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THE YOGA ANALOGY: SCALING-UP THE U.S.'S RENEWABLE ENERGY SECTOR MINDFULLY WITH NEW TECHNOLOGIES, EVOLVING STANDARDS, PUBLIC BUY-IN, DATA SHARING, AND INNOVATION CLUSTERS

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ABSTRACT

This paper focuses on innovative renewable energy devices, exploring how scientifically-based industry standards that continuously evolve with engineering design technology, the public's buy-in and feeling of connectedness with groundbreaking devices, and innovation clusters that accelerate device development through data sharing and public-private partnerships can all help advance the U.S.'s domestic renewable energy industry.

Part I analyzes challenges inherent to scaling-up novel renewable energy technologies while simultaneously developing the industry standards regulating them. Part II uses the Block Island Wind Farm, an offshore wind demonstration project, and Pavegen's globally-deployed arrays of piezoelectric smart flooring tiles as examples illustrating the importance connectedness and engagement play in garnering public buy-in during a cutting-edge renewable energy device's roll-out. Part III discusses private investors' critical role in bearing financial risks associated with backing experimental technologies, promoting aesthetically unusual device designs, and integrating novel devices into the built environment.

Part IV explores the advantages that data anonymization and data sharing within a data trust construct can produce for constituents in an innovation

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cluster, particularly those functioning together within a public-private partnership. Part V explores the benefits of introducing a renewable energy device prototype in an innovation cluster, where the government, academia, and industry collaborate and share data through public-private partnerships in an engaged, supportive, and technologically savvy community focused on accelerating the development of a particular industry.

This paper concludes that by setting industry standards that continuously evolve in tandem with technologies they aim to regulate, having businesses' investment-backed expectations remain a key driving force in renewable energy device development, and deploying government funding through innovation clusters that support data sharing and public-private partnerships in a particular industry, the U.S. can strike a desired balance and mindfully scale-up its nascent renewable energy industry.

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INTRODUCTION

The Warrior II Pose is a basic yoga stance that appears deceivingly simple and easy to execute.[2] Yet, the Virabhadrasana II,[3] this fierce Warrior pose's more complex original form, is harder than it looks. One's entire body must be aligned, with arms, legs, and feet all properly placed, to perform the pose correctly and not topple due to incorrect positioning.[4] It is no wonder, then, that this pose's purpose is to practice balance, increase stamina, and build inner strength.[5]

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[2] *Warrior II Pose*, YOGA JOURNAL, https://www.yogajournal.com/poses/warrior-ii-pose (database updated May 15, 2017).

[3] *Id.* (Virabhadrasana is a yoga pose named after Virbhadra, a fierce warrior who possessed one thousand heads, eyes, and feet, carried one thousand clubs, and wore a tiger's skin as a cloak.).

[4] *Warrior 2: A Yoga Pose That Is Not As Easy As You Think*, YOGA J., (Aug. 14, 2019), https://magazine.tintyoga.com/warrior-2-yoga-pose/ (A description of the "checkpoints" involved in attaining the proper body positioning for Warrior II is attestation to the pose's complexity.).

[5] *Warrior II Pose*, *supra* note 2.

In many ways, the Warrior II Pose is a metaphor for the current state of the U.S. renewable energy industry. We, as a country, must be grounded in what our knowledge has enabled us to achieve technologically to date. Like the Warrior II Pose, growing the domestic renewable energy industry is much more complex than it superficially appears. As we look undauntedly ahead, one hand is reaching behind us, into the past, representing our scientific advancements and achievements. Simultaneously, the other hand is reaching forward, symbolizing our venturing toward our unknown renewable energy future. All the while, we are concentrating on being well-positioned, striking a three-way balance among past, present, and future. We use the strength of our ever-increasing body of knowledge about certain technologies as the core of our being to produce this harmony.

Using lessons learned from countries further advanced down the renewable energy continuum, particularly in certain discrete sectors,[6] the U.S. can create a well-informed, focused strategy that will propel us successfully into our renewable energy future. For instance, we need to understand and apply the latest scientific discoveries to inform industry standards that regulate novel devices. We also need to lay the foundation for these standards to evolve in tandem with the technologies themselves. Moreover, we need to focus on generating public buy-in for groundbreaking technologies so that consumers endorse and promote imaginative devices that deploy renewable energy in innovative ways. Finally, we need to gain greater public recognition and support for innovation clusters and the data sharing within public-private partnerships that exists therein, as this combination of factors collectively catalyzes the testing, scaling-up, and rolling out of promising technologies and cutting-edge devices for commercial deployment. Failure to assemble a mindful plan that balances all of the aforementioned factors may cause crucial aspects of the renewable energy industry to severely misalign. The resulting setbacks can be massive, having the potential to collapse a particular

[6] *See* Kimberly E. Diamond, *Grouted Connections, Hurricanes, and the Evolving U.S. Offshore Wind Industry: Are Cutting-Edge Scientific and Engineering Technologies Sufficient to Meet Potentially Unrealistic Standards?*, OFFSHORE WIND: TECH., ECOLOGICAL RISKS, & PROSPECTS, 79 (Chester Mendoza ed., 2015) (For instance, as a result of its Round 1, Round 2, Round "2.5," and Round 3 of its seabed lease awards, the UK has become the global leader in offshore wind development, with over 1,000 offshore operational wind turbines generating renewable energy); *see* discussion *infra* Part I, *infra* subsec. B.2; *see also* Part II., *infra* subsec. B (The UK is also more well-advanced than the U.S. in terms of its deployment of piezoelectric flooring arrays.).

renewable energy sector or chill investment across the entire renewable energy industry.

This paper focuses on innovative renewable energy devices, exploring how scientifically-based industry standards that continuously evolve with engineering design technology, the public's buy-in and feeling of connectedness with groundbreaking devices, and innovation clusters that accelerate device development through data sharing and public-private partnerships can all help advance the U.S.'s domestic renewable energy industry. Part I analyzes challenges inherent to scaling-up novel renewable energy technologies while simultaneously developing the industry standards regulating them. This Part focuses on the offshore wind sector, closely examining the initial High Court of Justice decision, the Court of Appeal (Civil Division) decision, and the Supreme Court decision in the UK case *MT Højgaard v. E.ON Climate and Renewables*.[7] This Part also discusses how miscalculations of climate change-induced[8] weather conditions significantly impacted the Robin Rigg offshore wind farm[9] despite historic scientific data, cutting-edge engineering technology, and an industry-standard aimed at protecting against the damage that actually occurred. Additionally, this Part discusses the nuclear energy case *Cooper v. Tokyo Electric Power Co.*,[10] focusing on how compliance with standards that do not give sufficient weight to extreme versions of natural phenomena can trigger black swan events.[11] Part II uses the Block Island Wind Farm, an offshore wind demonstration project, and Pavegen's globally-deployed arrays of piezoelectric smart flooring tiles as examples illustrating the importance connectedness and engagement play in garnering public buy-in during a cutting-edge renewable energy device's roll-out. It also uses the Ivanpah concentrated solar power facility to illustrate how negative public sentiment about a renewable energy project can infect people who are unable to examine the technology first-hand. Part III discusses private investors' critical role in bearing financial risks associated with

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[7] HØjgaard v. E.ON Climate and Renewables [2014] EWHC (TCC) 1088, [2014] BLR 450 (Eng.) [hereinafter the Original *MT HØjgaard* Judgment].

[8] *See infra* notes 19, 22, and 23 and accompanying text for each (For purposes of this paper, climate change is a phenomenon presumed to exist.).

[9] *See* Part I., *infra* subsec. B (For a more in-depth information regarding the Robin Rigg offshore wind farm.).

[10] *Cooper v. Tokyo Elec. Power Co.*, 860 F.3d 1193 (9th Cir. 2017).

[11] *See* Part I., *infra* subsec. C (For a discussion about black swan events, including the history of the derivation and meaning of this phrase.).

backing experimental technologies, promoting aesthetically unusual device designs, and integrating novel devices into the built environment. This Part also discusses how habitat destruction resulting from the use of the "best" technology currently available may pose financial and other risks to investors. Part IV explores the advantages that data anonymization and data sharing within a data trust construct can produce for constituents in an innovation cluster, particularly those functioning together within a public-private partnership. Part V explores the benefits of introducing a renewable energy device prototype in an innovation cluster, where the government, academia, and industry collaborate and share data through public-private partnerships in an engaged, supportive, and technologically savvy community focused on accelerating the development of a particular industry. This Part advocates that innovation clusters may be a preferable strategy for advancing the more rapid development, refinement, and commercial viability of cutting-edge renewable energy devices. This paper concludes that by setting industry standards that continuously evolve in tandem with technologies they aim to regulate, having businesses' investment-backed expectations remain a key driving force in renewable energy device development, and deploying government funding through innovation clusters that support data sharing and public-private partnerships in a particular industry, the U.S. can strike a desired balance and mindfully scale-up its nascent renewable energy industry.

I. CHALLENGES TO SCALING UP RENEWABLE ENERGY PROTOTYPES FOR UTILITY-SCALE USAGE

A. *Difficulties with Setting Industry Standards for Evolving Technologies*

For renewable energy sectors seeking to expand the production and implementation of breakthrough renewable energy devices, having uniform standards within a country or across international borders provides global, industry-wide consistency. Generally, within a specific sector, experts apply their knowledge to develop standards governing the novel technologies being created therein. These standards set expectations, establish benchmarks, and provide a common baseline for all industry players. As a result, adherence to these guidelines can potentially assist with rapidly scaling-up and commercially deploying innovative devices. It can also ensure that contracting parties bear an awareness about performance obligations and desired outcomes in the contracts they negotiate so that they avoid certain undertakings that can lead to litigation.

Developing standards for industries evolving simultaneously with the technologies they seek to regulate, though, is akin to flying a plane while the plane is being built.[12] This presents significant challenges. Good practice dictates that industry standards must be set up-front. Yet, industry experts bear the awesome duty of developing relatively flawless, Mary Poppins-like standards insofar as these standards need to be "practically perfect in every way"[13] from their inception. Like flying a plane, failing to craft a resilient, flawless standard could steer the industry off-course, effectively causing it to veer significantly in the wrong direction. To mitigate against this bleak scenario, scientists and engineers endeavor to simulate actual, real-world conditions for novel design prototypes that are developed by testing these devices in laboratories. To do this, these experts use state-of-the-art scientific knowledge and historical data, as well as projections derived from a combination of both.[14] Consequently, it is not unusual for trailblazing industry standards to be derived from laboratory test results yielded from prototypes of the very devices these standards are designed to regulate.

Laboratory testing, though, is not a substitute for live, real-world trials in a non-controlled environment. Depending on the test facility's location, devices can be developed and tested in isolation,

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[12] *See* Ruth Walker, *Build the Plane While You're Flying It*, CHRISTIAN SCIENCE MONITOR (Mar. 24, 2016), https://www.csmonitor.com/The-Culture/The-Home-Forum/2016/0324/Build-the-plane-while-you-re-flying-it (This idiom is credited to multiple sources.).

[13] *See Practically Perfect Lyrics – Mary Poppins*, ALL MUSICALS, https://www.allmusicals.com/lyrics/marypoppins/practicallyperfect.htm (last visited May 23, 2021) (In the musical *Mary Poppins*, the lead character of the same name shares with Jane and Michael Banks, the two children for whom she is a nanny, that she is "practically perfect in every way".).

[14] *E.g.*, Wind Technology Testing Center, MASS. CLEAN ENERGY CTR., https://www.masscec.com/wind-technology-testing-center (database updated Apr. 2021) (The Massachusetts Clean Energy Testing Center's (MassCEC's) Wind Technology Testing Center (WTTC) in Boston, MA endeavors to simulate real-world conditions to test both onshore and offshore utility-scale wind turbine blades); *see also WTTC Experience*, MASS. CLEAN ENERGY CTR., https://files-cdn.masscec.com/WTTC_Flyer_3.14.19%20%28003%29.pdf (database updated Apr. 2021) (Attesting to its quest to accurately simulate actual conditions, WTTC's brochure states that WTTC is "innovating and constantly improving testing methods to better represent field operations in the lab.").

devoid of actual, unexpected conditions. This becomes problematic for standards based solely on laboratory testing results, as device prototypes are not always subjected to the gamut of climate change-induced weather conditions and other atmospheric and subsea anomalies that a device in the "real world" may encounter. Standards failing to adequately acknowledge and address these real-world factors contain inherent flaws and therefore pose risks, no matter how remote. Investors, developers, engineers, and other industry players who have a stake in a newly-designed device and its performance optimization undertake this risk. This risk is heightened when a standard's "public premier" accompanies a device's roll-out at utility-scale-size when the device has only undergone prototype testing.

B. *The Dangers of Defective Standards: Lessons Learned from Litigation Involving the UK's Robin Rigg Offshore Wind Farm*

A misalignment between laboratory-simulated conditions and real-world conditions can be costly when an industry standard based solely on the former proves to be inaccurate. If engineers follow a faulty standard when designing a state-of-the-art device, the resulting device may contain a significant, latent design defect.[15] This defect may potentially subject the renewable energy device to substantial physical impairment, remedial measures for which may be extremely expensive, presuming such measures are even technologically and commercially available. A defect that adversely impacts device performance can potentially expose the device's engineering and design team to litigation. This litigation may seek to rectify the defective performance problem through tremendous monetary damages, specific performance to repair the defective device or both. Consequently, depending on the magnitude of the industry-wide damage due to the sheer number of defective devices that are operational and have been placed in service, a flawed standard can deal a staggering blow to the industry itself.

The High Court of Justice's original ruling, the decision of Court of Appeal (Civil Division) setting aside this ruling, and the Supreme Court's reinstatement of the original ruling in the matter of

[15] *Latent Defect*, BLACK'S LAW DICTIONARY, 883 (6th ed. 1990) (A latent defect is a hidden defect that could not be discovered after reasonable inspection and about which the device owner had no knowledge notwithstanding the exercise of reasonable care.).

MT Højgaard v. E.ON Climate and Renewables ("*MT Højgaard*"),[16] a case involving offshore wind turbines at the Robin Rigg offshore wind farm ("Robin Rigg") that was brought in the UK's High Court of Justice, Queen's Bench Division, Technology & Construction Court, provides an excellent example of what happens when a disconnect occurs between laboratory testing and real-world conditions. It also illustrates how industry reliance on a defective standard, one that inadequately accounts for this disparity between laboratory and real-world conditions, can result in exponential damages that trigger a black swan event.[17] The enormity of a black swan event may potentially taint public perception about the impacted industry for years.[18] To understand the magnitude of the damage the global offshore wind industry's reliance on a defective standard caused, it is important to first understand the state of the global offshore wind landscape, as well as the atmospheric and oceanic conditions that existed around Robin Rigg, prior to and at the time *MT Højgaard* was first heard.

1. *Atmospheric and Oceanic Anomalies, the J101 Standard, and Impacts on Robin Rigg*

Due to the rate of global temperature rise over the last few decades,[19] unprecedented and unanticipated extreme weather events are disrupting traditional expectations in the short-term regarding atmospheric and oceanic conditions. These weather events distort historic scientific data in unpredictable ways that negatively affect scientific predictions about particular conditions impacting offshore wind turbines' site locations. As a result of global temperatures rising at an accelerated rate, years of scientific data on which reasonable reliance traditionally has been made and upon which reasoned predictions were based now has become somewhat unreliable. This unreliability factor subjects those relying on this data to chance. As illustration, in recent years, there has been an accelerated rate of sand wave migration along the seabed floor in Scottish waters, due to a combination of rougher tidal currents and surface waves than predicted

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[16] Original *MT Højgaard* Judgment, *supra* note 7.

[17] *See* Part I., *infra* subsec. C (For a discussion about black swan events).

[18] *Id*.

[19] *See Global Temperature*, NASA, https://climate.nasa.gov/vital-signs/global-temperature/ (database updated Apr. 5, 2021) (According to the Global Land-Ocean Temperature Index data from the National Aeronautics and Space Administration's (NASA's) Goddard Institute for Space Studies (GISS), global surface temperatures have been increasing steadily since 1980, with 19 of the 20 warmest years on record occurring post-2001.).

(collectively, the "Subsea Anomalies").[20] Scotland has also experienced stronger, more turbulent winds,[21] as well as more frequent, extreme storms with higher intensities and storm surges,[22] than historic data projected.[23] These conditions have resulted in waves with higher heights, frequency, and magnitudes than scientists originally anticipated (the "Surface and Atmospheric Anomalies").[24]

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[20] *See* Giovanni Besio, et al., *On the Modeling of Sand Wave Migration*, 109 J. OF GEOPHYSICAL RES. 1, 1 (2004) (Local tide current intensity is a key factor impacting the sand wave migration rate. An unanticipated increase in tidal currents' intensity can cause sand waves to migrate faster than predicted.); *see also* Steven IJzer, *Influence of Surface Waves on Sand Wave Migration and Asymmetry*, GRADUATION REP. 1, 3 (June 2010), https://www.utwente.nl/en/et/wem/education/msc-thesis/2010/ijzer.pdf (Wave activity also impacts the sand wave migration rate); *see also Waves and Sea Level*, MARINE SCOT. INFO., http://marine.gov.scot/themes/waves-and-sea-level (database updated Mar. 2020) (The seabed, including sand wave migration across it, impacts waves at shallow water depths, as these waves can become steeper and higher as they approach the shore.).

[21] *Storms are Getting Stronger*, NASA EARTH OBSERVATORY (Mar. 5, 2013), https://earthobservatory.nasa.gov/features/ClimateStorms/page2.php (According to one satellite-based study, wind speeds globally increased by an average of 5% since the early 1990's.).

[22] *See What Impact Will Climate Change Have on Scotland?*, EVENING EDINBURGH NEWS, (June 19, 2015), https://www.edinburghnews.scotsman.com/news/environment/what-impact-will-climate-change-have-scotland-884119 (Since 1961, Scotland's eastern side has seen a 36.5% increase in precipitation, while its western and northern sides have seen a 67–69% increase.); *see also* American Wind Energy Association, AWEA LARGE TURBINE COMPLIANCE GUIDELINES: AWEA OFFSHORE COMPLIANCE RECOMMENDED PRACTICES (2012): RECOMMENDED PRACTICES FOR DESIGN, DEPLOYMENT, AND OPERATION OF OFFSHORE WIND TURBINES IN THE UNITED STATES (Sept. 16, 2012) (Storm surges include wind and atmospheric pressure variations that cause irregular movements in the impacted water bodies); *see also UKCP09 Projections – Sea Level/Storm surges, Tides and Wave Height Change (Medium Emissions, 2080 – 2090 Projections)*, MARINE SCOT. INFO. (2009), http://marine.gov.scot/information/ukcp09-projections-sea-level-storm-surges-tides-and-wave-height-change-medium-emissions (database updated on Aug. 30, 2017) (Higher tides and storm surges generally occur on Scotland's western coast, compared to Scotland's eastern cost.).

[23] Ella Wills & Francesca Gillett, *More Hurricane-Force Storms Could Hit UK Because of Climate Change, Experts Warn*, EVENING STANDARD (Oct. 18, 2017), https://www.standard.co.uk/news/uk/more-hurricaneforce-storms-could-hit-uk-because-of-climate-change-experts-warn-a3661311.html (Due to the oceans' warming, in recent years, hurricanes have formed north of the equator and have headed east toward Europe, rather than heading west toward the U.S.).

[24] *See Waves and Sea Level*, MARINE SCOT. INFO., http://marine.gov.scot/themes/waves-and-sea-level (database updated Mar. 2020)

The confluence of the Subsea Anomalies and the Surface and Atmospheric Anomalies (collectively, the "Anomalies") was something that neither scientists nor engineers anticipated when modelling real-world atmospheric and subsea conditions to test state-of-the art prototypes of monopile foundation offshore wind turbines ("monopile turbines"). [25] This divergence between anticipated versus actual conditions meant such prototypes were not subjected to the Anomalies that existed in the real world, resulting in enormous repercussions. These monopile turbines' laboratory performance and testing history, nevertheless, informed the crafting and testing of DNV-OS-J101 (the "J101 standard"), an international, industry-wide design standard for these devices[26] that was published in June 2004.[27] This standard was relied upon and used in practice for the designs of numerous offshore turbines deployed around the UK and throughout the North Sea.[28]

Moreover, regarding monopile turbines' grouted connections,[29] the J101 standard relied on results from testing

(Reporting that the effects of wind on the ocean's surface determine the height of "surface waves" based on the distance the wind blows over the ocean (called the "fetch") and the length of the time it takes for the wind to blow over the fetch. For western Scotland, due to Northern Atlantic Ocean conditions, fetches are long. These long fetches create "swells," or rather, large waves that occur regularly. Marine Scotland further notes that tides can impact wave height.); *see* WAVE ENERGY CONVERSION, *infra* note 86; *see also* Steven McKenzie, *Could Big Waves be Big News for the Western Isles?*, BBC NEWS (Feb. 4, 2013) https://www.bbc.com/news/uk-scotland-highlands-islands-21324654.

[25] Diamond, *supra* note 6, at 80 (For an in-depth description of monopile turbines.).

[26] *See* Diamond, *supra* note 6, at 82–83 (Certification authority Det Norske Veritas (DNV) set this design standard for offshore wind turbines, based on limited test data available at that time. A prior standard, ISO 19902 (2007), had been used in the petroleum and natural gas industries for their steel offshore structures.)); Marcus Klose, et al., *Grouted Connections – Offshore Standards Driven by the Wind Industry*, PROCEEDINGS OF THE TWENTY-SECOND INT'L OFFSHORE AND POLAR ENG'G CONF., RHODES, GREECE 434 (2012). For a more in-depth discussion of the DNV-OS-J101 design standard, *see also* Diamond, *supra* note 6, at 82-86.

[27] *HØjgaard v. E.ON Climate and Renewables* [2015] EWCA Civ 407, [14] (appeal taken from Eng.) [hereinafter *MT HØjgaard* Appeal].

[28] *Id.*

[29] For a discussion of grout's usage in monopile turbines, *see* Diamond, *supra* note 6, at 80–82 (*See also* parenthetical in *infra* note 57.).

conducted at the University of Aalborg during approximately 2000.[30] These test results indicated that shear keys[31] were unnecessary to bolster grouted connections' strength.[32] Notably, the science and engineering team conducing this research (the "Aalborg Team") did not test all aspects of the grouted connections, such as their axial load capacity.[33] Also, unknown to the Aalborg Team during prototype testing, a vast gap existed between real-world atmospheric and subsea conditions relative to laboratory-simulated ones. This disparity greatly impacted each monopile turbine's axial load capacity, something the J101 standard sought to cover. Moreover, the Aalborg Team failed to expose the monopile turbine prototypes to the heightened intensity of the real-world conditions accompanying the Anomalies. The actual monopile turbines at scale, however, experienced these increases.[34]

The J101 standard was used as design guidance for offshore monopile turbines worldwide, resulting in disastrous consequences for numerous offshore wind farms, including Robin Rigg. Given the Aalborg Team's test results, the J101 standard did not recommend or require shear key usage. Consequently, offshore wind developers industry-wide did not require the engineers designing their wind turbines to include shear keys in their monopile turbine designs. Shear keys, as a result, were viewed as an extra "belt and suspenders" measure that offered additional, non-mandated protections and increased the developers' bottom lines when it came to the price of each turbine. Not surprisingly, many developers opted to forego shear keys in their monopile turbine designs.

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[30] *MT HØjgaard* Appeal, *supra* note 27, para. 12.

[31] Diamond, *supra* note 6, at 82 (Shear keys are bump-like protrusions on the monopile's (the inner cylinder's) outside surface and on transition piece's inside surface, thought to improve the sliding resistance between the steel surfaces of both of these pieces between which the grout is inserted.); Original *MT HØjgaard* Judgment, *supra* note 7, para. 3.

[32] *MT HØjgaard* Appeal, *supra* note 27, para. 12.

[33] *Id*. (A force, in this instance, can refer to strong winds, waves, and tidal currents.); *The Theory of Axial Load Explained with Diagrams and Examples*, https://sciencestruck.com/axial-load-explained-with-diagram (last visited May 19, 2021) (An axial load, also known as "thrust load," is a force that causes stress on a particular object. Unlike the radial load, which runs horizontally and parallel to the surface of an object (such as a pole), the axial load runs vertically in the object, parallel to the object's axis of rotation (if the object, such as a pole, were to rotate). Axial load runs perpendicular to the object's surface and is responsible for the force that passes through the object's center.).

[34] *See* Part I., *supra* subsec. B.1. (See definition of "Anomalies.").

As a result of this widespread absence of shear keys in monopile turbines' foundations, the Anomalies caused over two thirds of Europe's 948 offshore monopile turbines to undergo grouted connection failures, causing them to tilt on their foundations.[35] Notably, as of 2009, 65.2% of all European offshore wind turbines had monopile foundations, a percentage that increased to 88% in 2010.[36] This meant that a supermajority[37] of all operational offshore wind turbines globally experienced an epidemic of the same design defect, causing them to tilt. The estimated cost of repair for damages these turbines sustained was in the hundreds of millions of dollars. Consequently, due to the enormity of the damage a flaw in just one design standard, this flaw triggered adverse consequences for all monopile turbine devices across the entire global offshore wind industry.

2. *Significance of the Robin Rigg Wind Farm to the UK's Offshore Wind Industry*

Robin Rigg was one of the 18 offshore wind farms included in The Crown Estate's Round 1, the first in a series of rounds of UK seabed leasing for offshore wind farm development projects ("Round 1").[38] Given the global offshore wind industry's infant state in 2001

[35] Riki Stancich, *Monopile Retrofits and Designs Going Forward: Room for Grout?*, REUTERS EVENTS (Apr. 11, 2001), https://www.reutersevents.com/renewables/wind-energy-update/monopile-retrofits-and-designs-going-forward-room-grout.

[36] Eize de Vries, *Offshore Monopile Failure – A Solution May be In Sight*, WINDPOWER MONTHLY (June 22, 2010), http://www.windpowermonthly.com/article/1011507/offshore-monopile-failure---solution-may-sight.

[37] James Chen, *Supermajority: What is a Supermajority?*, INVESTOPEDIA (Oct. 26, 2020), https://www.investopedia.com/terms/s/supermajority.asp.

[38] *See* Diamond, *supra* note 6, at 87 (Under the Energy Act, 2004, The Crown Estate received vested rights to license offshore wind farm projects within the Renewable Energy Zone along the UK's continental shelf, extending out to 200 nautical miles.); s*ee also, Guide to an Offshore Wind Farm: Updated and xEtended*, THE CROWN ESTATE 1, 2 (Jan. 2019), https://www.thecrownestate.co.uk/media/2861/guide-to-offshore-wind-farm-2019.pdf [hereinafter *Guide to an Offshore Wind Farm*]. *See* Diamond, *supra* note 6, at 79 (The Crown Estate's leasing of the UK's seabed for offshore wind farm development continued, with Round 2 (consisting of 15 lease awards) occurring in 2003 and Round 3 (consisting of 9 lease awards) occurring in 2010, respectively. In 2009, there was a "Round 2.5" that provided developers in Rounds 1 and 2 with the opportunity to tender for site extensions for their existing (or planned) projects, so

when Round 1 was announced,[39] Robin Rigg was one of the very first large-scale offshore wind farms to be built.[40] Robin Rigg's role in helping to launch the global offshore wind market placed it directly under the scrutiny of the world's eyes. Moreover, its location in Solway Firth along the Scotland/England border made Robin Rigg Scotland's first large, commercial-scale offshore wind farm.[41] This meant Scotland likely would be keenly interested in this project, given the precedent it would set for other Scottish offshore wind farms.

3. *MT Højgaard: A Case Illustrating the Dangers that Occur When Real-World Factors Misalign with a New Industry Standard*

a. *Case Factual Background*

MT Højgaard illustrates the dramatic effect a defective design standard may have on a particular offshore wind farm and on a renewable energy industry as whole. In *MT Højgaard*, Robin Rigg's project developer, E.ON Climate and Renewables, UK Robin Rigg East Limited and E.ON Climate and Renewables, UK Robin Rigg

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that they could commence construction on these site extension areas prior to development beginning on Round 3 projects; For a complete list of the offshore wind farms included in Rounds 1, 2, and 3, *see id.*; *see also Offshore Wind Leasing Round 4 Officially Opens*, THE CROWN ESTATE (Oct. 14, 2019), https://www.thecrownestate.co.uk/en-gb/media-and-insights/news/2019-offshore-wind-leasing-round-4-officially-opens/ (Round 4 of The Crown Estate's offshore wind leasing officially opened on Oct. 14, 2019, offering seabed leasing around England and Wales that could total more than 7 GW of offshore wind projects.).

[39] *Guide to an Offshore Wind Farm*, *supra* note 38, at 2.

[40] Diamond, *supra* note 6, at 87.

[41] *See Robin Rigg Offshore Wind Farm, United Kingdom*, POWER TECH., https://www.power-technology.com/projects/robinriggwind/ (database updated on Apr. 2021); *see also* Richard Walls & Sally Shenton, *The Marine Environmental Monitoring Plan for Scotland's First Offshore Wind Farm: Robin Rigg, Solway Firth, Scotland*, http://marine.gov.scot/datafiles/lot/Robin_Rigg/Monitoring/MEMP%20Robin%20Rigg%20Offshore%20Wind%20Farm.pdf (last visited May 19, 2021); *Solway Firth*, https://www.visitscotland.com/info/towns-villages/solway-firth-p243731 (last visited May 19, 2021); Craig Smith, *The Solway Firth – Dumfries & Galloway: Complete Visitor Guide* (Apr. 11, 2018), https://outaboutscotland.com/solway-firth/ (last visited on May 19, 2021); Diamond, *supra* note 6, at 87 (Located off Scotland's southwest coast, this estuary is located northeast of the Isle of Man in a portion of the Irish Sea that forms the border between England and Scotland.).

West Limited (collectively, "E.ON"),[42] bore responsibility for permitting, planning, constructing, and commissioning Robin Rigg's offshore wind turbines.[43] In 2006, E.ON invited MT Højgaard[44] to participate in a competitive bid contest regarding the sub-structure work on the foundation design for all 60 offshore wind turbines within Robin Rigg. In December 2006, MT Højgaard submitted its bid and won the bid tender. E.ON then hired MT Højgaard to design and install the foundations for the two arrays of 30 Vestas monopile wind turbines, each with a nameplate capacity of 3 MW,[45] constituting this

[42] *See US Clears RWE's Acquisition of E.ON's Local Renewable Ops,* RENEWABLESNOW (May 24, 2019), https://renewablesnow.com/news/us-clears-rwes-acquisition-of-eons-local-renewable-ops-655307/(last visited May 19, 2021) (E.ON is a global, German electric utility company); N. Sonnichsen, *E.ON: Statistics & Facts,* STATISTA (Oct. 13 2020), https://www.statista.com/topics/1459/eon/#dossierSummary (E.ON, an investor-owned electricity utility service provider, was established in 2000 and operates globally as one of the world's largest electric utility service providers.).

[43] Original *MT HØjgaard* Judgment, *supra* note 7, para. 1; Diamond, *supra* note 6, at 87.

[44] *See About MT Højgaard,* MT HØJGAARD (2017), https://mth.com/About-us/About-MT-Hoejgaard (last visited Apr. 1, 2021) (Founded in 1918, MT HØjgaard is a leading construction and civil engineering company in the Nordic region.).

[45]*See* Original *MT HØjgaard* Judgment, *supra* note 7, para. 1; *see also* Diamond, *supra* note 6, at 80 (The monopile in a monopile turbine looks like a gigantic, hollow steel tube that forms the turbine's base, is approximately 4.5 to meters in diameter (for 3 MW turbines), and is drilled approximately 40 meters into the seabed in water depths of up to 30 meters.); Subhamoy Bhattacharya, *Challenges in Design Foundations for Offshore Wind Turbines,* THE INST. OF ENGINEERING AND TECH., ENGINEERING & TECH. REFERENCE 1, 2 (2014). *See Nameplate Capacity,* WINDUSTRY http://www.windustry.org/resources/nameplate-capacity (last visited Apr. 1, 2021) ("Nameplate capacity" or "rated output" means the maximum amount of power a device has the capacity to generate when operating under ideal conditions over a certain fixed period of time.); *see also Nameplate Capacity or Rated Output*, ENERGYMAG, https://energymag.net/nameplate-capacity-or-rated-output/ (last visited Apr. 1, 2021); *Watt,* DICTIONARY.COM, https://www.dictionary.com/browse/watt (A "watt" is a unit of power equivalent to one joule per second and is abbreviated as "w" or "W."); *see also* Rapid Tables, *Kilowatt Definition*, https://www.rapidtables.com/electric/kW.html (One kilowatt (1 kW) is the equivalent of 1,000 watts, while a megawatt is the equivalent of 1,000,000 watts (1 MW.); *see also Megawatt*, THE FREE DICTIONARY, https://www.thefreedictionary.com/megawatt (last visited Apr. 1, 2021). *See* Kevin Lee, *How Much Power Does a Wind Turbine Generate?* (Apr. 24, 2018), https://sciencing.com/much-power-wind-turbine-generate-6917667.html (In relation to wind turbines, a 1 MW wind turbine will produce 1 MW of energy if it

180 MW project.[46] MT Højgaard, as the designer/contractor, then entered into a contract with E.ON, as the developer/employer (the "Contract"). MT Højgaard proceeded to engage Rambøll Danmark A/S ("Rambøll") as its subcontractor to formulate the grouted connections' design in the Robin Rigg monopile turbines' foundations.[47]

In and around 2006 – 2007, only eight operational offshore wind farm projects existed globally. Of these, only two, one of which was a demonstration project, used shear keys[48] in their monopile turbines' foundations.[49] In fact, the world's largest offshore wind farm

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were to operate for an entire hour, with the wind blowing optimally during that period. To calculate a particular offshore wind project's megawatts (MW), multiply its number of turbines by the number of megawatts associated with the nameplate capacity of each turbine. For Robin Rigg, there were 2 sets of 30 turbines at 3 MW each, so the calculation for the wind farm's overall potential energy output is (2 x 30) x 3 MW = 180 MW. However, less than 100 percent of the wind passing through a turbine's blades get converted into energy. The amount of wind actually converted to energy is called the "efficiency factor." So, a wind farm's MW amount may be significantly greater than its energy output amount, depending on its efficiency factor. For instance, presuming wind is available and blowing optimally for 24 hours a day all year, and presuming a 25 percent efficiency rating, each Robin Rigg turbine would generate 6,570,000 kW per year (365 days x 24 hours x 3,000 kW x .25 efficiency factor = 6,570,000 kW). This amount is substantially less than the 26,280,000 kW (365 days x 24 hours x 3,000 kW = 26,280,000 kW) per year that a calculation devoid of the efficiency factor produces. This explains why consideration should be given to turbines' efficiency factors in a particular wind farm array when considering that wind farm's nameplate capacity.).

[46] Diamond, *supra* note 6, at 80.; *See also* POWER TECH., *supra* note 41.

[47] *MT Højgaard* Appeal, *supra* note 27, para. 4, 46.

[48] *See* Klose, *supra* note 26 (Scientific studies conducted subsequent to 2006 indicated that shear keys helped remarkably to increase the strength between the monopile and transition piece areas to which the grout adhered.).

[49] *See* MT Højgaard Appeal, *supra* note 27, para. 13 (According to the filing in The Court of Appeal (Civil Division) on Appeal from the High Court of Justice, The Queen's Bench Division, Technology and Construction Court, the two offshore wind farms whose turbines were built with shear keys were the Barrow offshore wind farm [hereinafter Barrow] and the Arklow Bank offshore wind farm [hereinafter Arkow Bank].); *Barrow (UK),* MHI VESTAS OFFSHORE WIND [MHI] (2018), http://www.mhivestasoffshore.com/barrow/ (last visited Apr. 1, 2021) (Barrow is a 30 turbine, 90 MW wind farm located in the East Irish Sea near Cumbria, England that was built in 2006 as part of Round 1 of the UK's offshore wind construction.); *see also Arklow Bank Wind Park,* SSE IR., https://ireland.sse.com/what-we-do/our-projects-and-assets/renewable/arklow-bank-wind-park/ (last visited Apr. 1, 2021) (Arklow Bank is a 25.2 MW wind farm

at the time, Horns Rev 1, was built without shear keys.[50] Given this very small sample size, Rambøll provided its detailed foundation design plans, which did not include shear keys. The plans were in-line with the majority of the offshore wind farms' monopile turbines' foundation designs that existed at that time. Moreover, Rambøll's design decision was compliant with the stability principles for offshore turbines and grouted connections in the J101 standard. [51] These principles estimated the annual probability of foundation stability failure to be extremely remote if the foundation was designed in accordance with this standard.[52]

The Robin Rigg monopile turbines were installed between mid-2006 and mid-2007 and, as per the terms of the Contract, were supposed to have had an operational, in-service life of 20 years without any "major retrofits or refurbishments," and with all parts functioning "safely and reliably in the environmental conditions that exist on the site" for a minimum of this 20-year period (the "20 Years In-Service Requirement").[53] Under the J101 standard, each wind turbine's foundation design was required to incorporate a "design fatigue life" that would enable the turbines to satisfy this 20 Years In-Service Requirement.[54] Rambøll completed construction on the Robin Rigg turbines in September 2009, and the project became operational in April 2010, four years after MT Højgaard's commissioning.[55]

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that was built in 2004 as a demonstration project off the Arklow, Co. Wiklow coast of Ireland.).

[50]*MT Højgaard* Appeal, *supra* note 27, para. 13; *see also Vattenfall – Horns Rev 1*, VATTENFALL, https://powerplants.vattenfall.com/horns-rev/ (last visited on May 20, 2021) (The Horns Rev offshore wind farm possesses 80 wind turbines and is located approximately 20 kilometers off the coast of Denmark, in the North Sea.).

[51] Original *MT Højgaard* Judgment, *supra* note 7, para. 4; *MT Højgaard* Appeal, *supra* note 27, para. 17.

[52] Original *MT Højgaard* Judgment, *supra* note 7, para. 4; *MT Højgaard* Appeal, *supra* note 27, para. 17 (Specifically, the estimated probability of failure was in the range of 10^{-5}– 10^{-4}. While this probability is extremely remote and improbable, it is not an impossibility.).

[53] Original *MT Højgaard* Judgment, *supra* note 7, para. 5 (23 – 24); *MT Højgaard* Appeal, *supra* note 27, para. 2.

[54] *MT Højgaard* Appeal, *supra* note 27, para. 20 (*quoting* para. K104, Section 7 of the J101 standard, which states, "The design fatigue life for structural components should be based on the specified service life of the structure. If a service life is not specified, 20 years should be used.").

[55] *Robin Rigg Offshore Wind Farm*, *supra* note 41.

At Robin Rigg, Anomalies occurred both during and after the time of wind turbine installation. These Anomalies impacted the seabed's benthic[56] region in which the Robin Rigg monopile turbines were located. They also impacted the oceanic and atmospheric conditions to which these turbines were exposed. All of the Robin Rigg monopile turbines' sub-structures and their respective grouted connections[57] were subjected to a higher amount of stress and fatigue than predicted from historical scientific data. The J101 standard's effectiveness, which covered grouted connections, was only then first actually tested against the harsher-than-projected, real-world conditions the Anomalies presented, including their aggregate effects.

In 2009, just several years after their installation, all 60 Robin Rigg turbines experienced issues with their sub-structure foundations due to movement in their grouted connections.[58] Only after this movement was discovered did DNV conduct an internal review of the J101 standard.[59] It was at that time, after structural damage had already started to occur to the Robin Rigg turbines – as well as to most other monopile turbines globally – that DNV discovered a major error in the J101 standard. As a result of Rambøll's following the flawed J101

[56] *See Benthic*, MERRIAM-WEBSTER, https://www.merriam-webster.com/dictionary/benthic (last visited Apr. 1, 2021) ("Benthic" refers to the bottom-most region of a body of water.).

[57] Diamond, *supra* note 6, at 80–82 (The "sub-structure" of an offshore wind turbine consists of two parts, a monopile and a transition piece. The transition piece, which has a marginally greater diameter than the monopile, is placed over the monopile and is secured to it at its bottom and at the monopile's top. The transition piece's purpose is to compensate for imperfections in the angle of the monopile after it is driven into the seabed, correcting these imperfections and allowing it and the turbine's tower – the other piece to which the transition piece is connected and the piece that holds the turbine's nacelle and rotors at its top – to remain vertical. Grout, a high-strength concrete bonding material, is placed between the monopile and the transition piece to secure these two pieces together and prevent the transition piece from moving or slipping. This connection between the monopile and the transition piece is called the "grouted connection" and works by friction, rather than adhesion, between the steel and the grout. The grouted connection must be strong enough to withstand vertical loads from wind and horizontal loads from waves, as well as the weight of the turbine's tower. For a more in-depth discussion regarding the grouted connection and the transition piece, *see id*.).

[58] Original *MT HØjgaard* Judgment, *supra* note 7, para. 5–6.

[59] *Id*. para. 5; *MT HØjgaard* Appeal, *supra* note 27, para. 50; *id.* para. 22–24, 50 (Specifically, the value for one of the parts of a key parametric equation was wrong by a factor of 10, causing those who followed the equation to substantially overestimate the resistance to axial load capacity.).

standard, in April 2010, grouted connection failures occurred in the Robin Rigg turbines' sub-structures, resulting in their transition pieces slipping down their respective monopiles and causing the turbines to tilt.[60] It was estimated that the remedial repair on these wind turbines' foundations would cost €26.25 million, or approximately $32.15 million.[61] The outcome of *MT Højgaard* would therefore determine which party would bear the liability burden for these costly remedial measures attributable to design defects resulting from reliance on a faulty industry standard.

b. Whether a "Fit for Purpose" Contractual Provision Requires Going Above and Beyond the Industry Standard

MT Højgaard is a landmark case for the offshore wind industry specifically and the renewable energy industry generally because it addresses whether parties who follow an industry standard are obliged to merely meet this standard, or to go above and beyond it to satisfy what may be an aspirational contractual provision. Under the Contract, the Robin Rigg turbines were to be designed to satisfy the 20 Years In-Service Requirement, making them "Fit for Purpose."[62] Rambøll designed the turbines so that they complied with the J101 standard, believing that such compliance would enable the turbines to satisfy this "fit for purpose" requirement. Unfortunately, compliance with the defective J101 standard prevented the Robin Rigg turbines from doing so.

The *MT Højgaard* court was then required to considered whether "fit for purpose" may have been an aspirational, unrealistic requirement under the four corners of the Contract, given the

[60] *MT Højgaard* Appeal, *supra* note 27, para. 52.

[61] *See* Original *MT Højgaard* Judgment, *supra* note 7, para. 6; *see also Convert from Euro (EUR) to United States Dollar (USD)*, THE MONEY CONVERTER, https://themoneyconverter.com/EUR/USD?amount=26250 (The equivalent amount of Euros in US dollars is based upon a Jan. 4, 2021 exchange rate.).

[62] *MT Højgaard* Appeal, *supra* note 27, para. 29, 42 (According to Part C of the Contract, the List of Definitions defined "Fit for Purpose" as meaning "fitness for purpose in accordance with, and as can properly be inferred from the Employer's Requirements"; "Employer's Requirements" were defined as including the Technical Requirements of the Contract, which, in turn, required in relevant part that the offshore wind turbines be designed "for a minimum site specific 'design life' of twenty (20) years without major retrofits or refurbishments . . . .").

Anomalies the turbines encountered. The court evaluated whether "fit for purpose" implied a duty for engineering and design firms such as Rambøll to take a commercial approach by undertaking commercially reasonable efforts to satisfy the 20 Years In-Service Requirement. The court also contemplated whether "fit for purpose" instead implied a more rigorous, best efforts standard that required the firm to go above and beyond reasonable efforts, including re-examining and re-calculating formulas in the J101 standard, in addition to designing turbines that satisfied the 20 Years In-Service Requirement.

Given these factors to sort and balance, the *MT Højgaard* court faced the predicament of determining which party should bear the cost of remedial damages – E.ON, as project developer/owner, or MT Højgaard, as the original contractor having responsibility for its subcontractor Rambøll's engineering designs and monopile turbines' construction. This case's outcome, therefore, would set new precedent and have significant implications for developers, engineering/design firms, the global offshore wind industry, and other renewable energy industries creating breakthrough renewable energy devices.

c. Contract Sanctity vs. Encouraging, Not Deterring, Developers and Engineering Firms from Industry Participation

The threat of litigation and liability can deter industry participation, stifle creativity, chill investment, and stunt a young renewable energy industry's growth and ability to evolve. Innovators do not want to risk incurring substantial damages payments, remedial measures that need to be undertaken, negative publicity, and reputational harm. This is perhaps why in *MT Højgaard*, the Court of Appeal (Civil Division) set aside the High Court of Justice's original ruling in favor of E.ON.[63] Specifically, while the Court of Appeal affirmed the lower court's ruling against MT Højgaard and upheld the Contract's provisions, the Court of Appeal granted E.ON relief through only a nominal damages award of £10.[64] This Court of Appeal's Judgment allocates the risk burden almost equally between the contracting parties and sets a precedent that does not discourage firms from entering the offshore wind industry in the future.

[63] Original *MT Højgaard* Judgment, *supra* note 7, para. 5, 23–24.
[64] *MT Højgaard* Appeal, *supra* note 27, para. 143.

Nevertheless, in its 2017 decision, the UK's Supreme Court overturned the Court of Appeals' ruling and reinstated the High Court of Justice's original ruling, imposing full liability on MT Højgaard for remedial work on the turbines (the "*MT Højgaard* Supreme Court Ruling").[65] Upholding the sanctity of contractual language in effort to preserve contractual integrity, the Supreme Court reasoned that courts must look to the terms of the contract and give full effect to the enforcement of those terms upon which the parties agreed, such as meeting a fitness for purpose obligation that the offshore turbine foundations would achieve the result of lasting 20 years.[66] This ruling upheld the Contract's provision specifically stating that MT Højgaard would not be exempted from liability due to its failure to spot defects or mistakes.[67] The key question on which the Supreme Court focused was whether MT Højgaard was in breach of contract, despite its exercise of "due care and professional skill, adher[ence] to good industry practice, and compli[ance] with J-101."[68] Delivering a unanimous ruling, Lord Neuberger reasoned that, based on historic precedent from both the UK and Canada, courts are inclined to uphold the requirement that "the item as produced complies with the prescribed criteria"[69] and that, based on the rationale in the case *Thorn v. Mayor and Commonalty of the City of London*, "a contractor who bids on the basis of a defective specification provided by the employer only has himself to blame if he does not check their practicality and they turn out to be defective."[70] The *MT Højgaard* Supreme Court Ruling emphasizes the point that while it is lofty for engineering firms and other contractors to aspire to reach certain goals of which they may or may not be capable of achieving, they must take caution when articulating such goals as contractual terms, as the sanctity of these terms, no matter where located in the contract,[71] must be upheld and enforced.

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[65] *MT Højgaard v. E.ON Climate and Renewables* [2017] UKSC 59 (appeal taken from Eng.) [hereinafter the *MT Højgaard* Supreme Court Ruling].

[66] *Id.*

[67] *See id.* para. 16 (*citing* clause 2.1, Part D of the Contract); *see also id.*, para. 17–20.

[68] *Id.* para. 27.

[69] *Id.* para. 44.

[70] *Id.* para. 38; *see Thorn v. Mayor and Commonalty of the City of London* [1876] 1 App. Cas. 120 (HL) 132 – 133, 138 (appeal taken from Eng.).

[71] *MT Højgaard* Supreme Court Ruling, *supra* note 65, para. 49; *MT Højgaard* Appeal, *supra* note 27, para. 29, 42 (Location of the Technical Requirements within the Contract is irrelevant for purposes of enforcing its terms.).

From a policy perspective, it is important to encourage developers, engineers, designers, architects, and other creative individuals to participate in the inception of innovative renewable energy devices and the projects showcasing them. Thinking out-of-the-box and devising clever, never-before-seen creations that deploy or generate renewable energy has social benefit, as these creations may improve the human condition by replacing other devices in commercial operation that are less environmentally friendly. A fledgling renewable energy industry itself, though, is not only responsible for igniting potential players' interest in industry participation. Rather, it also bears a responsibility to emphasize the sanctity of contractual terms to its constituent players, so that parties to a contract can be confident in their reliance on the negotiated terms therein. Parties to these contracts will then possess a heightened awareness about the contractual terms and obligations to which they will be bound, so that they can consider them carefully before agreeing to them in effort to appropriately manage and minimize their litigation and liability risk. The effect of the Supreme Court's ruling in *MT Højgaard*, though, may have a chilling effect on the number of contractors willing to undertake the building and design risks that may appear in construction contracts for novel renewable energy devices.

C. *Black Sawn Events: Are They Inevitable When It Comes to Standards for a New Industry?*

1. *A Defective Standard Can Trigger a Black Swan Event*

A standard that has only been laboratory tested yields limited results that may not account for all potential real-world environmental phenomena. As *MT Højgaard* illustrates, highly improbable Anomalies that scientists and engineers do not simulate in device-testing laboratories can and do occur in practice. It was only when the J101 standard was tested in real-world conditions that hindsight indicated that such standard should have been derived differently to account for Anomalies.

Compliance with a defective industry standard can precipitate a black swan event. A black swan event is an extremely low probability, high risk event that, if it occurs, will result in astronomical damages with sweeping consequences, but in hindsight, appears to have been predictable and preventable.[72] The phrase is synonymous with the danger of relying on a limited set of data to make broad conclusions upon which many rely.[73] Indeed, the J101 standard in *MT Højgaard* was the trigger for a "black swan event" across the global offshore wind industry. Theoretically, recalculating the J101 standard could have made monopile turbines' grouted connection failures a predictable and preventable event. Having a recalculated, more accurate J101 standard would have avoided the offshore wind industry's reliance upon and compliance with the defective J101 standard. This, in turn, would have enabled the offshore wind industry to refrain from using the inaccurate J101 standard, the factor that ultimately was the root cause of titling monopile turbines at Robin Rigg, throughout the North Sea, and elsewhere across Europe.

2. *Black Swans in Other Energy Sectors: The Fukushima Daiichi Example*

Black swan events are not specific to renewable energy industries. They have plagued other traditional energy industries, too. For instance, a black swan event befell the global nuclear energy industry during the 2011 disaster at Japan's Fukushima Daiichi nuclear power facility ("Fukushima"). Specifically, three of Fukushima's six operational nuclear reactors automatically shut down as a result of an earthquake that registered 9.0 – the highest magnitude possible – on

[72] *See* Diamond, *supra* note 6, at 95; *Black Swan*, HASSO-PLATTNER-INST., http://blackswanevents.org/?page_id=26 (last visited Apr. 1, 2021); Deborah Minter, *Facts of the Black Swan*, (Dec. 23, 2017), https://owlcation.com/stem/Facts-of-the-Black-Swan (last visited Apr. 1, 2021) (The phrase "black swan" is credited to Dutch explorer Willem de Vlamingh, who, in 1697, was the first European to arrive in Perth, Australia. Upon his arrival, he discovered black swans living there. This was an unexpected, unprecedented scientific discovery, due to Western belief that only white swans existed, based on Europeans' only seeing white swans prior to such time. Vlamingh's discovery was so unexpected, it changed zoology. However, following this discovery, it seemed obvious that black swans had to exist somewhere, just as other species of different colors were known to exist across the animal kingdom. This is why the phrase "black swan event" has become a phrase synonymous with an unprecedented, highly improbable event that is only understood after it occurs and seems to have been obvious in hindsight.).

[73] *See Black Swan Event*, SEARCHCIO, https://searchcio.techtarget.com/definition/black-swan-event (last visited Apr. 1, 2021).

the Richter scale.[74] Water from the massive tsunami that followed disabled the generators needed to cool the reactors, causing the three units to melt down and leak radiation.[75] This earthquake's magnitude was highly unexpected and improbable. According to the U.S. Geological Survey, it was the fourth largest earthquake in the world since 1900 and was the greatest earthquake Japan experienced in 130 years, ever since modern equipment began recording these phenomena.[76]

In the case *Cooper v. Tokyo Electric Power Co.*,[77] the Fukushima Nuclear Accident Independent Investigation Commission (the "Fukushima Accident Commission") determined that the meltdown of the three reactors at the Fukushima, in hindsight, was reasonably foreseeable due to the facility's geographic location and to the known tsunami risk in the area.[78] Japan is located along the Ring of Fire, an area characterized by shifting tectonic plates, earthquakes, and sub-sea volcanoes along the Pacific Ocean's seabed,[79] making the risk of an earthquake probable, and the risk of a 9.0 earthquake remote, yet possible. These facts contributed to the Fukushima Accident Commission's finding that both the plant's owner and operator, Tokyo Power Company, Inc., together with the applicable regulatory entities, created this "manmade" meltdown, due to this unlikely, yet known, risk that a 9.0 earthquake could occur and their failure to take sufficient

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[74] *See Cooper, supra* note 10, at 1197; *see also Richter Scale*, THE FREE DICTIONARY, https://www.thefreedictionary.com/Richter+scale (last visited Apr. 1, 2021) (The Richter scale measures earthquake magnitudes on a scale of 0–9, with 9 being the most extreme. Each number on this scale represents an increase of 10 times the energy from the immediately prior number.).

[75] *Cooper*, *supra* note 10, at 1197.

[76] *See* Brett Israel, *Deadly Japan Earthquake Upgraded to 9.0-Magnitude*, LIVESCIENCE (Mar. 14, 2011), https://www.livescience.com/13232-japan-earthquake-upgrade-magnitude-9.html.

[77] *Cooper*, *supra* note 10, at 1197.

[78] *Id.* at 1198.

[79] *See Ring of Fire: Home to the Majority of the World's Active Volcanoes*, THOUGHTCO., https://www.thoughtco.com/ring-of-fire-1433460; *see also Ring of Fire: Seismic Belt*, ENCYCLOPEDIA BRITANNICA, https://www.britannica.com/place/Ring-of-Fire (The Ring of Fire is a 25,000 mile-long, horseshoe-shaped area that runs north from New Zealand to Japan and the east coast of Asia, continues northeast along the Alaskan islands and coastline, and then heads south along the west coasts of North America, Central America, and South America. The majority of the world's strongest earthquakes, and over 75% of the world's volcanoes, are found within the Ring of Fire.).

precautionary measures to address this disaster risk and prevent a meltdown.[80]

Globally, people generally are familiar with and reliant upon nuclear energy. This is why the Fukushima black swan event slowed, but not did not completely freeze, the continuation of the nuclear power industry, either in Japan or worldwide. Despite the horrific occurrence at Fukushima, and despite its location on the Ring of Fire, Japan still maintains other nuclear power plants.[81] In response to Fukushima, though, Japan has implemented new, more rigorous safety standards for these facilities, so that Fukushima-like disasters may be avoided in the future.[82] Moreover, the Fukushima black swan event did not completely deter nuclear energy usage globally. Nuclear facilities around the world continue to operate and be built.[83] Had nuclear power been a "less established" type of energy with which fewer people were familiar and reliant, the Fukushima aftermath possibly could have resulted in a more pervasive discontinuance of nuclear energy facilities, both in Japan and throughout the world.

3. Unleash a Flock of Black Swans on the World?

Presently, unique and unusual devices in various renewable energy industry sectors, such as the offshore wind, piezoelectric, and wave energy sectors, are endeavoring to scale-up and make their debut on the American stage. Standards regulating these areas are evolving, just as these technologies, too, continue to evolve. Before these standards can be refined, with as many kinks eliminated as possible, they need to be tested in practice. This means potentially building offshore wind farms along the U.S.'s upper East Coast in federally-

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80 *Cooper*, *supra* note 10, at 1197-98.

81 *See* Society, *Japan's Nuclear Power Plants*, NIPPON (Mar. 10, 2020), https://www.nippon.com/en/features/h00238/japan%E2%80%99s-nuclear-power-plants.html.

82 *Id.*

83 *See* Chris Mooney, *It's the First New Nuclear Reactor in Decades. And Climate Change has Made that a Very Big Deal.*, THE WASH. POST (June 17, 2016), https://www.washingtonpost.com/news/energy-environment/wp/2016/06/17/the-u-s-is-powering-up-its-first-new-nuclear-reactor-in-decades/ (In the U.S., for instance, a new nuclear reactor was added to Tennessee's Watts Bar nuclear plant in 2016.).

designated Wind Development Planning Areas[84] and subjecting them to hurricanes of greater frequencies and stronger magnitudes than these areas have historically experienced.[85] For wave energy, this means

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[84] *See BOEM Wind Planning Areas*, DATA.GOV (Jan. 28, 2020), https://catalog.data.gov/dataset/boem-wind-planning-areas; *Projects – Atlantic Wind Connection*, ATLANTIC WIND CONNECTION (2017), http://atlanticwindconnection.com/projects/ (These areas being considered for offshore wind development, formerly known as Wind Energy Areas (WEAs) are located along the Atlantic Coastline, from southern Virginia up to Massachusetts.).

[85]*See Hurricanes and Tropical Storms*, NASA, https://www.nasa.gov/mission_pages/hurricanes/main/index.html (last visited Apr. 1, 2021) (According to the National Aeronautics and Space Administration ("NASA"), hurricanes are the most powerful weather event on the planet); *see also Precipitation Measurement Missions: Climate Change - Trends and Patterns*, NASA, https://pmm.nasa.gov/science/climate-change (last visited Apr. 1, 2021) (Citing the Intergovernmental Panel on Climate Change's ("IPCC 's") 2011's findings, NASA's Goddard Space Flight Center has also indicated that increases in global temperatures as the world's climate changes may result in more chaotic weather events and intense storms, in areas where such storms previously were uncommon.); *see also* Steve Graham & Holli Riebeek, *Hurricanes: The Greatest Storms on Earth*, NASA EARTH OBSERVATORY (Nov. 1, 2006), https://earthobservatory.nasa.gov/features/Hurricanes (Hurricanes that proceed up the U.S.'s Atlantic Coast generally form over the Atlantic Ocean, west of Africa, due to the temperature differential between the warm air over the Sahara Desert and the air over the Gulf of Guinea. The thunderstorms generated as a result of this differential can develop into hurricanes.); *see also Tropical Cyclone Climatology: Hurricane Return Periods,* NAT'L OCEANIC AND ATMOSPHERIC ADMIN. [NOAA] - NAT'L HURRICANE CTR. AND CENT. PAC. HURRICANE CTR., https://www.nhc.noaa.gov/climo/ (database updated on Apr. 12, 2021) (As a result of increasing global temperatures and warmer ocean waters, NOAA estimates that the hurricane return period (e.g., over a period of 100 years, the number of years within that period between times that a Category 3, Category 4, or Category 5 hurricane occurred) along the U.S.'s East Coast is estimated to be approximately 12 – 16 years from the Virginia coastline up through the Maryland coastline and along the lower Massachusetts coastline, 17 – 24 from the Delaware coastline up through Rhode Island coastline, and 25 – 50 years between the upper Massachusetts and Maine coastlines. These estimates indicate that such areas respectively are likely to experience Category 3 or higher hurricanes approximately 7 times, 5 times, and 2 – 4 times during the next 100 years.); *see Saffir-Simpson Hurricane Wind Scale*, NOAA - NAT'L HURRICANE CENTER AND CENT. PAC. HURRICANE CENTER, https://www.nhc.noaa.gov/aboutsshws.php (database updated on Apr. 12, 2021) (According to the Saffir-Simpson Hurricane Wind Scale, a scale consisting of rating categories 1 – 5 for wind speeds, devastating damage can occur from Category 3 hurricanes (wind speeds of 111 – 129 mph), while catastrophic damage can occur from Category 4 hurricanes (wind speeds of 130 – 156 mph) and Category 5 hurricanes (wind speeds of 157 mph or higher).).

planning for the steepness, period, and height of hundred-year waves[86] that may occur with greater frequency. Proactively anticipating these wave anomalies may inform the designs of ultra-modern wave energy devices being developed and tested at various locations globally, as discussed in Part V.[87] For piezoelectric energy generated from footsteps on specially-designed outdoor flooring tiles, this means planning for extreme weather event impacts to which these devices may be subjected, including torrential rain, heavy snowfall, and blistering heat.[88] Testing these standards in practice at a demonstration project/prototype level minimizes the very real risk that other black swan events may be unleashed.

Industries grow and evolve by taking steps forward and not shying away from technologies merely because they are unusual or out-of-the-ordinary. Industries that roll-out technologically innovative devices in scaled-up form that are untested in the real world, though, need to apply lessons learned from both *MT Højgaard* and *Cooper*. This will enable such industries to proceed forward mindfully, taking adequate precautions by using available knowledge to develop standards that account for remote, yet probable and foreseeable, extreme atmospheric and oceanic events that are likely to occur with higher frequency in the future. These industry standards cannot be static, but, rather, need to be mutable, continuously evolving in tandem with the technologies they respectively regulate, enabling these standards to be as resilient as possible. These standards can then serve as a shield, protecting infant renewable energy industries from risks, including black swan risks, associated with real-world dangers that occur when expectations based on historical data misalign with reality.

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[86] *See* WAVE ENERGY CONVERSION, 1, 170 (R. Bhattacharyya & M.E. McCormick, eds., Elsevier Science Ltd. 2003), https://books.google.com/books?id=UGAXRwoLZY4C&pg=PA170&dq=%22hundred+year+wave%22&sig=ACfU3U1rgLoA2QatLY9vDgOTUzYemz84fQ#v=onepage&q=%22hundred%20year%20wave%22&f=false (Wave height for a particular wave depends on factors including climate, latitude, and fetch. The term "fetch" refers to the wind speed and the duration the wind blows across a fixed distance of ocean. *See Waves and Sea Level, supra* note 24. A "hundred-year wave" refers to a wave that occurs once or more within a period of 100 years, whose height meets or exceeds the highest of all wave heights used to calculate the average wave-height in a particular area.).

[87] *See* Part V., *infra* subsec. A., B. & C.

[88] *See FAQs – What is Pavegen's Plan for the Future?*, PAVEGEN (2019), https://pavegen.com/faq/#1558421823148-9b735482-6469 (Pavegen recently launched a digital platform that rewards people for taking footsteps on its energy-generating tiles.).

II. THE IMPORTANCE OF A RENEWABLE ENERGY TECHNOLOGY GAINING PUBLIC BUY-IN THROUGH CONNECTEDNESS AND HUMAN ENGAGEMENT

In addition to standards, renewable energy projects must possess other factors to be practically perfect when they are rolled-out publicly, in utility-scale form. Expertise from experienced industry leaders, as well as the opportunity for the public to engage and connect with a technology, as well as feel enthusiasm about it, are key factors that a novel renewable energy project must possess. These attributes best-position the project to gain public buy-in when it is placed in service. Demonstration projects, also known as pilot projects, can accomplish these goals. The Block Island Wind Farm, an offshore wind farm demonstration project, and Pavegen's numerous worldwide, small-scale arrays of piezoelectric indoor and outdoor flooring tiles, are excellent examples of pilot projects from two very different renewable energy sectors that are accomplishing these objectives. Juxtaposing these demonstration projects with the process used to roll-out the Ivanpah CSP facility exemplifies what can happen in terms of public perception if the general public lacks a feeling of connectedness with a utility-scale renewable energy project.

A. *The Block Island Wind Farm: Rolling Out the First US Offshore Wind Project Mindfully*

Public excitement about a new technology is tremendously valuable. Enthusiasts highlight the technology's positive qualities while the public promotes the technology itself and generates positive buzz about it. A company experienced in the operation and maintenance ("O&M") of breakthrough renewable energy devices showcasing a particular technology can fuel this public enthusiasm from behind the scenes. This is what occurred at the Block Island Wind Farm ("Block Island"), an offshore wind pilot project located off the Rhode Island coast and the U.S.'s first utility-scale offshore wind project.[89] In addition to being groundbreaking, this demonstration project possesses many factors that have enabled it to get off the ground in a "practically perfect" manner.

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[89] Phil McKenna, *Offshore Wind Lands in America*, PBS.ORG (May 1, 2017), https://www.pbs.org/wgbh/nova/article/block-island-wind/.

1. Unparalleled Expertise – Selection of "Varsity" Players

Having a company with a proven track record and industry expertise in either the new technology itself or in a field upon which that new technology relies is an extremely valuable commodity when it comes to debuting new technologies publicly. Given the technology's novel nature, only a small number of companies may possess these characteristics. These companies, the leaders who have established themselves as all-stars in their respective fields, already possess irreplaceable, on-the-job training. Consequently, their ability to showcase the particular renewable energy technology from a lessons learned perspective make them great assets to a new renewable energy project. Knowing what to expect from the project's outset and having experience handling atypical events makes these companies the varsity athletes among other players. Launching a new technology with a strong varsity team, compared to a team consisting of junior varsity or rookie players who lack this real-world experience, gives that project an industry advantage. While not evident through the technology-deploying devices themselves, this aspect of project operations and management advantages the project from its outset.

Block Island has embraced this real-world know-how factor, given that Deepwater Wind was its original project developer and that Ørsted US Offshore Wind[90] currently owns and operates this facility. Deepwater Wind's parent company was D.E. Shaw, a highly successful global investment and technology development hedge fund, with a reputation for careful risk management and interest in leading investment in U.S. renewable energy development.[91] Having a D.E. Shaw affiliate on its team meant that Block Island would have a varsity player at the helm of its finance team that was well-versed in complex investment and finance matters. Moreover, this meant that the Block Island project itself improved its likelihood for success at its outset, given that Deepwater Wind would assemble a well-baked financing package, with no gaps in financing that ratepayers would need to fill. Such gaps are likely to sour ratepayers toward the technology and

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[90] *See* Betsy Lillian, *Ørsted Completes $510 Million Deepwater Wind Acquisition*, N. AM. WINDPOWER (Nov. 8, 2018), https://nawindpower.com/orsted-completes-510-million-deepwater-wind-acquisition (Ørsted US Offshore Wind is the company formed when its parent company, Ørsted, acquired U.S. offshore wind developer Deepwater Wind in fourth quarter 2018.).

[91] *What We Do - Spotlights: Renewables*, D. E. SHAW & CO., https://www.deshaw.com/what-we-do/renewables (last visited Apr. 1, 2021).

derail demonstration projects, as has occurred previously in the U.S.'s offshore wind sector.[92]

In the offshore wind sector, Ørsted is a varsity, all-star player. A Danish company, Ørsted is the global leader in the development, construction, and operation of offshore wind farms, with projects in all corners of the world, including in Denmark, the UK, Germany, and Taiwan.[93] In fourth quarter 2018, Ørsted acquired Deepwater Wind to form Ørsted US Offshore Wind, and, in the words of Thomas Brostrøm, then-president of Ørsted North America, "tak[e] the U.S. [offshore wind] market to the next level."[94] Ørsted's unparalleled real-world experience and proven track record for its expertise operating offshore wind farms provides the Block Island project with legitimacy and credibility from a behind-the-scenes perspective.

2. *Fascination with Futuristic Devices Creates Excitement about the Technology Being Showcased*

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[92] *See* Diane Bailey, *Court Reprieve for New Jersey Offshore Project*, WINDPOWER MONTHLY (Aug., 19, 2014), https://www.windpowermonthly.com/article/1308307/court-reprieve-new-jersey-offshore-project?_ga=2.8859509.152855824.1586182379-1141821332.1586182379; David Watson, *Fishermen's Energy Suffers Court Setback*, WINDPOWER MONTHLY (June 1, 2015), https://www.windpowermonthly.com/article/1349408/fishermens-energy-suffers-court-setback?_ga=2.175112674.152855824.1586182379-1141821332.1586182379 (For instance, Fishermen's Energy, an offshore wind project developer, was interested in launching a 5-turbine, 25 MW offshore wind pilot project off Atlantic City, NJ's coast, using Chinese 5MW XEMC turbines. However, due to issues relating to the project's financing, the New Jersey Board of Public Utilities ("BPU") voted unanimously against the project in March 2014. The BPU re-visited its decision following an August 2014 New Jersey state superior court appellate division ruling. Nevertheless, the BPU arrived at the same decision, noting that despite the $47 million federal grant award Fishermen's Energy was positioned to receive for this project in May 2014, the project remained financially unfeasible. Specifically, New Jersey residents would ultimately be the parties bearing the gap in the project's financing, as would be reflected in their higher cost of electricity. The BPU considered this cost burden unreasonable. The New Jersey Superior Court, Appellate Division agreed with the BPU in its June 2015 ruling regarding the project's financial viability.).

[93] *About Ørsted*, ØRSTED, https://us.orsted.com/Wind-projects (last visited Apr. 1, 2021); *Our Business*, ØRSTED, https://orsted.com/en/Our-business/Offshore-wind/Our-offshore-wind-farms (last visited Apr. 1, 2021) [hereinafter Ørsted Acquisition].

[94] Ørsted Acquisition, *supra* note 93 (Ørsted acquired Deepwater Wind for a purchase prices of $510 million, obtaining a 100% equity stake in that company.).

Public intrigue, curiosity, and fascination with futuristic renewable energy devices can aid in obtaining public buy-in for the technology being showcased. Due to their never-before-seen, unique appearances, these devices have the potential to transfix and awe people. Familiarizing the public with these energy-deploying devices and explaining how they perform demystifies these devices and minimizes the risk of people experiencing "future shock."[95] Indeed, familiarization elevates these devices from being mere bizarre, science fiction-like contraptions to being cutting-edge, regal, artistic masterpieces whose function and operation the average person can grasp. The public's gaining understanding about a device that utilizes a particular renewable energy with which they are generally unfamiliar aids in promoting the type of energy that device showcases.

Block Island, embracing its role as the first U.S. grid-connected, utility-scale offshore wind farm, has tapped into people's curiosity about gigantic offshore wind turbines and offshore wind energy generally. This is because Block Island, as a demonstration project, familiarizes the public with cutting-edge renewable energy devices as well as with a technology that most Americans have not observed first-hand. Specifically, Block Island features the best offshore wind industry technology that was available on the market in 2015, the year its construction began. The 30 MW Block Island array consists of five offshore wind turbines, all 6 MW GE Haliade 150 devices that were considered state-of-the-art at that time (the "Block Island Turbines").[96] These turbine models were considered "next generation" relative to older offshore turbine models, insofar as they use both a direct drive operating system without a gearbox, as well as a permanent-magnet generator.[97] This streamlining in turbine design decreased the number of mechanical parts, making each Block Island Turbine more resilient, less prone to mechanical failure issues, and

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[95] *Future Shock*, MERRIAM-WEBSTER DICTIONARY, https://www.merriam-webster.com/dictionary/future%20shock (last visited Apr. 1, 2021) ("Future shock" is psychological phenomenon where a person suffers a form of mental distress because the technology they are seeing or experiencing is too vastly different from the ordinary items they are used to seeing in their existing environment.).

[96] *Block Island Wind Farm*, POWER TECHNOLOGY, https://www.power-technology.com/projects/block-island-wind-farm/ (last visited May 20, 2021).

[97] *First Offshore Installation of Alstom's Haliade-150*, MODERNPOWERSYSTEMS (Nov. 22, 2013), https://www.modernpowersystems.com/news/newsfirst-offshore-installation-of-alstoms-haliade-150.

more likely to reduce O&M costs over the course of that turbine's useful life than predecessor turbine models.[98]

Moreover, due to evolution and advancement in turbine design technology over only a few years' time, when the Block Island Turbines were installed, they ranked among the tallest offshore wind turbines globally, dwarfing predecessor turbine models manufactured just several years earlier. The Block Island Turbines, all of which are double the size of the offshore turbines installed at Robin Rigg less than a decade earlier,[99] have a tower height that stretches approximately 100 meters, or approximately 328 feet, from sea level into the sky – a height that is approximately 20 feet taller than the Statue of Liberty, measuring from Lady Liberty's statue base to the tip of her torch.[100] To add to the sheer ominousness of each turbine, each blade on its 3-pronged rotor reaches an additional approximately 75 meters, or approximately 246 feet, into the sky,[101] for a total turbine height of approximately 574 feet (328 feet + 246 feet = 574 feet). This means that, including blade height, each offshore wind turbine is taller than the 554-foot high Washington Monument in Washington, D.C.,[102] by approximately 20 feet. Given the Block Island Turbines' height, these colossal devices reach higher into the atmosphere than their smaller predecessor offshore wind turbine relatives. At higher altitudes, the wind blows at faster speeds, with more consistency and less turbulence.[103] Notably, at faster wind speeds, the amount of energy generated from wind increases by the cube (third power) of the wind

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[98] *Id.*

[99] Original *MT HØjgaard* Judgment, *supra* note 7; *MT HØjgaard* Appeal, *supra* note 27.

[100] *See How Tall is the Statue of Liberty?*, WORLDATLAS, https://www.worldatlas.com/articles/how-tall-is-the-statue-of-liberty.html (last visited Apr. 1, 2021); *see also Convert 100 Meters to Feet*, CALCULATEME, https://www.calculateme.com/length/meters/to-feet/100 (last visited Apr. 1, 2021); *MT HØjgaard* Appeal, *supra* note 27.

[101] *See First Offshore Installation of Alstom's Haliade-150*, *supra* note 97; *see also Convert 75 Meters to Feet*, CALCULATEME, https://www.calculateme.com/length/meters/to-feet/75 (last visited Apr. 1, 2021).

[102] *See* B. Philip Bigler, *Washington Monument – Monument, Washington, District of Columbia, United States*, BRITANNICA, https://www.britannica.com/topic/Washington-Monument-Washington-DC (last visited Apr. 1, 2021).

[103] Kimberly Diamond, *Technology, Curtailment, and Transmission: Innovations and Challenges Facing Today's U.S. Wind Energy*, 41 COLUM. J. ENVTL. L., 4 (Apr. 6, 2016), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2896213.

speed.[104] This means the taller the turbine, the greater the wind speeds the turbine can access and the more energy it can produce.[105] Consequently, the Block Island Turbines can generate substantially more power than other competitor devices that previously were the market standard.

3. *Physically Engaging with the Innovative "Tourist Attraction" Device Builds a Sense of Connectedness with the Technology*

Generating public buy-in and positive publicity for a novel renewable energy project is imperative during the roll-out of the renewable energy technology and the device employing it. Enabling people to "experience" and connect with the project physically while learning about how it operates accomplishes this goal. This is because this experiential learning process instills in people a sense of connectedness and engagement with the renewable energy devices as well as the technology it is showcasing. Labeling a project as a "tourist attraction" enhances this experiential learning aspect related to the project, insofar as such a designation shifts people's focus to the project's novelty, rather than to its being strictly an energy-generating device. This focus subconsciously instills in people a positive vibe about the project. Just as assigning a name to a group of symptoms can lend legitimacy to an "illness" that may or may not actually exist,[106] the mere fact that Block Island has been labeled an "attraction" has an allure, compelling people to be positively predisposed toward the technology, in advance of witnessing it. Indeed, names are very

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[104] *See id.*; *see also The Power of Wind: Cube of Wind Speed*, WINDPOWER.ORG, http://ele.aut.ac.ir/~wind/en/tour/wres/enrspeed.htm; *Wind Speed and Power*, IOWA ENERGY CTR., https://perma.cc/JRZ6-6C83 (As illustration, a wind speed of 10 mph produces 10 x 10 x 10 = 1,000 in terms of available energy, whereas a wind speed that increases by just one mph produces 11 x 11 x 11 = 1,331 and a wind seed that increases by 2 mph produces 12 x 12 x12 = 1,728. These numbers demonstrate that a slight wind speed increase results in a much higher energy output.).

[105] Diamond, *supra* note 103, at 4.

[106] E.g. Simon Chapman, *Spatio-Temporal Differences in the History of Health and Noise Complaints about Australian Wind Farms: Evidence for the Psychogenic,"Communicated Disease" Hypothesis,* SYDNEY SCH. OF PUB. HEALTH, U. OF SIDNEY, AUSTL., 4 (2006) (In his study focusing on the "communicated disease" hypothesis, Simon Chapman discusses how "labeling" a group of symptoms as a disease is a main feature that accelerates the proliferation of mass psychogenic illness with respect to maladies people experience upon exposure to wind farms.).

powerful tools for engendering certain feelings toward the items with which they are associated.[107]

Block Island is endeavoring to garner favorable publicity and public buy-in by marketing itself as a tourist attraction. There is no substitute for first-hand experience. Guided ferry tours being offered around this offshore wind farm[108] offer the public an opportunity to observe the Block Island Turbines up-close for themselves and learn about the benefits they offer. These tours' experiential component also enables tourists to observe first-hand how the Block Island Turbines operate. Specifically, people are presented with the opportunity to hear and assess for themselves the amount of noise the turbines actually make. Also, through the guided tour, tourists learn about the quantity of energy these turbines produce, how clean wind energy replaced a generator that had been running on the island since 1925 and consumed approximately a million gallons of diesel fuel annually,[109] and how this project enables the approximately 1,000 Block Island, Rhode Island residents to save money on their electric bills.[110] As a result of their overall experience on the ferry tour, tourists dispel for themselves myths about offshore wind that they or others whom they know may have read or heard. When these tourists share their first-hand knowledge with family and friends, they are essentially providing a continuous grassroots promotional campaign for the U.S. offshore wind industry.

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[107] *See Putting Feelings into Words Produces Therapeutic Effects in the Brain*, SCIENCEDAILY, (June 22, 2007), https://www.sciencedaily.com/releases/2007/06/070622090727.htm (According to a UCLA study, neural evidence shows that labeling emotions enables one to practice mindfulness meditation by focusing on present-moment experiences); *see also* Mary C. Lamia, *Emotional Memories: When People and Events Remain with You*, PSYCH. TODAY (Mar. 6, 2012), https://www.psychologytoday.com/us/blog/intense-emotions-and-strong-feelings/201203/emotional-memories-when-people-and-events-remain (Naming something can also trigger "cued recall," igniting emotional memories.).

[108] *Come Sail with Us to America's First Offshore Wind Farm!*, BLOCK ISLAND WIND FARM TOURS, https://biwindfarmtours.com/.

[109] *See* Abby L. Harvey, *Nation's First Offshore Wind Farm Releases Community from Decades of Diesel*, POWER (Dec. 1, 2017), https://www.powermag.com/nations-first-offshore-wind-farm-releases-community-from-decades-of-diesel/ (last visited May 20, 2021); Crystal Bui, *Block Island Shuts Down Generators, Draws Power from Wind Farm* (May 1, 2017), https://turnto10.com/news/local/block-island-draws-power-from-wind-farm (last visited May 20, 2021).

[110] *See* Harvey, *supra* note 109; Bui, *supra* note 109.

4. *Using Tourists' Social Media Posts to Generate Positive Publicity*

Tourists who ride the Block Island ferry help advertise and popularize offshore wind through their social media posts, items tantamount to publicity campaigns. Similar to the Grand Canyon or other "natural wonder" tourist attractions, Block Island is a "man-made wonder" tourist attraction. For this reason, a tourist's family and friends may not yet have seen this wonder, making that tourist a "first mover" among these others to visit Block Island. If these others are the tourist's social media contacts, by snapping selfies and other photos that feature the Block Island Turbines and sharing them with a brief post describing his or her experience, the tourist becomes a first mover and attains higher prestige within his or her social media circle.[111] Moreover, to the extent that this post gets shared extensively and gains mass appeal, the post may garner "influencer" status for this tourist, instilling in that person a sense of accomplishment or personal pride.[112] A tourist, then, can create something that he or she values as a result of using a visual medium to promote this wind farm. Additionally, a tourist's photos can potentially drive behavior, insofar as those receiving the communication may themselves be inspired to visit Block Island. The ripple effect these factors collectively may have throughout multiple social media circles illustrates how social media technology assists in elevating a new-on-the-scene technology such as offshore wind to that of a unique phenomenon that is a must-see for all.

Popularizing offshore wind through social media can potentially assist in public receptiveness to this technology during its roll-out on a much larger scale in areas relatively close to the demonstration project site. Currently, Ørsted has been granted development rights for six offshore wind projects that will be located off the coasts of Rhode Island, Connecticut, New York, New Jersey, Delaware, Maryland, and Virginia, and will have a collective capacity

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[111] Kimberly Diamond, *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*, 28 FORDHAM ENVTL. L. R. 136, 173 (2017), http://ir.lawnet.fordham.edu/elr/vol28/iss2/1/.

[112] *Id.*

of 2,700 MW.[113] By having tourists engender widespread positive feelings toward offshore wind within their social networks regarding the Block Island demonstration project, these tourists can effectively help the project developer to conduct a virtual ground campaign, with the tourists themselves serving as the proponents for the technology. Consequently, the grand-scale offshore wind farm projects Ørsted is currently slated to develop along the U.S.'s Atlantic Coast may meet with more public receptiveness, rather than public push-back and dissent, as a result of the Block Island project.

B. Pavegen Piezoelectric Flooring Arrays Take Public Engagement to the Next Level

Pavegen, a UK-based developer of piezoelectric outdoor and indoor flooring tiles, has done a masterful job of harnessing people's connectedness with its devices to earn public buy-in for its product. The Pavegen model involves proving its expertise, product competitiveness, market savvy, and company resilience through the installation of the company's signature piezoelectric flooring arrays in multiple countries and in a diverse variety of venues. Pavegen showcases its ever-evolving state-of-the-art devices that deploy kinetic energy created from footsteps in locations host to vast amounts of foot traffic. Pavegen also combines this innovative technology with apps on hand-held mobile and cellular devices that track the piezoelectric energy a person generates. As a result, Pavegen is attracting well-established energy industry players as its partners. The goodwill and name recognition associated with these others elevates Pavegen's brand recognition. It also helps Pavegen to gain consumer loyalty and earn respect for piezoelectricity as a viable renewable energy. Through its pilot projects, then, Pavegen is pairing technology with public engagement, proving that endorsement of a renewable energy device can create a disruptive force for how people view energy and make economic decisions.

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[113] *Our Projects in the U.S.*, ØRSTED, https://us.orsted.com/Wind-projects (last visited Apr., 1, 2021) (The projects for which Ørsted has been granted development rights include: (1) Revolution Wind, a project located off the Rhode Island and Connecticut coasts; (2) South Fork Wind, a project off the coast of Montauk Point, the tip of New York's Long Island peninsula; (3) Sunrise Wind, a second project off the Montauk Point coast; (4) Ocean Wind, a project located off New Jersey's southern coast; (5) Skipjack Wind Farm, a project located off the Delmarva (Delaware, Maryland, and Virginia) coast; and (6) Coastal Virginia Offshore Wind, a project located off the Virginia Beach coast.).

1. *Unparalleled Expertise: Going Above and Beyond to Gain Credibility for Both the Technology and the Device Deploying It*

Pavegen, a start-up company, embodies the importance of establishing market credibility, becoming a trusted brand name, and becoming the industry leader known for its unparalleled expertise in piezoelectric flooring. To achieve these milestones, Pavegen distinguished itself from other piezoelectric flooring companies internationally. It is instructive, therefore, to analyze both the piezoelectric flooring industry's landscape prior to when Pavegen publicly introduced its first arrays, as well as Pavegen's strategic approach that enhanced its ability to attain industry frontrunner status within a relatively obscure renewable energy industry.

a. *Recent History of Newcomers in the Piezoelectric Flooring Sector*

During the last two decades, many companies throughout the world rolled-out their piezoelectric flooring products publicly, yet they were unable to solidify their places as global leaders in the piezoelectric flooring field. For instance, from Oct. 16, 2006 – Dec. 8, 2006, the East Japan Railway Company (JR East), in a joint venture with JR East Consultants Company and the New Energy and Industrial Development Organization (the "Japan Joint Venture Team"), deployed its piezoelectric Power-Generating Floor demonstration project in Japan's Tokyo Station subway station, which use the kinetic energy from people's footsteps to power ticket gates at the Marunouchi North Exit.[114] The Japan Joint Venture Team launched a second, larger Power-Generating Floor demonstration project during January 19, 2008 – early March 2008, once again in Tokyo Station, at its concourse, ticket gates, and stairs near the Yaesu North Exit.[115] Despite these two successful demonstration projects, the global media has not mentioned anything further about either the Japan Joint Venture Team or its Power-Generating Floor technology. This is why

[114] *Demonstration Experiment of the 'Power-Generating Floor' at Tokyo Station*, E. JAPAN RAILWAY CO. (Jan. 11, 2008), https://www.jreast.co.jp/e/development/press/20080111.pdf.

[115] *Id.; see also Energy-Generating Floors to Power Toyko Subways*, INHABITAT (Dec. 11, 2008), https://inhabitat.com/tokyo-subway-stations-get-piezoelectric-floors/.

public awareness about these demonstration projects remains relatively non-existent, such as in the U.S.

While other U.S.-based start-ups also debuted their piezoelectric flooring devices as demonstration projects, they, too, did not meet with widespread recognition for their inventions. As illustration, circa 2010, a Michigan-based start-up called POWERLeap installed its piezoelectric flooring device to create piezoelectric sidewalks in Ann Arbor, Michigan that harvested kinetic energy from footsteps to power streetlights.[116] More recently, in 2016, New York City-based EnGoPLANET rolled out its footstep- and solar-powered streetlights at Boulder Plaza in the Las Vegas Arts District (the "Las Vegas Project").[117] Notably, another company acquired POWERLeap's technology, and EnGoPLANET discontinued its manufacturing of piezoelectric flooring devices.[118] Irrespective of how well these companies' respective devices operated, there was little fanfare, coverage, or information that permeated news channels and social media outlets countrywide regarding either these devices or piezoelectric flooring technology. This lack of widespread publicity was a hurdle these start-ups could not overcome. Consequently, the phenomenon of kinetic sidewalk technology failed to gain notoriety in the U.S., thereby preventing POWERLeap's and EnGoPLANET's brand names from rising to the level of national, mainstream public consciousness.

In recent years, other European start-ups, such as Enviu and Energy Floors, have gained notoriety for their piezoelectric flooring. However, this acclaim at first was tainted with the negative connotation of piezoelectricity being a "gimmicky" energy that was not to be taken seriously, due to its being used only in gadget-like

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[116] A.K. Streeter, *Six Sidewalks that Work While You Walk,* TREEHUGGER (Feb. 22, 2010), https://www.treehugger.com/clean-technology/six-sidewalks-that-work-while-you-walk.html.

[117] Joshua Marks, *World's First Streetlights Powered by Footsteps Installed in Las Vegas*, INHABITAT (Nov. 8, 2016), https://inhabitat.com/worlds-first-streetlights-powered-by-footsteps-installed-in-las-vegas/.

[118] *See POWERLeap*, SENSITILE, https://www.sensitile.com/projects/powerleap (Minimal information about POWERLeap flooring tiles is located on the Sensitile Systems website.); *see also Projects In: United States*, ENGOPLANET, https://www.engoplanet.com/projects (EnGoPLANET's website completely omits mention of the piezoelectric devices it previously deployed. For their Las Vegas Project, only a short video clip featuring the streetlights themselves appears.).

products. As an example, more than a decade ago, Enviu partnered with Professor Han Brezet of Delft University of Technology to install piezoelectric flooring in the Netherlands, inside the Wvatt ("WATT") nightclub in Rotterdam.[119] Dancers' footsteps power the LED lights embedded in this flooring, which constitutes the club's dancefloor.[120] However, when this futuristic flooring gained international acclaim in 2009, certain people did not applaud this groundbreaking effort to deploy at scale a relatively unknown type of renewable energy, in advance of years of future design refinement or further product research and development that could transpire. Instead, they quickly pointed out the inefficiencies in this flooring's design, doubting piezoelectricity's feasibility as a competitive energy source and calling piezoelectricity a "poor use of resources," a "complete hoax" conceptually, and uneconomical.[121]

Despite these taunts and public non-receptiveness among vocal objectors, Enviu has survived the test of time and has now existed for over a decade. [122] While it has partnered with a company called Energy Floors to rent and sell piezoelectric flooring in over 20 countries for exhibitions and for locations in the transportation, architecture, and education sectors, the specific whereabouts and purpose of these arrays are not specified on the Energy Floors website.[123] This information's absence raises questions about the function for which Enviu's devices are being used. More precisely, it is unclear whether these arrays are intended to serve as decorative, art-like commodities, or as futuristic,

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[119] David Atkinson, *The Power of Dance*, THE GUARDIAN (Sept. 12, 2008), https://www.theguardian.com/travel/2008/sep/13/rotterdam.netherlands.

[120] *Id.*

[121] *See* Xuguang Leng, Comment to *Breakthroughs in Piezoelectric Power: Raising Public Awareness is a Step in the Right Direction for U.S. Sustainable Development*, ENERGYCENTRAL (Apr. 23, 2009), https://energycentral.com/c/um/breakthroughs-piezoelectric-power-raising-public-awareness-step-right-direction#ece-comments ; *see also* Jim Beyer Comment to *Breakthroughs in Piezoelectric Power: Raising Public Awareness is a Step in the Right Direction for U.S. Sustainable Development*, ENERGYCENTRAL (Apr. 27, 2009), https://energycentral.com/c/um/breakthroughs-piezoelectric-power-raising-public-awareness-step-right-direction#ece-comments*; see also* Richard Vesel Comment to *Breakthroughs in Piezoelectric Power: Raising Public Awareness is a Step in the Right Direction for U.S. Sustainable Development*, ENERGYCENTRAL (Apr. 28, 2009), https://energycentral.com/c/um/breakthroughs-piezoelectric-power-raising-public-awareness-step-right-direction#ece-comments.

[122] *Ventures – Energy Floors*, ENVIU, https://www.enviu.org/work/energy-floors/ (last visited Apr. 1, 2021).

[123] *Id*.

disruptive equipment that can replace traditional, conventional energy-powered lighting fixtures. As the Enviu and Energy Floors example illustrates, even a start-up company that has survived for years in the piezoelectric flooring industry may have difficulty convincing the world that piezoelectric flooring, with further research and development, could be more than just an expensive, quirky, novelty item.

b. *Steps Pavegen Took to Distinguish Itself from Others*

(i) Highly Visible Demonstration Projects Providing Functional Credibility

To be a credible trailblazer in piezoelectric flooring, Pavegen likely drew upon lessons learned across three continents from other companies involved in this niche area. First, similar to the flashing dancefloor concept that WATT employed, Pavegen designed its product to be aesthetically pleasing to the masses in terms of flash and glam appeal, with sufficient functionality to be taken seriously as a viable energy-producing product, rather than a gimmicky, high-tech toy. As illustration, Pavegen installed one of its early pilot projects in the walkway from the West Ham tube station to the Olympic Greenway at the 2012 London Olympics (the "London Olympics Project"), where its flooring lit up like a dancefloor while also collecting five to seven watts (or five to seven joules per second[124]) of energy from each footstep.[125] The energy generated from the vast amount of foot traffic on the Pavegen tiles throughout this walkway was estimated to be approximately 72 million joules, enough to power 10,000 mobile phones for one hour each.[126] This energy was stored in batteries and used to power 12 LED floodlights that lit the walkway.[127] Placing the Pavegen array at an event site with an immense global viewership was strategic genius, as it was the first time a piezoelectric flooring device was deployed in transportation infrastructure and

[124] *See Electricity and Energy Terms in Lighting (J, kW, kWh, Lm/W)*, STOUCHLIGHTING, https://www.stouchlighting.com/blog/electricity-and-energy-terms-in-led-lighting-j-kw-kwh-lm/w (last visited Apr. 1, 2021) (A joule is an international standard by which energy is measured. One watt is the equivalent of one joule per second (1W – 1 J/s).).

[125] Wired Staff, *People-Power Lights 2012 Olympic Walkway*, WIRED (July 19, 2012), https://www.wired.com/2012/07/people-light-olympic-walkway/.

[126] *Id.*

[127] *Id.*

produced tangible results the world could see and understand.[128] Demonstrating to the world that piezoelectricity was economical, a good use of resources, and not a hoax elevated this energy type and the Pavegen name to the mainstream, giving both credibility.

As a further boost to piezoelectricity being viewed as a safe, cost-effective renewable energy, in 2014, Pavegen rolled out another pilot project as a 200-tile array of kinetic panels beneath a soccer field's AstroTurf in the Morro da Mineira favela, an impoverished hillside community of approximately 15,000 residents located near Rio de Janeiro, Brazil (the "Brazilian Soccer Field Project").[129] Players on this field, ranging from young children to older adults, used the power of footfall, combined with electricity generated from solar panels around the field, to generate enough electricity to power six LED floodlights.[130] This field's popularity resulted in its continuous usage, with players occupying the field from 5 a.m. to midnight on a regular basis, and with lighting available throughout this timespan.[131] This, in turn, had the positive consequence of generating the entire community's support, spurring the renovation of bars and housing located near the field, and inspiring children to associate science with fun and to become interested in pursuing careers in scientific fields.[132] The Brazilian Soccer Field Project cleared doubt about Pavegen's piezoelectric devices' ability to be competitively functional for purposes of generating electricity and lighting, compared to traditional electricity-generating sources for lighting. It also proved that piezoelectricity can, indeed, have widespread appeal to people of all ages and backgrounds, and can play a role in retrofitting and illuminating the built environment, from destitute areas to upscale, urban smart cities of the future.

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[128] *Id.*

[129] 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 2014 Video] (For a more in-depth discussion of Pavgen's array at the Morro da Mieneira favela, *see* Diamond, *supra* note 111, at 136, 185–186.).

[130] Donna Bowater, *Pelé Unveils Unique Football Pitch Where Players' Energy Produces Electricity*, THE TELEGRAPH (Sept. 11, 2014), https://www.telegraph.co.uk/news/worldnews/southamerica/brazil/11089313/Pele-unveils-unique-football-pitch-where-players-energy-produces-electricity.html; *Brazilian Soccer Field Harnesses Player-Power*, CBS NEWS (Sept. 11, 2014), https://www.cbsnews.com/news/soccer-field-power-players-kinetic-energy-brazil-electricity/ [hereinafter CBS News Article].

[131] Shell 2014 Video, *supra* note 129.

[132] *Id.*

(ii) Partnering with Global Giants in the Energy Industry

By partnering with giants in the global energy industry as well as with famous athletes, and by having these others promote its piezoelectric flooring device, Pavegen not only distinguished itself from its competition, but it bolstered the perception of piezoelectricity and as a technology the world needs to take seriously. For instance, Pelé, a world-famous Brazilian superstar soccer player,[133] was present at the inaugural game held at the Brazilian Soccer Field Project.[134] To publicize his participation in this event, Royal Dutch Shell, a global, traditional energy company and a Pavegen partner, used its own marketing capabilities and brand stature to create YouTube video footage featuring this iconic star, and to facilitate international press coverage for the Brazilian Soccer Field Project's opening night.[135]

Also, in 2013, Pavegen installed 178 tiles of its piezoelectric flooring system along the first 82-foot stretch of the Champ Elysées at the beginning of the 37th Paris Marathon ("Paris Marathon Project").[136] Partnering with one of the largest global electronic engineering firms, Schneider Electric, at this event, Pavegen proved that its device produced enough energy to power lights and information kiosks,[137] and that large companies in the electricity field were sufficiently confident in this technology to associate their brand names and reputations with it. Leveraging brand goodwill from already-established global energy powerhouses and linking them to its own brand name helped Pavegen gain instant credibility, providing an additional reason for earning public buy-in globally, and

[133] *Pelé*, ENCYCOPEDIA.COM, https://www.encyclopedia.com/people/sports-and-games/sports-biographies/pele-soccer-player (last visited Apr. 1, 2021).

[134] *In Brazilian Slum, Running of Players on New Scientific Soccer Field Helps Power the Lights*, ASSOCIATED PRESS (Dec. 12, 2015), https://www.foxnews.com/world/in-brazilian-slum-running-of-players-on-new-scientific-soccer-field-helps-power-the-lights [hereinafter Fox News Article].

[135] See, e.g., *id.*; *see also, e.g.*, CBS News Article, *supra* note 130.

[136] Pavegen, *Pavegen – Schneider Paris Marathon*, YOUTUBE (Dec. 16, 2014), https://www.youtube.com/watch?v=ij5-1s95clM; Paul Ridden, *Pavegen Harvests Energy from Paris Marathon Runners*, NEW ATLAS (Apr. 18, 2013), https://newatlas.com/paris-marathon-kinetic-energy-tiles/27131/.

[137] Ridden, *supra* note 136.

distinguishing Pavegen from other players in the piezoelectric flooring field.

2. *Refining the Technology Spurs Product Efficiency, Lower Cost, and Big-Name Confidence*

Its ability to attract major industry players as partners enabled Pavegen to accelerate research and development ("R&D") for its piezoelectric flooring device, leading to the refinement and evolution of this device's design and resulting in a less expensive, more efficient product. For instance, in 2014, each tile in the Brazilian Soccer Field Project cost £600.[138] Just three years later, in 2017, due to Pavegen's streamlining its manufacturing process, the tiles cost approximately £307, or about $500 each.[139] The tiles' price decrease to almost half of their original cost illustrates how R&D and confidence in a futuristic concept – such as combining a novel renewable energy like piezoelectricity with an innovative device that deploys it – can catalyze mass production of these devices. This mass production makes each individual unit less expensive and a more affordable, viable option for cost-conscious purchasers. Pavegen has adopted this model through its 2019 partnership with The Hinduja Group, a $50 billion engineering conglomerate, insofar as Pavegen plans on The Hinduja Group helping it to sell great quantities of its piezoelectric flooring tiles in India and Southeast Asia, at costs lower than those mentioned above.[140]

Moreover, through engineering advances facilitating design refinement and improvement, the tiles' energy production rate has become more efficient.[141] For example, in 2011, Pavegen installed its

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[138] Saadiqbal786, *Football Pitch of Rio de Janeiro Generates Electricity with Pavegen's Tiles*, IAMCIVILENGINEER (July 7, 2017), https://www.iamcivilengineer.com/football-pitch-of-rio-de-janeiro/ [hereinafter Football Pitch Article]; Shell 2014 Video, *supra* note 129 (Shell International Limited also produced a YouTube video featuring Pelé as well as Shell key officials, including Shell's Brazil Country Chair and Shell's Global Head Brand Communications.).

[139] Football Pitch Article, *supra* note 138.

[140] Paul Brackley, *Pavegen's Energy-Harvesting Walkways Backed by Hinduja Group in £5 Million Funding Campaign*, CAMBRIDGE INDEP. (May 31, 2019), https://www.cambridgeindependent.co.uk/business/pavegen-s-energy-harvesting-walkways-backed-by-hinduja-group-in-5m-funding-campaign-9071982/.

[141] Football Pitch Article, *supra* note 138.

tiles in the Isle-of-Wright, in Bestival's dance floor.[142] These tiles were made from 100 percent recycled materials and stainless steel, producing an estimated 2.1 watts (or 2.1 joules per second) of energy per footstep.[143] Despite Pavegen up-cycling existing materials to make its flooring product that produced renewable energy, the tiles' efficiency rate became people's focus. The array received public mocking and derision, with people calling the electricity Pavegen tiles produced "malarky" and labeling each tile as a non-cost-effective "feel good thing" and as a "flashy gimmick with no real practical application."[144] Yet, only one year later in 2012, Pavegen refined its tiles' design so that these tiles produced five to seven joules per second at the London Olympics Project.[145] Fast-forwarding to 2016, after additional design refinement and investment in the technology had occurred, Pavegen commercially released its V3 flooring device, a product that maximized energy output and was 200 times more efficient than the original flooring device Pavegen developed in 2009, just seven short years earlier.[146]

Over a decade after deploying its original flooring device, Pavegen has flooring arrays installed in the hearts of major cities, including London, Washington, D.C., and Johannesburg, South Africa.[147] These pilot projects each blend into the built environment in an attractive, aesthetically pleasing manner that is complimentary to the existing, unique cityscape outdoors and surrounding décor indoors. Having these cities endorse Pavegen's piezoelectric flooring by featuring it as an attraction in high foot traffic areas attests to major

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[142] Bryan Clark, *Pavegen Tiles Harvest Energy from Footsteps*, NEW ATLAS (Oct. 21, 2011), https://newatlas.com/pavegen-tiles-kinetic-energy-harvesting/20235/.

[143] *Id.*

[144] Mark Quickel, comment to *Pavegen Tiles Harvest Energy from Footsteps*, NEW ATLAS (Oct. 21, 2011), https://newatlas.com/pavegen-tiles-kinetic-energy-harvesting/20235/; *see also* Gadgeteer, comment to *Pavegen Tiles Harvest Energy from Footsteps*, NEW ATLAS (Oct. 23, 2011), https://newatlas.com/pavegen-tiles-kinetic-energy-harvesting/20235/.

[145] Wired Staff, *supra* note 125.

[146] *6 Years, 129 Prototypes. 1 New Product. Pavegen Unveils the Future of Digital Flooring*, PAVEGEN (May 11, 2016), https://pavegen.com/wp-content/uploads/2019/05/Pavegen_V3.pdf.

[147] *Pavegen – Broadgate, London*, PAVEGEN, https://pavegen.com/case-studies/broadgate-london/ (last visited Apr. 1, 2021); *Pavegen – DuPont Circle, USA*, PAVEGEN, https://pavegen.com/case-studies/dupont-circle/ (last visited Apr. 1, 2021); *Pavegen – Samsung, South Africa*, PAVEGEN, https://pavegen.com/case-studies/samsung-johannesburg/ (last visited Apr. 1, 2021).

cities' local government officials having confidence in piezoelectricity as a viable technology. This gives piezoelectricity an authoritative, municipally-backed vote of confidence while giving Pavegen's flooring device legitimacy as a renewable energy option worthy of public interest, further exploration, and additional investment.

Moreover, Pavegen has proven incorrect the naysayers from a decade earlier by demonstrating its tiles' practical application and proving that major companies believe these devices are more than mere "feel good" contraptions. In 2019, for instance, Pavegen partnered with Globalworth, the leading office building investor in the Central and Eastern Europe ("CEE") region, to produce a 40 square meter permanent flooring array installed in Globalworth Tower in Bucharest, Hungary, constituting the largest kinetic flooring in an office building worldwide.[148] In contrast to the temporary array appearing at the Paris Marathon Project, this permanent array lends further credibility to piezoelectricity technology generally and to Pavegen's flooring device specifically, due to Globalworth's willingness to stake its brand name and reputation on Pavegen's piezoelectric flooring product's regular, daily performance.

Also, The Quayside ("TQS"), an ultra-modern, sustainability-focused building built in 2019 in Kowloon, Hong Kong that aims to promote work-life balance, features a 40-meter-long Pavegen jogging track in its podium garden. TQS's incorporation of Pavegen tiles into its design framework highlights architects' confidence in these tiles. Specifically, not only are these devices considered to be an integral energy-generating measure within the building, but they are also viewed as a means to educate the public, encourage people to adopt a healthy, green lifestyle, and consistently reminds building occupants that energy is a precious resource that merits conservation.[149] Through its ability to attract private investment partners for research and development purposes, and through its top-name partners' confidence in its flooring's abilities, Pavegen continues to erase doubt about its devices' performance. Moreover, Pavegen has produced clear results

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[148] *World Premiere: Globalworth Inaugurates the Biggest Kinetic Floor in an Office Building Worldwide*, GLOBALWORTH (Nov. 17, 2019), https://www.globalworth.com/business-news/world-premiere-globalworth-inaugurates-the-biggest-kinetic-floor-in-an-office-building-worldwide.

[149] Construction+, *Building a Smart City,* 17 CONSTRUCTION+: BRINGING THE BUILDING AND DESIGN INDUSTRY TO YOU 1, 37–38 (Dec. 2019), http://www.constructionplusasia.com/hk/3d-flip-book/constructionhkg-issue-17/.

everyone can see and understand. These results constitute evidence disproves original allegations that piezoelectric flooring is merely an absurdity, a flashy gimmick for showcasing an inefficient technology, and a device that is too expensive to upscale. This is important, as such evidence proves that funding promising renewable energy technologies can help accelerate device refinement and evolution, elevating that technology from "joke" to "game changer" status in the public eye.

3. Positive Subliminal Associations

Pavegen has also distinguished itself from among its competitors by strategically placing its piezoelectric tile arrays in high-end retail stores and shopping centers – all places where positive subliminal associations with the venues themselves are transferred to the Pavegen product. At these locations, the Pavegen flooring cleverly attracts people who are literally ready to "try on something new" and explore contemporary, and potentially unfamiliar, items. As studies have shown, when someone is exposed to an image, their feelings about that image can subliminally influence how they feel about other things they associate with it.[150] The positive associations people feel when they arrive at the Herrod's flagship store (an ultra-upscale department store) in the heart of London,[151] Mercury Mall in Romford, East London,[152] or a leading mall in Johannesburg, South Africa,[153] combined with the positive association they feel when they see their favorite brand's logo in these respective venues, create positive supraliminal and subliminal messaging about their shopping experience.

[150] Jeff Stibel, *How to Use Subliminal Messaging to Your Advantage in Business and in Life*, USA TODAY (Mar. 27, 2018), https://www.usatoday.com/story/money/columnist/2018/03/27/how-use-subliminal-messaging-your-advantage-business-and-life/454784002/.

[151] *Pavegen's Power-Generating Floor Tiles Harness Untapped Human Energy in Many Parts of the World*, FUTUREENTECH (May 13, 2016), https://futureentech.com/pavegens-power-generating-floor-tiles/ [hereinafter *Pavegen's Power-Generating Floor Tiles*].

[152] *Pavegen – The Mercury Mall, Romford*, PAVEGEN, https://pavegen.com/case-studies/the-mercury-mall/ (last visited Apr. 1, 2021).

[153] *Pavegen – Samsung, South Africa*, PAVEGEN, https://pavegen.com/case-studies/samsung-johannesburg/ (last visited Apr. 1, 2021).

As a result, shoppers at each of these respective locations subliminally transfer their "positive shopping experience" feelings at these venues to piezoelectricity and to the Pavegen flooring. This transferring of feelings predisposes these shoppers subconsciously to think approvingly about both of these two things: the interesting, unusual type of energy and the innovative device deploying it. Pavegen's ability to capitalize on this subliminal messaging contrasts sharply with predecessor piezoelectric flooring companies that did not place their devices in malls or other shopping venues. These other companies did not receive the benefit of shoppers' subliminally transferring their "positive shopping experience" to these companies' respective piezoelectric flooring devices. Using subliminal messaging as a marketing strategy is yet another way that Pavegen obtains consumer buy-in, while enabling consumers to connect with its product and view piezoelectricity as a viable renewable energy.

4. *Ability to Participate Physically in the Energy-Generation Process Creates Intrigue, Excitement, and a Unique Way to Connect with the Technology and People's Egos*

By deploying its piezoelectric devices in venues numerous people frequent, Pavegen piques widespread public intrigue and curiosity about piezoelectricity generally and about its kinetic flooring device specifically. Despite Pavegen's installation of over 100 of its small demonstration project arrays globally,[154] the average American has neither heard of piezoelectricity as a type of renewable energy nor of the Pavegen flooring tiles that deploy it. This creates a mystique and allure about Pavegen arrays when they first appear in permanent form in U.S.-based locations. For instance, a Pavegen 240-square foot array is integrated into the sidewalk on the Connecticut Avenue Overlook pocket park on the south side of DuPont Circle, near the DuPont Circle Metro Station in Washington, D.C.[155] Pedestrians traversing this

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[154] *Pavegen's Power-Generating Floor Tiles, supra* note 151.

[155] *Pavegen – DuPont Circle, USA, supra* note 147; Brackley, *supra* note 140; *Redesigned Plaza Combines Beauty, Function and Clean Energy*, GOLDEN TRIANGLE (Nov. 18, 2016), https://goldentriangledc.com/news/connecticut-avenue-overlook-generates-buzz-and-electricity/. *See Steps to Renewable Energy*, GOLDEN TRIANGLE, https://goldentriangledc.com/initiative/footsteps-copy/ (last visited Apr. 1, 2021); (The Connecticut Avenue Overlook pocket park is a collaboration between the District Department of Transportation ("DDOT") and the Golden Triangle Business Improvement District (the "Golden Triangle BID"), and is part of an effort to make Washington, D.C. one of the premier U.S. cities for smart

walkway on their way to this subway station or otherwise can explore piezoelectricity personally, using their senses of sight and touch to physically connect with Pavegen tiles and undergo a fully immersive, unique sensory experience.

In addition to engaging people's senses, Pavegen tiles appeal to people's egos. People's footsteps create the force generating the energy the tiles harvest. When people realize that a Pavegen tile will not generate energy unless they step on it, they are likely to experience a feeling of self-importance that accompanies their realization that they are essential for the device to function properly. This feeling of "I matter" and that "my footsteps have value" translates into people to feeling "needed." The physiological state of people experiencing a "need to be needed"[156] fosters a unique way for people to feel fulfilled, connect with technology, and think about renewable energy.

This holistic sensory and psychological experience is why it is important for signage promoting both piezoelectricity and Pavegen tiles to be located conspicuously at or near the array itself. Absent such signage, such arrays either may not attract visitors as a tourist attraction, or may cause other, more regular visitors to remain oblivious to the social benefit and energy contributions their footfall provides. This unawareness results in tourists being oblivious to this attraction and, as a result, not even considering visiting the array, even when other destinations on their itinerary are in close proximity to the array's location. Along with the more regular visitors who are uninformed about the array's importance, these tourists miss out on the opportunity to undergo the sensory and psychological experience necessary for them to connect fully with piezoelectric technology.[157]

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technology.); *see also id.* (ZGF Architects worked with the DDOT and the Golden Triangle BID to re-design the concrete semicircle at the pedestrian overpass above Connecticut Avenue into a pocket park. Sustainable DC provided this project's funding, illustrating how public-private partnerships can play a key role in transforming the existing built environment); *see* sec. V., *infra* (For a more in-depth discussion of public-private partnerships and their role in renewable energy projects.).

[156] Michael Mamas, *Our Need to Feel Needed . . . And When It Must Change*, HUFF POST (Mar. 7, 2017), https://www.huffpost.com/entry/our-need-to-feel-needed-and-when-it-must-change_b_58be08eee4b0ec3d5a6ba1ed.

[157] *Initiatives - Environmental Sustainability*, GOLDEN TRIANGLE, https://goldentriangledc.com/initiatives/ (last visited Apr. 1, 2021 (For a picture of the Connecticut Avenue Overlook pocket park.) (For instance, as of the end of

In addition to an energy generation component and an experiential component, the greater mission of an array of novel renewable energy devices is to educate the public and spark public interest about the technology. Curiosity about the technology may prompt people to become more knowledgeable about it, investigate it further, and spread the word about it to their networks. Educating the public about renewable energy technology is a continuous process. A lack of signage near such an array, consequently, translates into a triple missed opportunity to do the following: (i) produce renewable energy at that site, (ii) educate site visitors about piezoelectric technology generally, and (iii) have these visitors disseminate their newly-acquired knowledge to others through social media, discourse, or other means of experience sharing. Erecting such signage is a simple change that can prevent these missed opportunities from occurring and have a positive ripple effect. As a matter of policy, having permanent signage near the renewable energy site – even for a small demonstration project – is something local communities need to promote and support as a post-installation follow-up measure for new renewable energy projects within their borders. Such signage will help educate the public about novel types of renewable energy and generate further public buy-in for the type of renewable energy being showcased.

5. *Beyond Selfies: Using Next Generation Smartphone Technology as a Disruptive Force for Engagement and Economic Decisions*

Another way Pavegen is distancing itself from predecessor piezoelectric flooring companies, establishing market credibility, and connecting with consumers is by combining its piezoelectric flooring product with a smartphone app that offers economic-based incentives. This technological step forward has triggered a mindset shift, elevating people's view of Pavegen's piezoelectric tiles to that of "smart" flooring technology, something that has a place in smart cities of the

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second quarter 2020, there was no conspicuous signage at the Connecticut Avenue Overlook pocket park regarding the Pavegen tiles. This means that those pedestrians who walked on the DuPont Circle Pavegen array who lacked prior knowledge about these tiles and their function did not known about the benefit they were providing with their footsteps. It likely would have seemed to such pedestrians, particularly those who walked upon these tiles in broad daylight, that the Pavegen array was merely an artistic display to be observed and not touched or walked upon.).

future.[158] Moreover, apps that offer consumers the ability to earn discounts, bonuses, or other financially-based rewards through their actions incentivize them to alter their behavior by frequenting venues where they can earn these rewards.[159] Pavegen has created such an app, so that consumers can reap rewards from their footsteps.

At Mercury Mall in East London, for instance, of the 60,000 shoppers who pass through the mall's entryway each day, those who download The Mercury Smart Rewards app and walk on the six-square meter Pavegen array can earn points and discounts that can be applied at various merchants in that mall.[160] This enables consumers to benefit in two different ways. First, they receive instant gratification, knowing that the kinetic energy from their footsteps is being converted into electricity. Second, they tangibly profit from their footfall contribution through the app-based shopping rewards they receive.

Taking this off-grid, distributed generation technology to the next level, Pavegen envisions using apps to treat people's footsteps as commodities that will result in a behavior-based economy shaped by financial incentives.[161] The thought is that in the future, when people take steps on Pavegen flooring installed in a shopping mall, stadium, airport, or other venue, they will be able to earn discounts, credits, or other incentives that can be used at that venue or that can be applied toward the purchase of items for use at other venues, such as upgraded concert tickets or tickets to stadium-based sports events.[162] The app would also indicate on a person's smartphone the number of remaining

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[158] Brackley, *supra* note 140.

[159] Diamond, *supra* note 111, at 173.

[160] Brackley, *supra* note 140; *see also* April Roach, *Romford's Mercury Mall Launches Energy-Generating Floor that Turns Footsteps into Electricity*, ROMFORD RECORDER (May 11, 2018), https://www.romfordrecorder.co.uk/news/environment/romford-s-mercury-mall-launches-energy-generating-floor-that-turns-footsteps-into-electricity-1-5513806.

[161] Diamond, *supra* note 111, at 189; *see Energy and the Environment – Distributed Generation of Electricity and Its Environmental Impacts – About Distributed Generation*, U.S. ENVTL. PROTECTION AGENCY [EPA], https://www.epa.gov/energy/distributed-generation-electricity-and-its-environmental-impacts (database updated Feb. 19, 2021) [hereinafter *Energy and the Environment – Distributed Generation*] ("Distributed generation" refers to devices that employ technology to generate electricity near the point at which the electricity will be used. These devices can be connected to an electric utility's lower voltage distribution lines. This can reduce the loss of electricity along the electric grid's transmission and distribution lines.).

[162] *Id.*

steps that person needs to take to reach the next incentive-based rewards level.[163] Given this incentivization, consumers would likely then elect to shop at certain venues rather than others, due to the presence of Pavegen tiles and their ability to earn footfall-related benefits at select venues. This means vendors at locations lacking Pavegen smart flooring could lose business to vendors offering the same or similar products at locations where Pavegen arrays are installed. Shaping people's purchasing decisions through financial incentivization based on engagement with Pavegen devices, therefore, serves as a disruptive force that can change people's perceptions about renewable energy, drive people's behavior, and impact business economics.

C. Ivanpah Concentrated Solar Power Facility and What Happens in the Absence of Public Engagement

In contrast to the favorable public reception Block Island and Pavegen are experiencing through their ability to engage the public, the Ivanpah Solar Electric Generating System, a 392 MW concentrated solar power ("CSP")[164] facility ("Ivanpah") possesses a more unfortunate history. Ivanpah exemplifies how a renewable energy project may attract negative publicity when the public is unable to see, "experience," or become enthusiastic about the technology.[165] Located far away from civilization in the Ivanpah Dry Lake in California's Mojave Desert just five miles from the California/Nevada border, Ivanpah occupies 3,500 acres, yet is hidden in plain view from the public's sight.[166] The lack of this facility's constant, visual presence prevents people from using their sense of sight to establish memory recognition and familiarity with this CSP project.[167]

Due to its remote desert location, this CSP facility subjects people to "sensory deprivation risk."[168] This means that if shown a picture of a CSP facility, those who have not ventured into the desert and seen first-hand what either Ivanpah or another CSP facility looks

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[163] *Id.*

[164] The phrase "concentrated solar power" is generally used interchangeably with the phrase "concentrating solar power." Both share the "CSP" acronym to reference the same type of solar power technology.

[165] *See* Diamond, *supra* note 111, at 145–146.

[166] *Id.* at 146.

[167] *Id.* at 156.

[168] *Id.* at 155.

like, may be unable to identify the technology depicted. This lack of personal exposure to CSP technology, an advanced form of utility-scale solar power technology, acts as an invisible barrier that blocks the public from experiencing a sense of amazement and awe upon seeing either Ivanpah's three 40-story power towers that are each approximately 100 feet taller than the Block Island Turbines' towers (the height of one 40-story power tower (approximately 433 feet) – the height of one Block Island Turbine tower (approximately 328 feet) = approximately 105 feet),[169] or its 173,500 heliostats (solar collectors the size of large garage doors) that form concentric circles around each of the three power towers and focus sunlight onto the boiler atop the particular power tower they face.[170]

Furthermore, due to this invisible barrier, public inquisitiveness and interest about Ivanpah's benefits and operational mechanics has not been piqued. For example, it is generally not widely known that Ivanpah powers approximately 140,000 homes and avoids approximately 400,000 tons of carbon dioxide emissions annually from its clean energy production.[171] Also, the public is generally unaware that Ivanpah's state-of-the-art design uses heated water from the heliostats' reflected sunbeams as the project's heat transfer fluid ("HTF"), creates superheated steam, and pipes that steam to turn a turbine at ground-level.[172] If the public realized some or all of these facts regarding this project's technological sophistication, they potentially may have expressed more vocal support for it when Ivanpah first became operational.

Also, the public is largely unaware that Ivanpah ranked as the largest CSP facility globally when it came on-line in January 2014,[173] serving as the springboard project for design improvements for

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[169] *Power Tower System Concentrating Solar Power Basics*, OFF. OF ENERGY EFFICIENCY & RENEWABLE ENERGY (Aug. 20, 2013), https://www.energy.gov/eere/solar/articles/power-tower-system-concentrating-solar-power-basics [hereinafter Power Tower System Basics] (For an overview of CSP basics, including a labeled diagram of what a CSP facility looks like.); *Convert Feet to Stories – Conversion of Measurement Units – Convert Foot to Story*, CONVERTUNITS.COM, https://www.convertunits.com/from/feet/to/stories (last visited on May 21, 2021) (Forty stories is the equivalent of approximately 433 feet.).

[170] *See* Diamond, *supra* note 111, at 146.

[171] *Id.*

[172] *Id.*

[173] *Id.* at 147.

successor U.S.-based CSP facilities and enabling these projects to become more competitive with traditional energy facilities. As illustration, the groundbreaking 110 MW Crescent Dunes Solar Energy Project facility, situated in a remote location in northern Nevada, became operational in November 2015 ("Crescent Dunes")[174] after improvements had been made to Ivanpah's design. Crescent Dunes advanced the U.S.'s CSP industry by becoming the first domestic CSP facility to use molten salt, rather than water, as its HTF. This technological evolution enabled Crescent Dunes to store thermal energy for 10 hours, an almost two-fold improvement upon the five to seven hours of thermal storage available at Ivanpah.[175] Also, molten salt's heat storage capability eliminates the need for an additional battery to store energy. Because the molten salt system runs a steam turbine, it effectively "cycles," generating energy similarly to nuclear, natural gas, and coal plants that spin a turbine to produce energy. This boost in CSP heat storage capability and the ability to generate power similarly to conventional power plants empowers Crescent Dunes to compete head-to-head with conventional energy projects in terms of demand response electricity available for electric grid onboarding.[176]

Remarkably, this design improvement that Crescent Dunes evidences was achieved less than two years after Ivanpah became operational. The invisible barrier from lack of physical exposure to either Ivanpah or the Crescent Dunes renewable energy project, coupled with this void in public awareness regarding the positive attributes and magnitude of achievements relating to CSP technology, results in the public suffering from a "connectedness deficiency,"[177] an obstacle impeding people's ability to appreciate fully a renewable energy project for its energy-generating benefits and its landmark technological advances.

The cumulative impacts of an "out of sight, out of mind" location for a renewable energy facility, together with this "connectedness deficiency," causes people to rely heavily on what the press reports about a particular project. Such reliance can significantly increase the risk of poor public perception about the project, due to the project's vulnerability to negative stories written about it. This is the fate that befell Ivanpah at the time of its public roll-out.

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[174] *Id.* at 149; Power Tower System Basics, *supra* note 169.
[175] Diamond, *supra* note 111, at 149, 157.
[176] *Id.*
[177] *Id.* at 155.

CSP projects generally are extremely expensive to build, and Ivanpah was no exception. Ivanpah cost approximately $2.2 billion to construct, with $1.6 billion being provided in the form of a U.S. Department of Energy ("DoE") federal loan guarantee.[178] To those unfamiliar with the CSP landscape and construction costs for a CSP project, in the abstract, a price tag of $2.2. billion to construct a single facility sounds like an exorbitant amount. Likewise, absent publicity about how much federal funding other CSP projects receive,[179] the public has no benchmark for comparing the cost of this project to other CSP projects, or to other energy projects whatsoever. This absence of a benchmark made the $1.6 billion Ivanpah received seem like an outrageous, over-the-top amount.

Consequently, when Ivanpah initially generated less energy than predicted, the press used the public's absence of first-hand, positive sensory experience-based familiarity with the Ivanpah facility to its advantage. Capitalizing on this known sensory deficiency all members of the public experienced, the press elected not focus on the technological advances that Ivanpah incorporated, downplaying the facility's technological accomplishments. Rather, the press endeavored to influence the public's opinion about CSP generally and Ivanpah specifically, focusing on the enormous, "controversial" federal government funds expended on this project that resulted in this project's disappointing performance.[180] Negative news articles prompted people to believe that CSP is a ridiculously expensive technology whose energy production ability does not justify the exorbitant amount of federal taxpayer funds that financed it.

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[178] *Id.* at 147.

[179] *See* Diamond, *supra* note 111, at 148–49 (In fact, there were other U.S.-based CSP projects that were smaller projects than Ivanpah yet had also received vast amounts of federal funding. These other projects include the Mojave Solar Project, which received a $1.2 billion DoE loan guarantee; the Genesis Project, which received an $825 million DoE partial loan guarantee; and the Crescent Dunes Project, which received a $737 million DoE loan guarantee. These funding amounts provide relative context for the DoE funding amount provided for Ivanpah.).

[180] *Id.* at 162.

By the press amplifying Ivanpah's "early operating woes,"[181] downplaying its positive attributes, and diminishing CSP's emergence as a viable technology that can be improved with additional research and development, CSP's technological achievements fell by the wayside. Without experience-based support, people filled their connectedness deficiency regarding what to think about CSP with negativity that abounded in pessimistic articles about Ivanpah. Unlike Pavegen's ability to focus the public on its smart flooring's benefits, the press's ability to focus the public on Ivanpah's shortcomings may have subconsciously soured people toward CSP, predisposing them to push back against other large CSP projects proposed in the future.[182]

III. HANDLING TECHNOLOGY AND FINANCIAL RISKS: THE PRIVATE SECTOR'S ROLE IN SHAPING THE ROUTE TECHNOLOGICAL ADVANCEMENTS TAKE

For decades, the private sector has played a critical role in shaping the development of renewable energy technologies by determining which investments are viable and worth their risk. Using the Warrior II Pose yoga analogy, banks, funds, and other private investors have reached back and evaluated what commonalities a myriad of inventive devices from different asset classes have shared that have enabled them to be successful in terms of performance history, profitability, and public receptiveness. These private sector actors also have looked forward, weighing and evaluating numerous risks, including the product's obsolescence horizon, including how quickly after its introduction the product will be replaced with improved goods. Additionally, they have considered the risks associated with the product's ability to be scaled-up, as well as more aesthetic concerns. For instance, if the product appears too futuristic and alien, it can cause the public to experience future shock[183] and revulsion toward the product, rather than feeling comfortable with it and embracing it. An investor needs to weigh these and other risks, such as habitat destruction resulting from certain devices' installations, when determining whether to invest in a device showcasing an innovative technology. From a relative risk perspective, investors

[181] 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.

[182] Diamond, *supra* note 111, at 194.

[183] *See* definition of "future shock," *supra* note 95.

collectively consider all of these aforementioned risks and evaluate whether, when aggregated, they are worth taking, compared to their potential future return on the investment. These risks often make attracting big-ticket investors a high hurdle to surmount, particularly for companies with ultra-novel products. Accordingly, to attract these investors and secure their confidence, companies debuting a novel renewable energy device must "de-risk" investments to the extent possible.

A. Future Shock: Determining Where to Draw the Line

1. Skeuomorphic Design

Certain exotic renewable energy devices may be designed in never-before-seen, imaginative formats. Investors play a pivotal role in determining these products' viability given the burden they bear of guessing the public's future appetite for the benefits such devices offer. Indeed, investors may need to gamble on whether the public will welcome a device or technology as something sensational and exciting, or whether the public instead will perceive it as too mind-blowing and bizarre. This is why products that incorporate skeuomorphic design, the concept of using of traditional elements and features associated with an already known or predecessor device to make the related, new device appear less foreign and more recognizable,[184] may more readily find success in appealing to the public and attracting investors.

Skeuomorphic design acts as a bridge between the already familiar and the unexpected, enabling people to take a step toward the future, untroubled. People are accustomed to "familiar" objects that serve particular, established functions. Drawing upon the mental ease this familiarity provides enables people to become comfortable with other high-tech, innovative objects that serve the same purpose and potentially other functions as well. Common examples of such items include images for app icons on computers or on smart phones that mimic or are reminiscent of objects whose respective real-world functions these apps now perform virtually.[185] Such precedent-setting

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[184] Tony Ho Tran, *What's Skeuomorphic Design?*, INVISION (Oct. 11, 2019), https://www.invisionapp.com/inside-design/skeumorphic-design/.

[185] *See Id.*; *What Is Skeuomorphism?*, INTERACTION DESIGN FOUNDATION, https://www.interaction-design.org/literature/topics/skeuomorphism (last visited May 21, 2021).

images include a calendar image for the "calendar" function, a garbage can image for the "trash/delete" function, and the now technologically obsolete floppy disc for the "save" function. As a result, while new technology may be daunting and scary to some, the familiarity these images provide may dispel anxiety and prompt engagement with the technology that may not otherwise have occurred.

a. Pavegen Piezoelectric Flooring Tiles Combine the Familiar with the Unfamiliar

As Pavegen has proven through its smart piezoelectric flooring tiles, skeuomorphic design belongs in smart cities and the built environment. People understand and are familiar with the concept of walking on a sidewalk or pavement. Pavegen tiles combine this familiarity with the more obscure, unusual concept of using the kinetic energy harvested from footsteps on this flooring to generate energy for immediate deployment or storage. Consequently, rather than being dismissive of Pavegen flooring tiles and the renewable energy it captures, people conceptually are able to grasp how these devices work and operate, resulting in their ability to engage with and be intrigued by this curious, yet enticing, futuristic device. This "familiarity factor" is potentially one reason why Pavegen has attracted private investment from large companies, including Shell, the Hinduja Group, Siemens, and Schneider Electric.[186]

b. The "Strawscraper": The Risk of Leapfrogging Over the Familiar to Purely Futuristic Design

(i) Design Advantages Futuristic Piezoelectric Straws Offer

The absence of the skeuomorphic design bridge is apparent in certain architectural designs that envision employing high-tech renewable energy devices in creative, never-before-seen ways. For

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[186] *See* SmartCitiesWorld News Team, *Pavegen Partners to Bring Down Cost of Manufacturing*, SMARTCITIESWORLD (May 28, 2019), https://www.smartcitiesworld.net/news/news/pavegen-partners-to-bring-down-cost-of-manufacturing-4216 (The Hinduja Group is an engineering and manufacturing conglomerate that is partnering with Pavegen to lower Pavegen's manufacturing and production costs.); *see also* Part II., *supra* subsec. B.1.b.(ii) (discussing Schneider Electric)*; see also* Diamond, *supra* note 111, at 186; *see also Siemens MindSphere, Abu Dhabi*, PAVEGEN, https://pavegen.com/case-studies/siemens-mindsphere/ (last visited Apr. 1, 2021); *see also* Shell 2014 Video, *supra* note 129.

instance, the "Strawscraper" design from architecture firm Belatchew Arkitekter in Stockholm, Sweden consists of a futuristic, urban skyscraper covered in piezoelectric straws.[187] These straws blow and ripple in the wind at low wind velocities, generating kinetic energy as they move. The overall visual effect makes the building look alive, as if it is covered in iridescent hair. Conceptually, this idea is very promising for purposes of integration into smart cities, as the piezoelectric straw devices can be fitted onto new construction as well as retrofitted onto existing buildings.[188] Tall buildings, effectively, can be transformed into urban power plants. Moreover, the piezoelectric straws move with minimal noise and are not disruptive to wildlife.[189] They also can be placed on the exterior of multiple stories of a particular building, rather than merely on the building's rooftop or area outside its ground floor. This means that compared to small-scale wind turbines or roof-mounted solar panels, piezoelectric straw devices are just as, if not more, conducive for use in a metropolitan environment.

Despite the advantages the Strawscraper's piezoelectric straws offer, their accompanying regulatory and public receptiveness risks offer insight into both why the Strawscraper has not yet been built in Stockholm as originally proposed, and why no other buildings to date incorporate piezoelectric straws on their exteriors. These two risks spring from the public's lacking something familiar with which to analogize these mysterious straws. It is easy for people to liken something they have never seen before that serves an unusual purpose to other things that already exist. It is harder for people to become instantly comfortable with something highly unusual to which no analogy is made.

(ii) Regulatory Risk of Analogizing to the Familiar

Because law generally lags behind science, courts and other law makers tend to analogize new technologies to those for which there

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[187] *Strawscraper Belatchew Labs*, BELATCHEW ARKITEKTER, https://belatchew.com/en/projekt/strawscraper/ (last visited Apr. 1, 2021) (The Strawscraper design was originally intended to be an extension of the Soder Torn building located in Sodermalm, Stockholm, Sweden. Due to financing issues occurring in 1997, only 26 stories of the originally envisioned 40 stories of this building were built. The Strawscraper design would enable the addition of the 14 missing stories and would enable the building to incorporate futuristic energy production simultaneously.).

[188] *Id.*

[189] *Id.*

is already legal precedent. As discussed in Part I.C.3. above, when looking for standards by which to regulate a novel item, it is much simpler and easier to draw upon existing precedent rather than to create from scratch an entirely new, unique regulatory scheme for the item. For this reason, many regulatory schemes analogize the extraordinary item to something that already exists. This approach enables lawmakers to draw upon the body of law specific to that already-existing item, extrapolating from and adapting it to cover the novel item and revising it in tandem with the item's technological evolution. Even when no similar industry exists, lawmakers nevertheless attempt to regulate the new technology or device by equating it to similar things in another industry, if a logical connection between the two exist. The risk here, though, is that lawmakers may liken the novel technology to something undesirable.

For instance, algae is used as a biofuel in Texas, yet oil and gas regulations are not used as standards for its governance. Instead, the Texas Parks and Wildlife Code serves as the governing body of law. [190] This statute analogizes algae to an "exotic aquatic plant," insofar as it is a plant non-indigenous to Texas that is normally not found in the state's riparian or aquatic areas.[191] As a plant, algae is subject to the same penalties as are other dangerous, invasive plant species. Accordingly, if algae "escapes" from the facility at which it is being cultivated and finds its way into the public water system without a special permit, the algae is treated like a noxious, dangerous pest, and the facility is deemed to have committed a misdemeanor or a felony offense, depending on the number of times such escape occurs.[192] Consequently, while Texas possesses standards for algae's regulation, the negative connotation associated with these guidelines neither elevates public perception of algae as an innovative renewable energy resource, nor does it encourage algae's development as a biofuel.

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[190] Heather Hunziker, *NOTE: Finding Promise in Pond Scum: Algal Biofuels, Regulation, and the Potential for Environmental Problems*, 42 TEX. ENVTL. L. J. 59, 75 (Fall 2011), (*citing* Tex. Parks and Wildlife Code §66.0072(b) (2011), https://texas.public.law/statutes/tex._parks_and_wild._code_section_66.0072).

[191] Huunziker, *supra* note 190 (*citing* Tex. Parks and Wildlife Code § 66.015(e) (2011), https://texas.public.law/statutes/tex._parks_and_wild._code_section_66.015 and Tex. Parks and Wildlife Code §66.012(b) (2011)), https://texas.public.law/statutes/tex._parks_and_wild._code_section_66.012.).

[192] *Id.* (The first two times the algae escapes, it is a class B misdemeanor offense; the third time and thereafter, it is a felony offense.).

(iii) Public Receptiveness Risk in the Absence of a Familiar, Awe-Inspiring Name

Similarly, if both the innovative technology and the futuristic, extraordinary device deploying it are highly unusual, then the greater the chance is that people nevertheless will try to analogize the device to other things they have seen previously. This is why it is important for the device's designer or owner to create the analogy first and widely publicize this analogy, comparing the new creation to something people already perceive positively that can provoke further interest. As illustration, Singapore is home to a "Supertree Grove" in its Gardens by the Bay, located in the city's now-redeveloped downtown area.[193] All 18 of these 50-meter-high towering sculptures draw upon the concept of biomimicry,[194] appearing from afar to be giant trees. When viewed up close, though, people can see that each sculpture-like structure houses vertical gardens that include diverse varieties of ferns and flowering tropical plants.[195] Also, 11 of the Supertrees are adorned with solar panels, which help to light the park in which these Supertrees reside. Analogizing devices that are effectively gargantuan metal planters and solar panel holders to very large trees, naming those creations "Supertrees" to solidify the analogy, and globally marketing the Supertrees as "art" has proven successful insofar as Gardens by the Bay is now a highly-frequented eco-tourist destination.[196]

The danger of failing to provide an analogy that captures the public's imagination effectively is that the public may themselves begin to equate the innovative devices with things that do not necessarily carry a positive connotation. For instance, in the case of exterior piezoelectric straws on buildings, the building needs to bear a

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[193] *Supertree Grove*, GARDENS BY THE BAY, https://www.gardensbythebay.com.sg/en/attractions/supertree-grove-observatory-ocbc-skyway/supertree-grove.html (last visited Apr. 1, 2021); Lauren Said-Moorehouse, *Solar-Powered 'Supertrees' Breath Life into Singapore's Urban Oasis*, CNN (June 10, 2015), https://www.cnn.com/2012/06/08/world/asia/singapore-supertrees-gardens-bay/index.html.

[194] *Biomimicry*, MERRIAM-WEBSTER, https://www.merriam-webster.com/dictionary/biomimicry ("Biomimicry" is when an invention or design imitates a naturally occurring biological design, in appearance, function, or both.).

[195] Said-Moorehouse, *supra* note 193.

[196] *Supertree Grove*, *supra* note 193.

catchy name reflecting either the technology or the building's appearance. As discussed previously in Part II.A.3., giving something a name can be a very powerful tool for engendering certain feelings toward that item. The risk here is that if a snappy name with a great background story is missing initially from the device's narrative, then the public may devise its own nickname or analogy for the technology. People may liken the devices to things that are scary, unflattering, aesthetically unattractive, humorous, or some combination of these things, rather than to items conjuring positive impressions.

As illustration, rather than equating piezoelectric straws to beautiful hair stands that ripple and flow in the breeze, people may instead liken them to horrid-looking tentacles that make the building look like a colossal, writhing bug monster. Alternatively, due to the building's being covered in "hair," people may analogize the building to strange, yet humorous, fictitious creatures, such as Cousin Itt from the television show *The Addams Family*[197] or Mr. Snuffleupagus from the television show *Sesame Street*.[198] Living in "The Cousin Itt Building" or the "Snuffleupagus Building" does not necessarily carry with it the element of chicness investors desire.

2. *Exclusivity and Climate Consciousness May Outweigh Pure Aesthetics*

To make investment in piezoelectric exterior building straws viable, investors need to be confident that other elements of attractiveness exist and outweigh these aesthetic risks. For instance, a new skyscraper outfitted with exterior piezoelectric straws could be marketed to the elite as a marquis, cream-of-the-crop, Class A

[197] *See* Fandom, *The Addams Family Wiki*, https://addamsfamily.fandom.com/wiki/Cousin_Itt (Cousin Itt possesses a body that is so completely covered in hair, his face, limbs, and other body parts cannot be seen. While able to wear a top hat and sunglasses, Cousin Itt never appears to be wearing any other article of clothing, except, occasionally, gloves.).

[198] *See* DICTIONARY.COM, *Snuffleupagus*, https://www.dictionary.com/e/fictional-characters/snuffleupagus/ (Mr. Snuffleupagus is a muppet character that looks like a brown, hairy elephant (a wooly mammoth) with very big eyes and extremely long eyelashes. Originally, he was depicted as Big Bird's imaginary friend.); *see also Snuffleupagus – Big Bird*, BRITANNICA.COM, https://www.britannica.com/biography/Snuffleupagus.

building[199] that possesses first-of-its-kind, trailblazing devices that generate renewable energy in the built environment. Elements of exclusivity and social awareness, then, could be associated with this building in which only wealthy clientele can afford the hefty price tag associated with buying or leasing space therein. Even so, short of a litmus test to gauge potential tenant interest, it is uncertain whether this elite, "built to impress" angle will be well-received among potential building tenants, others in the surrounding community, or investors.

From a different perspective, if an older, Class B skyscraper building[200] were to be retrofitted with these piezoelectric exterior straws, investors would have the opportunity to renovate the building, upgrade it with these new devices, and potentially realize a significant return on their investment. The public acceptance risk would be applicable to such a Class B building, just as it would to a Class A building, ultimately making the project a risky one. Moreover, if the Class B building already possessed an established reputation for not being as posh and elite as other exclusive buildings, the luster and appeal of occupying such a building may be less than is needed to make investment in the building financially worthwhile. Investors like certainty, as do banks and other lenders who often make particular investments possible. Consequently, as piezoelectric exterior building straws illustrate, a truly innovative project may be un-financeable if it is too unusual, due to a lack of investor appetite based on project riskiness.

B. Accelerated Roll-Out and Scaling-Up of Experimental Technologies and Devices Can Pose Financial Risks

Financial risks accompany the rapid scaling-up and commercial deployment of an innovative device in its prototype stage, especially when that device is based on a novel, unfamiliar technology. The too-rapid scale-up of a novel product from prototype to commercial-scale form can present new, additional risks that may not

[199] *See* Nell Lanman, *How to Distinguish Among Class A, Class B, and Class C Buildings (2020 Edition)* (Feb. 2, 2020), https://www.squarefoot.com/blog/class-a-buildings-class-c-buildings/ (Commercial buildings are generally categorized into three classes, Class A, Class B, and Class C. Class A buildings constitute the newest, most modern buildings that tend to be located in the most desirable neighborhoods.).

[200] Upcounsel, *Commercial Building Definition: Everything You Need to Know – Types of Commercial Properties*, https://www.upcounsel.com/commercial-building-definition.

have been present when the product was in a more miniature form. Consequently, investors need to be mindful and strategic about scaling-up a promising invention to mitigate against these potential additional risks as well as minimize costs associated with rectifying issues arising from these risks. Also, as discussed in Part I.B., although a device works in a small-scale form, there is no guarantee that its larger version will function similarly if placed in another location and exposed to different conditions. Like the latent design defects that impacted the Robin Rigg offshore wind turbines, there may be design defects associated with the larger, utility-scale version of a device that should be addressed before it is placed in service. Failure to identify and rectify these defects could cause the device to perform poorly, potentially resulting in the bankruptcy of the company producing the device to which investors have already provided funding. The performance risks associated with the scaled-up version of a device, though, may be so unique that they are unidentifiable in the device either during laboratory testing or when deployed in an array in the real world, at smaller-than-utility-scale size.

1. Vortex Induced Vibration ("VIV") Technology and the Vortex Bladeless Wind Devices

The Vortex Bladeless aerogenerator ("Vortex Bladeless"), for instance, offers a prime example of a promising, futuristic wind energy conversion device that draws upon a relatively obscure technology. This unconventional wind energy conversion device takes a theoretical concept from fluid mechanics and makes it a reality, while disrupting traditional notions of how wind energy devices both appear and work. The science behind how the Vortex Bladeless functions, as well background about how it operates in practice, provides insight regarding why this device may be attractive for investors, yet carries considerable risk if and when it is scaled-up to a larger size, compared to its current, compact size.

a. Description of Vortex Shedding Technology for Wind Energy Conversion

Physics and engineering provide the foundational basis for the vorticity and oscillation technology behind how the Vortex Bladeless functions.[201] Vorticity is a physics-based, fluid dynamics concept that measures the rotation of a fluid parcel, such as a parcel of air, within a horizontal plane.[202] A vortex is a whirling air mass that forms a vacuum in its center into which other objects can be drawn, making this mass potentially destructive.[203] Vortex shedding is a subset of vorticity that describes the phenomenon of a vortex forming on opposite sides of a stationary object, such as a barn or cylindrical pole, when exposed to wind in the freestream.[204] These vortices form at alternating times, so that when a vortex forms on one side of a pole, the pole then effectively releases, or "sheds," it downwind (the opposite side from which the wind came in contact with the pole), only to have another vortex immediately form on its other side.[205] The pole then proceeds to shed that second vortex in a similar fashion to how it shed the first vortex.[206] When a consistent wind blows, vortices regularly form and detach from a given pole in a cyclical pattern, based on the wind's velocity and the pole's shape.[207] Vortex shedding downwind from the pole creates alternating low pressure zones on

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[201] *How It Works – Fundamentals of the Idea*, VORTEX BLADELESS, https://vortexbladeless.com/technology-design/.

[202] *Vorticity*, SCIENCE DIRECT, https://www.sciencedirect.com/topics/earth-and-planetary-sciences/vorticity (*citing* ENCYCLOPEDIA OF ATMOSPHERIC SCIENCES, 451–454 (2d ed. 2015), https://www.sciencedirect.com/science/article/pii/B9780123822253004497); *Glossary - Vorticity*, NOAA'S NATIONAL WEATHER SERVICE, https://forecast.weather.gov/glossary.php?letter=v.

[203] *Vortex*, MERRIAM-WEBSTER, https://www.merriam-webster.com/dictionary/vortex; *Vortex*, THE FREE DICTIONARY, https://www.thefreedictionary.com/vortex.

[204] *Vortex Shedding*, SCIENCE DIRECT, https://www.sciencedirect.com/topics/engineering/vortex-shedding (*citing* Design and Analysis of Tall and Complex Structures, 5–80 (2018), https://www.sciencedirect.com/science/article/pii/B9780081010181000022); Sunden Bengt, *Vortex Shedding*, THERMOPEDIA (Feb. 2, 2011), http://thermopedia.com/content/1247/.

[205] Bengt, *supra* note 204; *see also How It Works – Fundamentals of the Idea*, *supra* note 201 (In-motion diagram from Duke University at Vortex Bladeless, *How It Works – Fundamentals of the Idea - Vortex Technology, Fluid Dynamics*).

[206] *How It Works – Fundamentals of the Idea*, *supra* note 201.

[207] *Id.*; *Vortex Shedding & Tall Structures – The Uncertainties of Wind Loading – What is Vortex Shedding*, SPARTA ENGINEERING, https://www.spartaengineering.com/vortex-shedding-and-tall-structures/; *Vortex Shedding & Tall Structures – The Uncertainties of Wind Loading – Why Does Vortex Shedding Matter?*, SPARTA ENGINEERING, https://www.spartaengineering.com/vortex-shedding-and-tall-structures/ [hereinafter *Why Does Vortex Shedding Matter?*].

each side of the pole. As air flows in to fill these low pressure zones, it produces a vibration at a fixed, calculable frequency.[208] If the vibration is close to or coincides with the pole's natural frequency, particularly with poles that are tall and of uniform shape and size,[209] the pole begins to vibrate and oscillate, moving back and forth in a consistent rhythm[210] and entering into resonance with the wind.[211] This phenomenon is called Vortex Induced Vibration, or VIV.[212]

Promoting vortex shedding in the form of VIV technology is a complete departure from wind industry norms. Traditional monopile turbines, both offshore and onshore, have tall, cylindrical poles constituting their towers. Vibrations resulting from vortex shedding from other turbines located upwind from these monopile turbines cause stress on the downwind turbines' towers, which in turn can damage the downwind turbines and lead to their premature failure, due to vibrational load fatigue.[213] For this reason, traditional monopile turbines endeavor to avoid, not capitalize upon, the vorticity phenomenon altogether. This is why monopile turbines incorporate vibration dampening systems into their structures, enabling their turbine towers to absorb these vibrations.[214] Monopile turbines' energy production capabilities, consequently, do not incorporate VIV as part of their energy production but instead fervently avoid VIV.

b. How Vortex Bladeless Wind Devices Function, Appear, and Operate

Given the scientific principles regarding VIV, the Vortex Bladeless marks a divergence and complete shift in the scientific principles upon which standard monopile wind turbines function. Rather than shunning vortex shedding and endeavoring to minimize VIV impact, the Vortex Bladeless does the opposite. Contrary to

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[208] *Why Does Vortex Shedding Matter?*, *supra* note 207.

[209] *Id.*

[210] *Oscillate*, THE FREE DICTIONARY, https://www.thefreedictionary.com/oscillate.

[211] *Why Does Vortex Shedding Matter?*, *supra* note 207; *How It Works – Fundamentals of the Idea*, *supra* note 201.

[212] *How It Works – Fundamentals of the Idea*, *supra* note 201.

[213] *Why Does Vortex Shedding Matter?*, *supra* note 207.

[214] *Vortex Shedding & Tall Structures – The Uncertainties of Wind Loading - How to Calculate Vortex Shedding: Step 4: Fixing the Problem*, SPARTA ENGINEERING, https://www.spartaengineering.com/vortex-shedding-and-tall-structures/.

traditional designs used in structural engineering, aeronautics, and architecture, the Vortex Bladeless aims to maximize and capitalize on the VIV phenomenon, turning its oscillation movements into energy.[215] The Vortex Bladeless, which readily adapts to changing wind direction, also takes advantage of turbulent airflow, rather than having wind turbulence adversely impact its structure or energy output.[216]

In terms of appearance and operation, the Vortex Bladeless also is an anomaly compared to standard monopile turbines with which the general public is familiar. Unlike traditional small-scale and utility-scale monopile turbines, the Vortex Bladeless lacks a spinning rotor, or blades, and also lacks a traditional tower as well as a nacelle, the "box" housing the turbine's gearbox, generator, drive train, and braking mechanisms.[217] The blades and the items contained within the nacelle reside atop the wind turbine's tower and convert kinetic energy from wind flow into mechanical energy that turns a generator to produce electricity.[218] Notably, blades, a pole-like tower, and a nacelle are standard features in traditional wind turbines and tend to be the three factors that cause the general public to identify a device possessing these attributes as a wind turbine.

In sharp contrast to the traditional monopile wind turbine, the Vortex Bladeless, lacks blades, a tower, and a nacelle, causing it to look like a tall, sleek, upside-down mascara container. At its top, the Vortex Bladeless possesses a long, slender, tubular mast that oscillates. The Vortex Bladeless's mast houses its rectifier,[219] alternator,[220] and

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[215] *How It Works – Fundamentals of the Idea*, *supra* note 201.

[216] *Id.*

[217] *Id.*; Nic Sharpley, *Nacelles: How Are They Manufactured?*, WINDPOWER (Apr. 13, 2015), https://www.windpowerengineering.com/how-is-a-nacelle-manufactured/.

[218] Sharpley, *supra* note 217.

[219] *See Rectifier*, TECHNOPEDIA (July 18, 2017), https://www.techopedia.com/definition/681/rectifier (A "rectifier" is an electrical device that effectively guides and straightens the directional flow of an electric current by converting this current from an alternating current (AC) that sometime flows in two directions, to a direct current (DC) that only flows in one direction.).

[220] *See* Josh Briggs, *How Alternators Work*, HOWSTUFFWORKS (Feb. 10, 2021), https://auto.howstuffworks.com/alternator1.htm (An "alternator" is part of the Vortex Bladeless's electric charging system that works together with the rectifier to generate power.).

tuning system.[221] At its bottom, the Vortex Bladeless possesses a much smaller, non-oscillating base.[222] The stationary base is anchored into the ground and is also responsible for converting the mast's oscillation movements into energy.[223]

The Vortex Bladeless, consequently, thwarts traditional notions of what people have come to expect when picturing a wind turbine and thinking about how it operates. Not only does the Vortex Bladeless look dissimilar from the wind turbines with people have been historically familiar, but this device's mechanical system functions much differently than does a standard monopile turbine, too. Together, these appearance and engineering characteristics are complete departures from the norm, potentially making these design improvements to the standard form of monopile wind turbines initially shocking and difficult for the public to grasp.

c. Non-Turbine Wind Energy Conversion Devices: Creation of a New Wind Device "Family" and Design Advantages vs. Performance Risk

Given its streamlined design, the Vortex Bladeless offers numerous mechanical and supply chain advantages compared to standard monopile wind turbines. Unlike traditional monopile wind turbines, the Vortex Bladeless lacks a rotor and possesses fewer mechanical parts, making it more resilient than traditional wind turbines. Specifically, the Vortex Bladeless is less prone to mechanical breakdown and failure resulting from constant exposure to friction.[224] This translates into lower maintenance, upkeep, and equipment replacement costs. From a manufacturing and supply chain perspective, fewer parts means fewer materials being sourced and delivered from distant locations to assemble the Vortex Bladeless. It also means that general disruptions to the supply chain may have less of an impact on the assembly of this device. Moreover, the Vortex

[221] *See How It Works – Fundamentals of the Idea*, *supra* note 201; *see also Tuning*, TECHNOPEDIA (Feb. 15, 2017), https://www.techopedia.com/definition/32326/tuning-databases (A "tuning system" is part of a wind turbine's operating system that keeps the power conversion system running smoothly and efficiently.).

[222] *How It Works – Fundamentals of the Idea*, *supra* note 201.

[223] *Id.*

[224] *Id.*

Bladeless will be subjected to fatigue[225] over the course of its operational life, similar to a standard monopile wind turbine. However, according to mathematical analyses conducted on the carbon fiber material constituting the Vortex Bladeless's exterior, this material is extremely hardy and prone to a very low level of potential deformation, meaning that a Vortex Bladeless turbine should have a very long service life.[226]

Essentially, the Vortex Bladeless creates a new "family" of wind energy conversion devices that produces energy at lower wind speeds than those in two other wind turbine families, the horizontal axis wind turbines ("HAWT") family and the vertical axis wind turbines ("VAWT") family.[227] The HAWTs are the most common wind turbines, whose blades face the wind and whose shafts are horizontal to the ground and turn a generator, producing energy.[228] Small HAWTs generally begin producing energy at an average cut-in point, or starting speed, of 4 miles/second.[229] In contrast, VAWTs possess shafts and blades that are connected vertically to their bases, and come in a number of different shapes and varieties.[230] Small VAWTs generally begin producing energy at an average cut-in point of 4.5 miles/second.[231]

The Vortex Bladeless differs structurally from turbines in both of these families insofar as it lacks a both a rotating blade and a gear-turning shaft that cranks a generator.[232] Additionally, the Vortex Bladeless has a lower cut-in point of around 3 miles/second.[233] Because this third, "new" wind turbine family generates energy at lower wind speeds than turbines from the other two already-existing families of wind turbines, they can generate energy for longer periods of time, daily.[234] This means even if the Vortex Bladeless generally

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[225] *Id.* ("Fatigue" is the weakening of a material due to a force repeatedly being applied to it.).

[226] *Id.*

[227] Luis Perez Maroto, *Cost-Effectiveness and Feasibility Analysis for Bladeless Turbines*, VORTEX BLADELESS, https://vortexbladeless.com/cost-effectiveness-analysis-bladeless/.

[228] *Id.*

[229] *Id.*

[230] *Id.*

[231] *Id.*

[232] *Id.*

[233] *Id.*

[234] *Id.*

produces less power than a HAWT or a VAWT produces at optimal capacity, in the long term, the Vortex Bladeless's ability to run for longer periods of time may enable it to produce more energy overall than these other turbines.[235] Moreover, in contrast to HAWTs and VAWTs, the Vortex Bladeless is "ominidirectional,"[236] as it can access and produce power from winds flowing to it from any direction. In contrast, traditional wind turbines only process wind flowing from select directions. Collectively, these characteristics make the Vortex Bladeless very well-suited for wind power optimization and deployment in the built environment, as well as for suburban distributed generation purposes.

Despite these positives, the singularity of the Vortex Bladeless's VIV technology usage means that theoretical projections for this device's performance may be inaccurate and overly optimistic when put in practice. Similar to performance risks associated with the Robin Rigg turbines, investors and other strategic partners who back the Vortex Bladeless are also undertaking a substantial performance risk. Up to this point, VIV has generally been used in the aquatic realm, not in the aeronautics realm. Scientists have known about VIV for years, as shoals of fish use these vibrations to swim in the most efficient manner, faster than their muscular capacities would ordinarily allow.[237] Specifically, "downstream" fish use the vortices created from fish in front of them to propel them forward and to help them glide between these vortices.[238] This is why VIV technology historically has been called "Fish Technology."[239] Indeed, underwater devices have been created that use VIV to harness energy in slow-moving ocean and river currents.[240] In the wind energy sector, though, devices utilizing VIV-based technology have not made their public debut. Furthermore, real-world commercial prototype deployment of the Vortex Bladeless has not yet occurred, so its performance track record cannot be analyzed.[241] Investors, therefore, are taking a leap of faith by investing

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[235] *Id.*

[236] *How It Works – Fundamentals of the Idea*, *supra* note 201.

[237] *What Is Fish Technology? What are Vortex Induced Vibrations?*, BRIGHTHUBENGINEERING (Apr. 22, 2009), https://www.brighthubengineering.com/hvac/32650-a-new-way-for-generating-energy-fish-technology/.

[238] *Id.*

[239] *Id.*

[240] *Id.*

[241] *Frequently Asked Questions (2019)*, VORTEX BLADELESS (2019), https://vortexbladeless.com/faq/#question4.

in a device that applies VIV technology in an unusual, industry-defiant manner.

d. Damages Risk – Mitigating Against Reasonably Foreseeable Outcomes and Black Swan Events

(i) VIV-Induced 1965 Collapse at UK's Ferrybridge C Power Station

Not only does the Vortex Bladeless present the performance risks described in Part III.B.1.c., but, based on historical data regarding VIV-induced vortices that caused black swan[242] accidents, this device may need to mitigate against additional risks if deployed at larger-scale than current prototypes. Historically, VIV has been responsible for black swan events on several continents. For instance, on November 1, 1965 at the Ferrybridge C Power Station in West Yorkshire, England,[243] due to the cooling towers' design defects and issues regarding the towers' physical layout, three of these eight 350-foot high towers collapsed just one year after their construction, with the remaining five towers sustaining severe damage as a result of their exposure to VIV produced from 85 mph gale wind gusts (the "1965 Ferrybridge Collapse").[244] An engineering defect caused the collapse, as the towers' structures were not designed to withstand sudden gusts and wind bursts.[245] Also, because the eight towers were configured in two parallel, staggered rows, westerly winds were funneled between and among them, resulting in vortex formation between the four first-row towers, which vortices traveled downwind to the four second-row towers.[246] Because the vortices' frequency was the same as the towers'

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[242] *See* Part I., *supra* subsec. C.1. (For a discussion about what constitutes a Black Swan event.).

[243] *Ferrybridge C Power Station, West Yorkshire*, POWER STATIONS OF THE UK, http://www.powerstations.uk/ferrybridge-c-power-station-west-yorkshire/ (The Ferrybridge C Power Station, a power station with a nameplate capacity of 2,000 MW at its main hard coal-based station and 68 MW at its gas turbine area, was ultimately decommissioned on March 23, 2016, approximately 50 years after being rebuilt.).

[244] *See id.*; *see also Ferrybridge C Power Station*, GRACE'S GUIDE TO BRITISH INDUS. HISTORY, https://www.gracesguide.co.uk/Ferrybridge_C_Power_Station.

[245] *Ferrybridge C Power Station, West Yorkshire*, *supra* note 243.

[246] *Id.*; *Ferrybridge C Power Station*, *supra* note 244.

natural frequency of 0.6 Hz,[247] three second-row towers collapsed after engaging in movements that eyewitnesses characterized as belly dancer-like.[248] While all eight towers were re-built to address these design and layout issues, the 1965 Ferrybridge Collapse serves as historic precedent for foreseeable aeronautical damages that VIV can cause.

(ii) VIV-Induced Collapse of Washington's Tacoma Narrows Bridge

Black swan events involving VIV have also occurred within the United States, due to flawed designs of structures applying complex engineering concepts, such as bridges. A prime example of such an event occurred in 1940 with respect to Washington's Tacoma Narrows Bridge.[249] Located approximately 40 miles south of Seattle and spanning Puget Sound from Tacoma to Gig Harbor, the over one mile-long bridge not only was the third largest suspension bridge in the world at the time of its construction, but was also the very first cable suspension bridge.[250] The engineers who designed this architectural achievement originally thought the bridge's design was safe, despite it exceeding previously-set standards for bridge length, width, and depth ratios.[251] When the bridge encountered high winds on November 7, 1940, just four months after it was built,[252] it buckled, undulated, and twisted so wildly that at one instance, the sidewalk on one of its sides was approximately 28 feet higher than the sidewalk on its other side.[253] This unusual display earned the Tacoma Narrows

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[247] *See Hertz*, THE FREE DICTIONARY, https://acronyms.thefreedictionary.com/HZ ("Hz" is the abbreviation for hertz, a measure of cycles per second.).

[248] *Ferrybridge C Power Station*, *supra* note 244.

[249] History.com Editors, *This Day in History, November 7, 1940 - Tacoma Narrows Bridge Collapses*, HISTORY (Nov. 5, 2019), https://www.history.com/this-day-in-history/tacoma-narrows-bridge-collapses.

[250] See *id.* (The bridge measured 5,959 feet, whereas a mile is only 5,280 feet.); *see also How Many Feet are In a Mile*, RAPIDTABLES,COM, https://www.rapidtables.com/convert/length/how-many-feet-in-mile.html; *see also* Ajay Harish, *Why the Takoma Narrows Bridge Collapsed An Engineering Analysis*, SIMSCALE (Jan. 27, 2020), https://www.simscale.com/blog/2018/07/tacoma-narrows-bridge-collapse/.

[251] History.com Editors, *supra* note 249.

[252] Smithsonian National Air and Space Museum, *The Collapse of 'Galloping Gertie*,' YOUTUBE (Nov. 4, 2019), https://www.youtube.com/watch?v=y0xohjV7Avo.

[253] History.com Editors, *supra* note 249.

Bridge the nickname "Galloping Gertie."[254] Even though the bridge's towers were constructed from structurally strong carbon steel, the bridge's vulnerability to VIV from wind flowing from a certain direction, coupled with the wind's frequency matching the natural frequency of the bridge's own structure, caused violent oscillation movements that resulted in the bridge's collapse.[255] Lessons learned from the Tacoma Narrows Bridge incident have spurred engineering design research into how to make bridge structures more wind-resistant.[256]

(iii) Resilience Considerations for Potentially Remote but Foreseeable Risks

Given the engineering catastrophes that resulted in the 1965 Ferrybridge Collapse and the Tacoma Narrows Bridge collapse (collectively, "Historic VIV Catastrophes"), in the future, investors in the Vortex Bladeless theoretically could be assuming a very remote, yet foreseeable, risk of damage to this device's surroundings. For example, as discussed in Part III.B.1.c., Vortex Bladeless arrays have not yet been "road-tested" within actual urban streetscapes. This means that no matter how unlikely, these devices' use of VIV could be the proximate cause of damages in the built environment, such as window glass shattering or building structures weakening and ultimately collapsing as a result. Should such highly improbable, yet technically possible, events occur, the question may arise of whether such event(s) were foreseeable based on Historic VIV Catastrophes that previously occurred. This determination will likely fall to the courts before which potential lawsuits regarding such incidents are presented, or, as was the case regarding the post-accident Fukushima investigation in *Cooper v. Tokyo Electric Power Co.*,[257] will fall in the hands of a special body tasked with investigating the resulting damage and conducting a foreseeability analysis, similar in function to the Fukushima Accident Commission.

In either scenario, the fact finder will need to balance the weightiness of the risk against the precautionary measures taken. This could mean evaluating the remoteness of this risk, considering hindsight based on Historic VIV Catastrophes precedent as well as

[254] Smithsonian National Air and Space Museum, *supra* note 252.
[255] History.com Editors, *supra* note 249; Harish, *supra* note 250.
[256] Smithsonian National Air and Space Museum, *supra* note 252.
[257] *See Cooper*, *supra* note 10.

historical data for severe weather patterns. The fact finder may also evaluate and consider known wind patterns, humidity levels, and weather trends impacting major cities along the U.S.'s East Coast, such as New York City and Boston, as part of the known background factors and risks to consider.[258] Aggregating and analyzing this scientific data provides a basis for the precautionary measures taken to mitigate against VIV-related black swan accidents. If the fact finder determines this basis was sufficient to warrant taking measures to protect against such accident risk, and if such measures were not taken, then Vortex Bladeless as a company, its manufacturing partners, and others could be liable for damages. Paying a large settlement amount can bankrupt a fledgling company such as Vortex Bladeless, thereby exposing both its secured creditors and unsecured creditors to investment loss and thwarting their expectations of realizing future profits or revenue streams from the Vortex Bladeless's market performance.

Moreover, investors may be unaware that the Vortex Bladeless relies on VIV as a mainstay of its operating system or that black swan event risk exists with respect to VIV. Due to the obscureness of VIV-induced vibrational risk, Vortex Bladeless, as a company, could decide that the risk is so remote and improbable that it does not rise to the level of being a reasonable risk. For this reason, while this risk may warrant disclosure as a risk factor in any offering circulars for initial rounds of investor capital raises that the company may undertake, if the very low probability and remoteness of this VIV-related risk is well-articulated in such risk factor disclosure, this disclosure will likely not deter investors from proceeding to take an equity stake in the company. As a result, although investors will know about the possibility of such a highly unlikely, yet potentially foreseeable and extreme, risk, they may be willing to undertake such risk nevertheless.

2. *Looking Far into the Future: Experimenting with Repowerings and Integration into New or Existing Wind Turbine Layouts*

While the Vortex Bladeless by its very nature is a game-changer within the wind industry, this device's reliance on VIV

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[258] Nate Silver, et. al., *Which City Has the Most Unpredictable Weather? – How Predictable is U.S. Severe Weather?*, FIVETHIRTYEIGHT (Dec. 4, 2014), https://fivethirtyeight.com/features/which-city-has-the-most-unpredictable-weather/ (Based on data from National Weather Service (NWS) weather stations, gathered from 1994 – 2013.).

technology may also offer additional opportunities for future exploration – a risk that early-stage investors may want to take. Currently, the Vortex Bladeless's "Vortex Takoma" model is in its prototype certification stage.[259] Because the Vortex Takoma is only 9 feet tall, its size necessitates its consideration for usage only as a small-scale wind energy conversion device, primarily for residential or rural use as an alternative to solar panels.[260] Conceivably, though, in the future, similar to the Robin Rigg turbines that were scaled-up from substantially smaller prototypes, the design for an enormous, scaled-up Vortex Bladeless model could be possible, particularly since Vortex Bladeless as a company envisions doing so.[261] This larger, currently hypothetical Vortex Bladeless device ("Giant Vortex Bladeless") could potentially play a major role in the utility-scale wind industry, disrupting current, conventional notions of wind farm operations and turbine layouts.

Utility-scale wind farms endeavor to optimize their energy production by designing wind turbine layouts that enable each turbine to be sited in a manner that maximizes its energy output. For each turbine, this includes minimizing wake generation impacts from other turbines' rotating blades, including avoiding downwind and lateral wind wakes from other neighboring turbines.[262] In short, wind wakes historically are something wind farm developers shun. They decrease wind speeds for downwind turbines and result in these turbines' lower energy production, causing the wind farm overall to underperform and deliver less energy to the grid than originally anticipated.[263] Wind

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[259] *Vortex Bladeless Biography & Current Stage – Current Status 2019*, VORTEX BLADELESS, https://vortexbladeless.com/story-vortex-bladeless-tech-startup/.

[260] *Id.*

[261] *Id.* (comment on July 13, 2019 at 22:21h, https://vortexbladeless.com/story-vortex-bladeless-tech-startup/).

[262] *See* Kimberly E. 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* (co-author), *22* DUKE ENVTL. L. & POL'Y F. 195, 202 - 212 (2011), https://scholarship.law.duke.edu/delpf/vol22/iss1/4 (For an in-depth discussion of wind wakes, wake effects, their impacts on other turbines and their energy output, and the economic feasibility of a wake-impacted wind farm project.).

[263] *See id.*: *see also* Kimberly E. Diamond, *Wake Effects, Wind Rights, and Wind Turbines: Why Science, Constitutional Rights, and Public Policy Issues Play a Crucial Role*, 40 WM. & MARY ENVTL. L. & POL'Y REV. 813, 817 - 818 (2016), https://scholarship.law.wm.edu/wmelpr/vol40/iss3/5 (For a more detailed

wakes also cause wear and tear on turbines located downwind or laterally in the same row as the wake-generating wind turbine, resulting in the need to replace of these impacted turbines' gears and other components or the need to replace the entire turbine much earlier than originally anticipated.[264] Collectively, such expenditures on replacements cuts into the wind farm's profits, reducing the wind farm's overall profits, something developers and investors endeavor to avoid.

The Giant Vortex Bladeless, though, may turn on its head the wind industry's traditional utility-scale wind farm model that focuses on wind wake avoidance. Rather than trying to avoid wakes and the fluid air turbulence they create, the Giant Vortex Bladeless could potentially thrive on wakes. This device would then be a complete game changer for the wind industry in terms of wind farm layouts, optimization, and number of traditional wind turbines that need to be purchased for a given wind farm. First mover developers who want to take advantage of VIV technology could design their to-be-built wind farms with layouts including only Giant Vortex Bladeless turbines, or layouts including these devices interspersed among traditional, 3-blade utility-scale wind turbines. Even for existing wind farms, first mover developers aiming to capitalize on VIV technology may consider integrating Giant Vortex Bladeless turbines among or in place of their existing turbines. In the case of the latter scenario, during a wind farm's repowering,[265] rather than partially retrofitting an "older" turbine with new, updated parts or replacing such turbine completely with an upgraded, improved standard wind turbine model, a Giant Vortex Bladeless could replace this older turbine altogether.

Using Giant Vortex Bladeless devices could potentially result in more energy produced than the contracted-for amount under the

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discussion of how turbulence intensity causes downwind turbines to become less efficient and to experience increased structural fatigue.).

[264] Diamond, *supra* note 262.

[265] *See* Diamond, *supra* note 263, at 832 (A repowering is a project "involve[ing] commercial wind turbines across one or more wind farms [that] generally includes replacing either obsolete turbines or turbines that are past their approximate 20–30 year life cycle with newer, more innovatively designed and efficient turbines for purposes of increasing renewable energy power production, something generally deemed to be in the public interest.").

wind farm's Power Purchase Agreement ("PPA").[266] With the use of evolving battery power storage technology co-located with Giant Vortex Bladeless devices, these devices operating in tandem with traditional, three-bladed turbines could result in excess power generation during peak energy production periods. This situation, however, would not be problematic insofar as the excess energy generated could be collected, stored, and released onto the grid when needed at any point during the day or night. Accordingly, this approach could potentially alleviate concerns associated with both wind intermittency and mitigate against the wind farm's inability to generate energy consistently throughout the course of an entire day, particularly when only insufficient wind or winds with wind speeds too low for energy generation are available.

Also, a Giant Vortex Bladeless could be more efficient than traditional turbines, generating energy for a more consistent, longer time and at lower wind speeds than traditional wind turbines. This could be of great benefit to the wind farm, as the Giant Vortex Bladeless devices would not only supplement the energy the standard, three-bladed turbines produce, but would also produce energy when these traditional turbines are unable to do so. For these reasons, the Giant Vortex Bladeless could be a boon to a wind farm's bottom line. The Giant Vortex Bladeless, then, could enable wind turbine investors to stay ahead of the curve, as VIV technology could herald the next new wave of wind power technology.

It is unknown, though, whether these hypothetical situations will be viable in practice insofar as they may be scientifically unrealistic. The carbon fiber and other materials that allow for the

[266] *Better Buildings Financing Navigator – What is a Power Purchase Agreement?*, U.S. DEPT. OF ENERGY [DOE] BETTER BUILDINGS, https://betterbuildingssolutioncenter.energy.gov/financing-navigator/option/power-purchase-agreement (A Power Purchase Agreement, or PPA, is a contract commonly used in the renewable energy sector under which a third party developer installs, owns, operates, and maintains an energy production system or device on its customer's property. Under the PPA, for a fixed period of time, the customer is required to purchase the energy that system or device generates. Customers benefit from this arrangement, as they do not need to pay the costs associated with purchasing the energy-producing equipment or wires connecting the equipment to the energy delivery point. Likewise, a PPA is advantageous for the developer insofar as it can become the beneficiary of tax credits associated with the energy produced, as well as receive profits from the energy it sells to the customer.).

Vortex Bladeless's light weight[267] at its current size work very well for the device's current prototypes' performance. Using different materials, or a different concentration of materials, though, may be necessary for the device's scaled-up, larger form. Such materials may work differently or not at all in terms of the device's mechanical operation at Giant Vortex Bladeless size. Moreover, the performance risks associated with a scaled-up, Giant Vortex Bladeless model are unknown currently, and likely will remain unknown until tested in practice in the real world. Given the physics involved with VIV technology, and given the Historic VIV Catastrophes, new legally mandated setback limits[268] may be needed for safety purposes as a precautionary measure with respect to Giant Vortex Bladeless devices, so that the VIV phenomenon does not destroy or disrupt the structural integrity of nearby buildings, including barns and homes. Accordingly in addition to the potential benefits that the Vortex Bladeless devices offer, these potential eventualities are considerations investors should contemplate when considering their investment and the long-term risk/reward ratio regarding Vortex Bladeless technology.

C. Habitat Destruction Resulting from "The Best" Available Technology May Pose Financial Risks

Implementing the best technology available may also prove risky due to its potentially causing adverse environmental consequences. From a holistic view of renewable energy projects, the benefits of proceeding with a project that incorporates an iterative improvement in design technology, or that relies on a promising scientific technology to become the new "replacement" market standard, need to be weighed against the permanent habitat destruction that the devices deploying this technology within the project may cause. Often, the legal decision-maker's thoughts regarding the scope and sufficiency of measures taken to protect certain species and preserve their habitat are balanced against their thoughts regarding whether these items take priority over producing vast amounts of

[267] *How It Works - Eco-Friendly - Environmental Impacts*, VORTEX BLADELESS, https://vortexbladeless.com/technology-design/.

[268] *See* Diamond, *supra* note 263, at 821 (A "setback limit" is "effectively a buffer zone established between (i) the shared property line between an upwind landowner and a downwind landowner and (ii) the closest distance the upwind landowner can site a commercial wind turbine on its property."); *see also id.*, at 821-24 (For an in-depth discussion of setback limits, including their relationship to wind wakes.).

renewable energy for the greater public good. If these decision makers resolve that the former approach should prevail, the protectionary measures selected for one or more animal species in a given area may result in an envisioned renewable energy project being terminated, delayed, partially restricted, or rendered unfeasible. As a result, the project developer risks losing certain up-front costs it invested in advance of the project's construction. Consequently, developers considering construction of utility-scale renewable energy projects that use state-of-the-art devices need to be resilient enough to withstand the financial risk associated with their original investment-backed expectations not coming to fruition.

1. Sage-Grouse's Impact on Utility-Scale Wind Projects and Developers' Investments

For years, the Greater Sage-Grouse has symbolized habitat preservation being weightier in the balance than renewable energy generation. In the upper Midwest and in other western states, numerous groups have championed the preservation of the sagebrush grasslands habitat in which these fluffy, feathery, chicken-like birds live.[269] A key reason for this is that the sage-grouse is thought to be an umbrella species, meaning that the preservation of its habitat is thought to also preserve other species' habitat.[270] Groups leading the fight to preserve this species and its natural surroundings have halted utility-scale wind farm projects from going forward and have restricted turbines from being erected in certain areas.

An example of one such wind farm whose construction did not occur is the Withrow Wind Farm, a 100-turbine wind farm proposed in approximately 2008 that was to be located in Douglas County, Washington in the Cordileran Ice Field.[271] The area selected for wind farm construction also possesses the largest of the two remaining sage-grouse populations in Washington,[272] meaning that construction of this wind farm would likely have foreseeable, adverse sage-grouse

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[269] *See Greater Sage-Grouse: Overview and Effects of Wind energy Development – Sage-Grouse Ecology*, AM. WIND WILDLIFE INST. (Sept. 2017), http://www.nationalwind.org/wp-content/uploads/2018/02/NWCC-Sage-Grouse-Fact-Sheet.pdf.

[270] *Id.*

[271] Michael A. Schroeder, *Greater Sage-Grouse and the Proposed Withrow Wind Farm*, report from the Washington Department of Fish and Wildlife (June 20, 2008), https://wdfw.wa.gov/publications/01315.

[272] *Id.*

impacts. The Washington Fish and Wildlife Department developed a sage-grouse management plan for this area in 1995, and later, followed-up with a species recovery plan.[273] In Fall 2010, the Withrow Wind Farm project was put on hold, ostensibly for reasons other than sage-grouse preservation.[274] What this non-construction does not reveal, though, are the sunk costs the developer expended when seeking to purchase or lease the land for this wind project. These costs include expensive wind resource studies, land surveys, and turbine layout modeling, all conducted in support of its investment-backed expectation that the wind farm would be built.[275] Failing to have the wind farm constructed as planned, therefore, involved real, non-recoverable monetary losses for the developer.

As a second example, the Chokecherry and Sierra Madre Wind Energy Project, illustrates how protection of the sage-grouse disturbed developer Power Company of Wyoming LLC's ("PCW's") original plan for its wind farm construction. Initially, this 3,000 MW wind farm, with its 1,000 wind turbines, was scheduled to be constructed in Rawlins, Wyoming and to rank as the largest onshore wind farm in North America.[276] Covering approximately 220,000 acres of land, this project was envisioned for construction in an area with a vast sage-grouse population.[277] Before project construction began, PCW spent five years and $3 million on a study focused on sage-grouse habitat and migration patterns.[278] Due to the sage-grouse congregating in particular parts of the project area, PCW eliminated from the project certain tracts of land with a wind power class rating of Class 7r[279] that

[273] *Id.*

[274] *Wind Power – Withrow Wind Project*, DOUGLAS COUNTY P.U.D., https://douglaspud.org/environment/wind-power.

[275] *See* Diamond, *supra* note 263, at 813, 816.

[276] Scott Streater, *Endangered Species – Massive Wind Project Aims to Save the Sage Grouse*, E&E NEWS (June 11, 2015), https://www.eenews.net/stories/1060020060.

[277] *Id.*

[278] *Id.* (This study included placing GPS tracking devices on the backs of numerous sage-grouses. The idea was to have pre-construction data along with post-construction/placed in service data to analyze the wind farm's impacts on the sage-grouse population.).

[279] *See*, *Wind Power Class*, TURBINEGENERATOR, https://www.turbinegenerator.org/wind/types-wind-turbines/power-class/ (last visited on May 22, 2021) (The wind power class rating system measures wind speeds at certain specified miles per hour (mph). Wind power class ratings range from Class 1 to Class 7, with Class 1 having the lowest wind resource with wind

possessed annual average, constant wind speeds of 25 mph, placing this area at the absolute highest end of the wind power class spectrum for excellent wind quality[280]As a PCW Vice President indicated, this meant that PCW "[gave] up quite a bit from a wind-resource standpoint."[281] Due to PCW being partially restricted from erecting turbines on certain areas of the land it acquired as part of its originally envisioned wind farm footprint, PCW effectively lost the money that it invested in conducting the wind resource studies on these sage-grouse-impacted areas.

2. *Solar Projects, Desert Animals, and Costly Legal Battles*

Other animals in the California and Nevada deserts have not been as fortunate as the sage-grouse in terms of habitat preservation and protection when balanced against utility-scale solar project construction. Species such as the Blunt Nosed Leopard Lizard, the San Joaquin Kit Fox, and the Desert Tortoise have each been subjected to habitat destruction for utility-scale solar facilities' construction.[282] Within the last decade, certain groups such as Defenders of Wildlife, the Sierra Club, and local Audubon Society chapters have brought lawsuits in federal court seeking preliminary injunctions, temporary restraining orders, or both,[283] to prevent project construction of utility-

speeds averaging 8.9 mph or less, and Class 7 having the highest wind resource with wind speeds averaging 20.1 mph or more. Generally, areas with a Class 3 wind power class rating possess average wind speeds of 15.7 mph and are considered "Good" quality sites that are suitable for utility-scale wind farm development. An area with a Class 7 wind power class rating is considered an "Excellent – HI" location for siting a utility-scale wind farm. The area that PCW eliminated from the Chokecherry and Sierra Madre Wind Energy Project, consequently, possessed average wind speeds that exceeded by approximately 5 mph the average wind speeds for an area with a Class 7 wind power class rating (25 mph – 20.1 mph = 4.9 mph).).

[280] Streater, *supra* note 276.

[281] *Id.* (*quoting* Garry Miller, a PWC Vice President).

[282] *Defenders of Wildlife v. U.S. Fish & Wildlife Serv.,* Case No. 16-CV-01993-LHK, (N.D. Cal. Aug. 17, 2016); *Defenders of Wildlife v. Jewell*, No. 12–1833ABJ, (C.D. Cal. Apr. 2, 2014) (consolidated with No. 12–1965 ABJ).

[283] *See Injunction*, CORNELL L. SCHOOL, LEGAL INFO. INST. (*last updated* 2017), https://www.law.cornell.edu/wex/injunction (A preliminary injunction and a temporary restraining order (TRO) are both equitable remedies and subgroups of the broader category of injunctions. A judge can generally issue either at the early stages of a lawsuit to prevent a defendant from proceeding with what the plaintiff alleges is harmful conduct. A TRO is generally a short-term remedy that suffices until something more permanent, such as preliminary injunction, can be issued. A

scale solar projects such as Ivanpah,[284] the Silver State North Solar Project, the Silver State South Solar Project, and the Stateline project in the Eastern Mojave Recovery Unit on federal land in the Mojave Desert[285] as well as in California's Panoche Valley.[286] Ultimately, these efforts proved unsuccessful, and the solar project developers prevailed on the merits of their respective cases.

While the developers related to these projects obtained legal victories, and while the power generation facilities at issue were built, these lawsuits nevertheless cost these developers substantial time and money in terms of attorneys' fees, court costs, mitigation plans for portions of the impacted areas, and other related legal expenses needed to enable these projects to go forward. Collectively, these undertakings illustrate that developers of innovative renewable energy projects undertake the risks and costs associated with being the respective defendants in protracted, costly litigation. To cover litigation costs, such developers must tap into their cash reserves and spend thousands or millions of dollars on litigation-related measures as tradeoffs for the profits they expect to receive as a result of the renewable energy project's projected future success.

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preliminary injunction, on the other hand, preserves the status quo until such time as final judgment on the case is reached. To determine whether a preliminary injunction is appropriate, a court will use the 4-pronged test articulated in Winter v. Natural Resources Defense Council, Inc., 555 U.S. 7 (2008), which includes considering whether: (1) the plaintiff is likely to succeed on the case's merits; (2) irreparable harm will occur if the injunction is not issued; (3) when balancing the equities, the scale tips in favor of the plaintiff; and (4) the injunction will be in the public interest.); *see also Preliminary Injunction*, CORNELL L. SCHOOL, LEGAL INFO. INST., https://www.law.cornell.edu/wex/preliminary_injunction.

[284] *See* Part II., *supra* subsec. C (For a more detailed discussion of the Ivanpah solar project.).

[285] *Jewell, supra* note 282, at 1, 2 (In this case, plaintiffs argued that the narrow linkage corridor proposed for the Desert Tortoise's migration route was insufficient to address the translocation of this species as a proposed means of minimizing impacts and mitigating harm posed to this species' population.).

[286] *U.S. Fish & Wildlife Serv., supra* note 282, at 1,8 (At issue in this case was whether the taking of species listed under the Endangered Species Act, 16 U.S.C. § 1531 *et seq.*, as threatened or endangered, such as the blunt-nosed leopard lizard, the San Joaquin kit fox, and the giant kangaroo rat, would jeopardize the survival and recovery of these species. "Taking" in this instance means "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct" with respect to a listed species.); *see also* 16 U.S.C. § 1531(a)(1)(B).

IV. INNOVATION CLUSTERS: HOW PUBLIC-PRIVATE PARTNERSHIPS AND SMART CITIES CONSTRUCTS HELP TO ACCELERATE TECHNOLOGICAL ADVANCEMENTS WHILE BENEFITING STAKEHOLDERS

During the last decade, the U.S. experienced a surge in the number of innovation clusters countrywide along with a concurrent increase in the federal and state funding flowing to them.[287] This innovation cluster proliferation phenomenon is a result of the many benefits these clusters offer to both their constituents and others. Due to their smart cities features, incubator-like characteristics, and public-private partnerships thriving within, innovation clusters accelerate the speed of progress along the technology continuum. Also, small-scale innovation clusters generally assist their constituent organizations to identify and formulate collaborative solutions to address a specific issue, or a series of related issues, inherent to their respective cluster. It is within these smaller clusters that novel devices can be designed, developed, and tested with state-of-the-art technology and collaborative input from many cluster constituents.

Those small-scale innovation cluster members that work collaboratively in a public-private partnership with one another possess the potential to share their knowledge through data that can be accessed among like-minded individuals who are focused on achieving the same goal. The ability to generate and share this data, along with other technological know-how, ideas, and advances, accelerates the speed at which discoveries are made and breakthroughs are achieved. As a result, this knowledge sharing elevates our society overall insofar as it escalates others' intelligence and accelerates the rate of state-of-the-art device deployment.

Also, ingenious advances that are born and refined within an innovation cluster, including know-how that improves technological capabilities, frequently can be "exported," so that the local community as well as others outside the cluster benefit. In particular, the ability for cluster-based breakthroughs to be accessed, deployed, or replicated elsewhere exponentially increases these breakthroughs' exposure to people in other communities or regions who may derive benefit from

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

them. Due to small-scale innovation clusters' ability to foster collaboration through data trusts, the devices that are created, refined, and scaled-up in these clusters have the potential both to showcase cutting-edge technologies as well as to undergo continuous optimization to become the most advanced-level device of its type that current knowledge allows. As a matter of policy, then, small-scale innovation clusters may provide one of the most ideal platforms for sharing knowledge and data, collaboratively experimenting with evolving technologies, and pushing the boundaries of what is possible with respect to ultra-modern, advanced devices before they make their more wide-scale commercial debut.

A. Background – What Constitutes an Innovation Cluster

An innovation cluster can exist in different sizes, ranging from very large-scale to very small-scale. A large-scale innovation cluster, for instance, is also commonly known as a regional center of innovation, an "innovation corridor,"[288] or a "smart region,"[289] all of which terms are smart cities constructs. While there is no universal, specific definition of what constitutes a large innovation cluster, historically, these entities share the following five characteristics:

(i) A geographic location in a region strategically positioned to give the cluster a comparative advantage in its specific focus area;

(ii) Start-up companies and other independent firms concentrating in the focus area, with opportunities for venture capital investment, research, and development to foster the growth of ideas at their conceptual level;

(iii) A physical location near a college, university, or other research organization that promotes networking, social interaction, information dissemination, knowledge exchange, and technology transfer among cluster participants to spur continuous inventiveness;

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[288] Lisa Brown, *Smart Buildings & Campuses: Driving Smart Developments* panel at SMART CITIES WEEK: 2020 GLOBAL COLLABORATIVE ENGAGEMENT (Oct. 21, 2020), https://smartcitiesweek.vfairs.com/en/hall#topics-tab.

[289] Shawn Irvine, *The Rise of Smart Regions* panel at SMART CITIES WEEK: 2020 GLOBAL COLLABORATIVE ENGAGEMENT (Oct. 19, 2020), https://smartcitiesweek.vfairs.com/en/hall#topics-tab.

(iv) An ability to be "magnet-like" by enticing and attracting the best and brightest industry leaders in the cluster's specialty area, thereby elevating and concentrating the talent level, and;

(v) Access to facilities, infrastructure, and other shared amenities that further the innovation cluster's purpose.[290]

Collectively, these components constitute "agglomeration," a phenomenon that occurs when firms cluster together to accelerate economic advantages and become more productive.[291]

A small-scale innovation cluster, in contrast, develops in a manner slightly different from its large-scale sibling. These micro-clusters are generally less expansive in their size and draw upon already-established local talent, goods, and pre-existing local services. First, in terms of scope, these clusters tend to involve several or more neighboring municipalities, cities, or counties.[292] Second, through collaborative efforts among cluster stakeholders, as further discussed in Part IV.C., knowledge among these stakeholders gets pooled, creating a unique platform that yields customized measures to address and resolve a single challenge, issue, or problem within the cluster's borders.[293] Third, due to the cluster's location and relatively petite size, in addition to potentially partnering with local high schools or other educational institutions in close proximity, cluster members may partner virtually, rather than physically, with one or more colleges or universities that are situated far away from the cluster itself.[294]

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[290] Diamond, *supra* note 287; *Innovation Clusters – Definition*, INNOVISCOP, http://www.innoviscop.com/en/definitions/innovation-clusters.

[291] Ryan Donahue, Joseph Parilla, & Brad McDearman, *Rethinking Cluster Initiatives*, THE BROOKINGS INST. (July 25, 2018), https://www.brookings.edu/research/rethinking-cluster-initiatives/.

[292] Jim Fiorentino, *Smart Buildings & Campuses: Driving Smart Developments – Panel,* SMART CITIES WEEK: 2020 GLOBAL COLLABORATIVE ENGAGEMENT (Oct. 21, 2020), https://smartcitiesweek.vfairs.com/en/hall#topics-tab.

[293] *Id.;* Mansoor Hanif, *Accelerating Human Progress – The Vision and Plan for NEOM - Panel,* SMART CITIES WEEK: 2020 GLOBAL COLLABORATIVE ENGAGEMENT (Nov. 2, 2020), https://smartcitiesweek.vfairs.com/en/hall#topics-tab; Smart Cities Connect, *Smart Disruptors: Reimagining American Cities*, Zoom webinar (June 24, 2020 @ 1–2 p.m. EST).; Diamond, *supra* note 287.

[294] *See* Part IV., *infra* subsec. D.2. (For an example of such an innovation cluster, see the discussion regarding the Lake Nona Project.).

Fourth, as further discussed in Part IV.B and Part IV.C., within the cluster, at a project's outset, cluster members already possess the mindset that they will share their data with other cluster members. This plan to share data enhances intra-cluster collaboration,[295] generates momentum within the cluster, and provides value to those outside of the cluster who are endeavoring to tackle similar issues in other geographic locations.[296] This replicability element distinguishes smaller innovation clusters from larger ones. Specifically, small-scale innovation clusters often aim to be non-bespoke in nature, so that other towns and small regions are able to replicate and employ a particular cluster's technological breakthroughs.

Fifth, like larger, regional innovation clusters, small-scale innovation clusters tend to grow organically and not be based on a specific, standard formula. Often, this entails launching a project or testing and refining a novel device that provides a non-static solution to a challenge on which the innovation cluster is strategically well-positioned to focus. As the cluster generates data and analytics with respect to the device's operations, cluster constituents – particularly those within the same public-private partnership – then have the ability to analyze and interpret this data. These entities' ability to apply what they have learned enables their members to continuously tweak the technology and upgrade the device so that it produces more optimal outcomes. Knowledge aggregation such as this enables cluster stakeholders to use newly-obtained data to build their knowledge on an accelerated basis. This continuous "knowledge evolution process" provides an organic element to the project surrounding the device itself, so that the project grows and evolves in ways beneficial to cluster members.

B. Public-Private Partnerships within Innovation Clusters Provide Unique Value

1. General Background About Public-Private Partnerships

Public-private partnerships serve as the backbone of small-scale innovation clusters, insofar as they link together an ecosystem of different types of cluster entities. Generally, in a traditional public-private partnership, also known as a "P3," a government-funded or

[295] Hanif, *supra* note 293.
[296] *Id*.

government-subsidized entity, which may take the form of a public agency or an academic institution such as a college or university, collaborates with one or more private companies to finance, build, and operate a project.[297] If the project involves multiple businesses, these private partners can supplement government-sponsored financing of the project, in return for some reward that flows to them.[298] For instance, in traditional infrastructure development projects, these rewards can include tolls and fees, such as in highway development projects.[299]

In a smart cities-focused public-private partnership that exists within a small-scale innovation cluster, all entities within the partnership are involved in a particularized venture or project. They also have a certain common goal in mind, share in the risks and rewards associated with that project, and are committed to achieving simultaneously different categories of goals: their own goals, the goals of their other partnership members, and the goals relating to the project itself.[300] Within the partnership, there is no lone entity that implements an initiative single-handedly or that maintains sole expertise about the partnership's project. Rather, multiple entities converge to execute on a strategic plan. As a result, there is a unique connectivity between and among partnership players that produces measurable outcomes and that ultimately drives these players to actualize the cluster's overarching purpose.[301] Within this context, the public-private partnership focuses on producing a demonstrable and rapid return on investment, in terms of three criteria: (1) social impact or financial impact; (2) the ability to deliver results quickly; and (3) all partners having a vested interest in the success of the project on which they are working within the cluster.[302] Partnership members determine the

[297] Will Kenton, *Public-Private Partnerships*, INVESTOPEDIA (Mar. 28, 2019), https://www.investopedia.com/terms/p/public-private-partnerships.asp (An example of a public-private partnership's results that appear in the built environment is the one that produced the Pavegen array at DuPont Circle.); *see also* Part II., *supra* subsec. B.4.

[298] *Id.*; Elyse Maltin, *What Successful Public-Private Partnerships Do*, HARV. BUSS. REV. (Jan. 8, 2019), https://hbr.org/2019/01/what-successful-public-private-partnerships-do.

[299] Maltin, *supra* note 298.

[300] *Id.*

[301] Bill Maguire, *Effective Public Private Partnerships: The Key to Smart Community Success – Panel,* SMART CITIES WEEK: 2020 GLOBAL COLLABORATIVE ENGAGEMENT (Nov. 2, 2020), https://smartcitiesweek.vfairs.com/en/hall#topics-tab.

[302] *Id.*

unique strategy for focusing on each of these elements to best address the overarching issue the cluster seeks to solve.

2. *Best Practices: Two Schools of Thought for Cluster-Based Public-Private Partnership Operations*

a. *Allocate Responsibilities in Silos*

There are two schools of thought regarding best practices for how to achieve milestones within a small-scale innovation cluster-based public-private partnership. The first is for the partnership to follow the traditional route of allocating responsibilities between the public partners and the private partners at the outset of the partnership relationship, according to historical norms. This segregation of responsibilities causes partnership organizations to operate in different silos, with a high degree of non-transparency regarding the progress they are making on their assigned tasks.

The downside of this silo-ing is that certain partners may neither be aware of the items on which their other partners are working, nor may they be aware of the challenges these partners may be facing. From a practical perspective, this means that certain organizations are unlikely to have a hand in the assigned tasks for which their partner organizations are responsible. For instance, the private partners in the partnership may bear responsibility for the project's design, completion, and implementation, while the public partners may only be responsible for defining and monitoring compliance.[303] From an efficiency perspective, this situation is not optimal. Indeed, one of the downsides of responsibility silo-ing is that certain partners potentially may have been able to provide guidance, help inform the process, or help resolve certain challenges confronting a partner handling a particular responsibility. Lack of transparency with respect to progress being made on assigned responsibilities, therefore, is not ideal for the partnership overall.

b. *The Collaborative, Team-Driven Approach*

The second school of thought is a more preferable one, wherein public-private partnership members act collaboratively and follow a team-driven approach. Within this structure, leaders from each

[303] Kenton, *supra* note 297.

organization in the partnership (the "Organization Leaders") are appointed and are assigned key targets for their respective organizations to meet by certain deadlines.[304] Organization Leaders are then required to report to one another at regular intervals with their progress on meeting their respective key targets and fulfilling their assigned responsibilities. This collaborative reporting enables Organization Leaders to know about the projects on which their respective partners are working, as well as the status and progress being made on each. As a result, to the extent that they or members of their organization can offer assistance to their partners, there is timely opportunity to do so. This team-driven structure, then, provides three key benefits: (1) the ability to establish mutually beneficial operating principles for the partnership at a project's outset, (2) the ability to draw upon institutional knowledge from diverse organizations within the partnership, and (3) the ability for all partnership member organizations to be well-informed about issues as they arise insofar as meeting cluster-based and partnership-based targets, so that these issues may be addressed promptly.

The first benefit of a team-driven structure is that it facilitates Organization Leaders' ability to establish operating principles for a project up-front, as well as allows all partnership organizations to be aware of the "rules of the game" from the outset. This ensures that each partnership organization is best-positioned to interact with its partners as an integrated team. As a cohesive unit, partnership member organizations are more apt to share knowledge and collaboratively solve problems as they arise.[305]

The second benefit of a team-driven structure enables Organization Leaders to address and discuss issues in real-time, accept shared responsibility for outcomes, and enhance their collective ability to devise a solution to a particular issue or assigned cluster-based task. Cluster-driven targets may not always be articulated in contracts between or among partnership parties.[306] Accordingly, having Organization Leaders regularly share their concerns with one another helps the partnership to resolve issues quickly and efficiently.[307]

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[304] Maltin, *supra* note 298.
[305] *Id.*
[306] *Id.*
[307] *Id.*

There are a number of ways that Organization Leaders can engage with one another to accomplish this problem-solving effort. For instance, they can hold meetings at fixed intervals with each other, either on a weekly or bi-monthly basis. This structure helps to diffuse blame from flowing from one partnership member to another for unmet milestones. The partnership as a whole can then work together to create solutions to cure deficiencies, as well as to address other issues.[308] Also, having Organization Leaders engage in regular e-mail exchanges with one another can keep partnership organizations in-tune with the progress that their partners are making, and can assist in identifying areas in which further support and assistance are necessary. Additionally, if the project involves a project site, requiring partnership member organizations to visit this site according to a fixed schedule assists in promoting a goal-driven, collaborative environment among partnership members.[309]

The third benefit of a team-driven approach arises as a result of synergies that develop between and among organizations within the public-private partnership. Within a public-private partnership, partnership member organizations often hail from different industries, or from different segments within a particular industry. Moreover, each person within each partner organization, including the Organization Leader, possesses a unique background, expertise, and skill set. When aggregated, this breadth of experience serves as a valuable resource that helps to expand the knowledge base available to the partnership unit. It also allows for diverse perspectives and expertise to be available to address both the overarching issue the cluster seeks to solve, as well as the more granular issues that the cluster must tackle to achieve such greater goal. The synergies created among entities in public-private partnership, therefore, enable the cluster itself to thrive while simultaneously empowering partnership members who are best positioned for guiding the process to be able to do so.

Accordingly, within an innovation cluster, a public-private partnership's adopting a team-driven approach, setting team-driven goals, and establishing strategies to meet these goals drives the cluster's momentum and helps the partnership, as well as the cluster itself, to function. These factors facilitate experimentation conducted

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[308] *Id.*
[309] *Id.*

within the partnership and within the cluster more broadly, as partnership-sponsored cluster projects are able to evolve continuously and be scaled-up quickly, in a transparent manner.[310] Also, a team-based approach assists in positioning the partnership to develop a positive reputation and a proven track record that may assist it in winning additional projects on which to work that originate from outside the cluster, including projects involving the replication of the cluster's product(s) elsewhere.[311] Setting ground rules at the outset for the public-private partnership's operations and electing to use a team-driven approach, therefore, not only determines how cluster-specific problems will be handled before they occur, but it facilitates the public-private partnership's ability to set a shared vision and assemble a plan for how to actualize this vision. Such ground rules also help to promote a strong working relationship among all partnership organizations, so that each member organization feels included, believes that its voice can be heard in partnership decisions, and sees that its input matters to the project's overall outcome.[312]

C. Trust: A Key Element for Constructing and Managing the Data Platform

One key element of a public-private partnership within the context of a small-scale innovation cluster is that its outcome-driven collaborations are predicated on trust among the partnership's constituent organizations.[313] Data sharing is a critical factor that enables an innovation cluster to thrive. Before data sharing among partnership organizations can occur, though, the foundational and essential element of trust among these entities must be established and in place. Absent this trust prerequisite, building the technical infrastructure required for data sharing may be difficult or unable to occur.

Laying the foundational groundwork for an intra-cluster data sharing network means that a number of milestones need to be reached.

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[310] Rick Cimerman, *Effective Public Private Partnerships: The Key to Smart Community Success – Panel,* SMART CITIES WEEK: 2020 GLOBAL COLLABORATIVE ENGAGEMENT (Nov. 2, 2020), https://smartcitiesweek.vfairs.com/en/hall#topics-tab.

[311] *Id.*

[312] *Id.*

[313] Natalie Evans Harris, *Data Sharing: Civic Data Trusts – Panel,* SMART CITIES WEEK: 2020 GLOBAL COLLABORATIVE ENGAGEMENT (Oct. 21, 2020), https://smartcitiesweek.vfairs.com/en/hall#topics-tab.

First, an analysis must be conducted that builds the "data use case" for the platform on which the data can be accessed. Partnership members' ability to collaborate around data is essential. This is why identifying and building the specialized capacities of the shared platform on which the data will placed facilitates collaboration. To clearly identify and take into account factors that will make this platform successful, partnership members must, at a minimum, take into account the following considerations when building the platform:

(1) The overarching purpose of the collaboration;
(2) The reasons why partnership members want to share the data with each other;
(3) The best approach for educating one another an ongoing basis so that all partners understand the confidentiality and data privacy aspects of the data being shared;
(4) The appropriate partnership member to act as gatekeeper and "data trustee,"[314] from both a practical and legal perspective, and;
(5) Which partnership partners are going to provide data, and which are going to receive and interpret it.[315]

With these factors adequately addressed, the data trust concept can be effectuated.

1. Open Data, Data Sharing without Coercion, and the Data Trust: Background

A "data trust" is a construct that allows multiple organizations within the public-private partnership to access shared data anytime, improving upon the traditional point-to-point sharing arrangement

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[314] *See* Part IV., *infra* subsec. C.2.

[315] Dan Wu, *Data Sharing: Civic Data Trusts – Panel,* SMART CITIES WEEK: 2020 GLOBAL COLLABORATIVE ENGAGEMENT (Oct. 21, 2020), https://smartcitiesweek.vfairs.com/en/hall#topics-tab; *see also* Carlos Rivero, *Data Sharing: Civic Data Trusts – Panel,* SMART CITIES WEEK: 2020 GLOBAL COLLABORATIVE ENGAGEMENT (Oct. 21, 2020), https://smartcitiesweek.vfairs.com/en/hall#topics-tab (From a legal and compliance perspective, what the participating government entity's interpretation of the data privacy laws and regulations is may not be entirely accurate. This is why legal guidance from outside this entity may need to be sought in order to sort what the government entity thinks is the case for what can and cannot be done with respect to data sharing, and what in reality can and cannot be done with the data assets.).

between only two partners.[316] A data trust not only functions as a relationship builder and a catalyst for action, but it also presents a legal framework that facilitates data sharing among member partners.[317] Due to these organizations' amenability to sharing their data without being coerced into doing so, a data trust enables partner organizations to build their collective intelligence more rapidly than if each were working independently from one another.

This willingness to set aside competitive risk issues reflects an organizational maturity that facilitates the partnership's ability to create a team-driven, digital platform for a particular project. The partnership can then together identify the different types of data that the data trustee will need to include and host on that shared, digital platform. A data trust's ability to promote such digital readiness among public-private partnership members can better inform these constituents' respective data-driven decisions on a firm-specific level, and, more generally, can catapult the success of the partnership's project.[318]

2. *Appointment of a Partner Who Will Serve as the "Data Trustee"*

The first step for implementing operational controls for the data trust is to establish which organization in the public-private partnership will serve as data trustee. As a fiduciary of the data, the data trustee is responsible for ensuring that the data assets are shared only with authorized entities and individuals therein who have been designated specifically to receive such information.[319] The data trustee also effectively acts as the relationship manager among all partnership parties. This allows the data trustee to oversee and smooth the data gathering and distribution process.[320] It also ensures that the data trustee bears a certain level of accountability to all partnership constituents.

For the reasons stated above, it is crucial for the data trustee to act like a consultant and engage in ongoing, regular communications with the Organization Leaders. This constant dialogue informs the data

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[316] Rivero, *supra* note 315.
[317] *Id.*
[318] *Id.*
[319] *See* Part V., *infra* subsec. C.3.
[320] Rivero, *supra* note 315.

trustee's understanding of which partners are consuming the data and for what purpose.[321] With this knowledge, the data trustee can configure the data platform more precisely on an ongoing basis, so that the data itself appears in a relevant, useful, and easily digestible format that is adequately suited to address each partner's individual needs. Effectively, the data trustee is tasked with the responsibility of building an open platform that optimizes the data in a manner enabling partnership members to arrive collaboratively at the best outcomes, based upon their collective data analysis.[322]

3. Data Collection and Release Policy

As noted in Part IV.C.2., the data trustee bears responsibility for customizing the data sharing platform through access controls, so that only certain organizations within the public-private partnership and individuals within those organizations are granted access to particular data within a given database.[323] One of the best ways to establish the data sharing parameters is to articulate them in a data collection, anonymization, and release policy (the "Data Policy"). As the fiduciary of the data trust, the data trustee maintains, shares with partnership members, and enforces the Data Policy. Generally, the data trustee provides all partnership members with the Data Policy, which they respectively are required to acknowledge. Once a partnership member completes this acknowledgement, that partner is legally bound by the Data Policy's terms and conditions. Having a Data Policy with this required legal commitment from all partnership participants gives the Data Policy teeth and acts as a control system that mitigates against the risk of having a "data commons" where all partnership members would otherwise have access to all available data on the shared platform.

With a Data Policy in place, the data trustee can create a verification and authorization process. A Data Policy restricts the release of classified or sensitive information to only those entities or

[321] *Id.*

[322] *Id.*

[323] Justine Hastings, *Data Sharing: Civic Data Trusts – Panel*, SMART CITIES WEEK: 2020 GLOBAL COLLABORATIVE ENGAGEMENT (Oct. 21, 2020), https://smartcitiesweek.vfairs.com/en/hall#topics-tab (For instance, if a chart is shared on a cloud-based platform, access to see and modify data within particular columns in the chart can be determined on an individualized basis.).

individuals authorized to receive such "restricted use" data.[324] Moreover, having an established Data Policy in place provides standardization and sets uniform guidelines by which all partnership members are expected to abide. This allows for predictability, transparency, and process security with respect to the data's dissemination, while enhancing each partner organization's ability to make decisions in real time based on analytics from the shared data.[325] Ultimately, a Data Policy encourages partner organizations to act as nimbly and efficiently as possible and helps the partnership advance more rapidly toward arriving at its goals.

4. Data Anonymization

Having a Data Policy in place also facilitates data anonymization within the data platform and data trust. For the data anonymization process to occur, the data trustee must consider the type of data available that the applicable partnership partners will provide, as well as the necessary parameters for anonymizing incoming data itself. The data trustee's ability to address these points assists in creating a platform with data that member partners can readily access and easily interpret.

The data anonymization process also entails the data trustee's ability to determine how to optimize data received while simultaneously maintaining the confidentiality of any confidential information. Implementing this process provides a means for confidential information to be protected, shared, and used in a consistent fashion, while also addressing data privacy concerns and allowing partners' equities to be aligned and protected.[326] This democratization of data incentivizes partners to collaborate in innovative and creative ways around the anonymized data residing in the data trust.[327] Fostering such creativity, in turn, spurs these partners to participate in pooling their insights regarding the data.[328] This pooling of ideas helps catalyze the rate of achieving the cluster's

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[324] Carlos Rivero, *The Many Different Flavors of Open Data – Panel*, SMART CITIES WEEK: 2020 GLOBAL COLLABORATIVE ENGAGEMENT (Oct. 27, 2020), https://smartcitiesweek.vfairs.com/en/hall#topics-tab.

[325] Dr. Peter Pirnejad, *The Many Different Flavors of Open Data – Panel*, SMART CITIES WEEK: 2020 GLOBAL COLLABORATIVE ENGAGEMENT (Oct. 27, 2020), https://smartcitiesweek.vfairs.com/en/hall#topics-tab.

[326] Harris, *supra* note 313; Hastings, *supra* note 323.

[327] Harris, *supra* note 313; Hastings, *supra* note 323.

[328] Harris, *supra* note 313; Hastings, *supra* note 323.

targets and moves the needle forward in terms of resolving the cluster's overarching issue. Data sharing through data anonymization within a data trust, consequently, protects the data's integrity, keeps confidential information confidential, alleviates data sharing concerns, promotes an open data exchange, and unifies organizations within the public-private partnership by making them comfortable participating in such open data exchange. Accordingly, having anonymized data within a data trust offers an attractive means for accelerating the development of innovative technologies as well as the devices deploying them.

D. Examples of Innovation Clusters that are Improving Industries in Traditional Sectors

1. Northwest Ag Innovation Hub: A Regional, Agriculture-Based Innovation Cluster

The agriculturally-focused, tri-county Northwest Ag Innovation Hub (the "Hub") is a regional, small-scale innovation cluster located near Independence, Oregon[329] that is strategically based near its two public partners, Western Oregon University and Oregon State University.[330] Within this Hub, the Strategic Economic Development Corporation ("SEDCOR"), based in Salem, Oregon, is using "rural tech innovation" to unite a regional network of farmers from Polk, Marion, and Yamhill Counties in Oregon's Mid-Willamette Valley.[331] By creating synergies between the agricultural economy characterizing this region and technology-oriented entrepreneurs, SEDCOR is helping this cluster to accelerate the deployment of promising agricultural solutions.[332] Through "ecosystem-building"

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[329] Irvine, *supra* note 289; George Plaven, *SEDCOR Receives Grant for Northwest Ag Innovation Hub*, CAPITAL PRESS (Oct. 6, 2020), https://www.capitalpress.com/state/oregon/sedcor-receives-grant-for-northwest-ag-innovation-hub/article_66c80274-072f-11eb-9a66-ab84152c9936.html.

[330] Chris M. Lehman, *Oregon Town to Get Help Developing Its Rural Tech Hub*, KLCC (Feb. 12, 2019), https://www.klcc.org/post/oregon-town-get-help-developing-its-rural-tech-hub (Western Oregon University is located in Monmouth, while Oregon State University is located in Corvallis.).

[331] *Farmers need to be innovative, adaptive, and creative to ensure their competitive advantage in national and international markets. How do we get them the technology to meet that need?*, SEDCOR - NORTHWEST AG INNOVATION HUB, https://www.sedcor.com/page/aghub#region-trig [hereinafter NORTHWEST AG INNOVATION HUB]; Plaven, *supra* note 329.

[332] NORTHWEST AG INNOVATION HUB, *supra* note 331; Plaven, *supra* note 329.

events, conducted both virtually and in-person, entrepreneurs, software developers, and others work with individual farmers to conceptualize prototype solutions to agricultural problems, incubate and accelerate these promising solutions' development, and then roll out these solutions publicly.[333] This team-driven focus, along with local community support, has enabled the teaming of technological innovation with agricultural know-how, and has fostered Hub members' ability to scale-up rapidly farmer-specific innovations.

The regional farmers network that exists within the Hub is also involved in several larger initiatives. First, this group is involved in the Oregon Entrepreneurs Network ("OEN"), a non-profit organization that supports scalable start-up companies from industries of all types statewide.[334] OEN also offers its start-ups the ability to connect with investors who provide funding.[335] This enables farmers to make the leap from having a good idea to developing a financeable business that has the potential to achieve greatness.[336]

Second, this Hub offers its farm constituents the opportunity to participate in a national farmers network that encourages and enhances the ability of Oregon farmers to have their breakthroughs and technological achievements replicated elsewhere in the country.[337] This reproduction of originally cluster-based projects enhances "farm-centric" problem-solving on a national scale.[338] Through AgLaunch, a national, Memphis, Tennessee-based non-profit that initially received funding from the USDA Rural Development and the Delta Regional Authority and that supports agricultural innovations for farmers throughout Tennessee, farmers in Oregon can plug into an "agritech" data platform that connects technology-oriented entrepreneurs with growers.[339] Anonymized data on this platform can then be shared, benefitting communities in multiple, unconnected geographical

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[333] Irvine, *supra* note 289; NORTHWEST AG INNOVATION HUB, *supra* note 331.

[334] *About OEN – What We Do*, OREGON ENTREPRENEURS NETWORK, https://www.oen.org/about/what-we-do/.

[335] *Id.*

[336] *Id.*

[337] Irvine, *supra* note 289.

[338] *Id.*

[339] *A Partnership that Grows Progress – Our History*, AGLAUNCH, http://aglaunch.com/who-we-are/; NORTHWEST AG INNOVATION HUB, *supra* note 331.

regions.[340] As a result of the Hub's ability to improve farmers' performance, increase their product output, enhance their ability to receive funding, connect them with technology-focused start-ups, and create public-private partnerships where they likely would not have existed, the Hub is helping both farming technology and devices deploying this technology advance to the next level.

2. *The Lake Nona Project – A Small-Scale, Real Estate Technology-Based Innovation Cluster*

As a small-scale, 17-sqaure mile innovation cluster located just south of Orlando, Florida, the Lake Nona Project is driving the ability to incorporate advanced technologies and structural resiliency into real estate infrastructure in innovative and forward-looking ways.[341] There are two technology areas that converged for purposes of Lake Nona's real estate development: (1) a robust fiber optics network, and (2) "smart" building features, such as smart windows, smart ceiling tiles, and ultraviolet light technology, integrated into the buildings' designs. Embedding these features within Lake Nona's real estate has helped this smart city to evolve while addressing the cluster's key issue of how to optimize productivity among constituents from both a technological and health perspective. The convergence of these features in building designs, combined with the power of open data sharing, has enabled the Lake Nona community to thrive and become a model smart city whose blueprint other cities can follow.

At its outset, the Lake Nona area was a "medical city," with approximately 29 percent of its already-present residents working from home, pre-COVID-19.[342] Considering this community's needs along with its talent pool, the Tavistock Group, a company serving as Lake Nona's real estate project developer, as well as other local stakeholders, worked collaboratively with Cisco to lay 23,000 miles of fiber optic cable, creating the first 1G community in the U.S.[343] Given feedback from its constituents, the Tavistock Group was able to scale-

[340] *A Partnership that Grows Progress – Our History, supra* note 339; NORTHWEST AG INNOVATION HUB, *supra* note 331.

[341] Ken DiScipio, *Smart Buildings & Campuses: Driving Smart Development – Panel,* SMART CITIES WEEK: 2020 GLOBAL COLLABORATIVE ENGAGEMENT (Oct. 21, 2020), https://smartcitiesweek.vfairs.com/en/hall#topics-tab.

[342] *Id.*

[343] *Id.*

up Lake Nona's fiber optics network quickly, enabling this city to make the jump to 2G, and thereafter to 5G. By investing in critical infrastructure pre-COVID-19, Lake Nona residents were able to access this infrastructure, making possible their ability to run medically-oriented companies from their homes and enhancing their ability to earn household incomes of approximately four times that of residents in the greater Orlando area.[344]

Buildings in Lake Nona are designed to treat indoor air quality with smart windows and with a combination of ultraviolet light ("UV") technology and ceiling tiles.[345] Disruptive technologies promoting the treatment of indoor lighting and air quality have been incorporated into new construction in accordance with the Lake Nona area's "well-built building" design standards. Other existing commercial buildings await retrofits using these disruptive technologies, too. These installations are contributing to Lake Nona's commercial real estate's ability to improve the health of its occupants. As an example of these building innovations, View Dynamic Glass's "smart windows" (hereafter, "View® Smart Windows") have been installed in a new, 120,000 square foot Lake Nona office building.[346] These windows possess embedded sensors and electrochromatic coating, enabling these windows to test air quality, regulate and optimize natural light flowing into the building, control glare, save energy, and eliminate the need for blinds or shades.[347] Additional View® Smart Windows are scheduled

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[344] *Id.* (Specifically, pre-COVID-19, the average household income in Orlando, Florida was approximately $48,000, whereas the average household income in the Lake Nona community was approximately $160,000.).

[345] *Id.*

[346] *Id.*

[347] *See id.*; *How Smart Windows Work: Maximize Daylight. Control Glare. Reduce Heat.*, VIEW, https://view.com/product/how-it-works ("click webpage video link"); *Lake Nona Installs View® Smart Windows Across Commercial Projects*, LAKE NONA (Apr. 2, 2020), https://www.lakenona.com/news/lake-nona-installs-view-smart-windows-across-commercial-projects/ (These window use View® dynamic glass, which is regular glass coated with a "series of thin nano-coatings that react to a small electrical charge, creating different levels of tint." View® analyzes the direction the windows in a particular building will face, takes into account any obstructions to access to sunlight, and considers the arc of the sun during daylight hours to maximize and optimize the amount of natural light available throughout the day. With respect to office buildings, View® considers occupants' seating arrangement configurations within their office space to integrate lighting systems with cooling systems. View® also considers the building's local weather on a daily basis to control the windows' level of tint. Occupants of the

to replace existing windows in other commercial buildings, including a fitness studio, a restaurant/market, and an event facility. They are also currently slated for installation in new construction as well, such as in the to-be-constructed Lake Nona Wave Hotel.[348]

In addition to featuring "intelligent glass" for windows, other Lake Nona buildings are outfitted with UV-C light just under their ceiling tiles as a means of treating stagnant air.[349] This means that air can be circulated within a given room, channeled through a HEPA or other filter, and then treated with UV-C light that disinfects the air, killing harmful bacteria, mold, and viruses without using chemicals.[350] This environmentally-friendly and affordable means for treating air quality,[351] combined with smart windows technology, makes the communal work environment a more germ-free, healthier place for people to work within the Lake Nona community.

Also, in an interesting twist on working with a university, Lake Nona has effectively "worked" with Cornell University insofar as it has relied upon data from a Cornell professor's study that focused on View® Smart Windows' performance. Specifically, Professor Alan Hedge from Cornell's Department of Design and Environmental Analysis conducted a scientific research experiment involving 313 office workers from seven cities across North America, analyzing how lighting impacts worker performance.[352] Hedge compared workers who were exposed to natural light from "traditional" windows in their work environment against workers in a setting with View® Smart Windows that possess an auto-tint feature to optimize natural light and

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building are able to control individual windows or consecutive groups of windows via a network accessible through remote control, via an app or via control panels within the rooms of the building.).

[348] *Lake Nona Installs View® Smart Windows Across Commercial Projects, supra* note 347.

[349] DiScipio, *supra* note 341.

[350] *News – How UV Light Helps Clean Air and Surfaces – Explained*, HONEYWELL, https://www.honeywell.com/us/en/news/2020/07/how-uv-light-helps-clean-air-and-surfaces-explained; Paul Kapustka, *Perform Path Launches to Bring UV Disinfection Technology to Sports Venues*, STADIUM TECH REP. (June 23, 2020), https://www.mobilesportsreport.com/2020/06/perform-path-launches-to-bring-uv-disinfection-technology-to-sports-venues/; *Understanding the Power of Light to Kill Germs*, VIOLET DEFENSE (2017-2021), https://www.violetdefense.com/howitworks.

[351] *Understanding the Power of Light to Kill Germs*, *supra* note 350.

[352] *The Importance of Natural Light*, VIEW (*last updated* 2021), https://view.com/videos/alan-hedge ("click webpage video link").

reduce glare. Hedge found that those in the smart windows environment experienced higher levels of health and wellness and a higher degree of productivity relative to their counterparts.[353] By drawing upon this study's findings for which proof of concept was sought prior to its scale-up and usage in multiple Lake Nona buildings, the Tavistock Group, together with Lake Nona planners and strategists, were able to draw upon a world-class university's findings as a virtual means of "testing" an innovative device that, when rolled out in large scale, has the potential to significantly maximize the wellness and productivity of Lake Nona's workforce and residents.

Moreover, in addition to the above-referenced benefits that Lake Nona real estate offers, the occupants of various types of commercial buildings within the Lake Nona community – from office buildings to restaurants to recreation centers – participate in open data sharing. Aggregating data from these diverse classes of commercial real estate buildings helps to inform air quality data as well as identify the best metrics for improving air quality in various types of indoor environments. This platform facilitates real-world inputs from information derived from similar devices deployed in diverse building settings. This organic element enables Lake Nona to continuously evolve, so that facilities managers across different commercial real estate categories (e.g., office buildings, retail/restaurants, etc.) can utilize non-static data to constantly improve, produce more optimal results, and become operationally "smarter."

Having such an organic data sharing feature ties into Lake Nona's goal of developing relevant buildings for the next 20 – 30 years in the future, rather than only 10 years in the future.[354] It also enables Lake Nona to be in a position to aggregate and anonymize data and to utilize it while maintaining constituent privacy. Lake Nona possesses

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[353] *Study: Natural Light is the Best Medicine for the* Office, VIEW DYNAMIC GLASS (Jan. 31, 2018), https://view.com/sites/default/files/documents/daylight-research.pdf (Hedge's specific findings showed that workers who sat near smart window and therefore were exposed to optimized natural light experienced a 51% drop in eyestrain incidences, a 63% drop in headaches, a 56% decrease in drowsiness, and a 2% increase in productivity, compared to others in the study.) (Hedge estimates that this productivity factor equates to the equivalent of approximately $100,000 in annual value for every 100 workers, or the equivalent of approximately $2 million in value in terms of worker productivity across the expanse of the smart window's useful life.).

[354] DiScipio, *supra* note 341.

the ability to export this data to other cities, potentially monetize it, and assist other cities in replicating the advances this small-scale innovation cluster has achieved. As a result, communities located elsewhere in the world that invest in similar devices and implement and apply Lake Nona's data within their own borders can help their constituents to experience the health and technological benefits that those in the Lake Nona community are already enjoying.

V. SMALL-SCALE INNOVATION CLUSTERS FOR RENEWABLE ENERGY DEVICE TESTING PRESENT OPPORTUNITIES FOR PROMISING OUTCOMES

Given the positive outcomes that they can potentially produce, as discussed in Part IV., small-scale innovation clusters offer a promising means to invent, test, and scale-up novel devices that harvest renewable energy. These clusters have incubator-like settings, leadership teams, and local communities focused on a particular technology that addresses an issue important to that cluster. They also possess an ability to target and optimize one or more devices that deploy such technology. Moreover, these clusters possess their respective organizations' collective interest in sourcing, sharing, and benefitting from one another's shared data. When aggregated, these factors provide a supportive and intellectually robust location to test cutting-edge devices at their earliest stages, before they are deployed commercially at scale. Public-private partnerships formed in renewable energy-focused innovation clusters may offer a unique opportunity to tap into all of these benefits and enhance device development within them with both private and government support. By using wave energy technology and wave energy devices to illustrate the positive features a renewable energy-focused, small-scale innovation cluster offers, it becomes clear why these constructs will help to catalyze the evolution and refinement of devices that can gain investor confidence, be deployed at scale, and accelerate the efficient growth of the renewable energy industry.

A. Carnegie Clean Energy: Why Lone Companies May Experience a Roller Coaster Ride of Uncertainty

Companies that are at the leading edge of inventing, developing, and refining novel renewable energy devices are likely to experience exhilarating highs as well as frightening lows when pushing the boundaries of what is technologically possible. This roller coaster ride of uncertainty is magnified for individual companies that act in a solo capacity as a trailblazer in a relatively new area of technological development. In the marine renewable energy ("MRE") sector for marine and hydrokinetic ("MHK") energy generally and the wave energy area specifically, this is particularly true.[355] Carnegie Clean Energy's experience as a pioneer in the area of wave energy device development illustrates the risks and rewards of endeavoring to develop cutting-edge devices outside of an innovation cluster environment, where other companies with the same shared vision for wave energy device development would otherwise be physically present.

1. Comparative Advantages of Wave Energy Relative to Other Renewable Energy Technologies

Due to the tremendous and numerous benefits that wave energy offers, there are many upsides generally relating to wave energy devices. While these devices' cumulative environmental impacts are largely unknown at this time,[356] these risks are less weighty in the balance when compared to the energy potential wave energy presents. First, most wave energy devices do not emit carbon dioxide when they are operational, in contrast to fossil fuel- and biomass-based energy generation plants that generate such emissions as a matter of course. Also, wave energy devices do not generate hazardous waste products, as do nuclear energy plants. Increased reliance on wave energy devices, therefore, has the potential to promote emissions-free power generation, reduce greenhouse gas emissions, and mitigate against the likelihood of health-related public and private nuisance claims related to arrays of wave energy devices.

Second, electricity generated from wave energy devices can benefit numerous coastal cities from an energy efficiency, energy transmission, and load[357] perspective. Specifically, with respect to the electric transmission system constituting the electric grid, energy may

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[355] *See The PRIMRE Marine Renewable Energy Technology Database*, OPENEI, https://openei.org/wiki/PRIMRE/Databases/Technology_Database.

[356] TROY A. RULE, RENEWABLE ENERGY: LAW, POLICY AND PRACTICE 755 (West Academic Pub. 2018).

[357] *See Glossary of Energy Terms – Load*, EDF, https://www.edfenergy.com/large-business/glossary (In terms of energy transmission, "load" refers to "[t]he amount of electric power delivered or required at any specific point or points on an electrical system. The requirement originates at the energy-consuming equipment of the consumer.").

travel long distances over transmission lines to reach its final destination. During this process, energy being carried over these lines experiences transmission and distribution ("T&D") loss, a process by which energy is lost along the electricity transmission and distribution network, between the energy's generation point and its distribution point.[358] Shortening the distance that the energy needs to travel during its transmission process decreases T&D loss. Consequently, the transmission of energy from a wave energy device to its electricity distribution point located onshore just a short distance away means comparatively less energy will be lost during electricity transmission. Also, depending on the average wave intensity[359] for a particular area, many coastal cities may be located in close proximity to nearby wave energy devices that can access powerful waves. This close location between the wave energy devices relative to their electricity T&D points may offer those who access this wave energy the ability for distributed generation.[360] Distributed generation would enable commercial and residential energy consumers to receive their energy from these wave energy devices directly and reduce their need to rely solely on the electric grid for energy.

Third, from an aesthetics perspective, wave energy devices often are either fully submerged or placed far enough away from the shoreline that they are not visible to onlookers concerned about

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[358] *See* Jiguparmar, *Total Losses in Power Distribution and Transmission Lines*, ELECTRICAL ENGINEERING PORTAL [EEP] (Aug. 19, 2013), https://electrical-engineering-portal.com/total-losses-in-power-distribution-and-transmission-lines-1 (Factors causing this loss include fixed technical losses that occur from scientifically-based occurrences such as heat loss, corona loss, open-circuit losses, leakage current losses, and dielectric loss (electricity loss caused by differences between more than one conductor along different parts of the electrical insulating material).); *see also Frequently Asked Questions (FAQs): How Much Electricity is Lost in Electricity Transmission and Distribution in the United States?*, U.S. ENERGY INFO. ADMIN. [EIA] *(last updated* May 14, 2021), https://www.eia.gov/tools/faqs/faq.php?id=105&t=3 (EIA estimates that T&D loss accounted for approximately 5% of all electricity carried over domestic transmission and distribution lines from the period 2015 – 2019.).

[359] Samuel J. Ling et al., *16.5 Energy and Power of a Wave*, PHYSICS LIBRETEXTS (*last updated* Nov. 5, 2020), https://phys.libretexts.org/Bookshelves/University_Physics/Book%3A_University_Physics_(OpenStax)/Map%3A_University_Physics_I_-_Mechanics_Sound_Oscillations_and_Waves_(OpenStax)/16%3A_Waves/16.05%3A_Energy_and_Power_of_a_Wave ("Intensity" in the context of a wave refers to the power the wave carries, divided by the area through which the wave travels.).

[360] *See Energy and the Environment – Distributed Generation, supra* note 161 (For a definition of distributed generation.).

marring the natural viewshed. Unlike what has been the case for proposed offshore wind farms with immense wind turbines,[361] wave energy devices' minimization of visual impacts potentially decreases the likelihood of either NIMBY[362] complaints or aesthetics- and visual impact-based nuisance suits being filed. It also decreases the probability of temporary restraining orders or injunctions being sought as a means of preventing a wave energy device array from being constructed.[363]

Moreover, in addition to this reduced risk of litigation, wave energy offers benefits that solar and wind do not. Compared to utility-scale wind farms, less land is needed in open waters for a wave energy array. Also, unlike wind or sunshine when obscured by clouds, waves are not intermittent and can be predicted days or weeks in advance.[364] Wave energy is also constant insofar as waves are always available and accessible for energy harvesting, no matter the time of day, season, or weather condition. This means that in contrast to wind and solar, battery storage for wave energy devices is optional, rather than necessary, for storing and accessing wave-generated energy anytime throughout a given day. Based on these positive attributes that wave energy devices offer, wave energy harvesting is quite attractive and holds promise for populations worldwide.

2. *Risks and Rewards of Going It Alone*

a. *The CETO Wave Energy Device*

As a global frontrunner in the wave energy space, Australia-based Carnegie Clean Energy ("Carnegie") is a prime example of a

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361 S*ee e.g.*, *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*, N.Y. TIMES (Nov. 21, 2016), https://www.nytimes.com/2016/11/21/business/with-a-meeting-trump-renewed-abritish-wind-farm-fight.html; Tina Casey, *Trump Tilts at Offshore Wind Energy, Scotland Gets Last Laugh (Maybe)*, CLEANTECHNIA (Jan. 18, 2017), https://cleantechnica.com/2017/01/18/trump-tiltsoffshore-wind-energy-scotland-gets-last-laugh-maybe/.

362 "NIMBY" is an acronym representing the phrase "not in my backyard."

363 *See Injunction*, *supra* note 283 (For a more detailed explanation of injunctions, including temporary restraining orders.).

364 *See NOAA Tide Predictions*, NOAA TIDES & CURRENTS, https://tidesandcurrents.noaa.gov/tide_predictions.html (As illustration, NOAA provides tidal prediction updates on a regular basis.).

private firm that has experienced the highs and lows associated with being a solo wave energy device designer and developer at the forefront of wave energy technology, absent the many collaborative features of an innovation cluster. With respect to the inventive, "breaking new ground" aspect of this role, Carnegie has developed the CETO wave energy device (the "CETO device").[365] This giant, submerged buoy, whose dynamic cables and thin-legged, tripod-like mooring system make it look similar to an elegant, more friendly, polished, and evolved version of an alien from Steven Spielberg's 2005 science fiction movie production of H.G. Wells' *War of the Worlds*,[366] resides several meters below the ocean's surface.[367] Through the CETO device's ability to move with the ocean's waves and convert this motion into electricity, this invention, indeed, is groundbreaking, evidencing science fiction transforming into reality.

Also, Carnegie possesses its own Wave Energy Research Facility and holds a lease that grants it exclusive use over an offshore area in which it conducts ongoing prototype testing in a "subdued wave energy 'nursery' " setting.[368] These attributes enable Carnegie to rapidly test and make design improvements to the most recent models of its CETO device, prior deploying this device elsewhere.[369] Additionally, Carnegie has recently developed a Machine Learning ("ML") Wave Predictor (the "Predictor") that is integrated with the CETO device's control system.[370] The Predictor's wave sensors and artificial intelligence enable CETO devices to predict oncoming

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[365] *CETO Technology*, CARNEGIE CLEAN ENERGY, https://www.carnegiece.com/ceto-technology/.

[366] *See War of the Worlds (2005)*, IMDB, https://www.imdb.com/title/tt0407304/; *see also* Margaret Corpuz, *CETO System: Using Ocean Wave to Generate Clean Electricity and Desalinate Water*, VERSION DAILY (July 16, 2016), https://www.versiondaily.com/ceto-system-australia-uses-oceanic-wave-to-generate-clean-electricity-and-desalinate-water/ (For an underwater image of the CETO device's design in 2016.); *Id.* (For an underwater representation of the current CETO device's design as of Dec. 2020.).

[367] *CETO Technology*, *supra* note 365.

[368] *Research Facility*, CARNEGIE CLEAN ENERGY, https://www.carnegiece.com/research-facility/.

[369] *Id.*

[370] *Technology – Wave Predictor*, CARNEGIE CLEAN ENERGY, https://www.carnegiece.com/wave-predictor/ (This ML characteristic translates into the Predictor's ability to model complex phenomena and run calculations within a fraction of a second, whereas "physics based solvers" would take hours or days to run the same calculations.).

waves, optimize each wave's power, and avoid extreme waves during large storms.[371]

Despite these positive attributes relating to the CETO device, there are several drawbacks to testing this device in a non-innovation cluster setting. First, Carnegie collaborates with academic institutions such as the University of Tasmania, the University of Queensland, Australia, and the University of Western Australia among others.[372] However, Carnegie's own Wave Energy Research Facility does not possess certain high-tech capabilities on-site. This is why Carnegie developed and tested its Predictor using resources located at the Pawsey Supercomputing Centre ("Pawsey"),[373] a joint venture among the national and regional governments and a handful of universities.[374] Carnegie has tapped into this joint venture to access Pawsey's resources, effectively creating a public-private partnership among Carnegie, its university partners, Pawsey, and federal and state governments. Nevertheless, the Pawsey facility itself, located south of Perth in Kensington, Western Australia, is approximately 18 km east of Carnegie's North Fremantle location.[375] This means that rather than being able to use state-of-the-art scientific know-how on-location at its own Wave Energy Research Facility, members of the Carnegie team

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[371] *Id.*

[372] *Projects – Partners*, CARNEGIE CLEAN ENERGY, https://www.carnegiece.com/portfolio/.

[373] *Technology – Wave Predictor*, *supra* note 370.

[374] *About Pawsey*, PAWSEY SUPERCOMPUTER CENTRE, https://pawsey.org.au/about-us/about-pawsey/ (Pawsey's primary objective is to accelerate scientific research that benefits Australia. As one of Australia's two Tier-1, High Performance Computing facilities, this facility receives government financing from the governments of Western Australia and the Australian Federal Government. The facility is a joint venture among The University of Western Australia, Curtin University, Edith Cowan University, Murdoch University, and CSIRO (the Commonwealth Scientific and Industrial Research Organisation.); *About*, CSIRO, https://www.csiro.au/en/About.

[375] *See Contact – General Enquiries*, PAWSEY SUPERCOMPUTER CENTRE, https://pawsey.org.au/contact/; *Contact – Head Office*, CARNEGIE CLEAN ENERGY, https://www.carnegiece.com/contact/ (Specifically, it is an approximately 25 minute drive inland from Carnegie's physical address in Western Australia to Pawsey.); *see also Driving Directions*, GOOGLE MAPS, https://www.google.com/maps/dir/1+Bryce+Ave,+Kensington+WA,+Australia/21+North+Mole+Drive,+North+Fremantle+WA,+Australia/@-32.0034301,115.7402228,12z/data=!3m1!4b1!4m14!4m13!1m5!1m1!1s0x2a32bb627609b10f:0x25bdd1d8156e6047!2m2!1d115.8836443!2d-31.9926558!1m5!1m1!1s0x2a32a141fcb8930f:0x11c5145a4c14f794!2m2!1d115.7320622!2d-32.0461256!3e0.

must travel to Pawsey instead to access needed resources. If Carnegie and Pawsey were physically located closer to one another, such as in a physical innovation cluster-like setting, the difference would be that Pawsey's resources would be closer for Carnegie's Wave Energy Research Facility team to access, making CETO device testing more efficient.

Also, in contrast to innovation clusters such as the Northwest Ag Innovation Hub or the Lake Nona Project where data is constantly being gathered, shared, and received among multiple businesses, Carnegie is effectively acting in its own silo. Specifically, in the absence of other like-minded companies testing their devices in close proximity to the Wave Energy Research Facility, and in the absence of such companies sharing anonymized data about their respective devices in order to produce the most efficient, marketable devices that generate energy at utility-scale, Carnegie is responsible for relying solely upon the data it collects from its own CETO device to improve this device's design. For instance, due to its tethering to the sea floor, the CETO device could potentially cause adverse impacts to the benthic environment, in the form of seabed disruption, seabed erosion, migration disruption for certain animal species, and changes to the adjacent seashore due to sediment traveling at different rates and in different patterns than prior to the device's installation. If multiple firms physically were located next to or near Carnegie, were engaged in data sharing, took a team-driven approach for optimizing wave energy devices' designs generally, or shared their data in anonymized form through a data trust, Carnegie could potentially benefit from this collaborative ecosystem of firms and effectuate improvements to its CETO device's design on a more accelerated basis, including how to reduce the CETO device's aforementioned potential adverse impacts to the benthic environment.

b. Financing Firsts vs. Bankruptcy Risk

Developing a novel energy device, such as the CETO device, can mean reaching important financing milestones before others in the same industry. For example, in 2015, Carnegie, under its prior name of Carnegie Wave Energy Limited, achieved an unprecedented milestone when it entered into a $21 million credit facility with

Commonwealth Bank of Australia ("CBA").[376] As Australia's first wave energy financing transaction to assist with the CETO device's further technological development and deployment, this deal evidenced several important achievements. First, because this was a credit facility[377] rather than a single, stand-alone financing, CBA demonstrated that a well-known and respected financial institution believed strongly enough in the viability of the CETO device's capabilities and Carnegie's financial profile that it was willing to invest and undertake the risks involved in providing financing to Carnegie over a long-term basis. Second, by entering into this credit facility with Carnegie, CBA effectively made a statement that it believed it would receive the return on investment that it sought. Quite possibly, this included considerations such as projects involving CETO devices operating at commercial scale and generating steady revenues over the medium- and long-term, as well as Carnegie remaining a financially viable going concern for at least the term of the credit facility. These milestones not only likely provided investors with confidence in Carnegie as a going concern, but also added an aura of credibility to the wave energy industry itself.

Like many start-ups, though, Carnegie has not been immune to severe financial setbacks. In March 2019, Carnegie went into "Voluntary Administration," or, in other words, filed for bankruptcy, due to severe monetary difficulties it experienced as a result of issues with its microgrid business, Energy Made Clean.[378] This financial hardship stemming from Carnegie's non-wave energy division resulted in Carnegie's company shares being suspended from trading on the Australian Stock Exchange ("ASX") until their reinstatement

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[376] *Carnegie Secures $21m CBA Loan Facility*, NEWS.COM.AU (Nov. 20, 2015), https://www.news.com.au/finance/business/carnegie-secures-21m-cba-loan-facility/news-story/76124cc90fde490c37ee46b55ce702f5; *Carnegie Clean Energy Ltd (CCE) – Stock Watch,* MARKET INDEX (Dec. 27, 2020), https://www.marketindex.com.au/asx/cce.

[377] *Revolving Credit Facility,* BLACK'S LAW DICTIONARY, 883 (Online ed.), https://alegaldictionary.com/revolving-credit-facility/ (A "credit facility," also known as a revolving credit facility, is a secured or unsecured line of credit between a lending institution and a borrower that generally exists for a period of as few as six months or as long as five years or more. The borrower can draw down on this facility repeatedly for the term of the facility's existence.).

[378] Peter Milne, *Carnegie Clean Energy Looks to Raise Cash After $45 Million Loss*, THE WEST AUSTRALIAN (Mar. 5, 2019), https://thewest.com.au/business/energy/carnegie-clean-energy-looks-to-raise-cash-after-45-million-loss-ng-b881126679z.

on Oct. 31, 2019.[379] The risks that accompany many fledgling companies in novel industries, consequently, became very real for Carnegie's investors. Accordingly, despite Carnegie's many admirable achievements, including its CETO device technology and the milestones it reached in the finance arena, the financial rough patch that Carnegie experienced not only may have caused certain investors to re-evaluate their investment in this company, but, due to Carnegie's name being associated with the wave energy industry, may have deterred potential investors from investing in wave energy development companies altogether. As Carnegie's experience illustrates, when other entities are not physically located nearby in an innovation cluster setting to share collective skin in the game for achieving a common goal, such as advancing wave energy technology, investors in a single, trailblazing company handling the design and testing of a novel renewable energy device may need to evaluate whether they have the appetite and financial ability to ride the potential roller coaster of risks to which this company may subject them.

B. *The European Marine Energy Center: Absence of Certain Smart Cities Features in World-Class Testing Facilities May Hinder Industry Growth*

Stand-alone, world-class testing facilities that operate in relative isolation may also lack certain advantages that small-scale innovation clusters present. As illustration, the European Marine Energy Center Ltd. ("EMEC") is an open sea laboratory testing facility that is solely dedicated to marine energy, insofar as its purpose is to be a home for both wave energy and tidal energy device development.[380] Located in the Orkney, Scotland archipelago, a group of approximately 70 islands situated northeast of mainland Scotland between the North Sea and the Atlantic Ocean,[381] this facility has geographic access to excellent oceanic waves and sheltered harbors at its five different test site locations.[382] In fact, two of these test site locations host multiple

[379] *Notice: Carnegie Clean Energy Limited (ASX: CCE) – Reinstatement to Official Quotation Description The,* ASX (Oct. 19, 2019), https://www.asxonline.com/public/notices/2019/oct/1180.19.10.html.

[380] *About Us,* THE EUROPEAN MARINE ENERGY CENTER LTD. [EMEC], http://www.emec.org.uk/about-us/.

[381] John Misachi, *Orkney Islands Description*, WORLD ATLAS (Mar. 17, 2021), https://www.worldatlas.com/webimage/countrys/europe/ukorkney.htm.

[382] *See About Us*, *supra* note 380 (Specifically, these five test sites include two wave test sites, (Billia Croo, located at Stromness, Mainland Orkney; and

grid-connected wave energy device testing areas, with purpose-built berths designed specifically to host each wave energy device.[383] The EMEC's possession of such optimal testing conditions enables its "clients"[384] to gather important data about their respective device's performance, durability, and opportunities for further design refinement and optimization.

While the EMEC's facilities are generating state-of-the art data and offering the opportunity to gather groundbreaking insights with respect to various wave energy devices, the EMEC's set-up could be optimized and improved even further if it adopted a more smart-cities approach to data access and to its client relationships. First, not all EMEC clients may be conducting their testing in a collaborative manner, as would likely be the case in an innovation cluster. As illustration, while the EMEC hosted the University of Nottingham for testing the performance of its prototype "Energy Bag" device,[385] it is unclear what, if any, data flow existed between this academic institution and the EMEC or other EMEC clients. Due to the University of Nottingham being an EMEC "client" rather than a "partner," and due to the EMEC's other "clients" also not being "partners" with one another, the EMEC, or the University of Nottingham, no partnership-driven incentive exists to act cooperatively with each other. So, while many entities may be engaged in testing their respective novel devices at EMEC, they each could be effectively operating in their own knowledge silos.

This juxtaposition of many firms working at the same facility, yet working in isolation from one another, could mean that EMEC clients are keeping their data and knowledge proprietary, rather than

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Scapa Flow, located off St. Mary's Bay); two tidal test sites (Fall of Warness, located off the island of Eday; and Shapinsay Sound, located off Head of Holland), and one hydrogen production plant site (Caldale Hydrogen Production Plant, located on Eday).); *see also Facilities*, EMEC, http://www.emec.org.uk/facilities/.

[383] *About Us*, *supra* note 380.

[384] *See id.*(This includes the EMEC's "Research, Development and Innovation Clients," its "Wave Clients," and its "Tidal Clients."); *see also Research, Development and Innovation Clients*, EMEC, http://www.emec.org.uk/about-us/research-development-innovation-clients/; *see also Wave Clients*, EMEC, http://www.emec.org.uk/about-us/wave-clients/; *Tidal Clients*, EMEC, http://www.emec.org.uk/about-us/our-tidal-clients/.

[385] *See Nottingham University*, EMEC, http://www.emec.org.uk/about-us/research-development-innovation-clients/nottingham-university/ (The "Energy Bag" is a subsea, compressed air storage device that uses pressure from the water surround the bag to hold in the energy being stored.).

sharing this data among other EMEC clients. This leads to the second area for potential improvement at the EMEC: data sharing. Although the data each EMEC client generates may be proprietary, because the EMEC is currently partnering with Marine Scotland[386] to develop international wave energy standards,[387] it is clear that the EMEC has at least some level of access to its clients' data. What is unclear from the EMEC's website, though, is whether all past and current EMEC clients have authorized the anonymization of their respective data for purposes of sharing with the other firms testing their devices at the EMEC. It is also unclear whether the EMEC and its clients have mutually agreed to have the EMEC serve as data trustee for such purpose.

Presuming that such a data trust set-up is not in place, this approach is not ideal from a wave energy industry perspective. While the EMEC's clients may prefer this approach from an individual company, corporate-focused, shareholder profit maximization perspective insofar as keeping data private may give them an edge over competitor wave energy devices, failure to share wave energy data represents a lost opportunity for the newborn wave energy industry as a whole. Specifically, each EMEC client generates data that could inform and accelerate the collective knowledge of the wave energy industry and the protype devices being designed therein.[388] If the EMEC, its clients, and Marine Scotland adopted a more smart-cities approach and effectively became partners with one another, all of these entities would be working collaboratively together to advance the wave energy industry. Consequently, there would be a higher likelihood of these new partners entering into a data trust, sharing data, and developing a data anonymization arrangement. Such a public-private partnership would elevate all EMEC clients' knowledge,

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[386] *About Us*, SCOTTISH GOV'T, https://blogs.gov.scot/marine-scotland/about-us/ (Marine Scotland is the branch of the Scottish government that is responsible for managing Scotland's seas for purposes of environmental preservation and future prosperity.).

[387] *About Us*, *supra* note 380.

[388] *See Grid-Connected Wave Test Site*, EMEC, http://www.emec.org.uk/facilities/wave-test-site/ (At its Billia Croo location the EMEC's clients are testing devices in a variety of different shapes, sizes, and designs. For example, the Bulge Wave device looks like a sea snake that ripples beneath the ocean surface, the Rotating Mass is a half-sphere with a moving disc that rotates around a center pole tethered to the sea floor, and the Oscillator is reminiscent of a square tennis racquet that moves back and forth while being connected to a box affixed to the ocean floor.).

enable each partner to derive additional value from its EMEC operations,[389] reduce inefficiencies resulting from redundant research and findings, enhance data transparency, and potentially accelerate the more rapid development of wave energy devices that can be launched at scale.

C. Pac Wave: A Small-Scale Wave Energy Innovation Cluster Whose Model Others Should Follow

Located in and around Newport, Oregon, a deep-water port on Oregon's Pacific Ocean coastline, PacWave is a dual-location, open ocean wave energy testing facility and small-scale innovation cluster that incorporates a number of smart cities attributes.[390] The confluence of various factors forming this cluster's foundation illustrates why the PacWave model may offer the best approach for testing and scaling-up wave energy devices in particular, and why this innovation cluster sets precedent generally for other renewable energy device testing locations to follow. PacWave also may offer the most evolved example of how entities engaged in a public-private partnership on a local, regional, and global level can position themselves collectively to catalyze an entire industry.

1. Spotlighting Wave Energy's Potential Through Brand Recognition

For starters, there is local, national, and global interest in wave energy that is fueling this cluster's momentum. The leadership of this innovation cluster[391] recognized the importance of capitalizing on this momentum, gaining public buy-in, and generating support. Accordingly, to elevate the cluster's visibility and name recognition among the local community and beyond, in 2018, the cluster's leadership from Oregon State University's College of Earth, Ocean and Atmospheric Sciences ("OSU-EOAS") rebranded its two testing locations, changing their respective names from the Northwest National Marine Renewable Energy Center to PacWave North, and

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[389] Hanif, *supra* note 293.

[390] *Location*, PACWAVE, http://pacwaveenergy.org/location/; *Home*, PACWAVE, http://pacwaveenergy.org/.

[391] *See Partners*, PACWAVE, http://pacwaveenergy.org/partners/ (Oregon State University owns and operates the PacWave facility. It functions as the lead organization for this innovation hub's overall management, task allocation, and task execution.).

from the Pacific Marine Energy Center to PacWave South.[392] The "PacWave" brand name is shorter, snappier, and provides a much more user-friendly, memorable way to identify both cluster locations, PacWave North and PacWave South, as being one integrated unit. The name "PacWave" not only highlights the facility's geographic location on the U.S.'s West Coast and in the Pacific Ocean, but it also draws attention to OSE-EOAS and the community resources available in and around the Newport, Oregon area that present an ideal confluence of factors for a wave energy innovation cluster to thrive. In contrast to Carnegie's and the EMEC's branding, this innovation cluster's focus on marketing itself to the public by virtue of its name constitutes a conscious outreach effort to draw attention to itself, elevate its global visibility, and engage others.

Moreover, as discussed in Part III.A.1.b.(iii)., there is value in having an awe-inspiring name, or at least a name that predisposes the public's receptiveness to an item. The prefix "Pac" already carries with it a positive connotation. For instance, the "Pac-12" refers to a major college athletic conference, with eight of its 12 member schools located in U.S. West Coast states.[393] Accordingly, the "PacWave" name's prefix carries with it a positive subliminal association[394] relating to the Pac-12 brand – a brand with which many are familiar, particularly American collegiate sports fans. If the goal of a company name is to generate excitement and interest in a small-scale innovation cluster that is also a testing facility visible to the public and at the forefront of wave energy technology development, then drawing upon this subliminal association may spark additional interest in wave energy generally and in the PacWave innovation cluster specifically.

Additionally, rebranding as PacWave helps spotlight wave energy's potential, garnering greater attention for the promise wave energy holds for energy generation both nationally and abroad. As articulated in Part V.A.1., wave energy offers coastal communities the opportunity to generate vast amounts of energy. The name "PacWave" carries with it the potential to pique interest in wave energy generation,

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[392] *Oregon Wave Energy Test Site Rebranded as PacWave*, OFFICE OF ENERGY EFFICIENCY AND RENEWABLE ENERGY (Sept. 14, 2018), https://www.energy.gov/eere/water/articles/oregon-wave-energy-test-site-rebranded-pacwave; *Home*, *supra* note 390.

[393] *About the Pac-12 Conference*, PAC-12, https://pac-12.com/content/about-pac-12-conference.

[394] *See* Part II., *supra* subsec. B.3.

enticing those curious about wave energy generation to learn more about the potential it offers on a national scale. For instance, according to the U.S. Energy Information Administration, given its coastlines along its East Coast, West Coast, and southern states alone, the U.S. potentially can produce approximately 2.64 billion MW annually of wave energy-produced electricity, the equivalent of approximately 64% of the entire amount of all electricity generated in the U.S. in 2018.[395] The potential ability to produce almost two-thirds of the domestic energy supply in an emissions-free manner will enable the U.S. to substantially reduce its greenhouse gas emissions attributable to power generation.

2. *Phased Development Testing Facilities for Wave Energy Devices*

The PacWave facility not only offers developers access to a state-of-the-art, world-class testing facility and the ability to scale-up their devices mindfully, but it also offers an expedited process to test their devices in real-world conditions, at utility scale. According to an Oregon State University scientist, the reason why wave energy technology lags in technological development behind wind energy technology is due to the lack of open wave test facilities to test wave energy devices in practice.[396] PacWave, however, offers developers the opportunity to test their inventions using a "phased development" approach. PacWave North, situated in state waters two miles off the Oregon coast, is geared toward the first, early-phase testing of novel devices, while PacWave South, geared toward the second phase of testing, focuses on device viability at utility-scale.[397] With its shallower and closer-to-port location compared to PacWave South, PacWave North also offers device developers a streamlined permitting process of approximately one year.[398] Together, these offerings

[395] *Hydropower Explained – Wave Power*, U.S. ENERGY INFO. ADMIN. [EIA] (*last updated* Dec. 2, 2020), https://www.eia.gov/energyexplained/hydropower/wave-power.php.

[396] Jes Burns, *Oregon Wave Energy Testing Project Looks to Feds for Approval*, OPB (Apr. 24, 2018), https://www.opb.org/news/article/wave-energy-test-facility-oregon-state-proposal/.

[397] *See Frequently Asked Questions*, PACWAVE, http://pacwaveenergy.org/faq/ (Most types of wave energy devices, which PacWave calls "wave energy converters" or "WECs," are able to be tested at the PacWave facility, including point absorbers, oscillating water columns, attenuators, and other hybrid devices.).

[398] *Location*, *supra* note 390.

provide developers with the ability to test their early-stage, small-scale, and prototype wave energy devices on an expedited basis.

PacWave South offers developers a next-level stage of testing opportunity, providing a state-of-the-art, grid-connected facility for testing multiple arrays of wave energy devices at scale, including their resiliency and survivability in waters with "energetic waves and steady winds."[399] Because PacWave South is grid-connected and produces electricity from wave energy at utility-scale capacity,[400] the local community, as well as the world, has evidence of wave energy devices' potential as well as proof that their partner relationship with the PacWave facility produces measurable results – results that only a limited number of other wave testing facilities and demonstration projects have been able to produce.[401] Moreover, PacWave South, located seven miles off the Oregon coast in the Pacific Ocean, boasts a pre-permitted site.[402] For device developers, this eliminates an expensive, time-consuming permitting process that they would ordinally need to undergo, and fast-tracks the testing and optimization of their wave energy device designs.[403] This mindful, streamlined,

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[399] *See Home*, *supra* note 390; *Frequently Asked Questions*, *supra* note 397 (PacWave South has been designed to deliver up to 20 MW of electricity from the grid-connected wave energy devices being tested at that location.).

[400] *See About Us*, *supra* note 283.

[401] *See Projects – CETO 5 – Perth*, CARNEGIE CLEAN ENERGY, https://www.carnegiece.com/project/ceto-5-perth-wave-energy-project/; *see also ASX Announcement – Report to Shareholders for the Quarter Ended 31 December 2019*, CARNEGIE CLEAN ENERGY (Jan. 31, 2020), https://www.carnegiece.com/media/2020/02/200128-ASX-CCE-Quarterly-Update.pdf (For instance, Carnegie deployed its CETO 5 wave energy devices as part of its 2014 grid-connected project on Garden Island, located approximately 40 miles south of Perth, Australia (the "Perth Project"). The Perth Project supplied Australia's largest naval base, HMAS Stirling, with approximately 12 MW of energy throughout one year. The Perth Project was a public-private partnership, insofar as it was a joint venture between Carnegie and the Australian Department of Defence. The Perth Project received federal funding from the Australian government (a $13.1 million Australian federal government grant from the Australian Renewable Energy Agency) and funding from the Western Australian Government (a $10 million grant from the Government of Western Australia's Low Emissions Energy Development (LEED) Program).)

[402] *Frequently Asked Questions*, *supra* note 397 (Specifically, Oregon State University will receive a Federal Energy Regulatory Commission (FERC) license and a Bureau of Ocean Energy Management (BOEM) lease for PacWave South, which will keep this location compliant with the requirements of the Energy Policy Act of 2005 (Pub.L. 109-58).).

[403] *Home*, *supra* note 390.

two-staged phased approach to device development provides an ideal stage for wave energy devices looking to make their market debut.

3. *Public-Private Partnerships and Data Sharing*

PacWave showcases an advanced public-private partnership in action, attracting all-star players in the wave technology space and garnering maximum support from local communities.[404] With Oregon State University serving as the lead organization for management of cluster projects,[405] PacWave operates as a collaborative effort among this academic institution, the U.S. Department of Energy, the State of Oregon, the EMEC, a global engineering and construction firm, the local fishing industry, local businesses, residents from the local coastal communities, and other stakeholders.[406] Having engineers, scientists, industry experts, lawyers, and other professionals hail from these diverse entities positions PacWave to elevate its operations to public consciousness. It also positions PacWave to take advantage of cutting-edge intellectual know-how at the local, national, and international levels, and to access experts at the leading edge of wave technology in

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[404] *See Location*, *supra* note 390.

[405] *Partners*, *supra* note 391.

[406] *Id*. (In addition to numerous university-affiliated scientists and engineers working on the grid-connected project, top-tier talent from other organizations abounds. As illustration, project partners include the following firms: (i) European Marine Energy Center (EMEC), an organization that provides performance assessments and verification that certain wave energy industry standards are being met during testing;[406] (ii) Aquatera, Ltd., a company that provides performance testing, facility operations and maintenance protocols, and guidance for best operational practices; (iii) Pacific Energy Ventures, a consulting firm experienced in the hydrokinetic energy sector that provides expertise for grid interconnection, technology demonstration, market concept advancement, sustainable operations, and commercialization of early-stage technologies; (iv) 3U Technologies, a project management and engineering firm that provides subsea cables and grid interconnection; (v) NREL, a U.S. laboratory dedicated to advancing renewable energy and energy efficiency that provides guidance for safety procedures, operations and maintenance protocols, non-accredited systems, and business operations; (vi) Williwaw Engineer, a consulting firm to the marine and hydrokinetics (MHK) industry that specializes in the design and testing of ocean wave energy converters; (vii) H.T. Harvey & Associates, an ecological consulting and permitting firm with specialists highly-trained in the areas of aquatic ecology, plant ecology, and landscape architecture, that provides permitting and ecological support; (viii) HDR, a global engineering and construction services firm with sub-sea project expertise, that provides permitting assistance; and (ix) Stoel Rives, a national law firm with a strong West Coast presence that is well-known for its expertise in renewable energy and technology law.).

academia, the federal government, private industry, and local entities. This breadth of resources enables developers testing their devices at PacWave to draw upon this knowledge, including guidance regarding local environmental considerations, which can inform the process, timing, and procedures for their device testing.

Importantly, PacWave's partnering with the EMEC not only adds a dimension of international collaboration and an additional layer of technical expertise, but it also positions wave energy device developers to get their creations accredited and certified in accordance with international standards.[407] The EMEC is authorized to provide independent Environmental Technology Verification (EMEC-ETV) for wave energy devices.[408] This means the EMEC is able to provide device developers with independently verified performance assessments for their wave energy devices tested at PacWave.[409] The EMEC's accreditation capacity, coupled with its ability to provide technical expertise based on and its own experience as one of the first wave energy test centers, enhances PacWave's ability to devise and roll out cutting-edge performance testing standards, safety procedures, guidance for device operations and maintenance protocols, and best practices for new wave energy devices to adopt.[410]

Additionally, PacWave's relationship with international partners the EMEC and HDR, as well as its other public-private partnership partners, hints at the data trust and data sharing relationship among the cluster's partners that is likely occurring. Because Oregon State University serves as the cluster's umbrella organization for managing the cluster's operations,[411] and because of the numerous organizations involved as its partners, it makes sense that data is being anonymized and shared among partnership members rather than remaining siloed on a per developer basis. Also, Oregon State University or one of its partners, law firm Stoel Rives, is well-positioned to serve in the capacity of data trustee.[412] Moreover, due to

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[407] *Id.*
[408] *Id.*
[409] *Id.*
[410] *Id.*
[411] *See Partners*, *supra* note 391.
[412] *See id.* (Law firms are well-positioned to serve in the capacity of data trustee, due to lawyers' ethical obligations to guard client confidences and safeguard confidential information entrusted to them. They also may be better equipped with state-of-the-art data management software and information

the EMEC's providing its guidance to cluster partners and offering accreditation to developers, it makes sense that PacWave is exporting and sharing certain of its data with the EMEC. This type of data sharing on a collaborative, international scale among public-private partnership members helps to further ignite and accelerate the progress in wave energy device development that the PacWave innovation cluster is endeavoring to achieve. For these reasons, together with the reasons stated above, the PacWave innovation cluster serves as a model for others to replicate.

CONCLUSION

As the Roman Philosopher Seneca said, "Luck is what happens when preparation meets opportunity."[413] We are lucky. As we move forward as a country into our renewable energy future, we have the opportunity to apply lessons learned and proceed accordingly. Now that we can incorporate larger amounts of renewable energy into our current energy mix, we need to scale-up renewable energy devices mindfully. This approach will enable us to develop industry resilience, improve industry standards, and accelerate improvements upon existing technologies.

Realizing that a certain level of risk accompanies new, innovative devices when they are deployed at full-scale, we need to encourage and support those willing and able to undertake such risk. As we, as a nation, lunge forward and reach for the best future we are capable of creating, we must look at precedent from the UK, Japan, Australia, and other countries, as well as our own history. We can use the knowledge we have gained from weather and geological conditions at the Robin Rigg offshore wind farm to inform how we fashion and improve upon industry standards aimed at regulating evolving technologies and their related devices. We can benefit from our heightened awareness about black swan events, so that we assess and prepare for potential emerging issues related to extreme weather events, accelerated timelines for naturally occurring atmospheric and oceanic phenomena, and other factors associated with shifting weather patterns and sea level rise. This awareness will enable us to create

technology staff that can assist in designing, creating, testing, and managing the platform on which the shared data resides.).

[413] Seneca, *Quotable Quote*, GOODREADS, https://www.goodreads.com/quotes/17490-luck-is-what-happens-when-preparation-meets-opportunity.

standards that at their inception are able to reasonably address these eventualities to the extent possible. Like the Warrior II Pose, our ability to simultaneously reach back and draw upon precedent, incorporate foresight into our regulatory framework, and update this framework on an ongoing basis with new scientific data when received will help us in our quest to avert disasters in magnitudes similar to the grouted connection failures at Robin Rigg and at other European offshore wind farms, the 2011 Fukushima nuclear disaster, the 1965 Ferrybridge Collapse, and the 1940 Tacoma Narrows Bridge Collapse.

Pilot projects such as the Block Island Wind Farm and demonstration projects involving Pavegen piezoelectric flooring tiles have illustrated the importance of launching a new technology with experienced experts in that technology's field. These projects, too, have demonstrated the essentiality for an out-of-the-ordinary renewable energy device to gain public buy-in. In contrast to the Ivanpah project located far from the public's eye, we now know that public engagement, receptiveness to an unusual device, and a feeling of "connectedness" to it play significant roles regarding the public's welcoming and adopting out-of-the-ordinary technologies. We also know the importance of being committed to maintaining momentum post-launch of the device, so that we do not miss this crucial opportunity to sustain public engagement. This means taking basic steps to ensure that people enjoy the same degree of excitement, sensory, and psychological experience as they did at the time when the device was first installed, so that the original excitement about the project does not wane. New visitors to that device can then be inspired to use cell phone technology and social media at their fingertips to continuously promote the device and share their newly-acquired knowledge about the technology the device employs. Positive consumer-driven publicity, combined with positive publicity from other media outlets, is key to generating hype, knowledge about, and public acceptance of the device and the technology itself.

The ability to think out-of-the-box and apply technological know-how in never-before-seen, creative manners is also essential for propelling us forward in terms of renewable energy device deployment. Not being confined by traditional notions of device and architectural designs promotes innovation. This, in turn, enables imaginative, original creations to emerge that interweave artistic design with scientific ingenuity. Yet, as the lack of funding to actualize the building of the Strawscraper illustrates, non-traditional formulations for how to generate renewable energy need to be attractive to the general population and investors alike, both in terms of aesthetics and in terms of potential return on investment. Taking devices that are ultra-futuristic and bizarre in appearance, such as Carnegie's CETO device, and striking a balance between this appearance and consumer conscientious elitism is a fine line that inventors and designers collectively need to discover and cross. Successfully formulating how to do this will enable investors to feel more confident in actualizing their investment-backed expectations and will help to make real what is now only conceptual architecture. Breaking from tradition in this manner can help bolster resiliency and transform existing metropolises into smart cities.

Indeed, private investors play a key role in determining which of the many innovations in need of investor backing merit actual funding. While many inventions are intriguing conceptually and aesthetically, not all of them may meet with success when brought to market. Private investors are best positioned to evaluate the risk of a product's potential success or failure prior to that product's roll-out to the public. This is because such investors have skin in the game, given their stake in the product's ability to perform, market stamina, and public appeal. Factors such as the product's scalability, ability to be integrated with other existing technologies, and additional unique characteristics that give it a market edge, such as with the Vortex Bladeless, are attributes investors weigh and consider. Moreover, investors are tasked with contemplating and balancing a variety risks associated with the product, including performance risk, damages risk, public receptiveness risk, environmental risks, legal risk, and overall product viability. Considering these factors collectively and determining whether to invest in a novel device is a formidable task for an investor, particularly if such evaluation must occur prior to the device's demonstration or pilot project phase.

Combining industry, government, and academia together in an innovation cluster through public-private partnerships offers a winning combination that can ease private companies' and their investors' burdens by providing a robust environment for creativity, data sharing, and collaboration with partner entities to achieve a common goal. Innovation clusters also provide a creative means of data sharing and funding for kick-starting renewable energy technology initiatives. Private investors bear the heaviest burden for novel renewable energy devices in terms of financial risk. Firms participating in public-private partnerships within innovation clusters, though, may have access to their partners' data through data trusts, even if this data is in anonymized form and even if only certain data is shared with certain partners. Data sharing can help a cluster's industry generally and the partnership member firms specifically, as the funding one partnership member receives, whether a public or private partner, effectively supports the overall ability of the partnership as a collaborative unit to progress forward.

Innovation clusters have the ability to blend private and government resources together, foster creativity from the top minds worldwide in a particular renewable energy industry from both academia and the private sector, and catalyze development of cutting-edge renewable energy devices that can inform how we think about smart cities and our energy future. For these reasons, innovation clusters offer a collaborative, contemporary, compelling approach to synthesize federal, state, and local government funding together with private sector investment. Moreover, public-private partnerships and innovation clusters functioning as smart cities that engage in anonymized data sharing through a data trust possess the potential to catalyze the rate of technological breakthroughs in renewable energy device design. As the success of the PacWave innovation cluster demonstrates, local community support combined with public-private partnerships on a local, national, and global scale provide an opportunity to test innovative devices in an incubator-like setting, offer a reduced-risk arena for promising inventions to be tested, and bring the world closer to the commercial scale-up and widespread deployment of novel renewable energy devices.

Our energy future is a human issue, an important one that will impact our generation as well as future ones. As a country, we need to engage the public and elevate renewable energy to the level of public consciousness mindfully, so that the public wants to play a role in shaping our energy supply's destiny. By designing industry standards that evolve with the technology they regulate, preparing for naturally occurring aeronautic and subsea anomalies that may occur more frequently, engaging in cooperative federalism while involving industry and academia, deploying government funding through public-private partnerships within small-scale innovation clusters, utilizing data trusts to anonymize data and share knowledge, and continuing to encourage private sector businesses and investors to remain key driving forces in renewable energy development, the U.S. can mindfully grow a resilient renewable energy industry that fosters creativity, hastens the development and deployment of technological innovations, and produces the best outcome for the American public both now and in the future.