL THAN THE POWER OF THE SUN

Kimberly E. Diamond[*]

INTRODUCTION

Renewable energy holds promise for powering smart cities and cities of the future. Domestically, renewable energy does not currently constitute a large portion of the energy mix in most cities. As a result, in effort to become more energy efficient and reduce their carbon footprint, smart cities will need to find innovative ways to deliver this energy to local residents in an efficient and sustainable manner. To do this successfully, there must be public buy-in for the renewable technologies used. While achieving this buy-in can be difficult, it can be done through a number of creative and inventive approaches - ones that include appealing to people as individuals on a variety of psychological levels, including through the use of physical interactions, other sensory perceptions, and feelings of pride all with respect to the new technology.

As the still-novel concept of smart cities begins to evolve, it is anticipated that new emerging technologies will catalyze a more futuristic, information-driven, connected society - one in which breakthrough products pave the way for transformative innovations and social growth. The use of apps on mobile phones and other hand-held devices with which people are already familiar, together with the use of social media, can spur this process and serve as a driver of change. Moreover, because people can use social media to influence and modify the behavior of others, a truly phenomenal innovation can disrupt the way people think about renewable energy generation.

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With the advent of such innovations coming to market presently, lessons learned from what are currently considered to be among the most ultramodern, state-of-the-art advances in renewable energy technology can be instructive for informing standards, guidelines, and other product prerequisites for these innovations. Accordingly, this paper analyzes concentrated solar power technology and its current state of affairs both domestically and abroad. It also analyzes a breakthrough flooring technology that converts the kinetic energy from footsteps into energy used for powering light fixtures. By comparing and contrasting these two technologies against one another, this paper explores the key elements that can inform policy and that may be essential for launching a large scale roll-out of a new renewable energy technology within the confines of an urban environment.

I. THE IMPORTANCE OF ENHANCING SCIENTIFIC ADVANCEMENTS THROUGH INNOVATION, FUNDING, AND PUBLIC SUPPORT

A. The Significance of Building "Scale"

For a new technology to be taken seriously and viewed by others as a realistic, competitive venture that has staying power in the marketplace, it is important to build scale, or, rather, develop a project to its full size potential. The ability to achieve scale boosts the infant technology's credibility and enhances its ability to be taken seriously, either as a player in an existing industry or as a rookie in a new, emerging one.

Building scale, though, is a process that generally takes time to achieve. Particularly for new inventions and futuristic technologies, the public wants to see "proof of concept,"[1] or, rather, evidence that the technology actually works in practice and is therefore feasible and worthy of further exploration and development. This is why rolling out a new technology publicly may start small, in the form of one or more pilot projects or demonstration projects. Beginning small both enables the technology to be tested in practice and allows the product developer advancing the technology to identify, refine, and improve upon certain product design flaws identified following the pilot

1. *Proof of Concept,* INVESTORWORDS, http://www.investorwords.com/3899/proof_of_concept.html (last visited May 12, 2017).

project's debut. Moreover, enabling the public to see the product work in practice facilitates the public's engagement with the product and enables the public to appreciate the product's functionality.[2] This interaction between public and product builds trust, which in turn leads to public buy-in and support. The length of time it takes to build the appropriate level of trust and public buy-in, though, is an intangible that is somewhat difficult to calculate.

Taking the leap to building a large-scale, more robust version of the technology post pilot project roll-out generally requires a substantial investment of funds. Amassing such funds is often difficult to do, whether for an established company whose brand already has attained market recognition or for a young start-up company that is endeavoring to forge a path for its name to reach public consciousness. Obtaining funding from government resources, companies, or a combination of both, consequently, can play a pivotal role in fast-tracking a post-pilot project technology and helping to scale-up the technology to a much grander level.

B. Brief Background on Recent Government Funding of Renewable Energy Innovations in the U.S.

1. Innovation Clusters

Recently, substantial federal and state funds alike have been focused on "innovation clusters," or "regional centers of innovation," for energy projects that will help to improve energy efficiency.[3] A collaborative effort generally involving a combination of companies, universities, and state or local governments working together in novel ways, an innovation cluster is an intertwined community that gathers its momentum from already existing know-how in the particular community in which the cluster forms.[4] Examples of innovation clusters include Silicon Valley, which focuses on computer science

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2. See *infra* Part IV.B.1., for an example of engaging the public with such a product.

3. Kim Diamond & Paul Gelb, *Innovation Clusters: Drivers of Cutting-Edge Technologies for Our Energy Future*, RENEWABLE ENERGY WORLD (July 29, 2016), http://www.renewableenergyworld.com/articles/2016/07/innovation-clusters-drivers-of-cutting-edge-technologies-for-our-energy-future.html [http://perma.cc/2KJP-JUWP].

4. *Id.*

and software design, as well as Silicon Valley's Southern California cousin, the San Diego Regional Innovation Cluster, which focuses on promoting and developing defense technologies.[5] These clusters are attractive insofar as they draw talent, based on competing opportunities for mutual advancement and improvement.[6] While there is no strict formula for the elements characteristic of an innovation cluster, several common attributes that these clusters generally share is (i) the ability to attract venture capital for investment in start-up companies, research and development, and nurturing ideas at their conceptual level and (ii) dedicated facilities, enabling the best and the brightest leaders of the particular industry to join forces, cultivate their ideas, and give birth to novel developments.[7]

California, a state that takes prides in being at the forefront of renewable energy and energy efficiency matters, sees the value in investing state funds into new innovation clusters insofar as they promise to stimulate intensive interaction, promote entrepreneurship and competition, and yield futuristic, unique technologically-advanced products at an accelerated rate.[8] This is why last year alone, the California Energy Commission (CEC) announced approximately $15,000,000 in funding for four energy innovation clusters, the Central Valley Innovation Cluster, the San Francisco Bay Area Innovation Cluster, the San Diego Innovation Cluster, and the Los Angeles Regional Innovation Cluster.[9] Through these projects, government investment in innovation clusters promises to expedite inventiveness and spur economic growth.[10]

2. Offshore Wind Pilot Projects

Congress recognizes that access to funding accelerates the invention and deployment of state-of-the-art technologies. As evidence, Congress created the U.S. Department of Energy (DOE) federal loan guarantee program to spur innovation and accelerate the commercialization of technologically innovative projects, such as

5. *Id.*
6. *Id.*
7. *Id.*
8. *Id.*
9. *Id.*
10. *Id.*

renewable energy projects.[11] In recent years, the DOE has invested and deployed funds for futuristic projects in the renewable energy sector, to spur innovation and development of technologies in that area.

For instance, to promote the launch of the United States' infant offshore wind industry and accelerate the development of more efficient offshore wind turbines, the DOE awarded millions of dollars in federal funds to certain domestic offshore wind pilot projects located in state and federal waters.[12] These include several projects that use floating turbines, a state-of-the-art technology that to date has not been widely tested in the global marketplace.[13] Taking the view that offshore wind is an essential resource to incorporate into the United States' domestic energy mix, the DOE believes these projects are an investment in the nation's energy future that will help address challenges the domestic offshore wind industry currently faces, such as integrating power into the current electric grid and navigating the permitting and approval process.[14] Because these demonstration projects are somewhat experimental in nature, there is a built-in presumption that each project may encounter kinks along the way, and that these kinks will be identified and rectified before large scale deployment of the technologies used in these projects occurs.

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11. *See* Joe Desmond, *Ivanpah and the DOE Loan Guarantee Program,* BRIGHTSOURCE (June 5, 2012, 9:45 PM), http://www.brightsourceenergy.com/ivanpah-and-the-doe-loan-guarantee-program#.WMOWGqMo670 [http://perma.cc/T77V=PLCQ].

12. These offshore wind projects include Principal Power's WindFloat Pacific Demonstration Project in Coos Bay, Oregon, as well as the University of Maine's New England Aqua Ventus I project. *See WindFloat Pacific - Offshore Wind Pilot Project*, BUREAU OF OCEAN ENERGY MANAGEMENT, https://www.boem.gov/Renewable-Energy-Program/State-Activities/Offshore-Wind-Technology-Demonstration-Project.aspx (last visited May 12, 2017); *Department of Energy Awards $43 Million to Spur Offshore Wind Energy,* ENERGY.GOV (Sept. 8, 2011), https://energy.gov/articles/department-energy-awards-43-million-spur-offshore-wind-energy [http://perma.cc/JFG8-BZPK] [hereinafter *DOE Awards $43 Million to Offshore Wind Projects*]. In 2011 alone, DOE awarded 41 projects across 20 states a combined total of $43,000,000 to advance and improve offshore wind development. *See DOE Awards $43 Million to Offshore Wind Projects, supra* note 12.

13. *DOE Awards $43 Million to Offshore Wind Projects, supra* note 12.

14. *Id*.

3. Concentrated Solar Projects

Currently, photovoltaic (PV) technology and solar thermal electric systems, also known as concentrated solar power or concentrating solar power (CSP) systems, are the two technologies that are generally used globally for generating utility-scale solar power.[15] As discussed further in Part II.C.4. herein, a massive amount of federal funding has been used to assist with the financing that has enabled large, utility-scale CSP projects[16] to come to market domestically.[17]

II. BACKGROUND ON CONCENTRATED SOLAR POWER

A. How It Works

For a solar energy project to be considered a utility-scale project, the project itself must generate more than one megawatt (MW) of energy.[18] CSP systems, considered a state-of-the-art technology, create vast amounts of energy, with certain plants generating several hundred MW of energy.[19]

In a CSP project, specially-designed mirrors are used to focus the thermal energy from sun's rays onto a "receiver" containing flowing liquid or heat transfer fluid.[20] The receiver itself contains a heat transfer fluid (HTF), which, depending on the particular technology used, is pumped into either a storage tank or directly into heat exchangers to produce steam.[21] The steam is then used to spin a steam

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15. *A Review of Avian Monitoring and Mitigation Information at Existing Utility-Scale Solar Facilities, prepared for U.S. Department of Energy, SunShot Initiative and Office of Energy Efficiency & Renewable Energy, Environmental Science Division*, NATIONAL RENEWABLE ENERGY LABORATORY (NREL) AND ARGONNE NATIONAL LABORATORY, ANL/EVS-15-2 (Apr. 2015), at 4, 7 [hereinafter *DOE Solar Facilities Review*].

16. The term "CSP project" and the term "CSP plant" may be substituted for one another, as a CSP project is technically a power plant.

17. *See infra* Part II.C.4.

18. *DOE Solar Facilities Review*, *supra* note 15, at 7.

19. *Id*.

20. *Id*. *See also* Alyssa Cauble, *BrightSource's Heliostat Technology* (Jan. 3, 2013), http://www.brightsourceenergy.com/brightsource%E2%80%99s-heliostat-technology#.WLN3I6Mo670 [http://perma.cc/K7BV-58XM].

21. *DOE Solar Facilities Review*, *supra* note 15 at 7.

turbine, or generator, which creates electric power.[22] Currently, there are four categories of CSP systems that exist: (1) power towers; (2) parabolic trough; (3) compact linear Fresnel reflector; and (4) dish-engine.[23]

1. Power Tower Systems

A power tower system is a central receiver system, wherein hundreds of heliostats,[24] computer-controlled, flat, heat- and wind-resistant mirrors, are used to capture "solar flux," or direct ambient sunlight for conversion to energy.[25] The heliostats are generally arranged in concentric circles around an enormous cylindrical tower, commonly called a "power tower,"[26] where each heliostat reflects and focuses the sunbeams onto boilers located at the top of the power tower.[27] CSP projects having this unique configuration of heliostats around a power tower possess a configuration called a "heliostat solar-field."[28] Due to the vast numbers of heliostats simultaneously

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22. *Id*. *See also Concentrating Solar Power*, SOLAR ENERGY INDUSTRIES ASSOCIATION (SEIA), http://www.seia.org/initiatives/concentrating-solar-power (last visited May 16, 2017) [hereinafter *Concentrating Solar Power*].

23. *Concentrating Solar Power*, *supra* note 22.

24. As its Greek word origins suggest, a heliostat - derived from the Greek words "helios" meaning "sun," and "stat" meaning "stationary" - is a device used to track the sun from a specific, stationary point. *See* Cauble, *supra* note 20.

25. *See* Cauble, *supra* note 20. For context, with respect to the amount of direct ambient sunlight a heliostat receives, solar flux is a measurement of solar energy passing through a particular area, in which "one sun" of flux is the equivalent of approximately 1 kilowatt (kW) per square meter (kW/m^2). *See* DOE Solar Facilities Review, *supra* note 15, at 30. The heat-resistant quality of these mirrors enable them to withstand extreme desert temperatures, while their wind-resistant quality enables them to withstand harsh desert winds. *Id*. *See also Concentrating Solar Power***,** *supra* note 22.

26. *Birds Bursting Into Flames Above Solar Farm Stirs Calls to Slow Expansion,* CBS SF BAY AREA (Aug. 18, 2014, 11:25 AM), http://sanfrancisco.cbslocal.com/2014/08/18/birds-bursting-into-flames-above-solar-farm-stirs-calls-to-slow-expansion-streamer-solar-field-central-valley-heat-streamer-fire-burn/ [http://perma.cc/Z924-52VN] [hereinafter, *Birds Bursting*].

27. *Concentrating Solar Power*, *supra* note 22.

28. *Concentrating Solar Power Projects - Ivanpah Solar Electric Generating System*, NATIONAL RENEWABLE ENERGY LABORATORY, https://www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=62 [http://perma.cc/6AJJ-AH97] [hereinafter NREL, *Ivanpah*].

reflecting the sun's rays onto a single power tower, regions of intense solar flux converge on the tower's receiver.[29] While the tower's surface consists of a specially-designed surface coating that enables the tower to efficiently absorb most of the sunlight from the heliostats, the power tower nonetheless does not absorb all of the sunlight the heliostats direct to it.[30] This excess sunlight that converges above the top of the power tower can appear as a glowing cloud when dust or air particles are present directly above the tower itself.[31] The energy that the power tower absorbs is used to heat the HTF, such as molten salt, to extreme temperatures.[32] The heated HTF can then be stored as thermal energy and retrieved at a later time to produce power at night or when there is poor sunlight, thereby enabling the CSP system to generate power during a consecutive 24-hour period.[33]

2. Parabolic Trough Systems

In contrast to a power tower system, in a parabolic trough system, hundreds of connected parallel rows of curved mirrors[34] are used to focus sunlight onto a receiver in the form of a tube which is mounted just above the center of the trough.[35] The receiver tube contains the HTF, such as synthetic oil, which travels through a heat exchanger where it heats water and produces steam.[36] The steam then is used in a

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29. *See DOE Solar Facilities Review*, *supra* note 15, at 30.

30. This coating causes the tower to appear black. When the tower is exposed to high levels of solar flux, though, the minor amount of sunlight that the coating does not absorb causes the tower to appear to glow. *Id*. at 30.

31. *Id*.

32. These temperatures generally can be 1,000 degrees Fahrenheit, or greater. *See Concentrating Solar Power*, *supra* note 22.

33. *Id*.; *DOE Solar Facilities Review*, *supra* note 15, at 7, 9.

34. Because curved mirrors are more expensive than flat mirrors, power tower systems are generally considered to be more cost-effective than parabolic trough systems, despite parabolic trough systems being a comparatively more mature and more common technology. *See DOE Solar Facilities Review*, *supra* note 15, at 9.

35. The mirrors in a parabolic trough system are generally 15 - 20 feet long and measure 300 - 450 feet in length. *See Concentrating Solar Power*, *supra*, note 22; *DOE Solar Facilities Review*, *supra* note 15, at 9.

36. Generally, these tubes can be heated to temperatures of 750 degrees Fahrenheit or greater. *See Concentrating Solar Power*, *supra* note 22, at 1, 2.

conventional steam turbine power system format, thereby generating power.[37]

3. Compact Linear Fresnel Reflector (CFLR)

Somewhat of a hybrid mutation of a power tower system and a parabolic trough system, a compact linear Fresnel reflector (CFLR) system combines flat mirrors characteristic of a power tower system together with the tubular receivers mounted above the mirrors, characteristic of a parabolic trough system.[38] In a CFLR system, though, the tubes carry water, rather than synthetic oil, as the HTF.[39] When the water boils, it generates high-pressure steam, which, like the parabolic trough system, can be used to power a conventional steam turbine power system.[40]

4. Dish-Engine

Merging parabolic dish technology with mirror technology, a dish-engine system effectively uses large parabolic dishes which are each then covered in smaller, square-shaped mirrors.[41] The HTF used in this system is liquid hydrogen.[42] Once the HTF is heated in the receiver, it can be used to drive an engine, such as a Stirling engine.[43]

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37. *Id*.
38. *Id.*
39. *Id*.
40. *Id*. at 2.
41. *Id*. at 4.
42. In terms of heating, the liquid hydrogen is heated up to approximately 1,200 degrees Fahrenheit. *Id*.
43. *Id*. A Stirling engine is an engine that operates on a closed-cycle, regenerative, thermodynamic system, wherein the fluid in the system is a permanent fixture therein, the expansion and contraction of the fluid when it converts between a gaseous and a liquid state produces a net conversion of heat energy, and an internal heat exchanger and thermal store are present. *See Stirling Engine*, WIKIPEDIA, https://en.wikipedia.org/wiki/Stirling_engine [http://perma.cc/L6K5-R4XW]. While the Stirling engine was invented in 1816, to date, it is generally only used in special applications, such as submarines, auxiliary power generators for yachts, and in dish-engine systems. *See* Karim Nice, *How Stirling Engines Work*, (May 4, 2001) http://auto.howstuffworks.com/stirling-engine.htm [http://perma.cc/GP66-SJHP].

B. Current Scope, Scale, and Projects in the U.S.

In the United States, CSP is a relatively recent phenomenon.[44] To date, only seven states are home to CSP projects,[45] with certain projects already becoming non-operational for various reasons after only a few short years following their construction.[46] Since fourth quarter 2013, however, a handful of very large domestic CSP projects have been constructed and have become operational: the Ivanpah Solar Electric Generating System (hereinafter, the "Ivanpah Project" or "ISEGS"), the Genesis Solar Energy Project (hereinafter, the "Genesis Project"), the Mojave Solar Project, and the Crescent Dunes Project (collectively with the Ivanpah Project, the Genesis Project, and the Mojave Solar Project, the "Four CSP Projects").[47] In fact, because project completion for a majority of these Four CSP Projects occurred in 2014, that particular year - just a little over two short years ago - currently ranks as the highest year for domestic CSP development.[48] Collectively, the nameplate generating capacity[49] of these Four CSP

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44. *See* SOLAR ENERGY INDUSTRIES ASSOCIATION (SEIA) & GTM RESEARCH, SOLAR MARKET INSIGHT 2015 Q3 REPORT - CONCENTRATING SOLAR POWER (2015), http://www.seia.org/research-resources/solar-market-insight-2015-q3 [http://perma.cc/964D-8XZ9] [hereinafter *SEIA Solar Market Report*].

45. The seven states are: (1) Arizona; (2) California; (3) Colorado; (4) Florida; (5) Hawaii; (6) Nevada; and (7) Utah. *See Concentrating Solar Power Projects - Concentrating Solar Power Projects in the United States*, NREL, https://www.nrel.gov/csp/solarpaces/by_country_detail.cfm/country=US (last visited July 28, 2017).

46. For instance, in Colorado, the Colorado Integrated Solar Project (Cameo), was a hybrid CSP/coal plant, which used parabolic trough technology, was constructed in 2010 for testing purposes and was decommissioned when the coal plant was retired. *See* NREL, *Concentrating Solar Projects - Colorado Integrated Solar Project* (Nov. 21, 2013), https://www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=75 [http://perma.cc/PMD6-N3RS]. In Arizona, another plant that was built in 2010, the Maricopa Solar Project, which used dish-engine CSP technology, was decommissioned only a year later, in 2011. *See Concentrating Solar Projects - Maricopa Solar Project,* NREL (Nov. 21, 2013), https://www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=58 [http://perma.cc/T9HP-2YP5].

47. *SEIA Solar Market Report*, *supra* note 44, at 12.

48. As of fourth quarter 2014, the United States had 767 MW of CSP come on-line. *Id.*

49. "Capacity" measures actual production relative to possible production. "Capacity factor" is a ratio of actual power generation over a period of time,

Projects is vast, totaling over 1,000 MW.[50] To illustrate how CSP technology has evolved domestically in a relatively short period of time, a brief description of each of these projects follows.

1. The Ivanpah Project

The Ivanpah Project, located on 3,500 acres in California's Mojave Desert in the Ivanpah Dry Lake near Primm, Nevada, is situated approximately five miles from the California/Nevada border and collectively consists of three separate power tower units, Ivanpah 1 (with a capacity of 126 MW), Ivanpah 2 (with a capacity of 133 MW), and Ivanpah 3 (with a capacity of 133 MW), for a combined gross generation capacity of 392 MW, **e**nough to power approximately 140,000 homes and to reduce carbon dioxide emissions by over 400,000 tons annually.[51] The 173,500 heliostats, all in the shape and size of large garage doors, each possess two mirrors and focus sunlight onto the applicable power tower, each of which stands 459 feet tall, or approximately 40 stories in height.[52] When sunlight strikes the pipes of the 2,100 ton boiler atop each tower, water, the project's HTF, is heated and creates superheated steam.[53] The pipes carry the steam to a turbine at ground level, which then generates electricity.[54] The vast

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generally measured in megawatt hours ("MWhs"), divided by the potential for power generation if the plant produced energy at its full, possible nameplate capacity during such period of time (e.g., actual production , divided by maximum possible production). Kimberly E. Diamond, *Technology, Curtailment, and Transmission: Innovations and Challenges Facing Today's U.S. Wind Energy*, Field Report, 41 COLUM. J. ENVTL. L. 1, 4, 5-6 (2016).

50. *SEIA Solar Market Report*, *supra* note 44, at 12; *Birds Bursting*, *supra* note 26. *See also infra* Parts II.C.1.-4.

51. NREL, *Ivanpah*, *supra* note 28, at 1; *Birds Bursting*, *supra* note 27; *Ivanpah - Project Overview*, BRIGHTSOURCE, http://www.brightsourceenergy.com/ivanpah-solar-project#.WLoqFKMo670 [http://perma.cc/AKF2-ZJWD].

52. NREL, *Ivanpah*, *supra* note 28, at 1; *Birds Bursting*, *supra* note 27, at 2; BrightSource, *Ivanpah - Project Facts - Technology*, http://www.brightsourceenergy.com/stuff/contentmgr/files/0/8a69e55a233e0b7edfe14b9f77f5eb8d/folder/ivanpah_fact_sheet_3_26_14.pdf [hereinafter, *Ivanpah Project Facts*].

53. *See Ivanpah Project Facts*, *supra* note 51, at 2; Thomas W. Overton, *Ivanpah Solar Electric Generating System Earns POWER's Highest Honor*, POWER (Aug. 1, 2014), http://www.powermag.com/ivanpah-solar-electric-generating-system-earns-powers-highest-honor/?pagenum=1 [http://perma.cc/B5Y2-35E2].

54. *Id.*

size and generation capacity of this project caused it to be ranked as the largest CSP project globally as of August 2014 and to receive POWER Magazine's 2014 Plant of the Year Award.[55] This project, owned by NRG Energy, took over three years to build, came on-line in January 2014,[56] and cost approximately $2,200,000,000 to construct.[57] In addition to receiving funding from Google and BrightSource Energy, the Ivanpah Project received $1,600,000,000 in financing through a DOE federal loan guarantee.[58]

2. The Genesis Project

Also residing in a desert location, the Genesis Project is situated in California's Sonoran Desert, between Center and Blythe.[59] While similar to the Ivanpah Project insofar as it, too, consists of several units, the Genesis Project differs from the Ivanpah Project due to its employing parabolic trough technology - rather than power tower

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55. *Id.; Birds Bursting*, *supra* note 27, at 1.

56. NREL, *Ivanpah*, *supra* note 28, at 1.

57. *Id.*; *Birds Bursting*, *supra* note 26. The developer of the Ivanpah Project is BrightSource Energy, a co-owner of the project. The power generation offtakers for the energy generated from this project are Pacific Gas & Electric and Southern California Edison. NREL, *Ivanpah*, *supra* note 28. *See also* Eric Wesoff, *BrightSource Raises More Funding for Big CSP,* GREENTECHMEDIA (Sept. 27, 2010), https://www.greentechmedia.com/articles/read/brightsource-raises-another-30m-for-csp [http://perma.cc/Y9FK-D9LD]; Pete Danko, *More Problems for CSP: Ivanpah Solar Plant Falling Short of Expected Electricity Production,* GREENTECHMEDIA (Oct. 30, 2014), https://www.greentechmedia.com/articles/read/ivanpah-solar-plant-falling-short-of-expected-electricity-production [http://perma.cc/XCF2-FUKZ].

58. *See* William La Jeunesse, *World's Largest Solar Plant Applying for Federal Grant to Pay Off Federal Loan* (Nov. 8, 2014), http://www.foxnews.com/politics/2014/11/08/world-largest-solar-plant-applying-for-federal-grant-to-pay-off-its-federal.html [http://perma.cc/32UU-9FNK] [hereinafter, *Ivanpah Needs Federal Grant to Pay Off Federal Loan*]; *Ivanpah: One of the World's Largest Solar Thermal Projects is Online*, NRG, http://www.nrg.com/renewables/projects/generation/ivanpah/ [http://perma.cc/UC3P-HBF6]; Energy.Gov Loan Program Office, *Ivanpah*, ENERGY.GOV, https://energy.gov/lpo/ivanpah (last visited Apr. 15, 2017).

59. *Concentrating Solar Power Projects - Genesis Solar Energy Project*, NAT'L RENEWABLE ENERGY LABORATORY, https://www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=54 (last visited Apr. 15, 2017) [hereinafter NREL, *Genesis*].

technology - in its two 125 MW units.[60] Using a total of over 500,000 parabolic mirrors, the Genesis Project has a nameplate capacity of 250 MW and spans approximately 1,800 acres.[61] Developed by NextEra Energy Resources, LLC and Genesis Solar, LLC, the Genesis Project took just over three years to construct, becoming operational in March 2014.[62] In terms of funding, the Genesis Project received a DOE $852,000,000 partial loan guarantee.[63]

3. The Mojave Solar Project

Another large California parabolic trough project, the Mojave Solar Project, developed by Abengoa Solar, Inc. and Mojave Solar, LLC, occupies 1,765 acres and is located approximately 100 miles northeast of Los Angeles, in Harper Dry Lake, California, in an unincorporated area between Barstow and Kramer Junction.[64] Like the Genesis Project, this project consists of two facilities, having a combined generation capacity of 280 MW from each of its two 140 MW units.[65] Similar to both the Ivanpah Project and the Genesis Project, the Mojave Solar Project took just under three and a half years to construct, becoming operational in December 2014.[66] It also received a DOE federal loan guarantee in the amount of $1,200,000,000.[67]

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60. *Id*.

61. *Id.*

62. *Id.* The sole owner of the Genesis Project is Genesis Solar, LLC. The sole power generation offtaker for this project is Pacific Gas & Electric. *Id.*

63. Energy.Gov Loan Programs Office, *Genesis*, ENERGY.GOV, https://energy.gov/lpo/genesis (last visited Apr. 15, 2017).

64. *Concentrating Solar Power Projects - Mojave Solar Project,* NAT'L RENEWABLE ENERGY LABORATORY, https://www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=57 [http://perma.cc/8DF6-W5Y] [hereinafter NREL, *Mojave*]. Mojave Solar, LLC is the sole project owner. Similar to the Ivanpah Project and the Genesis Project, Pacific Gas & Electric is the project's power generation offtaker. *Id. See also* Thomas W. Overton, *Top Plant: Crescent Dunes Solar Energy Project, Tonopah, Nevada*, POWER, at 26 [hereinafter, Overton, *Top Plant Crescent Dunes*].

65. NREL, *Mojave*, *supra* note 64.

66. *Id.* While much smaller than the Ivanpah Project, the Crescent Dunes Project generates enough energy to power 75,000 homes. *Crescent Dunes - Project Facts*, SOLARRESERVE, http://www.solarreserve.com/en/global-projects/csp/crescent-dunes (last visited Apr. 15, 2017).

67. Loan Programs Office, *Mojave*, ENERGY.GOV, https://energy.gov/lpo/mojave.

4. The Crescent Dunes Project

Located in northern Nevada, northwest of Tonopah, the 110 MW Crescent Dunes Project is a single 640-foot power tower project that possesses over 10,000 billboard-sized heliostats and spans 1,600 acres.[68] Developed by SolarReserve, LLC and costing over $1,000,000,000 to construct - with $737,000,000 coming from a DOE federal loan guarantee - the project took over four years to build and became operational in November 2015.[69] Unlike the Ivanpah Project, the Crescent Dunes Project uses molten salt as its HTF.[70]

The Crescent Dunes facility is an icon of scientific advancement for several reasons.[71] First, it improves upon existing technological know-how for power towers. Previously, state-of-the-art the technology only allowed for only five to seven hours of thermal energy to be stored.[72] By comparison, the Crescent Dunes facility, through its use of molten salt technology used in space exploration, is equipped with the ability to store 10 hours of thermal energy, or approximately 1.1 GWh.[73] Second, the Crescent Dunes facility is highly efficient, exceeding its contracted power production levels under its power purchase agreement (PPA) with NV Energy and achieving higher efficiency levels than originally predicted.[74] Third, and perhaps most importantly, the Crescent Dunes facility has broken new ground,

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68. *Concentrating Solar Power Projects - Crescent Dunes Solar Energy Project*, NATIONAL RENEWABLE ENERGY LABORATORY, https://www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=60 [http://perma.cc/5254-GMT4] [hereinafter, NREL, *Crescent Dunes*]; Overton, *Top Plant Crescent Dunes*, *supra* note 64, at 26.

69. NREL, *Crescent Dunes*, *supra* note 68. The sole project owner of the Crescent Dunes Project is SolarReserve's Tonopah Solar Energy, LLC. The power generation offtaker for this project is NV Energy. *Id. See also* Overton, *Top Plant Crescent Dunes*, *supra* note 64, at 28; Loan Programs Office, *Crescent Dunes*, ENERGY.GOV, https://energy.gov/lpo/crescent-dunes.

70. NREL, *Crescent Dunes*, *supra* note 68.

71. In fact, Power magazine recognizes the Crescent Dunes plant as one of its 2016 Renewable Top Plant Award Winners. *See* Overton, *Top Plant Crescent Dunes*, *supra* note 64 at cover page, 26.

72. *Id.* at 26. Currently, the largest battery storage projects in development are only able to store approximately 400 MWh. *Id*.

73. *Id*. at 26, 28. Crescent Dunes is the first CSP project in the United States to use molten salt technology. *Id*.

74. *Id*. at 28.

possessing the capability to generate dispatchable energy around the clock, 24 hours a day.[75] This advance is a great achievement for the Crescent Dunes facility and for solar power more generally. Having an operating profile similar to that of an average gas-fired combined cycle power plant,[76] the Crescent Dunes facility is a utility-scale renewable energy facility that is on par and competitive with conventional power generation plants.

C. Commonalities of CSP Projects in the U.S.

1. Vast Quantities of Contiguous Space Necessary

With each of the Four CSP Projects occupying between approximately 1,600 and 3,500 acres,[77] or the equivalent of between approximately 70,000,000 and 152,000,000 square feet,[78] one obvious commonality among the Four CSP Projects is that each requires a tremendous amount of contiguous space. To put this in perspective, 2.25 acres, or 100,000 square feet, is the estimated figure that engineers use for a city block.[79] The colossal amount of adjoining space needed for these projects illustrates why it is impractical, if not impossible, to site a large CSP project in an urban location and why a desert location with vast quantities of contiguous space is conducive for being a CSP project site.

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75. *Id*. at 26. Due to its PPA with NV Energy only mandating that it generate 500 GWh annually and provides 12 - 14 hours of power generation on a daily basis, the Crescent Dunes facility does not regularly run for an ongoing, 24-hour period. However, for proof of concept purposes, in July 2016, SolarReserve operated the Crescent Dunes facility for a continuous 120 hour period. *Id.* at 26, 28.

76. *Id*. at 28.

77. *See supra* Part II.B.1 - Part II. B.4.

78. *Unit Converter - 1,600 acres to square feet*, UNIT CONVERTER, http://unitconverter.io/acres/square-feet/1600 (last visited Apr. 15, 2017); *Unit Converter - 3,500 acres to square feet*, UNIT CONVERTER, http://unitconverter.io/acres/square-feet/3500 (last visited Apr. 15, 2017).

79. *How Many Feet are In a City Block?,* REFERENCE, https://www.reference.com/science/many-feet-city-block-3cd5b079ba790626 (last visited Apr. 15, 2017).

2. Isolated Location and Impacts of the "Out of Sight, Out of Mind" Phenomenon

As the Four CSP Projects described in Part II.B. and Part II.C. herein illustrate, the sheer size and quantity of specialized equipment used in CSP projects, as well as access to venues with sparse cloud cover, minimal to no shading, few to no obstacles - such as trees or tall buildings - blocking the sunlight throughout the year, and high levels of solar irradiance,[80] often necessitates that CSP projects be sited in remote locations with long exposures to sunlight. A desert location possesses all of these characteristics. Not surprisingly, one commonality among the Four CSP Projects is that they each are situated in remote desert locations in the Southwestern United States.

The isolation inherent to a CSP project's remote location means that there is a lack of visual and physical "connectedness" between the CSP project and the general public. While there are certain advantages to this, from a purely social, interactive perspective, the disadvantages outweigh these advantages. With respect to advantages, one key advantage of a utility-scale CSP project's faraway location relative to most neighboring communities is that the CSP project is unlikely to be a magnet for attracting as great a level of public dissent on aesthetic-based nuisance claims as are other renewable energy projects that are in plain view and close proximity to residents and other neighboring landowners.[81] This contrasts sharply with both offshore and onshore

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80. *Concentrating Solar Power*, *supra* note 22. Solar irradiance, also called "solar insolation," is the result of the hours of sunlight exposure, combined with the strength of sunlight throughout that entire period of exposure. Shade poses one of the biggest risks to a solar energy system, insofar as a small amount of shade can have a significant adverse impact on the entire solar array. For instance, in a solar photovoltaic system, if approximately 5% of a solar panel is located in the shade, it potentially will cause the entire solar array to lose more than 50% of its solar power production. *See* MICHAEL BOXWELL, SOLAR ELECTRICITY HANDBOOK 2015 EDITION, 37, 45, 56 (2015).

81. In the United States, when groups allege aesthetic-based nuisance claims against a renewable energy project, these claims generally fall under the umbrella of a "public nuisance." According to the Restatement (Second) of Torts, a public nuisance is "an unreasonable interference with a right common to the general public." JAMES A. HENDERSON, JR., RICHARD N. PEARSON, AND JOHN A. SILICIANO, THE TORTS PROCESS, 500 (1994), *citing* Restatement (Second) of Torts § 821B(1). An analysis that may lead to a finding that a public nuisance exists includes the examination of the applicable circumstances, including "(a) whether the conduct

utility-scale wind projects which are prone to NIMBY[82] public challenges, objections, and protests for marring or spoiling the natural landscape.[83]

Aesthetics have long been the basis for some of the most publicized efforts to block the construction of renewable energy projects globally. In the United Kingdom, for example, prior to being elected President of the United States, Donald Trump initiated well-publicized litigation in effort to block the 11-turbine European Offshore Wind Deployment Centre (EOWDC), an innovative testing facility developed by Aberdeen Offshore Wind Farm Ltd (AOWFL) with a maximum generation capacity of 100 MW, from being built in Aberdeen Bay approximately two miles offshore from his golf course and resort development in Aberdeenshire, Scotland, due to his belief that such wind farm would ruin the pristine views from this golf course.[84]

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involves a significant interference with the public health, the public safety, the public peace, the public comfort or the public convenience, (b) whether the conduct is proscribed by a statute, ordinance or administrative regulation, or (c) whether the conduct is of a continuing nature or has produced a permanent or long-lasting effect, and, as the actor knows or has reason to know, has a significant effect upon the public right." *Id*., *citing* Restatement (Second) of Torts § 821B(2)(a) - (c).

82. "NIMBY" is an acronym for the "Not in My Backyard Phenomenon," associated with a community's opposition to constructing something undesirable in their neighborhood, due to the nature of the project potentially adversely impacting their quality of life or property value. *See* Peter D. Kinder, *Not in My Backyard Phenomenon (NIMBY)*, ENCYCLOPEDIA BRITANICA (June 14, 2016), https://www.britannica.com/topic/Not-in-My-Backyard-Phenomenon (last visited July 28, 2017).

83. For instance, in the United States, the issue of aesthetics was a leading complaint that objectors voiced to the proposed Cape Wind U.S. offshore wind farm, as discussed further *infra*, Part II.C.2. In the international arena, prominent political figures have also publicly denounced utility-scale wind farms based on aesthetics. As illustration, Australia's Prime Minister, Tony Abbott, publicly denounced utility-scale wind farms as being "appalling," "utterly offensive," and "visually awful." *See* Lance Hosey, *The Aesthetics of Environmental* Equity, THE HUFFINGTON POST (June 29, 2015, 5:36 PM), http://www.huffingtonpost.com/lance-hosey/the-aesthetics-of-environ_b_7674974.html [http://perma.cc/C6LY-JU97].

84. *See* Trump Int'l Golf Club Ltd. and another v. Scottish Ministries, (2015) UKSC 74 (appeal taken from Scot.); Danny Hakim & Eric Lipton, *With a Meeting, Trump Renewed a British Wind Farm Fight*, THE NEW YORK TIMES (Nov. 21, 2016), https://www.nytimes.com/2016/11/21/business/with-a-meeting-trump-renewed-a-british-wind-farm-fight.html?_r= [http://perma.cc/23NS-EWV6]; Tina Casey, *Trump Tilts at Offshore Wind Energy, Scotland Gets Last Laugh (Maybe)*,

Allegedly, this impaired view would "materially diminish the amenity of the golf resort."[85] While the plaintiffs' motion for judicial review to overturn the Scottish Ministers' decision to grant consent for the project's construction was denied,[86] the litigation itself illustrates the triggering effect a renewable energy project located in plain view may have on the filing of aesthetics-based lawsuits.

Efforts to use the aesthetic-based nuisance concept as a basis for halting construction of offshore wind farms has also been used in the United States in the case of the Cape Wind offshore wind farm (hereinafter, "Cape Wind"). Slated to be the first offshore wind farm in the United States, Cape Wind was originally poised to be one of the largest offshore wind farms in the world.[87] Due to Cape Wind's proposed location off the coast of Martha's Vineyard, Massachusetts and Cape Cod, Massachusetts in Nantucket Sound's Horseshoe Shoal, many wealthy residents alleged that this project's tall wind turbines

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CLEANTECHNICA (Jan. 18, 2017), https://cleantechnica.com/2017/01/18/trump-tilts-offshore-wind-energy-scotland-gets-last-laugh-maybe/ [http://perma.cc/CFB5-BQCX]. The Crown Estate awarded AOWFL, a joint venture between Aberdeen Renewable Energy Group and Vattenfall, the right to develop this project, which will allow offshore wind farm developers and related supply chain companies to test their new designs and receive independent accreditation prior to commercial product deployment in the marketplace. The wind farm itself will have an installed capacity of 100 MW, with the capability to generate power to the equivalent of over 68,000 homes. *See European Offshore Wind Deployment and Centre (EOWDC)*, ABERDEEN RENEWABLES, http://www.aberdeenrenewables.com/about-areg/activities/european-offshore-wind-deployment-centre-eowdc/ (last visited Apr. 15, 2017).

85. Trump Int'l Golf Club Ltd., *supra* note 84.

86. Trump Int'l Golf Club Ltd., *supra* note 84; Judiciary of Scotland, *Petition for Judicial Review by Trump International Golf Club Scotland Limited and The Trump Organization* LLC, Summaries of Court Opinions, http://www.scotland-judiciary.org.uk/9/1224/Petition-for-Judicial-Review-by-Trump-International-Golf-Club-Scotland-Limited-and-The-Trump-Organization-LLC (last visited May 12, 2017).

87. Pub. Emps. for Envtl. Resp. v. Beaudreu, 25 F. Supp. 3d 67, 84-85 (D.D.C. Mar. 14, 2014). The Cape Wind farm was slated to contain an array of 130 offshore wind turbines, with a nameplate generation capacity of 454 MW. Wind-generated electricity from this offshore wind farm was to be delivered to the Cape Cod, Massachusetts mainland via a submarine transmission cable. *Id.*, *citing* 71 Fed. Reg. 30,693 (May 30, 2006).

would mar and permanently ruin their view,[88] one of the most publicized planks in opponents' platform to prevent Cape Wind from being built was based on nuisance-related aesthetic grounds. While these aesthetic nuisance allegations did not necessarily appear with frequency among the litany of other legal claims against this project filed in court,[89] the battle against Cape Wind on aesthetics-based grounds was tried, in part, by court of public opinion. The ferocity of nuisance-related aesthetic complaints from the local, wealthy homeowners as well as the local businesses were essential for generating the negative sentiment about Cape Wind.[90] The pervasiveness of this negative sentiment throughout the local community has been a contributory factor in stalling efforts to greenlight the Cape Wind project; to this day, Cape Wind has not yet been built.

Given the above-referenced offshore wind farm examples, having a CSP project situated in an out-of-the-way, remote location translates

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88. Each of the proposed offshore wind turbines were scheduled to reach heights of approximately 440 feet. Locals maintained that while the project was to be built more than three miles away from the mainland, the tall towers would still be a visible, unpleasant gash on their panoramic view of Nantucket Sound. *See* Melone v. Dep't of Pub. Utils., 462 Mass. 1007, 1008 (May 9, 2012).

89. For instance, many claims were alleged against the Cape Wind farm on other grounds, including various administrative law and environmental law violations. See *supra* note 81, for a discussion on aesthetic-based nuisance claims and what constitutes a public nuisance, including how a finding of a violation of an administrative ordinance can lead to a finding that a public nuisance exists. *See generally* Beaudreu, *supra* note 87; Alliance to Protect Nantucket Sound, Inc. v. Dep't of Pub. Utils., 959 N.E.2d 408 (Mass., Dec. 28, 2011). Because an evaluation of the gravity of harm to the plaintiff(s) from an aesthetic perspective is determined on subjective grounds, it is generally difficult to establish the existence of a public nuisance on aesthetic grounds alone. Nevertheless, the standards employed to make this "gravity of harm determination" include the following: (a) the extent of the harm involved; (b) the character of the harm involved; (c) the social value which the law attaches to the type of use or enjoyment invaded; (d) the suitability of the particular use or enjoyment invaded to the character of the locality; and (e) the burden on the person harmed of avoiding the harm. HENDERSON, et al., *supra* note 81, at 503, *citing* Restatement (Second) of Torts: Gravity of Harm – Factors Involved § 827.

90. *See Are Aesthetics a Good Reason Not to be a Fan of Wind Power?*, SCIENTIFIC AMERICAN, https://www.scientificamerican.com/article/earth-talks-aesthetics-good-reason/ [http://perma.cc/W32H-RHDV]; *Perfect Location for America's First Offshore Wind Farm,* CAPE WIND (2014), https://www.capewind.org/where (last visited July 28, 2017).

broadly into the potential minimization, if not elimination, of aesthetics-based nuisance lawsuits, as eliminating such project's visibility may deter people from filing such claims against these projects. From a practical perspective, the absence of such aesthetics-based claims, whether filed in an actual court or proffered in the court of public opinion, reduces administrative and litigation-related time delays and expenses, thereby facilitating a smoother plant permitting and construction process.

However, one of the greatest disadvantages of a utility-scale CSP project's having an obscure location, as is the case for each of the Four CSP Projects, is that the general public lacks a constant visual reminder of the plant's existence. The result epitomizes the proverb "out of sight, out of mind;"[91] if the general public does not see the project, then they are likely either to have knowledge about the project and forget about it, or to have no knowledge about the project's existence whatsoever, resulting in their having no awareness or idea about what the project looks like or how it operates. For the reasons discussed herein in Part II.C.2.a. - Part II.C.2.c., when balanced against the aesthetic nuisance avoidance aspect of a CSP project's remote location, the negative cumulative impacts of this "out of sight, out of mind" phenomenon collectively weigh heavier.

a. Lack of Connectedness Through Visual Object Recognition

With no constant visual reminder of a CSP project, the "out of sight, out of mind" phenomena can be detrimental to driving public support for a CSP project specifically and renewable energy generally. Logically, if something is "out of sight, out of mind," it runs the risk of being forgotten. Consequently, there is a risk that people will experience a lack of connectedness to the object that is "out of sight, out of mind." This "connectedness deficiency" is problematic for several reasons.

For instance, people who are the local energy-consuming beneficiaries of the power generated from a large CSP project that is located outside of plain view (hereinafter, "CSP Power Consumers") are prone to sensory deprivation risk with respect to the CSP project.

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91. *Out of sight, out of mind*, THE FREE DICTIONARY, http://idioms.thefreedictionary.com/out+of+sight,+out+of+mind (last visited May 12, 2017).

Specifically, because CSP Power Consumers cannot see the project, they may be unable to identify a CSP project if shown a picture of one or, at a more rudimentary level, may lack basic knowledge about what a CSP project is. According to neuroscience research, humans are among the few species that can engage in visual object recognition, a process that is both knowledge-driven and sensory driven.[92] The absence of a regular, visual presence of a CSP project effectively prohibits people from using their sense of sight to establish familiarity, context, and recognition memory with respect to that project.[93] In order to classify a CSP project as a solar project and also as a renewable energy power generation project, people who do not know what a CSP project is must have the opportunity to engage in knowledge transfer[94] and learn about that project through visual object recognition[95] by integrating their prior knowledge about renewable energy and solar projects with their new, incremental knowledge about such CSP project. Knowledge transfer about CSP projects, consequently, would occur if people possessed awareness about what a CSP project looks like and possessed a very general understanding about how a CSP project operates. From a scientific perspective, a CSP project's desolate location, therefore, is a barrier to CSP Power Consumers' connectedness and visual interaction with the CSP project itself; the location shields the public eye from viewing the CSP project, preventing the CSP Power Consumers from engaging in knowledge transfer through visual object recognition. There are adverse implications of this lack of public connectedness to a CSP project. On

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92. The knowledge driven element is known as "front end" processing, and the sensory driven element is known as "back end" processing. *See Cognitive Neuroscience of Visual Object Recognition*, https://en.wikipedia.org/wiki/Cognitive_neuroscience_of_visual_object_recognition (last visited May 12, 2017).

93. *Id.*

94. "Knowledge transfer" means a person's ability to take their prior knowledge and build off that existing knowledge. Knowledge transfer can occur through a person's use of contextual information, shared features, or previously received information to make connections between a familiar object and a new, unfamiliar object. *See* Li Fei-Fei, *Knowledge Transfer in Learning to Recognize Visual Object Classes,* ELECTRICAL AND COMPUTER ENGINEERING DEPT. & BECKMAN INST., U. OF ILL. URBANA-CHAMPAIGN, http://vision.stanford.edu/documents/Fei-Fei_ICDL2006.pdf (last visited May 12, 2017).

95. Visual object recognition is an area of social science research that has garnered keen interest and prompted research in recent years. *Id.*

a broad scale, this absence of connectedness obstructs the ability of CSP Power Consumers to be informed and aware about the actual state of renewable energy technology. On a more narrow scale, this absence of connectedness impedes CSP Power Consumers' ability to appreciate that a significant component of their energy mix is being sourced through renewable energy. This, in turn, hinders CSP Power Consumers' potential for valuing CSP as a viable, emerging technology whose substantial scale enables it to be competitive with conventional energy sources.

b. Unawareness of Environmental Benefits Offered

CSP Power Consumers also may not be aware of the environmental benefits in the form of avoided emissions that a CSP project offers. According to the Solar Energy Industry Association, one gigawatt hour (GWh) of solar energy generation results in avoided emissions of 690 metric tons of carbon dioxide (CO_2),[96] a substantial amount of atmospheric carbon emission reductions. This is because the integration into the electric grid of power produced from solar plants generally displaces electricity production from other electricity-generating sources that emit carbon dioxide into the atmosphere.[97] High penetrations of solar energy into the electric grid, consequently, have the potential to significantly reduce carbon dioxide emissions.[98]

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96. *Cutting Carbon Emissions Under 111(d): The Case for Expanding Solar Energy in America - Why States Should Take Advantage of Solar Under Section 111(d)* SOLAR ENERGY INDUSTRIES ASSOC. (May 27, 2014), http://www.seia.org/research-resources/cutting-carbon-emissions-under-111d-case-expanding-solar-energy-america (last visited July 28, 2017) [hereinafter, *Carbon Emissions Reductions*].

97. *Id.* Simple-cycle natural gas generators are examples of one category of plants that pollute the atmosphere with carbon dioxide, and whose power solar plants may displace when energy from a solar plant is integrated into the electric grid. *Id*.

98. In fact, NREL's Western Wind and Solar Integration Study found that through a combination of energy generated through wind and solar deployment, carbon dioxide emissions could be reduced by one-third, or approximately 260 - 300 billion pounds per year once the Western Interconnect (an area of the continental United States' power grid, consisting of several interconnection subregions in Canada and all subregions including and west of New Mexico, Colorado, and Montana) achieves thirty three percent of its electricity from wind and solar energy devices. *See id. See also Figure 1. Geographic Footprint of Westconnect Utilities[36]*, *published in* Jie Zhang et al., *Investigating the Correlation Between*

A CSP project also offers environmental benefits with respect to water consumption. Compared to fossil fuel plants, a CSP project does not require water for cooling because it is not a thermal cycle plant.[99] Also, even though power tower and parabolic trough CSP projects may use water in their respective operations, these plants consume significantly less water than natural gas fired plants, coal-fired plants, and nuclear power plants.[100]

c. Blissful Ignorance of Magnitude of Contribution to the Energy Mix

CSP Power Consumers also may be oblivious to the magnitude of the contribution to the total energy supply mix that a utility-scale CSP project provides. With the lack of connectedness that accompanies the "out of sight, out of mind" phenomenon, it is likely that many of these people do not realize how significantly a CSP project contributes to the blend of electricity carried on the power grid for their region. This lack of knowledge effectively acts as a barrier to public discussion about this contribution, which in turn prevents discussion about the benefits of integrating solar power from CSP projects into the electric grid from percolating up to the realm of public consciousness and general discourse. While many people in the general population are end-user focused and may not care where their power comes from as long as they can turn on their lights, the absence of a constant visual reminder about a CSP project's existence and contribution to the energy mix, consequently, hampers that project's ability to generate positive public discourse, making it more difficult for the project to attain large-scale public buy-in and garner public support. As discussed in Part II.C.3. herein, public buy-in is a key element for generating positive publicity about a renewable energy project, as well

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Wind and Solar Power Forecast Errors in the Western Interconnection, RESEARCHGATE (July 2013), https://www.researchgate.net/figure/267493133_fig1_FIGURE-1-GEOGRAPHIC-FOOTPRINT-OF-WESTCONNECT-UTILITIES-36 (last visited May 12, 2017).

99. *Carbon Emissions Reductions*, *supra* note 97.

100. *Id.* Specifically, while a parabolic trough or power tower CSP project uses dry-cooling technology, it can consume less than approximately 50 gallons of water/MWh. In comparison, a natural gas fired plant consumes approximately 200 gallons of water/MWh, a coal-fired plant consumes approximately 500 gallons of water/MWh, and a nuclear power plant consumes approximately 800 gallons/MWh. *Id*.

as an essential element for the project's ultimate success in the views of the local community it serves.

3. Public Buy-In Plays an Essential Role

For renewable energy projects and projects impacting renewable energy resources, the ability of a project to attract and retain public buy-in and support through robust public discourse should not be understated, as public buy-in is essential to the project's gaining community acceptance and popularity. Examples of how constituent engagement through public discourse regarding the benefits both individuals and their community receive from a particular project involving renewable energy sources can be seen in a variety of forums around the world. For instance, in the United States, with respect to wind farms, certain landowners in the Midwest have formed landowner wind energy associations, or LWEAs, that generally act as collective bargaining groups.[101] These LWEAs engage in discussions with wind farm developers and serve as a means of enabling all participants to have an understanding of the benefits they will receive from a proposed wind project in their particular community.[102] As a result, by gaining a deeper understanding and greater knowledge about a wind farm project that will generate energy for them and their local community, landowners who are members of LWEAs are well-informed about the benefits a wind project will bring to them and to their community. Not surprisingly, LWEA members generally support wind farm development in their respective areas.[103]

In Canada as well, public buy-in through community involvement and through knowledge about the economic benefits a wind project bestows upon local community, residents have paved the way for generating support for local wind farm development. In fact, a recent study has been conducted that compares policies between Nova Scotia on one hand, where concerted efforts have been made to support community-owned development and community involvement in wind

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101. K. Diamond & Ellen J. Crivella, *Wind Turbine Wakes, Wake Effect Impacts, and Wind Leases: Using Solar Access Laws as the Model for Capitalizing on Wind Rights During the Evolution of Wind Policy Standards*, 22 DUKE ENVTL. L. & POL'Y F. 195, 237 (2011).

102. *Id.* at 237.

103. *Id.*

farm planning as well as to keep the economic benefits from the project in the province, and Ontario on the other hand, where the 2009 Green Energy Act has limited community involvement during wind farm planning stages and has resulted in public criticism of corporate wind farm development.[104] The results of this study show that support for local wind farms is three times higher, and negative perceptions about adverse health effects is three times lower, in Nova Scotia than it is in Ontario.[105] This study also uses empirical data to discuss why residents' perceptions regarding fair distribution and the amount of local economic benefits received factor heavily into the amount of support a wind project receives, despite these perceptions being nuanced.[106]

Even in the context of access to sunlight, for over 50 years, Japan's approach to conflicts concerning light obstruction has involved a participatory, community-oriented approach.[107] Specifically, under Japan's Building Standard Law of 1950, as amended by the "Sunshine Amendment" of 1976, homeowners and developers are encouraged to engage in discourse to discuss and resolve their differences, so that concerns regarding sunlight obstruction are addressed through a non-judicial process, and bilateral negotiations between a building developer and a single resident can be expanded into multilateral negotiations among such developer, the resident, and the resident's impacted neighbors to achieve the most favorable outcome among directly impacted stakeholders.[108] As this and the other foregoing examples illustrate, public buy-in and discourse in which economic

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104. *See* Colin Perkel, *Local Involvement Key to Wind-Farm Buy-In: Study* (Mar. 5, 2017), http://www.durhamregion.com/news-story/7172735-local-involvement-key-to-wind-farm-buy-in-study/ [http://perma.cc/7QYL-RXY2], *citing* Chad Walker & Jamie Baker, *'It's Easy to Throw Rocks at a Corporation': Wind Energy Development and Distributive Justice in Canada*, J. OF ENVTL. POL'Y & PLANNING (on-line edition) (Jan. 1, 2017), http://www.tandfonline.com/doi/full/10.1080/1523908X.2016.1267614?scroll=top&needAccess=true [http:/perma.cc/3VSU-WCH5] [hereinafter, *Walker and Baker Buy-In Study*]. *See also* The Canadian Press, *Local Planning, Sharing Benefits Key to Wind-Farm Buy-In, Study Finds,* CBC NEWS (Mar. 5, 2017, 11:27 AM), http://www.cbc.ca/news/nova-scotia-ontario-wind-farms-1.4010653 [http://perma.cc/5VKV-X4X4].

105. *Id.*

106. *Walker and Baker Buy-In Study*, *supra* note 104, at 1.

107. Diamond & Crivella, *supra* note 101, at 221.

108. *Id.*

and other benefits to local constituents are discussed and which make these impacted locals feel a sense of "connectedness" to a project are key to generating local support for projects involving renewable energy resources.

4. Federal Funding Received

Each of the Four CSP Projects relied substantially on federal funding as a core source of financing for project construction. Due to the substantial size of the DOE loan guarantee each of the Four CSP Projects received,[109] it is reasonable to conclude that but for this federal government backing, construction of these projects would not have been able to come to fruition.

Interestingly, in addition to the Four CSP Projects being physically out of general public's sight, the manner of funding for each project is conspicuously absent from certain project summaries and statistics that appear on particular federal websites for these projects, such as NREL's project description page for each.[110] This is perplexing insofar as NREL, the United States' primary laboratory for renewable energy research and development, is a federal government-owned facility that is funded annually through the DOE as a member of DOE's national laboratory system.[111] The sources from which a utility-scale renewable

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109. *See supra* Part II.B.1 - Part II. B.4.

110. For instance, on its page describing the Mojave Solar Project, NREL lists a multitude of statistics under the following categories for this project: Background, Participants, Plant Configuration, and Project Overview. Nowhere in these statistics, though, is there mention of the sources contributing to this project's initial funding. *See* NREL, *Mojave*, *supra* note 64. The same is true regarding the information NREL provides for the Ivanpah Project, the Genesis Project, and the Crescent Dunes Project, respectively. *See* NREL, *Ivanpah*, *supra* note 28; NREL, *Genesis*, *supra* note 59; and NREL, *Crescent Dunes*, *supra* note 68.

111. *NREL at 40: Driving Advanced Energy Research - Laboratory History*, https://www.nrel.gov/about/40th-anniversary.html (last visited May 12, 2017). NREL was founded by President Jimmy Carter in 1977 as the Solar Energy Research Institute (SERI). In 1991, President George H.W. Bush changed SERI's name to the National Renewable Energy Laboratory and granted SERI the status of member of DOE's national laboratory system. *Id. See also National Renewable Energy Laboratory*, https://en.wikipedia.org/wiki/National_Renewable_Energy_Laboratory (last visited May 12, 2017); *National Renewable Energy Laboratory - Recent Funding*, https://www.nrel.gov/about/funding-history.html (last visited May 12, 2017).

energy project receives project financing is part of the inherent characteristics of the project itself. From a policy perspective, it is important for the public to be aware that federal funding is essential for promoting innovation in the area of renewable energy projects. Posting this information on select, rather than all, federal government websites containing descriptions of the Four CSP Projects impedes the public from receiving a comprehensive overview of each of these projects.

Similar to those who need to drive out to the desert to actually see one of the Four CSP Projects, depending on the websites they initially visit, those who want to see exactly how each of the Four CSP Projects was financed need to invest time and effort to go beyond the statistical facade of "important facts" on these websites that are most readily accessible to the public. This raises the question of why federal funding sources for each of the Four CSP Projects are not more widely broadcast.

The tinge of secretiveness regarding the Four CSP Projects' respective funding sources may be due to the desire not to publicize more than absolutely necessary the immense amount of federal government funding each of the Four CSP Projects received. This is because if a renewable energy project employs technology that is either untested or relatively new in the marketplace, and if that project at its outset does not operate according to original expectations, the federal funding it received is subject to negative spin and negative publicity. For instance, the Ivanpah Project received federal financing under the DOE's loan guarantee program, in addition to financing from NRG and Google.[112] However, due to the enormity of the federal construction loan this project received,[113] when this project initially generated less energy than originally anticipated, certain members of the public and the press were keen on highlighting the magnitude of federal funds invested in this project that was experiencing "early operating woes,"[114] and condemning this project for paying less than market rate for the "controversial" government financing it received.[115]

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112. *Ivanpah and the DOE Loan Guarantee Program*, *supra* note 11.
113. *See supra* Part II.B.1.
114. *See* Danko, *supra* note 57.
115. *See Ivanpah Needs Federal Grant to Pay Off Federal Loan*, *supra* note 58.

As discussed in Part I.B. herein, obtaining funding for innovative renewable energy projects is critical for purposes of widescale deployment of the cutting-edge technology itself. Also, as noted in Part I.B., it is realistic for newly-rolled out, novel technologies to experience kinks that need to be identified and worked out over time. A CSP project falls under the umbrella of being a new technology in the renewable energy realm that, irrespective of its roll-out in large scale, still needs fine tuning. The press and the general public's expectation that CSP projects will function practically perfectly, and deriding CSP projects that fall short of doing so, is not only unrealistic and misguided, but it is dangerous and counterproductive. This is because promoting scientific advancement is a non-partisan issue that should be supported at any juncture. The power industry as a whole, including traditional and renewable energy resources, benefits from innovations in scientific technologies, insofar as these breakthroughs assist in help to improve electricity's reliability and make the electric generation process increasingly cleaner.[116] Governmental support, through endorsement, special programs, and funding, serves as an important bridge between the scientists developing a particular product whose operation advances a particular technology, and the marketplace in which that product is deployed.

D. Commonalities of U.S.-Based CSP Projects with CSP Projects Elsewhere in the World

To date, 23 countries globally are home to CSP projects.[117] From a lessons learned perspective, it is instructive to compare the overarching commonalities of U.S.-based CSP projects against those of non-U.S.-based CSP projects to better understand the characteristics that have enabled CSP technology to flourish outside the United States.

One common characteristic among the larger CSP projects globally is their respective desert locations. It is efficient to site a CSP project in a desert location because vast quantities of contiguous space is present there, as is abundant amounts of unobstructed sunlight. The

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116. Gail Reitenbach, *Energy R&D is Essential to Any Great Country*, POWER, at 8 (Feb. 2017).

117. *Concentrating Solar Power Projects - Concentrating Solar Power Projects by Country*, NREL, https://www.nrel.gov/csp/solarpaces/by_country.cfm (last visited July 28, 2017).

utility of siting a CSP project in a desert location is illustrated through Israel's Ashalim Solar Thermal Power Station, currently under construction.[118] Slated to become operational in 2018, this plant, when completed, will not only generate approximately 310 MW of electricity and power 130,000 homes, but it will also possess a tower 820 feet high, making it the tallest CSP tower in the world.[119] Situated in the Negev desert, the plant will feature over 50,000 heliostats that will occupy approximately 740 acres, or approximately over 32,000,000 square feet.[120] Given its immense size, this project is conveniently hidden in plain view in the desert, tucked away from the urban population's line of sight.

Another common aspect of CSP projects globally is that of government support and funding. The importance of government support and funding is apparent through Spain's example. Currently, Spain is the global leader in CSP technology and plant deployment, leading all other European nations in the area of solar energy development.[121] One of the key reasons for CSP's success in Spain initially is the support it received from the Spanish government in the form of Royal Decree 436, which in March 2004 established a feed-in tariff, or guaranteed price, for solar thermal power.[122] Because the costs involved in the upfront development of CSP projects are front-loaded, unlike traditional oil, gas, or coal plants, having access to

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118. Cat DiStasio, *Israel Building World's Tallest Solar Tower to Power 130,000 Households,* INHABITATS (Jan. 5, 2017), http://inhabitat.com/israel-building-worlds-tallest-solar-tower-to-power-130000-households/ [http://perma.cc/Z4G7-ZG4Z].

119. *Id.*

120. *Id. See also Unit Converter - 740 acres to square feet,* http://unitconverter.io/acres/square-feet/740 (last visited May 16, 2017).

121. *Solar Power in Spain*, WIKIPEDIA https://en.wikipedia.org/wiki/Solar_power_in_Spain (last visited May 16, 2017).

122. Instituto Español de Comercio Exterior (ICEX), *Solar Energy in Spain*, MIT TECHNOLOGY REVIEW, http://icex.technologyreview.com/articles/2009/01/solar-energy-in-spain/ (last visited May 16, 2017) [hereinafter, ICEX, *Solar Energy in Spai*n]. Royal Decree 436/2004, also known as the "Special Regime for the production of electricity from RES," amends Royal Decree 2818/1998, promoting renewable energy development by offering a financial incentive in the form of a tariff to renewable energy generators who either sell power from their plants to a distributor or sell their power on the free market. *See Special Regime for the production of electricity from RES (Royal Decree 436/2004)*, INTERNATIONAL ENERGY AGENCY (2004), https://www.iea.org/policiesandmeasures/pams/spain/name-22445-en.php [http://perma.cc/W4V4-WEBC].

funding through governmental initiatives was essential in bringing early Spanish CSP project development to fruition.[123] Government financial backing during the infant stage of the roll-out of a cutting-edge technology such as CSP appears to have been a crucial element for propelling Spain to its current top position in the global CSP market.

III. BACKGROUND ON SMART CITIES AND MAKING EXISTING CITIES MORE ENERGY EFFICIENT

A. What is a Smart City?

Smart cities are a new, evolving phenomenon wherein the urban landscape draws upon emerging technologies and innovations to drive a more futuristic, information-driven, connected society. What distinguishes a smart city from other cities is its ability to foster the creation and deployment of disruptive technologies through competitive innovation, where the introduction of high-tech, state-of-the-art, breakthrough products creates fertile ground for unprecedented technological advancement and transformative growth.[124] Smart cities also have an aspirational quality, insofar as they endeavor to address the need to integrate these advancements city-wide, catalyzing change at a rapid rate in terms of unique, previously inconceivable solutions while simultaneously addressing projected demographic shifts.[125] A smart city, then, is the end-product of a confluence of certain broad factors: (i) vision and strategy, (ii) technological and intellectual property innovations, and (iii) the ability to drive demand for particular products through consumer brand loyalty.

Because the notion of a smart city is still very novel at this time, agreement has not yet been reached as to the exact characteristics that must be present for a smart city to exist. The elements necessary for a

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123. ICEX, *Solar Energy in Spain*, *supra* note 122.

124. *See generally Vision & Strategy - Technology & IP - Brand & Demand*, FROST & SULLIVAN, https://ww2.frost.com/ (last visited May 12, 2017).

125. *See Report Summary: Smart Cities Market Analysis By Application (Smart Energy Management, Smart Security, Industrial Automation, Smart Healthcare, Smart Buildings, Smart Homes, Smart Transportation) and Segment Forecasts to 2020*, Report ID 978-1-68038-270-9, GRAND VIEW RESEARCH, (Nov. 2014), http://www.grandviewresearch.com/industry-analysis/smart-cities-market [http://perma.cc/PY3T-RM76][hereinafter, *Grand View Research*].

"smart city" to subsist, consequently, are nebulous. Some define a smart city as the high-tech ability of data to be collected in an urban setting from multiple sources, to enhance and coordinate the performance of diverse activities occurring in an urban setting.[126] Others define a smart city as a city with more well-managed infrastructure than other cities, wherein the gathering and analysis of certain data is used to adjust and refine such infrastructure to optimize resources.[127] There are some, such as Growth Consulting firm Frost & Sullivan, who endeavor to define a smart city by enumerating certain elements necessary for a smart city, including (i) smart governance, (ii) smart building, (iii) smart healthcare, (iv) smart mobility, (v) smart infrastructure, (vi) smart technology, (vii) smart energy, and (viii) smart citizens.[128] Notwithstanding the current debate over the exact ingredients essential for smart cities, this last element - the necessity of having "smart citizens" living in and around smart cities - is the unifying feature and the one that is the most crucial for a smart city's existence and evolution. This is because citizens who live in smart cities are likely to make "smart choices," which, in turn, will drive the growth and proliferation of these cities.[129] As discussed further in Part IV.C. herein, these smart choices reflect a shift to a behavior-based economy, dependent on consumers telling their stories and influencing others' behavior through apps and other digital media. As a result, the integration of certain high-tech products into a smart city's fiber will be significantly impacted by social behavior, through consumer brand loyalty and consumers' ability to increase organically demand for certain products and services.[130]

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126. James S. Hiller & Jordan M. Blanke, *Smart Cities, Big Data, and the Resilience of Privacy*, 68 HASTINGS L.J. 309, 316 (Feb. 2017).

127. Matt Hamblen, *Just What IS a Smart City?,* COMPUTERWORLD (Oct. 1, 2015), http://www.computerworld.com/article/2986403/internet-of-things/just-what-is-a-smart-city.html?page=2 [http://perma.cc/E6PF-2JCN].

128. Liz Enbysk, *New Reports Highlight Smart Security, Smart Citizens and Smart City Essentials*, SMART CITIES COUNCIL (Nov. 14, 2014), http://smartcitiescouncil.com/article/new-reports-highlight-smart-security-smart-citizens-and-smart-city-essentials [http://perma.cc/F7U4-C9G5]

129. *Id.*

130. Frost & Sullivan, *Brand and Demand Solutions - Go-To-Market with Confidence*, https://ww2.frost.com/brand-and-demand-solutions/ (last visited July 28, 2017).

B. Embracing Energy Efficiency Measures as the Low-Hanging Fruit for Energy Conservation and Usage

Implementation of energy efficiency measures in buildings is effectively the low-hanging fruit for energy conservation and usage. According to the International Energy Agency (IEA), electricity generation is the primary contributor to energy-related greenhouse gas emissions,[131] with lighting being responsible for approximately 20% of electricity consumption in buildings worldwide.[132] The IEA has also noted that buildings, as the largest energy-consuming sector globally, are responsible for over one-third of total final energy consumption.[133] Against this backdrop is the DOE's Building Technologies Office of the Office of Energy Efficiency & Renewable Energy's (hereinafter, the "Building Technologies Office's") finding that more than 70% of all electricity used in the United States is used for the purpose of powering commercial buildings and homes.[134] This consumption reflects approximately 40% of the United States' domestic energy bill.[135] It also contributes substantially to the United States' portfolio of greenhouse gas emissions, accounting for 40% of the United States' national carbon dioxide emissions, 55% of the United States' sulfur dioxide emissions, and 18% of the United States' nitrogen oxide (N_2O) emissions.[136] The Building Technologies Office has also determined that approximately 30% of the energy used for commercial buildings and homes is wasted annually, a statistic that could be drastically reduced and could save approximately $80,000,000,000 per year on

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131. According to the Kyoto Protocol, there are six main greenhouse gases: (i) carbon dioxide (CO_2), (ii) nitrous oxide (N_2O), (iii) methane (CH_4), (iv) hydrofluorocarbons (HFCs), (v) perfluorocarbons (PFCs), and sulphur hexaflouride (SF_6). *See* United Nations Framework Convention on Climate Change, *Kyoto Protocol*, http://unfccc.int/kyoto_protocol/items/3145.php (last visited May 12, 2017).

132. IEA, *Lighting*, https://www.iea.org/topics/energyefficiency/subtopics/lighting/ (last visited May 12, 2017); IEA, *Lights Labour's Lost*, OECD/IEA (2006), https://www.iea.org/publications/freepublications/publication/light2006.pdf.

133. IEA, *Buildings*, https://www.iea.org/topics/energyefficiency/subtopics/sustainablebuildings (last visited May 12, 2017).

134. *About the Building Technologies Office*, DOE'S BUILDING TECHNS. OFF. OF THE OFF. OF ENERGY EFFICIENCY & RENEWABLE ENERGY, https://energy.gov/eere/buildings/about-building-technologies-office (last visited May 12, 2017).

135. *Id.*

136. *Id.*

energy bills.[137] With respect to commercial buildings alone, the upfront investment costs associated with improving an existing building with energy efficient upgrades are offset in the long run through the resulting lower energy bills.[138] Implementing strategies to reduce and more effectively manage electricity consumption in commercial buildings while also making them more energy efficient is, therefore, an important step toward reducing overall energy utilization and reducing greenhouse gas emissions.

Smart cities embrace the concept of making urban settings more energy efficient, feasting on the low hanging fruit necessary to make cities less dependent on non-renewable energy resources.[139] This banquet has brought to the table many big "tech" companies such as IBM, Intel, and GE, as well as other lesser-known technology companies, insofar as they are endeavoring to position themselves to contribute to this energy efficiency objective through their development of certain new innovations - such as software and apps - geared toward making cities more energy efficient.[140] These innovations relate to improvements in areas such as building design, urban mobility, street lighting, and energy management.[141]

C. Community Buy-In, Government Backing, and Local Business Support Essential

To be successful, a smart city must foster a sense of community connectedness while receiving buy-in from local government entities, local businesses, and local residents. For this to occur, a smart cities initiative must possess a game plan, or rather, a foundational strategy upon which to lay its groundwork and build its momentum. The execution of this strategy, however, may prove challenging in practice. As discussed previously in Part III.A., smart cities initiatives generally have at their core an information technology network, comprised of technological and intellectual property innovations.[142] For such a

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137. *Id.*

138. *Id.*

139. *See Grand View Research*, *supra* note 125.

140. Hamblen, *supra* note 127.

141. *Grand View Research*, *supra* note 125.

142. *Getting Smart on Gigabit: How Applications Impact Communities,* SMART CITIES CONNECT WEBINAR (Feb. 21, 2017) [hereinafter, *Applications Impact Communities]*.

network to be successful, the local government leadership and the local business and technology community must effectively become partners who support the direction and vision of a particular a smart cities initiative.[143]

Building these synergies between government officials and local businesses is essential for a smart city initiative's successful launch, from both a legislative and economic perspective. This is because local government officials can promote the particular smart cities innovation by helping to initiate, drive positive community sentiment and support for, and pass implementing ordinances or other legislation to facilitate the innovation's implementation. Moreover, building momentum at the governmental level as a means of generating positive publicity and public buy-in allows for a longer time period for the innovation's developers and promoters to engage different community leaders and stakeholders.[144] Having influential advocates in the local government can therefore expedite the timeline for the innovation's adaptation and implementation. Moreover, buy-in from local government officials and local businesses may result in municipal funds and private funds being earmarked for the project construction associated with the innovation's integration into the local infrastructure.

Achieving this buy-in and support from local government officials and business owners is often a difficult feat to accomplish, as it entails getting these people comfortable with the notion of effectively getting on board an airplane that has taken flight while it is simultaneously being built. This is particularly the case with new, unique, and sometimes exotic innovations that are invented to address twenty-first century challenges cities face; given the rapid rate at which technology evolves, data upgrades and improvements may come into being even as a new projects that were originally designed with state-of-the-art concepts get underway for construction.[145] Not surprisingly, these

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143. *Id.*

144. *Id.*

145. *Id.* For instance, Dr. Michael Dunaway, Institute Director at the National Incident Management and Advanced Technologies (NIMSAT) at the University of Louisiana at Lafayette, noted that a recent 24-hour hackathon event conducted at the University of Louisiana, Lafayette, was conducted in conjunction with the local mayor's office and also engaged a number of sponsor companies to support the event. Through this collaboration, which was effectively a public/private partnership, the city leadership, local businesses, and the university administration, all came

local government officials and businesses owners must have confidence in both the technology itself, as well as the people who are developing and continuing to work on refining the emerging technology in question.[146] This often entails the inventors and promoters of the innovation itself investing time and effort to build relationships with elected officials, so that they can see the beneficial impacts these technologies will have on their constituents.[147] Consequently, the lead-in time for an innovation's adaptation in a smart city may be quite long, with the ever-present risk that these potential partners will not ultimately appreciate the merits of the technology and will not endorse its adoption.

D. The Role of Apps in a Smart City

1. Background on Social Media, Apps, and the Ability to Influence Behavior

Social media can be a very powerful tool for engaging others and influencing their behavior. People in smart cities want to feel connected to one another as well as to their urban environment. Also, due to society driving toward a more interactive, interconnected, personalized existence in which the brick and mortar world as we once knew it is morphing into a virtual one, people need to feel that evolving technologies are impacting their personal lives, and that they, too, are assisting in making an impactful difference in their community.[148] Most people in today's society - particularly those living in and around modern cities - own and carry with them smartphones or other mobile

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together as a community in support of both this event and the resulting developments that it generated. A key factor in the event's success was the confidence the local businesses and local government had in the university's graduate students involved in this endeavor, particularly as the university serves as a conduit for many such students to become employed upon their graduation with the local, sponsor businesses that are involved in the disaster recovery industry, the specific area toward which the hackathon was geared. *Id*.

146. *Id.*

147. Dominic Papa, Executive Director of the Institute for Digital Progress (located in Phoenix, Arizona), advised that this is one of the most critical elements to attain at the outset of any smart cities initiative. *Applications Impact Communities*, *supra* note 142.

148. *Id.*; Ken Strutin, *Social Media and the Vanishing Points of Ethical and Constitutional Boundaries,* 31 PACE L. REV. 228, 229 (2011).

devices as a matter of course.[149] An app on these devices that encourages these people to engage with one another and with their surroundings in a meaningful way has the ability to transform their actions and influence an emerging behavior-based economy.

As background, an "app" is an abbreviation for an "application," a mobile software program that is designed to run on smartphones, other mobile devices, and computers.[150] To obtain a particular app, all people need to do is download it and use it. [151] Ease of usage makes apps attractive to people. Due to our society evolving from one where content is generated from top-down publishing to one in which consumers, or users of apps, generate their own content through self-publishing and re-publishing without limit,[152] the ease of use of certain apps can be used to influence behavior in a relevant market.[153]

2. Disrupting the Way Business Operates Through the Use of Apps

Through people's use of apps, mobile technology and services are disrupting the way businesses and economies operate, through the power to influence the behavior of others. If a consumer understands that use of an app can work to their economic benefit, they may be

149. In the United States in particular, most people view having a mobile phone as an essential component of their daily operations that they must carry with them regularly and throughout the day, similar to their wallet or keys. *See* Jason W. Croft, *Antitrust and Communications Policy: There's an App for Just About Anything, Except Google Voice,* 14 SMU SCI. & TECH. L. REV.1, 2 (2010); Hemant Bhargava et al., *The Move to Smart Mobile Platforms: Implications for Antitrust Analysis of Online Markets in Developed and Developing Countries*, 16 U.C. DAVIS BUS. L.J. 157, 158 (2016). In fact, the average American spends more than an hour daily using their smartphones, primarily for online activities, with 87 percent of that time spent on using apps. *Id.*

150. Marziah Karch, *What Are Apps? - Definition and Examples*, LIFEWIRE (Oct. 5, 2016), https://www.lifewire.com/what-are-apps-1616114 (last visited Apr. 14, 2017); WIKIPEDIA, *Mobile App*, https://en.wikipedia.org/wiki/Mobile_app (last visited Apr. 14, 2017). "Apps" are also known as software, programs, executables, and packages. *See* Karch, *supra* note 150.

151. Karch, *supra* note 150.

152. Strutin, *supra* note 148, at 236, 242.

153. According to the Tenth Circuit, a "relevant market" consists of two elements: (i) the product market and (ii) the geographic market. *See* Lantec, Inc. v. Novell, Inc., 306 F.3d 1003, 1024 (10th Cir. 2002).

incentivized to modify their behavior to incorporate that app into their routine.

Certain merchants have capitalized on this notion, creating apps to incentivize people to shop in their stores. Target, for instance, launched its own app in April 2016 called "Cartwheel," which allows consumers physically present in a Target store to apply additional savings toward their purchases, in addition to any savings they receive from manufacturer coupons and other Target promotions.[154] These "bonus savings" create additional incentive for people to shop at Target, rather than at one of Target's retail store competitors. Also, because consumers use the app to scan the barcode of each item they are purchasing in order to amass additional savings during their shopping experience, Cartwheel is viewed as being "fun-to-use."[155] As a result of certain consumers viewing their shopping experience with Cartwheel as an interactive game of sorts, Cartwheel has been called a "runaway success,"[156] with a following of die-hard fans, affectionately dubbed "Super Scanners."[157] Additionally, Target consumers can use the Cartwheel app's "Friends" tab to publicize to their friends exactly how much they saved during their Target shopping experience.[158] From an economic perspective, Target is not only benefitting from this consumer-driven positive publicity, but it is also benefitting financially from Cartwheel users themselves visiting a Target store

154. In fact, Cartwheel's Internet home page touts this app as "[t]he rewarding way to save at Target." TARGET CARTWHEEL, https://cartwheel.target.com/ (last visited Apr. 14, 2017). The app works by the consumer using the app to scan the barcode of each item they are purchasing; the savings from digital manufacturer coupons on certain items are tallied to create a cumulative dollar amount discount when a consumer purchases his or her goods at the checkout counter. FTM REAL SAVINGS REAL SOLUTIONS, *How to Use Cartwheel to Save at Target*, (Jan. 6, 2014 8:00 AM) http://forthemommas.com/articles/how-does-the-target-cartwheel-app-work [http://perma.cc/AX76-TMRE]. *See also* Target Corporate, *A New Way to Save with Target's Cartwheel! Plus a Few Tips and Tricks from the App's Creators,* A BULLSEYE VIEW (Apr. 4, 2017), https://corporate.target.com/article/2016/04/cartwheel-creators-share-app-hacks [http://perma.cc/4VYD-VVDR] [hereinafter, "TARGET CORPORATE"].

155. Target Corporate, *supra* note 154.

156. Phil Wahba, *Target Finds Rare Tech Edge: Its Popular Cartwheel Shopping App*, FORTUNE (June 5, 2014, 4:17 PM) http://fortune.com/2014/06/05/target-cartwheel/ [http://perma.cc/EHC2-SW2S].

157. Target Corporate, *supra* note 154.

158. Wahba, *supra* note 156.

more frequently and spending on the average 30% more each trip than non-Cartwheel users.[159] Cartwheel, then, has been a successful social media tool, driving demand for Target products through its ability to build consumer brand loyalty.

Target's Cartwheel app illustrates several important take-aways regarding the use of apps generally. First, apps are convenient and efficient. As a technology-driven solution that people can use on their handheld devices to increase their efficiency, certain apps can be used to alleviate demands on people's time. Second, an app that offers consumers economic incentives, such as additional savings, discounts, or the like, can alter consumer behavior, incentivizing people to frequent the locations where the app registers and accrues such rewards. Third, apps can be used to convert ordinary consumers into social media influencers, insofar as their posts, messages, photos, emojis[160] or other communications with their friends and contacts can have a profound impact on these people's ideas and can drive their behavior.[161] Not only do these communications have the potential to drive everyday behavior of the family and friends who receive them, but if the communications offer an idea or sentiment that has enough mass appeal and is shareable on social media, they have the potential to go viral.[162] Fourth, apps induce the "pride" and "first mover" factors in people, motivating them to share with others a source of pride and accomplishment - such as saving more money than others as a result of the app - or to be a "first mover," or the first among their friends, contacts, and other followers on social media to engage in a certain activity.

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159. *Id.*

160. The term "emoji" is derived from Japanese terms for "picture" and "writing." Emojis are standardized ideogrammic icons in electronic messaging, such as on a mobile phone. THE FREE DICTIONARY, *Emoji*, http://www.thefreedictionary.com/imogee (last visited Apr. 15, 2017).

161. Jo Stratmann, *What is a Social Media Influencer?,* FRESHMINDS (Nov. 18, 2010), http://www.freshminds.net/2010/11/what-is-a-social-media-influencer/ [http://perma.cc/RL2L=5UGV].

162. In terms of social media, going "viral" means a piece of content that spreads as rapidly as a virus, due to people becoming "infected" from the content. The emotions that spur the desire to share the communications with others is generally what triggers the infection. *See* Elise Moreau, *What Does It Mean to Go Viral Online?,* LIFEWIRE (March 14, 2017), https://www.lifewire.com/what-does-it-mean-to-go-viral-3486225 [http://perma.cc/B2F6-E92L].

3. Hackathons to Create Apps that Benefit Both the Consumer and the Local Community

For certain communities endeavoring to incorporate particular smart city features, certain cities have conducted hackathons[163] to devise apps that address issues important to the local residents. For instance, in Phoenix, Arizona, academic institutions such as Arizona State University and Grand Canyon University conducted a joint hackathon to develop an app so that people can monitor pollution levels in the city and the region in real time.[164] The local residents' goal for this app is for it to help the greater community reduce traffic pollution, thereby having the positive social impact of reducing the community's exposure to pollution and making the air healthier.[165] Another example is a hackathon that was held to foster the development of a disaster hypothetical recovery app that would enable individuals in a particular community in which a natural disaster has struck to access tools enabling them to take appropriate steps toward recovery.[166] The thought behind the invention of this app was that the app would not only directly benefit the consumer, but will also have a broader benefit to the local community.[167]

Hackathons not only spur innovation, promote dialogue among stakeholders, and catalyze new, visionary approaches to addressing a particular local issue, but their unique characteristics also provide other social benefits. By its nature, a hackathon is a forum set up to stimulate creativity and to entice people in the local community to unleash their problem-solving skills.[168] In contrast to a typical job or

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163. A "hackathon" is a sprint-like event in which those involved in software development and computer programming gather together in an intense manner over a short period of time (e.g., between a day and a week) to collaborate together, accelerate and build upon existing technologies, and create new, innovative software products that are generally created for educational or social purposes. *See* TECHNOPEDIA, *Hackathon - Definition - What Does Hackathon Mean?,* https://www.techopedia.com/definition/23193/hackathon (last visited Apr. 15, 2017); WIKIPEDIA, *Hackathon*, https://en.wikipedia.org/wiki/Hackathon (last visited Apr. 15, 2017).

164. *Applications Impact Communities*, *supra* note 142.

165. *Id.*

166. *Id*.

167. *Id*.

168. HACKWORKS, *Benefits of Hackathons*, https://www.hackworks.com/benefits (last visited July 28, 2017) [hereinafter, HACKWORKS].

school setting where risk taking can prove costly, a hackathon encourages people to innovate without worry and take risks worry-free, due to there being minimal at risk on a personal level.[169] Also, hackathons generally only last for a very short period, usually between 24 and 72 hours.[170] This abbreviated, fixed time constraint causes hackathon participants to engage in a race of sorts that combines individuals' vision, passion, wit, and skill with their ability to engage with other participants and use knowledge transfer[171] to build off of one another's ideas.[172] Mixing together a plethora of novel ideas within a compressed, tight time parameter is a recipe for productivity insofar as the incubator-like atmosphere requires people to collaborate together as a team, condense and refine their ideas, and transform these ideas from concept to actionable measures.[173] As a result, the atmosphere a hackathon creates for development, innovation, and social collaboration increases the likelihood of unlocking innovative solutions to the issue at hand.

Additionally, hackathons provide unique benefits to both the local community and to the individual hackathon participants. First, on a "community benefit" level, hackathons build bonds between the people developing the technology and the people who use it, including community leaders, mentors, local businesses, and potentially corporate sponsors. From a public benefit perspective, a hackathon may not only help develop a prototype of an app, but it can also advance other helpful, novel concepts that, with further investment and time, can be used and expanded upon further post-hackathon. Moreover, from an economic perspective, local scientific, research, or technology companies can use hackathons as a forum for attracting new talent, with the advantage of seeing in practice how potential new employees develop and promote their ideas while working with others.[174]

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169. *Id.*

170. Grace Metri, *Top 10 Benefits of Hackathon Participation,* INTEL DEVELOPER ZONE (Nov. 10, 2015), https://software.intel.com/en-us/blogs/2015/11/10/top-10-benefits-of-hackathon-participation [http://perma.cc/C3V6-J936].

171. See *supra* note 94, for a definition and discussion of knowledge transfer.

172. *See* HACKWORKS, *supra* note168.

173. *Id.*

174. *Id.*

Second, on an "individual benefit" level, hackathons provide a number of advantages. Because the hackathon organizers generally provide all equipment, tools, workshops, and mentors to participants, participants have a low cost/high benefit opportunity to craft a launching pad for developing their creative ideas, with mentors supporting and encouraging them throughout the process.[175] By investing time in a hackathon, an individual participant becomes familiar with a local issue and gets the opportunity to tackle it in a high-tech forum while learning a new technical skill.[176] From a gratification perspective, hackathon participants generally learn a vast amount of information within a very short time and leave with a tangible product reflecting their efforts when the hackathon ends.[177] Additionally, hackathons provide an opportunity for participants to refine their soft skills.[178] By communicating effectively with others and determining each other's strengths, participants are able to transform a room of previously unconnected individuals into a cohesive unit, where each person's strengths are identified and applied to maximize efficiency in the development of a single app.[179] Finally, hackathons provide participants with the ability to enhance and grow their professional network. Working under pressure with individuals driving toward the same goal establishes camaraderie and develops professional relationships that last even after the hackathon ends.[180] For these reasons, hackathons serve as a powerful means of igniting individual creativity, getting people to focus on social issues in an interactive, creative manner, and involving people on a social and intellectually engaging level so that they see how innovating an app can prove highly beneficial on both a personal and community level.

175. *See* Metri, *supra* note 170.
176. *Id.*
177. *Id.*
178. *Id.*
179. *Id.*
180. *Id.*

IV. COMMERCIAL SMART-FLOORING: BACKGROUND ON PAVEGEN TECHNOLOGY AS A PRIME EXAMPLE OF A SMART CITIES INNOVATION

A. Predecessor Technology: Piezoelectricity and the Flooring of the Future

1. Background on Recent Developments

While piezoelectricity may be a foreign concept to most people, the scientific community has been aware of this form of energy for decades, as French scientists discovered this technology in the 1880s.[181] The name of this technology itself encapsulates how a device harnessing certain kinetic energy operates. Specifically, term "piezoelectricity" originates from the Greek words "pizo" or "piezein," which mean "to squeeze or press."[182] In non-scientific terms, piezoelectricity is the ability of certain materials, such as quartz crystals and select ceramics, to generate an electrical charge when mechanical pressure is applied.[183] The applied charge allows voltage to be generated across the material; when no force is applied, no electric charge is generated.[184]

The practical application of piezoelectric devices in modern times have ranged from the commonplace to the ultra-novel and high-tech. For example, ordinary devices that draw upon piezoelectric technology include quartz watches, gas lighter wands, motion detectors, and sonar.[185] In recent years, futuristic piezoelectric devices have debuted in various public forums around the world, generally in

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181. Kimberly E. Diamond, *Give New Applications of Piezoelectric Power a Chance: Technological Innovations from Evolving Alternative Energy Area Offer Opportunities in the Environmental and Finance Markets*, CLIMATE CHANGE, SUSTAINABLE DEV., & ECOSYSTEMS COMMITTEE NEWSL., Vol. 12, No. 3 (A.B.A., Chicago, IL), July 2009, *reprinted in* INT'L ENVTL. L. COMMITTEE NEWSL., Vol. 11, No. 2 (A.B.A., Chicago, IL) July 2009, *and* SEC. OF INT'L L.'S ENVTL. L. COMMITTEE NEWSL., Vol. 2, No. 2 (A.B.A., Chicago, IL) July 2009, at 23.

182. *Id.*

183. *Id.*

184. *Id.*

185. *Id.*; Kim Diamond, *Breakthroughs in Piezoelectric Power: Raising Public Awareness is a Step in the Right Direction for U.S. Sustainable Development*, ENERGYPULSE (Apr. 17, 2009), http://www.energycentral.com/c/um/breakthroughs-piezoelectric-power-raising-public-awareness-step-right-direction [http://perma.cc/C3VM-3RU4]

the form of flooring that harnesses the kinetic energy people produce when walking or dancing.[186] Initially, these revolutionary innovations capitalizing on the concept of "crowd farming," or harvesting power from people's footsteps in crowded areas,[187] appeared as experimental roll-outs in public forums. In 2006, two high-profile public forums in which these roll-outs appeared included Japan's Tokyo Station and Shibuya Station, where Soundpower Corp.'s "Power Generation Floor" containing piezoelectric pads were embedded within the flooring under the ticket gates.[188] Because each of these venues attracts several million people on an average day, the sheer number of people translates into a tremendous amount of footfall-generated power, the energy from which is used to illuminate electronic signboards in each of these stations.[189] Several years later, in 2008, piezoelectric flooring appeared in other venues globally, such as in London's eco-nightclub, Club Surya, and in Rotterdam's sustainable dance club, Wvatt, supplying each club with a significant portion of that club's energy needs.[190]

2. Why "Foot Power" is Renewable Energy

Using kinetic energy from human footsteps to create power marks a paradigm shift, insofar as it is heralds an astonishing change in the way we view what constitutes renewable energy. In the past, the phrase "renewable energy" has generally been associated with widely-known energy sources, such as solar, wind, wave, tidal, and geothermal energy. "Renewable energy," though, is broadly defined to include energy collected from "renewable resources."[191] A "renewable resource," in turn, is generally defined as a "natural resource" which

186. Diamond*, supra* note 185*;* Diamond, *supra* note 181.

187. Diamond, *supra* note 185.

188. Diamond, *supra* note 181, at 24. These installations were a collaborative effort between the East Japan Railway Company (JR East) and researchers at Japan's Keio University. *See id.*; *see also* Mail Foreign Service, *The Power of the Commuter . . . Japan Uses Energy-Generating Floor to Help Power Subway*, THE DAILY MAIL (Dec. 12, 2008, 12:10 PM), http://www.dailymail.co.uk/news/article-1094248/The-power-communter—Japan-uses-energy-genertating-floor-help-power-subway.html [http://perma.cc/6XRG-Y78V].

189. Mail Foreign Service, *supra* note 188.

190. Diamond, *supra* note 185.

191. *See Renewable Energy*, WIKIPEDIA, https://en.wikipedia.org/wiki/Renewable_energy (last visited July 28, 2017).

uses a naturally recurring process to replenish itself.[192] Because a "natural resource" can include animal life that can be found within the natural environment, human beings can be considered natural resources.[193] The naturally recurring process that a person can use to "replenish" their footsteps is either to take new footsteps themselves, or to have someone else take footsteps in their place. Footsteps, consequently, can be considered a "renewable resource." Due to our ability to harvest the kinetic energy from footsteps, this energy can be considered "renewable energy." Pushing the boundary of what constitutes renewable energy, and getting people to think of renewable energy from an entirely different perspective, is a breakthrough step in introducing to the world "foot power" as a disruptive technology.[194]

B. Why Pavegen Technology Epitomizes a Transformative Smart Cities Innovation

1. Improvement on Existing Technologies in the Marketplace

Escalating the power of the human foot and the concept of electricity-generating flooring to the next level, and proving why "foot power" is a disruptive technology changing how the world views renewable energy, Laurence Kemball-Cook developed Pavegen technology. From a scientific perspective, this groundbreaking innovation involves taking the downward force of a footstep and converting this force into energy stored in a flywheel, a rotating mechanical device used for purposes of storing rotational energy.[195]

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192. *See Renewable Resource*, WIKIPEDIA, https://en.wikipedia.org/wiki/Renewable_resource (last visited July 28, 2017).

193. *See Natural Resource*, WIKIPEDIA, https://en.wikipedia.org/wiki/Natural_resource (last visited July 28, 2017).

194. According to the McKinsey Global Institute, a "disruptive technology" is an emerging technology or technological advance that will transform life, business, and the global economy. *See* James Manyika, et al., *Disruptive Technologies: Advances that Will Transform Life, Business, and the Global Economy*, MCKINSEY & COMPANY (May 2013), http://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/disruptive-technologies [http://perma.cc/GCR3-8D6S].

195. *Keynote Launch*, PAVEGEN, http://www.pavegen.com/livestream/ (last visited May 16, 2017) [hereinafter, PAVEGEN, *Keynote Launch*]; *Flywheel*, WIKIPEDIA, https://en.wikipedia.org/wiki/Flywheel (last visited May 16, 2017).

This energy is then used to power lighting fixtures in close proximity to the Pavegen flooring array.[196]

The public's first exposure to this flooring technology occurred in 2012 at the Olympic Games in London (the "London Olympics"), where a prototype of Mr. Kemball-Cook's Pavegen system was installed in West Ham Station, along a key walkway connecting this tube station to the Olympic Village.[197] Through what Mr. Kemball-Cook dubbed as "footfall harvesting," the Pavegen tiles generated 20 kWhs, or 72 million joules, of energy over the two-week period during which the London Olympics were held.[198] Not only did this energy generated from pedestrian foot traffic provide sufficient power to light-up a row of streetlamps throughout the night, but it also powered them during the day, with extra power to spare.[199]

There are several reasons why Pavegen technology embodies the type of product that is ideally found in a smart city, with respect to the characteristics discussed in Part III.A. herein. One reason is that Pavegen technology evidences technological and intellectual property innovations relative to its piezoelectric flooring cousins. Improving on flooring technologies of the not-so-distant past, as discussed in Part IV.A.1. herein, the Pavegen flooring array that appeared in West Ham Station offered one key feature not present in its predecessor energy-generating flooring devices: the ability to track footfall through wireless, real-time movement data analytics.[200] As illustration, through the West Ham Station installation, the Pavegen tiles were able to match the energy generation source with the energy generated, counting the over one million footsteps from pedestrian traffic during the London Olympics.[201]

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196. *Id*.

197. *See West Ham Station - Olympics 2012, London*, PAVEGEN, http://www.pavegen.com/west-ham-station/ (last visited May 16, 2017) [hereinafter, *West Ham Station*]; Oliver Balch, *Power Generating Tiles Pave the Way to Renewable Energy Breakthrough* (Aug. 16, 2012, 12:58 PM), https://www.theguardian.com/sustainable-business/power-generating-tiles-renewable-energy [http://perma.cc/R2QE-X7ZE].

198. Balch, *supra* note 197.

199. *Id.*; *West Ham Station*, *supra* note 197.

200. *About - How Does the Pavegen Technology Work?,* PAVEGEN, http://www.pavegen.com/about/ (last visited May 16, 2017).

201. *West Ham Station*, *supra* note 197.

Also, over the course of the last few years, Pavegen technology itself has evolved on several levels. Advancements in its own product design have enabled the Pavegen product on the market today to become more efficient and effective at capturing footfall-generated energy, producing with each footstrike 200 times more energy than a single footstep alone would have generated.[202] Similar to the computers that were enormous in size relative to the much more compact computers of today, Pavegen made its flooring's components, such as the flywheel, much simpler and smaller, so that every cubic millimeter of its flooring generates power.[203] Pavegen has also incorporated state-of-the-art, breakthrough features into its current product, refining and improving upon its prior model. As illustration, the current Pavegen product can be used to track efficiency, using its footfall tracking feature to predict peak footfall during a given day at prime locations, as well as using its heat mapping to identify footfall "hotspots" by gauging footfall intensity and calculating the number of pedestrians that traverse a particular area.[204]

2. Vision and Strategy in Product Deployment Globally and in Partner Selection is Effective in Promoting Public Buy-In

a. Global Product Deployment Through Small-Scale Projects

Another reason why Pavegen technology exemplifies the type of product well-suited for smart cities is because Pavegen has employed vision and strategy in its product deployment globally. As discussed in Part I.B.2. herein, successful pilot projects are essential for testing a state-of-the-art technology that is new or has never before appeared in the marketplace.[205] Pavegen has embraced this notion, deploying globally small-scale, demonstration-size projects containing Pavegen flooring installations while simultaneously heightening people's

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202. PAVEGEN, *Keynote Launch*, *supra* note 195. Specifically, in contrast to the "old" Pavegen product whose flywheel spun at 18 revolutions per minute (rpm), Pavegen's "new" product spins at 1,500 rpm, producing an exponentially greater amount of power than the "old" product. *Id.*

203. *Id.*

204. *Capturing Information from Every Footstep*, PAVEGEN, http://www.pavegen.com/what-we-do/ (last visited May 16, 2017).

205. *See supra* Part I.B.2., a discussion regarding several United States offshore wind pilot projects.

curiosity and interest in the product itself. As illustration, Pavegen arrays of different sizes and colors have appeared in venues such as Federation Square in Melbourne, Australia (a 5-tile project, consisting of all green, square-shaped tiles) (the "Melbourne Project"), Heathrow Terminal 3 in London's Heathrow Airport (a 51-tile project, consisting of a mix of green, purple, and blue square-shaped tiles) (the "Heathrow Project"), and a football field at the Federal College of Education in Lagos, Nigeria (a 100-tile project, consisting of tiles embedded under the field itself) (the "Lagos Project").[206]

Domestically, in November 2016, Pavegen rolled out its installation in a high profile, high foot traffic location in Washington, D.C.[207] Exposed to approximately 10,000 pedestrians per day as well as to the elements outdoors, the 68-tile pilot project, consisting of three arrays of triangular-shaped silver tiles, occupy 240 square feet on the Connecticut Avenue Overlook pocket park, just south of the Dupont Circle Metro Station (the "Dupont Circle Project," and together with the Melbourne Project, the Heathrow Project, and the Lagos Project, the "Four Pavegen Projects"), garnered substantial media attention during its debut and remains an attraction for resident locals as well as those who live in the surrounding suburbs.[208] Ultimately, by walking

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206. *Federation Square, Melbourne, Australia*, PAVEGEN, http://www.pavegen.com/federationsq (last visited May 16, 2017); *Heathrow Airport, London, UK,* PAVEGEN, http://www.pavegen.com/heathrow (last visited May 16, 2017) [hereinafter, PAVEGEN, *Heathrow Airport*]; *Nigeria Football Pitch, Lagos, Nigeria*, PAVEGEN, http://www.pavegen.com/shell-nigeria (last visited May 16, 2017).

207. *Dupont Circle, Washington DC*, PAVEGEN, http://www.pavegen.com/washington (last visited May 16, 2017) [hereinafter, PAVEGEN, *Dupont Circle*]; Sarah Simmons, *Pedestrians Generating Electricity in Dupont Circle by Walking on Kinetic Sidewalks*, Fox 5 DC News (Nov. 18, 2016, 11:05 PM), http://www.fox5dc.com/news/local-news/218522170-story?mc_cid=24d86a6651&mc_eid=737a08343a [http://perma.cc/PEU8-Y53K]. Notably, this installation was not Pavegen's first U.S.-based project. Prior to the Dupont Circle Project, Pavegen installed an 8-tile array in a public school in Bloomington, Indiana. *See Bloomington School, Indiana, USA*, PAVEGEN, http://www.pavegen.com/bloomington-school (last visited July 28, 2017).

208. PAVEGEN, *Dupont Circle*, *supra* note 207; Simmons, *supra* note 207; Hillary Brueck, *In Washington, DC, People are Using Their Feet to Turn on the Lights*, FORBES, (Nov. 18, 2016, 1:07 PM), https://www.forbes.com/sites/hilarybrueck/2016/11/18/pavegen-energy-generating-sidewalk/#41366a1c78da [http://perma.cc/VZ27-EJMV]; Karen Turner, *Small steps in Dupont Circle Add Up*

on the Dupont Circle Project, ordinary city dwellers in our nation's capital have injected into their otherwise ordinary walking experience an element of fun, novelty, and knowledge that their "step-fueled energy"[209] is helping to generate power in quantities substantial enough to literally cause the lights to go on.[210] In essence, this kinetic sidewalk technology is showing people that they, as individuals, matter and that their engagement with this technology can make a real difference in changing traditional notions of energy production.

Pavegen's vision and strategy of slowly rolling-out its product into the global marketplace cleverly is serving as a catalyst for change. In each of the above Four Pavegen Projects, people who walk or run across Pavegen tiles undergo an interactive and impactful experience, seeing the immediate benefits of their footsteps when nearby hallway lights, field lights, LED streetlights, or other nearby LED lights, as applicable, light up after each step they take on this flooring.[211] By integrated its disruptive kinetic flooring technology into people's everyday lives, Pavegen is not only creating public buy-in by engendering positive feelings about its product in the public's eyes, but it is transforming the manner in which the global public perceives traditional notions of energy generation - particularly those associated with electric lighting.

b. Appealing to People on Various Psychological Levels

Pavegen's vision and strategy for its product roll-out also cleverly involves appealing to people at a psychological level, in several different ways. The first way is through a sense of connectedness to the Pavegen tiles themselves. Through their interaction with Pavegen tiles, people can take pride in helping to generate electricity autonomously, potentially motivating them to generate more electricity. As illustration, 176 Pavegen tiles were installed across the

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to Strides Toward Cleaner Energy, THE WASHINGTON POST (Nov. 19, 2016), https://www.washingtonpost.com/news/innovations/wp/2016/11/19/new-tiles-harness-the-energy-of-footsteps-in-washington-d-c/?utm_term=.ffeb5ee2130b [http://perma.cc/5N8F-XQQW].

209. Turner, *supra* note 208.

210. According to Rick Kenney of the District Department of Transportation, the daily foot traffic on the Dupont Circle Project is enough to generate approximately six hours of LED street lighting each evening. *See* Simmons, *supra* note 207.

211. Brueck, *supra* note 208.

Champs-Elyseés, part of the course of the 37th Paris Marathon (the "Paris Marathon Project").[212] As people ran across the last 25 meters of the course where the Pavegen array was located, the energy each runner generated was displayed on a large screen, displayed in real time.[213] Consequently, not only could the runners see and appreciate the value of their footsteps on the marathon course, but they could also see how much energy they were producing, relative to the other runners near them.[214] The screen's digital display not only enabled the racers to participate in an interactive experience with revolutionary technology, but also indirectly encouraged them to interact with their fellow runners in a competitive, yet collaborative, process, due to each person's ego-based incentive to surpass his or her "finish line peers" as measured by the amount of energy they produced individually. The importance of Pavegen technology prompting people to interact with others and influence their behavior is discussed further in Part IV.C.

The second way Pavegen appeals to people on a psychological level is through aesthetics. As discussed above in Part II.C.2., aesthetic-based nuisance claims, whether filed in an actual court or aired in the court of public opinion, can play a part in delaying or derailing a renewable energy project. Bearing in mind that the best defense is not to offend, Pavegen has fashioned its product to visually intrigue people. From the dazzling lights and multi-colored tiles in the Heathrow Project[215] to the sleek, silver tiles in the Dupont Circle Project[216] to the subdued, marbled-gray tiles in an office location in London Bridge, UK (the "Renaissance Works Offices Project"),[217] Pavegen combines the power of visual sensory perception with an attractive product, tailored to the unique setting in which it is installed. Engendering positive feelings about the Pavegen product through its alluring facade is therefore a way this company is using aesthetics to

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212. Paul Ridden, *Pavegen Harvests Energy from Paris Marathon Runners*, NEW ATLAS (Apr. 18, 2013), http://newatlas.com/paris-marathon-kinetic-energy-tiles/27131/ [http://perma.cc/5SZM-CUPD].

213. *Paris Marathon, Schneider Electric, France*, PAVEGEN, http://www.pavegen.com/paris-marathon/ (last visited May 16, 2017) [hereinafter, PAVEGEN, *Paris Marathon*].

214. *Id.*

215. *See* PAVEGEN, *Heathrow Airport*, *supra* note 206.

216. *See* PAVEGEN, *Dupont Circle*, *supra* note 207.

217. *Renaissance Works Offices*, PAVEGEN, http://www.pavegen.com/rcp (last visited May 16, 2017).

its advantage, while simultaneously endeavoring to keep nuisance claims at bay.

Building a sense of pride in a project around which a particular community can rally, as well as using science to educate and inspire people, are the third and fourth ways, respectively, that Pavegen has appealed to people on a psychological level and has transformed, inspired, and uplifted certain cities. This has been the case in the Morro da Mineira favela[218] community in Rio de Janeiro, Brazil, where Pavegen's 200-tile installation under the Astroturf of a soccer field has invigorated the locals since its roll-out in 2014 (the "Rio Project").[219] Not only has the ability to run on this field and generate electricity for its lighting[220] enabled the children who play on this field to learn first-hand that power can be generated from themselves as well as from the earth and sun, but it has also inspired these children to want to study science and engineering.[221] From a child's perspective, playing a sport such as soccer is fun. Children playing on a soccer field suited with Pavegen tiles realize and are excited by the notion that they are powering the field's lighting with their own footsteps each time they run.[222] As a result, these children begin to associate the fun they have playing a soccer game with engineering, clean energy generation, and scientific concepts being fun. Pavegen, by enabling children to engage

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218. A "favela" is a term that is commonly used to describe a shantytown, or slum area consisting of shacks, in or near a Brazilian city. *See Favela*, MERRIAM-WEBSTER, https://www.merriam-webster.com/dictionary/favela (last visited May 16, 2017) [hereinafter, MERRIAM-WEBSTER, *Favela*]. The origin of the term "favela" is purportedly from the Brazilian Portuguese name for a hill in the vicinity of Rio de Janeiro where such towns were built. *See Favela,* DICTIONARY.COM, http://www.dictionary.com/browse/favela (last visited May 16, 2017). *See also* MERRIAM-WEBSTER, *Favela*, *supra* note 218.

219. Rowland Manthorpe, *This Football Pitch is Floodlit by Foot Power*, WIRED (Apr. 14, 2016), http://www.wired.co.uk/article/pavegen-kinetic-energy-tiles-floodlit-football-pitch [http://perma.cc/2TQE-49V5]; PAVEGEN, *Keynote Launch*, *supra* note 195.

220. For this particular field, the lighting consists of six LED floodlights. *See* Donna Bowater, *Pelé Unveils Unique Football Pitch Where Players' Energy Produces Electricity,* THE TELEGRAPH, (Sept. 11, 2014), http://www.telegraph.co.uk/news/worldnews/southamerica/brazil/11089313/Pele-unveils-unique-football-pitch-where-players-energy-produces-electricity.html [http://perma.cc/WTB3-ALTU].

221. PAVEGEN, *Keynote Launch*, *supra* note 195.

222. *See generally id.*

in play while being a human game piece in a science-in-action puzzle, has discovered a unique and creative way to make science fun, appealing, and accessible to children throughout the world and of all social classes, inspiring them to potentially want to pursue science studies and careers. This ability to teach children scientific concepts and transform their behavior organically while they are at play has phenomenal implications for current and future generations.

Additionally, the Rio Project demonstrates how a local community's convergence around and support of a Pavegen project has enabled that community to undergo a positive metamorphosis. Home to over 15,000 people, the Morro da Mineira favela is an impoverished area that was generally occupied by police in 2011.[223] Fast forwarding to post-2014, after the Pavegen array was installed under the local soccer field, the Rio Project began attracting people from 5 a.m. to midnight.[224] This, in turn, engendered a sense of pride and protectiveness in the local residents, spurring them to renovate the houses and bars surrounding the immediate vicinity in which the Rio Project is located and improving that area.[225] This positive community impact demonstrates public buy-in at its best; similar to a hackathon where community members rally together to develop a new technology in the form of an app, people rally around the new Pavegen technology, making it the unifying focal point around which community members converge to elevate the community itself to a higher, more advanced state of being.

c. Ability to Partner with Pivotal Players

Vision and strategy in Pavegen's ability to partner with the right players has played a pivotal role in the success of each of the Four Pavegen Projects, the Paris Marathon Project, and the Rio Project. As discussed previously in Part III.C. herein, a smart city innovation must receive buy-in as well as economic support from the local government. Because the local press or other news media may not always cover this aspect of a project, it may be difficult for the general public to know

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223. Bowater, *supra* note 220.

224. Shell, *Shell and Pelé Inspire Future Energy Scientists With Soccer Pitch*, YOUTUBE (Sep. 12, 2014), https://www.youtube.com/watch?v=_Ikb682Mk-k [hereinafter, Shell Video].

225. *Id.*

the degree of behind-the-scenes local government involvement invested in the project to bring it to fruition. Due to this factor, it is a boon for a project when local governmental agencies and officials publicly endorse it. Pavegen has been fortunate in its ability to garner positive support from the press, and to showcase the support it has received from local government entities for certain of its projects. For instance, for the Dupont Circle Project, Pavegen received buy-in and support from the District Department of Transportation, a factor that was publicly announced in the media promptly after the project's construction.[226] Moreover, the positive press coverage the Dupont Circle Project received from non-local sources enabled people outside the Washington, D.C. metropolitan area to learn about both the project itself and the local government support it received.[227]

Also as discussed in Part III.C. herein, a smart city innovation must accomplish the difficult feat of achieving buy-in and support from local leaders, or leaders whose opinions the local community respects - something that Pavegen has also been able to achieve. In the case of the Rio Project, for example, internationally acclaimed Brazilian soccer legend Pelé not only participated in the inauguration ceremony for the soccer field under which the Pavegen array was installed, but he extolled the virtues of Pavegen technology as well.[228] Having a national celebrity endorse a futuristic technology is not only a means of winning public buy-in and support, but it is also a way to indirectly signal to the public that the project also maintains the buy-in of local officials who authorized the soccer icon's participation in the official ceremony for the array's launch.

Additionally, as discussed in Part III.C. herein, businesses owners must have confidence in both the technology itself, as well as the people who are developing and continuing to work on refining the emerging technology in question. Pavegen has been able to achieve buy-in from and partner with prominent businesses of global renown who have confidence in both Pavegen's technology and Pavegen's research and development team – a team that continues to find ways

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226. Brueck, *supra* note 208.

227. Forbes, for instance, covered the Dupont Circle Project's launch, quoting District Department of Transportation project manager Rick Kenney's comment, "Every footstep has the potential to be caught and stored as energy." *See* Brueck, *supra* note 208.

228. Bowater, *supra* note 220; Shell Video, *supra* note 224.

to improve their product. As illustration, Shell, a large, internationally-known oil and gas company,[229] partnered with Pavegen to refurbish the soccer field with Pavegen tiles, solar panels, and LED floodlights to make the Rio Project a reality.[230] Similarly, Harrods, an internationally-known luxury department store located in Knightsbridge, London, demonstrated its confidence in Pavegen's product by partnering with Pavegen to install 12 Pavegen tiles that power an LED lighting display in its store, around the EKOCYCLE collection.[231] Through endorsements from companies such as Shell and Harrods whose names and brands people around the world recognize, Pavegen has been able to establish itself to a global audience as a company whose product merits their buy-in, has market credibility, and possesses staying power.

C. Driving Demand: The Brilliance of Combining Pavegen Technology with Apps

One feature that promises to set Pavegen technology apart from other energy-generating flooring devices is Pavegen's invention of a unique, smart city app that integrates data output gathered from the Pavegen tiles themselves to track footfall and offer rewards to those using this app.[232] The vision for this app can already be seen in practice. For certain of its installed arrays, Pavegen offers consumers the ability to see in real time on the Internet the data collected from the array's tiles, including how their steps translate into energy, and how much energy they are generating with each footstep.[233] Through use of their cell phones or other handheld devices, these consumers effectively are getting a glimpse of part of the app's capabilities, before the app has been rolled out.

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229. *See About Us*, SHELL, http://www.shell.us/about-us.html (last visited May 16, 2017).

230. Bowater, *supra* note 220; Shell Video, *supra* note 224.

231. *See Harrods*, WIKIPEDIA, https://en.wikipedia.org/wiki/Harrods (last visited May 16, 2017); *Ekocycle at Harrods - Knightsbridge, London*, PAVEGEN, http://www.pavegen.com/harrods (last visited May 16, 2017) [hereinafter, PAVEGEN, *Harrods*].

232. PAVEGEN, *Keynote Launch*, *supra* note 195.

233. *Renaissance Works Offices*, PAVEGEN, http://www.pavegen.com/rcp (last visited May 16, 2017).

While the Pavegen app is currently in the design process and has not yet come to market, the implications of this app are extraordinary. Similar to Target's Cartwheel app discussed in Part III.D.2. herein, Pavegen envisions its app disrupting the way businesses and economies operate by influencing consumer behavior and creating dynamic change by catalyzing a behavior-based economy. As part of this view toward the future, Pavegen anticipates incentivizing people through the use of rewards, effectively treating people's footsteps as commodities. Specifically, like the Target model which requires consumers to be inside a Target store for the Cartwheel app to provide them with monetary incentives, the Pavegen app would enable people to receive economic incentives when people take steps on Pavegen tiles when they visit a store, shopping mall, stadium, or other venue in which a Pavegen array has been installed.[234] These economic incentives potentially would take the form of things such as additional discounts that could be earned in a particular store and applied to merchandise therein, or credits that could be earned in one venue and applied toward concert tickets in another venue.[235] As illustration, a person could walk on Pavegen tiles in a particular store, with the Pavegen app indicating the number of additional steps that person needs to take to reach the next level of incentive discount awards in that store.[236] Likewise, a person could walk on a Pavegen array at a rock concert, earn credits from those steps, and have those credits applied toward upgraded tickets or discounts at a different venue, such as at a baseball stadium or other sports venue.[237] The idea is that, similar to the effect the Cartwheel app has on the frequency with which Cartwheel users visit Target stores,[238] people will view their energy-generating footsteps as a commodity, frequenting venues more regularly at which their footfall-earned currency is being accumulated.[239] More importantly, the Pavegen app will cause people

234. PAVEGEN, *Keynote Launch*, *supra* note 195.

235. *Id.*

236. *Id.* For example, after a person walks into a retail store and walks on the Pavegen tiles in that store, the Pavegen app could state something to the effect of "You just walked 23 steps, generating [x] amount of electricity and powering 100% of the lighting around the [name of brand or product] display. If you walk another 7 steps on the Pavegen tiles, we will give you $[y] off of your purchase today." *Id*.

237. *See generally id.*

238. *See supra* Part III.D.2.

239. PAVEGEN, *Keynote Launch*, *supra* note 195.

to focus on renewable energy on a very individualized level, in a manner different from how they may have perceived it previously, appreciating first-hand that energy generation matters, as does the source from which it is generated.[240]

The futuristic Pavegen app promises to play a significant role in shaping the evolution of smart cities for a number of reasons. First, the Pavegen app will be convenient and easy to use, as people will be able to access this app on their smartphones and other hand-held devices. Second, the Pavegen app, by offering discounts, credits, and the like that can be earned at one venue and either applied there or at another venue, as applicable, can alter consumer purchasing behavior, prompting people to frequent venues that value their footsteps and, consequently, value renewable energy. People literally will have the power to endorse a particular store, mall, or other venue, based on that venue's choice of energy sources. The Pavegen app, therefore, can drive demand for a particular venue or product and create consumer brand loyalty, an essential quality for a smart city innovation. Third, because consumers can use social media, and potentially the Pavegen app itself, to let their friends, family, and others know about both their interactive experience with Pavegen tiles and the benefits they received from this interaction, the Pavegen app can be used to as a means to influence these people's everyday behavior, with the potentiality that an extremely positive text, tweet, picture, or emoji regarding that consumer's interactive experience with the Pavegen tiling and the Pavegen app may cause that communication regarding Pavegen technology to go viral.[241] Fourth, the Pavegen app can be used to capitalize on people's pride and desire to be a first mover among their friends, contacts, and other social media followers with respect to engaging with the state-of-the-art Pavegen tile technology and reaping an economic benefit from such engagement.

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240. *See generally id.*

241. For example, a teenager may send a text to his or her friends, indicating that he or she is going to go to a particular mall to shop, due to that mall or certain stores in it, possessing Pavegen tiles and therefore valuing people's footsteps. These friends may then meet up with the teenager at that particular mall, rather than meeting up at another mall with equally attractive shopping options, effectively voting to endorse that particular mall's use of Pavegen tile technology.

V. COMPARING CSP PROJECTS TO PAVEGEN PROJECTS AND PAVEGEN'S FORTHCOMING APP: WHY THE POWER OF THE FOOT MAY RIVAL OR EXCEED THE POWER OF THE SUN

While CSP projects and Pavegen tile projects are two very different types of renewable energy projects, it is instructive to compare the attributes of each against one another, for purposes of highlighting areas of success and areas for improvement in renewable energy deployment and delivery. The lessons learned through this analysis can assist in informing potential guidelines, standards, and aspirations for elements that will improve renewable energy's integration into smart cities of the future as these cities continue to evolve.

With respect to project scale, there is an advantage to starting small. Similar to offshore wind pilot projects in the United States, the Pavegen model has awakened the public's awareness about the power of footsteps by constructed small pilot projects. By gradually rolling out these projects over time globally, Pavegen is slowly exposing and acclimating the world with its new, advanced kinetic tile technology. Because the public gets to engage with the product and become familiar with it over time, Pavegen is using the scale of its projects to build public trust and public buy-in. It is also garnering positive press coverage in manner such that those who do not live near one of its arrays can see, hear, and learn about the project through other channels. Collectively, these efforts are assisting to elevate renewable energy in the eyes of the general public. In contrast, while there may have been small CSP projects rolled out worldwide and in the United States, these projects did not rise to a sufficient level of public consciousness to inform and familiarize the general public adequately enough with this new solar technology. As a result, the reception that recently-built, large CSP projects have received has not necessarily been a warm, welcoming one. Particularly in the United States with respect to the Four CSP Projects, instead of press coverage being used to advance and promote the roll-out of large-scale CSP projects, the media coverage that projects such as the Ivanpah Project received has at times been less than positive. This negative press coverage, in turn, engenders negative public sentiment about the CSP projects themselves, which translates into people not having as positive an impression about renewable energy as possible.

The ability to construct projects in and around existing urban and suburban areas is also important, particularly in terms of shaping the appearance of tomorrow's smart cities. The ability to deploy a renewable energy project in this environment is, therefore, a positive quality. Using footfall and Pavegen tiles to generate energy in this setting is an easy fit. These tiles have the ability to not only co-exist with, but to rely upon and interact with, humans in their living environments. As Pavegen's currently functioning arrays in office buildings, shopping malls, airports, outdoor soccer fields, and street-level walkways illustrate, Pavegen's technology has the ability to be deployed both indoors and outdoors. This is particularly important, due to the implications of this technology being able to be used in commercial buildings to help them become more energy efficient and reduce their greenhouse gas emissions. Due to its potential to be deployed in large-scale in buildings in and around suburban areas, Pavegen technology can transform the face of the built environment as we know it, with minimal invasiveness while this facelift takes place. As Pavegen's kinetic flooring design continues to evolve and become more efficient, maximizing the potential of this technology through massive penetration in the built environment has the potential to rival CSP projects in the amount of energy that can be produced; foot power, in this respect, could gain standing equivalent to or greater than the power of the sun. By comparison, large CSP projects are not well-suited to the urban landscape. These projects require a vast amount of space. Due to the ultrahazardous nature of CSP projects,[242] it is unrealistic to situate large CSP projects in existing urban and suburban environments where unoccupied space is minimal and people abound. Because large CSP projects need to occupy "new" space that is additional to the space used for the built environment, a desert, or other

242. CSP project are ultrahazardous due to the dangerous conditions that can be created through a mechanical malfunction. In the past, the extreme heat emanating from the power tower caused birds to burst into flames as they flew over such tower. *See* Birds Bursting Article, *supra* note 26. Consequently, the extreme heat that a single heliostat generates could cause people to experience severe burns or even death if such heliostat is angled improperly or damaged so that its original angle is shifted. Also, because HTF can reach a heat level of 1,000 degrees Fahrenheit or greater (*see Concentrating Solar Power*, *supra* note 22 and accompanying text), an accidental rupture could cause this molten fluid to scald, severely burn, or kill people who come in contact with such fluid. Situating a large CSP project in a large urban area would pose a great an unnecessary risk to the people in such area.

location outside cities of the future, is the most logical and practical place for a large CSP project. The extent to which CSP technology has the opportunity to transform the energy mix and the manner in which people use renewable energy in smart cities, consequently, will be invisible to smart cities' inhabitants.

Aesthetics, visual recognition, and the ability to interact with a new technology generally are also important for renewable energy projects, insofar as this sensory experience helps to build a sense of connectedness between a project and the local population. Pavegen's tiles are attractive and not generally perceived as eyesores that mar the existing landscape. Because they are located in high foot traffic venues, people not only grow to visually recognize and appreciate Pavegen tiles, but they also learn to interact with them. This interactive experience builds public buy-in, entices people to become more knowledgeable about the science and technology involved in these tiles, heightens their awareness of the environmental benefits that kinetic energy from their footsteps offers, makes them cognizant of renewable energy generation in a unique manner, and potentially alters their perceptions about how they have the power to make a difference in how we generate electricity. Large CSP projects, on the other hand, lack this interactive element. Because they are out of sight and out of mind, many people in the general population are unfamiliar with large CSP projects and cannot recognize them as a matter of course. As a result, a CSP project itself neither develops public buy-in through sensory experiences, nor inspires people to become more knowledgeable about either the technology it uses or science and technology generally.

The creative use of social media through strategically-designed apps is valuable for generating further interest in renewable energy projects and promoting consumer buy-in. As illustrated through Cartwheel and the Pavegen app that will be rolled out shortly, the ability to enhance people's connectedness through a medium that electricity consumers understand, such as through an app on their mobile devices, is important. The use of an app and its ability to drive consumer demand through social media can not only influence consumer choices, but it can also have a disruptive impact on where consumers elect to use their buying power in an evolving, behavior-based economy. Moreover, consumers understand the concept of mobile devices because they are personal objects that are part of their daily life and with which they are

familiar. The use of an app to promote a new technology essentially coats the novelty of the technology with a layer of familiarity, thereby making the technology more accessible from the outset. Generally, large CSP renewable energy projects do not have apps associated with them. As a result, the level of accessibility of the technology these projects use and the ability to impact consumers regarding their energy choice awareness is less than would be achieved if an app was available that effectively connected the project to the consumer based on the consumer's actions.

Partnering with key players while earning and retaining community backing, local business support, and government support is essential for a renewable energy project's success, as well as for the future success for similar predecessor projects. As Pavegen has demonstrated, earning the support of local governmental entities and prominent figures who are role models to people in a particular community in which the new, previously unfamiliar technology is being rolled out is vital for obtaining public support and garnering positive publicity. Retaining this support and momentum is important because it helps make the project less prone to public censure or derision throughout the project's life cycle, particularly if the project experiences kinks not unexpected of fledgling innovations. It also smooths the way for projects in the pipeline that use the same or similar technologies to gain approval and encounter less push-back. The negative publicity the Ivanpah Project received when it fell short of generating its originally targeted energy quota illustrates the vulnerable position in which a renewable energy project can find itself if sufficient visible and vocal public support for it is not regularly maintained. Negative publicity for an existing CSP project also potentially sets the stage for negative press and pushback for other large CSP projects going forward.

Receiving monetary backing from prominent players is also imperative for a cutting-edge renewable energy project's success and proliferation. As Pavegen has demonstrated, the ability to receive financial backing from large companies can catapult a start-up technology from relatively obscurity to the center of attention globally. However, not all start-ups are fortunate enough to receive substantial funding from large companies or other investors. This is why government funding remains essential for cultivating groundbreaking technologies in the renewable energy realm, facilitating the process for

bringing these technologies to market, and accelerating implementation and deployment of these technologies at a substantially faster rate than would take an organic process in which certain technologies lacked sufficient funding. As the Four CSP Projects, domestic offshore wind pilot projects, and innovation clusters collectively illustrate, federal funding, local funding, or a combination of both may be a prerequisite for enabling novel devices that capture and convert renewable energy to take the next step.

CONCLUSION

Today, we are at a juncture where the course of our actions can shape the smart cities of tomorrow, as well as our renewable energy future. With a view toward incorporating the most beneficial, advanced, and groundbreaking innovations into these more integrated, technologically advanced cities, we have the ability to implement in them state-of-the-art, breakthrough technologies. These technologies may not only serve their original purpose, such as using renewable energy to generate electricity, but they may also serve the greater social purpose of creating a sense of connectedness among residents and inspiring them to learn more about science and technology generally. Moreover, certain innovations, when combined with apps and other social media, can have a transformative effect, positively impacting the community as the community both adopts and adapts to them.

As the examples of the Four CSP Projects, Pavegen's kinetic flooring, and Pavegen's soon-to-be-developed app technology illustrate, an innovative renewable energy project must appeal to people on various psychological levels so that they can understand and engage with it. Clearing this hurdle will make it easier for people to demonstrate buy-in for the new technology the project advances and to feel positive about incorporating the project's benefits into their daily lives. As a result, people will be more inclined to adopt a disruptive technology that causes them to re-think their actions regarding sustainability, energy usage, and energy consumption.

Currently, however, there is no national mandate, legal policies, or guidelines in place that are specifically geared toward developing, fostering, and supporting breakthrough renewable energy technologies that will be used in smart cities to transform the existing built

environment by making it more energy efficient. At this time, states such as California are endeavoring to accelerate the development of these new technologies by funding innovation clusters and by providing the physical space to host renewable energy projects that incorporate certain of these technologies. The federal government, too, has supported innovation efforts through the DOE's awarding and loaning of federal funds to various cutting edge renewable energy projects during the past few years. Nevertheless, as a matter of policy, a better approach would be to create a legal framework that allows for more permanent federal funding for and increased federal government endorsements of these projects. Such framework could be crafted to supplement and be integrated with state initiatives, such as California's, in order to create a robust environment that fosters creativity, accelerates innovation, and allows for technologies such as Pavegen's that have been successfully pilot tested to be more rapidly scaled-up and deployed in commercial buildings, public spaces, and elsewhere. While such a framework may be novel, the positive long-term benefits smart cities will reap as a result of its implementation will be worth the effort.