HEARTS, MINDS, & kWh

ROOFTOP SOLAR AS A MECHANISM FOR COMMUNITY ENGAGEMENT IN WEST VIRGINIA

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PREPARED FOR THE NATURE CONSERVANCY

PRESENTED TO THE FRANK BATTEN SCHOOL OF LEADERSHIP AND PUBLIC POLICY

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The Nature Conservancy

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FOREWARD

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Disclaimer
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Honor Pledge
On my honor as a student, I have neither given nor received aid on this assignment.

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Executive Summary

As the United States grapples with the daunting future of climate change, policy makers are shifting away from coal energy towards greener, more sustainable sources. West Virginia, compared to the rest of the U.S., has been slow to adopt solar energy. The state's reluctance to embrace a greener future, however, is weighing on West Virginia's bottom line. The Nature Conservancy West Virginia hopes to help West Virginians understand the potential benefits of solar energy through thoughtful stakeholder engagement and conservation. However, The Nature Conservancy has not yet been successful at mustering broad-based support for their environmental exploits in West Virginia.

This analysis seeks to disentangle why West Virginia thus far lags behind neighboring states in solar adoption, as well as propose two alternatives for increasing stakeholder engagement. The proposed alternatives seek to alleviate the costs, both economic and social, of installing rooftop solar in West Virginia as well as disseminate reliable information through established local community networks. The alternatives are as follows:

1) Provide free solar to a select number of West Virginia homeowners

2) Partner with Lowe's Home Improvement stores in West Virginia to advertise rooftop solar and other solar products in-store.

Both alternatives will be analyzed on the basis of cost, reach, effectiveness, administrative feasibility, and cost effectiveness. Ultimately this report finds it is most cost effective for The Nature Conservancy to collaborate with Lowe's Home Improvement locations in West Virginia to disseminate information about rooftop solar. Additionally, I recommend The Nature Conservancy begin tracking rooftop solar market expansion in order to better understand locality-specific consumer behavior and improve future forecasting models. Overall, creative stakeholder engagement that considers the experience of West Virginians will ensure The Nature Conservancy protect West Virginia's land, waterways, and people.

Introduction

Problem overview

For centuries, extractive industry in West Virginia supplied a resource-hungry nation (Ward, 2018). While Americans were consuming electricity and steel, West Virgininans were reeling from mine cave-ins, horrific work-site accidents, and deadly black lung disease (Ward, 2018). West Virginia’s waterways ran black and mines tore up irreplaceable wilderness land. For nearly two centuries, America enjoyed seemingly limitless resources at the expense of West Virginia’s land and people. Despite launching America to the forefront of the industrialized world, West Virginia has not seen the fruits of their labor reinvested into their own communities (McCormick, 2021). Now, as the nation reckons with the increasingly urgent global climate crisis, West Virginia risks being left behind again.

Beginning with a series of Obama-era regulations on coal-fired power plants, climate-conscious policy-makers have attempted to move the needle on American climate policy (Knickmeyer, 2019). Incrementally, the nation is shifting away from coal towards natural gas, solar, wind and other low carbon sources. Declining demand for coal along with carbon reduction goals have forced many West Virginia Mines to shut their doors. Over the past decade, nearly 800 mines in West Virginia have closed, accounting for a net loss of more than 6,000 jobs in just ten years (Douglas, 2021). Since 1971, mining jobs have plummeted from 43,875 to just 11,511 as of 2021 (Douglas, 2022). While stalling coal production has been key to reducing green-house gas emissions, it has left many West Virginians out of work and struggling to cope with the loss of their way of life and, in many cases, long family legacy.

The Nature Conservancy (TNC), a global non-profit with a chapter in West Virginia, is seeking to assist West Virginians in dealing with mine closures by revitalizing the economy in a way that also safeguards the planet. A large part of their recent work has focused on kickstarting West Virginia's solar market. However, as an environmental organization, the Nature Conservancy is not positioned well to facilitate change for West Virginians struggling to embrace a future without coal. Despite some recent wins, TNC struggles to muster broad-based support for solar expansion projects. As of 2023, West Virginia still ranks 48th in the nation in terms of installed solar capacity (SEIA). Should TNC West Virginia empathetically consider its constituency and creatively tailor its approach to public engagement, TNC can grow its impact and help West Virginians see the potential benefits of embracing green energy. A growing body of evidence suggests rooftop solar, as opposed to utility scale or commercial solar, is itself effective at demystifying and destigmatizing solar, promoting positive associations with solar and other green technologies, and helping community members overcome uptake barriers.

Client Overview

The Nature Conservancy, founded to “protect and care for nature,” is one of the most effective and wide-reaching environmental organizations in the world (The Nature Conservancy, n.d.-a). TNC’s one million members and hundreds of staff around the world impact conservation in 76 countries and territories. TNC's work in West Virginia takes an integrative approach that prioritizes both economic development and land conservation. In Appalachia, TNC is a recognized authority on the impact of energy development and promotes the advantages of renewable energy alternatives and energy efficiency practices. According to TNC, West Virginia must act swiftly on solar energy development to ensure it doesn't lag behind other Appalachian states embracing clean energy. “As the market demand for solar energy increases and the pace of solar development around West Virginia grows rapidly,” says TNC, “there’s a small window of opportunity for state leaders to take proactive action and ensure these projects come to West Virginia and not just surrounding states” (The Nature Conservancy, 2020). Solar energy development has the capacity to create jobs, grow the state economy, attract new industry, and diversify the state’s energy portfolio.

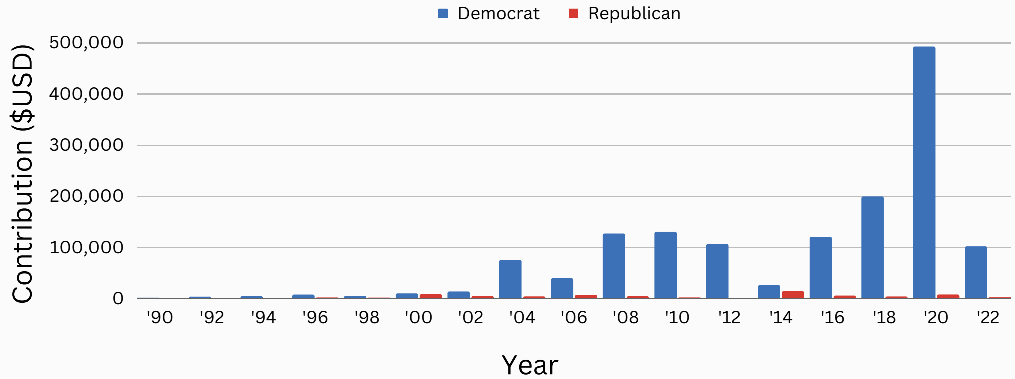
To date, TNC has primarily focused on expanding utility scale solar. In 2019, TNC WV launched the "Roadmap to Solar on Mine Lands," a vision for West Virginia’s solar future that leverages its legacy as a domestic energy titan by siting solar facilities on disused mining sites (The Nature Conservancy, 2019). TNC has identified 400,000 acres of former mine lands across central Appalachia that are suitable for large-scale solar developments. Should all this land be utilized for solar development, central Appalachia alone could double the total solar capacity of the nation.

Thomas Minney, Executive Director of TNC in West Virginia, believes that if more West Virginians understood the potential economic benefits of solar energy, they would be more receptive to the green energy transition. As Executive Director, Minney is responsible for promoting conservation efforts that benefit both the environment and the people of West Virginia. He notes that the public discourse around the shift to low-carbon energy lacks a vision that deals in real time or in a practical way. People are generally forced to fall on either side of the partisan line: those who support the traditional coal economy (climate deniers, conservatives, and traditionalists) and those who advocate for all renewables all the time (environmentalists and liberals). Minney argues that the reality of the renewable energy transition will take time, and rushing to adopt "all renewables all the time" policies risks leaving West Virginia as the state struggles to transition away from coal production. Ultimately, it is crucial that TNC ensure West Virginians themselves have a say in shaping the future of their communities. For more insight into TNC’s ongoing work and important developments taking place over the course of this project, see Appendix 1.

BOX 1: NON-PARTISAN ON PAPER, PARTISAN IN PRACTICE

On paper, TNC is a nonpartisan organization– they use a “practical, nonpartisan approach to show policymakers across the political spectrum how nature can provide effective solutions to major challenges like climate change” (The Nature Conservancy, n.d.-a). Because climate change and conservation are increasingly polarizing, however, it is challenging for TNC to remain non-partisan in practice. Though TNC’s leadership and affiliated institutions represent a spectrum of political parties, TNC tends to lobby for Democratic bills and support Democratic candidates. Of the 700 bills lobbied by TNC since 1986, 60% were Democrat sponsored (Willis, 2022). Campaign contributions since 1990 show even more support for the democratic party. Figure 1 shows TNC’s overwhelming financial support of Democratic candidates compared to Republican candidates since 1990.

Figure 1 Total TNC Contributions ($USD) by Party of Recipient (1990-present)



Source Open Secrets: Following the Money in Politics.

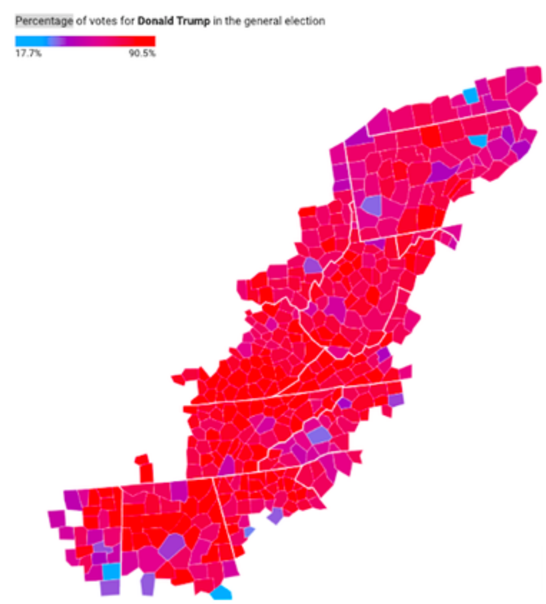
TNC's growing political contributions hold significance in understanding the role of political ideology in green energy market growth. Central to the renewable energy debate are ideological disagreements between Democrats and Republicans (Hess et al., 2016). Studies moreover indicate support for green policy has become increasingly divided along party lines, and Republicans tend to be more reactive against green energy policies in more progressive settings (Coley & Hess, 2012). Therefore, not only do TNC's partisan political contributions reflect the growing divide in our political landscape, but they also suggest TNC may struggle to gain support in Republican stronghold West Virginia.

Background

Appalachia

Appalachia, a region spanning from northern Alabama to southern New York, comprises 423 counties across 13 states (ARC, n.d.). The degree to which each state is considered part of Appalachia varies; Maryland has only three counties within Appalachia's geographic boundary, while Kentucky, Tennessee, and West Virginia each have over 50. Despite its size and diversity, the Republican Party has overwhelmingly dominated Appalachian politics since the mid-2000s. Even during President Obama's resounding win in 2008 Appalachia voted Republican (Oshnock, 2019). Situated in the heart of central Appalachia, West Virginia is often a Republican outlier even among other Appalachian states. In the 2020 presidential election, West Virginia was the second-best state for Trump, with Monongalia County being the only region where he did not receive a majority of the votes (Write, 2020).

Figure 2 How Appalachia Voted for President in 2020



Source 100 Days in Appalachia: Explore How Appalachia Voted in 2020

Figure 2 shows a detailed map of Appalachia's voting pattern in the 2020 election.

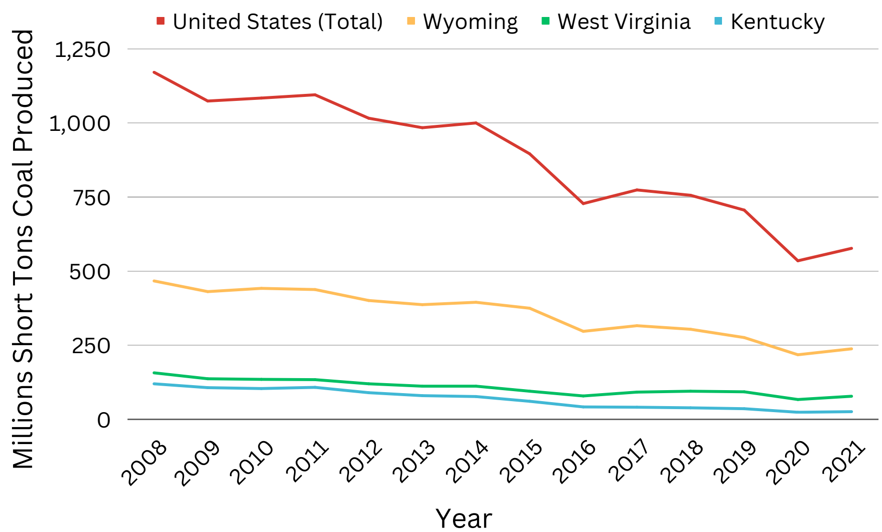
Political Affiliation and Green Policy

Understanding the political history of Appalachia is crucial to unraveling West Virginia's resistance to green energy adoption. The political landscape surrounding green energy policies has become increasingly partisan since the mid-2000s, with support for solar, wind, and other renewables becoming more closely tied to political affiliation (Coley & Hess, 2012). A study of 6071 state legislature votes on green energy laws between 2007 and 2011 found support for green energy is increasingly divided along party lines, and that such support is inversely related to the strength of a state's incumbent fossil fuel industry (Coley & Hess, 2012). Additionally, research has shown that political ideology is a strong predictor of individual attitudes related to environmental issues (Hess et al., 2016). West Virginia's reluctance to embrace solar power is deeply ingrained in the state's socio-political norms, which have long been shaped by the state's history of coal mining.

Coal Industry Decline & Growth of Renewables

The precipitous decline of coal manufacturing in West Virginia is linked to increasing federal policies favoring renewables. Figure 3 illustrates the decrease in total aggregate coal production both nationally and in the top three coal producing states: Wyoming, West Virginia, and Kentucky. Since 2010, mining production has fallen by approximately 47% nationally (from over 1 billion short tons in 2010 to just 500 million short tons in 2021) and 42% in West Virginia. West Virginia's coal industry experienced a brief but significant rebound in employment and production between 2017 and late 2019 thanks to soaring demand for coal overseas (EIA, 2019). The U.S. exported about 14% of its total coal production in 2019, compared to West Virginia's nearly 40% exportation rate. Despite a two-year boom in the global market, waning domestic demand has led major coal companies with operations in West Virginia to close their doors, including the state's largest producer, Murray Energy (Lego et al., 2020).

Figure 3 Annual Aggregate Coal Mine Production 2008-2021



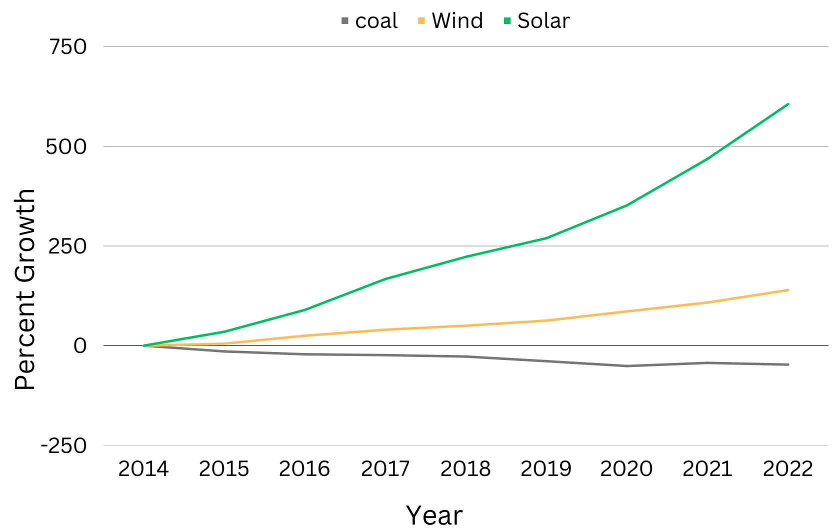
Source U.S. Energy Information Administration

Renewables are rapidly filling the gap left by the coal industry decline domestically. In April of 2019, the U.S. generated more electricity from renewable sources than coal for the first time ever, with solar and wind providing 23% of US electricity generation compared to coal's 20% (Milman, 2019). Michael Webber, an energy expert from the University of Texas, predicts that "the fate of coal has been sealed, the market has spoken... the trend is irreversible now, the decline of coal is unstoppable" (Milman, 2019).

At the same time, the U.S. is making strides in creating a new market for renewables. Net electricity generation by the solar industry has increased by more than 600% since 2014 (EIA, n.d.). The solar Investment Tax Credit (ITC) has played a vital role in supporting the growth of solar energy in the United States, and has been a key mechanism in creating jobs and investing billions of dollars in the U.S. economy since its passage in 2006 (Solar Investment Tax Credit, n.d.). Figure 4 compares the growing renewables market to the shrinking coal economy since 2014, highlighting the significant shift towards renewable energy in recent years.

As demand for coal wanes, electricity derived from coal has dropped by 47% since 2014 while wind and solar have increased by 139% and 605%, respectively (EIA, n.d.).

Figure 4 Electricity Generation Diversification Since 2014



Source U.S. Energy Information Administration

West Virginia's continued reliance on coal is proving to be a financial burden for ratepayers. While neighboring states are transitioning to renewable energy sources, utility prices in West Virginia are soaring. As of 2021, 91% of West Virginia's power came from coal, compared to just 22% nationally (Lavelle, 2022). With the domestic market for coal shrinking, West Virginians make up a larger portion of the nation’s demand, thus creating incredible increases in electricity prices. Between 2008 and 2017, West Virginia saw the fastest growth rate in electricity prices in the country (Misbrener, 2021). Residents of American Electric Power, one of the state's largest utilities, have experienced a 180% increase in rates since 2006– this is over five times the nationwide increase. According to James Van Nostrand, the Director of the Center for Energy and Sustainable Development at West Virginia University's College of Law, while the rest of the country embraced natural gas, wind, and solar, West Virginia doubled down on coal. And the West Virginia ratepayers are paying for that decision (Lavelle, 2022).

Solar in Appalachia

BOX 2: APPALACHIAN SOLAR AT A GLANCE

MW installed (as of Q4 2022): 29,695

Projected growth (MW over 5 year period): 40,514

Total jobs: 54,996

Regional leaders: NC, GA, VA, NY
Together these 4 states make up 73% of the Appalachian solar market with a combined total of 21,757 MW installed.

Source Solar Energy Industries Association

While North Carolina, Georgia, Virginia, and New York have emerged as a leaders in the adoption of renewable energy, other Appalachian states are also taking steps to embrace renewables. Without explicit regulatory support from state governments, the private sector in many states is making impressive strides in the development of solar energy, particularly at the utility scale (SEIA, n.d.).

Market expansions have had a positive impact on the overall solar landscape in Appalachia, but they have done little to change the perception of the green energy transition among residents. Rooftop solar, in addition to expanding the nation's solar landscape, inspires a complex peer-to-peer market diffusion model. Rooftop solar allows homeowners to model sustainable habits and promote collective environmentally-friendly action within their communities. While the development of large utility-scale solar installations has a significant impact on the overall solar landscape, the expansion of rooftop solar creates a more grassroots level of support for renewable energy. This support can help foster a culture of environmental responsibility and inspire residents to make changes in their own homes and communities.

BOX 3: THE MYSTERIOUS CASE OF NORTH CAROLINA

North Carolina, a solar outlier in Appalachian states, ranks 4th nationally in solar implementation (SEIA, n.d.). Not only has North Carolina far exceeded regional solar growth rates, but its solar market has grown alongside national leaders such as California and Arizona. North Carolina's solar boom can be attributed to the strong enabling environment built by the state legislature. According to the Database of State Incentives for Renewables & Efficiency (DSIRE), North Carolina has 65 state clean energy incentives, 14 of which are regulatory policies. A majority of North Carolina's regulatory policy was passed before 2010, with only four more policies being added between 2011 and 2022 (DSIRE, 2022). This is likely due to a state-wide surge in democratic values surrounding the Obama presidency, one of the only times North Carolina has voted Blue since the late 70s (MIT Lab, 2021). The other 41 policies, all passed after 2010, are financial incentives. North Carolina's strong regulatory foundation for solar, which seems to have been achieved during a time of fleeting political opportunity, laid the groundwork for them to become one of the nation's leading states for solar.

Recent Solar Wins in West Virginia

BOX 4: WV SOLAR

At a glance

30 MW installed

697 MW projected growth

372 total jobs

Despite West Virginia's lag in implementing solar policies, promoting sector growth, and creating solar jobs, the state has experienced some recent progress in its solar landscape, both in terms of solar capacity and policy environment. In 2020, the West Virginia legislature passed bills allowing American Electric Power and FirstEnergy Corp., the state's two largest utilities, to install solar power in 50-megawatt increments, despite opposition from the coal lobby (Silverstein, 2021). Additionally, West Virginia solar developers are now able to enter into power purchase agreements with churches, schools, and municipalities. Moreover, the United Mine Workers

Association– West Virginia's strongest labor union– has expressed support for President Biden's green energy evolution (Silverstein, 2021). Keena Mullins, co-founder of Revolt Energy, an Appalachian solar developer specializing in installations of all sizes, believes that this sequence of events indicates a promising future for solar energy in West Virginia. She explains, "Appalachian citizens who have benefited from coal understand that this industry is in decline. They want new jobs to move into. And it speaks volumes that the coal lobby has come out against the passage of bills to allow for more renewables but the actual workforce that makes up the coal industry is in favor of those laws" (Silverstein, 2021).

Following the passage of this breakthrough legislation, a 2021 Research America poll revealed 90% of West Virginia respondents and 95 percent of coal county respondents could identify the benefits of shifting focus from the traditional energy industry in West Virginia towards clean energy production (Adams, 2021). However, this poll revealed participants are torn between protecting their history and embracing the future they know is coming. When asked if they agree with the statement that coal is the backbone of the state and that renewable energy is hurting mining jobs, 59 percent of statewide respondents agreed. However, when asked whether they agree that the economy is shifting away from coal and fossil fuels towards clean and renewable energy sources, 69 percent of statewide respondents and 73 percent of coal country respondents agreed (Adams, 2021). The president of Poll America, Rex Repass, explains that it's clear in their polling results that West Virginians believe in the coal industry, have a desire to protect their culture, and support their prevailing economic system. There's also an apparent desire to support clean energy and the creation of jobs the coal industry evolves (Adams, 2021).

Review of Relevant Literature

The following literature review primarily examines existing patterns of market diffusion for rooftop solar as well as rooftop solar's unique capacity for community engagement. The existing body of literature suggests market proliferation of solar panels is a unique process– one that is not yet fully understood by researchers. Conventional market diffusion models, including the innovation diffusion model, Bass model, and agent-based model, are insufficient in explaining the growth of solar energy to date. Research suggests a combination of these modeling techniques may provide a more accurate forecast of solar expansion. Generally, diffusion of solar PV panels at the household level is driven by both endogenous (e.g. awareness, knowledge of technology, psychology of energy conversation etc.) and exogenous mechanisms (e.g. costs, regulations and market structure, characteristics of the technology) (Islam, 2014). The speed of market diffusion is determined by the interaction of these mechanisms. Some studies attempt to isolate the effects of particular market drivers, such as solar subsidies, solar community organizations, and marketing campaigns. The extent to which these mechanisms expedite market proliferation remains unclear, but all have positive directional effects on solar adoption.

Basic Market Diffusion Models

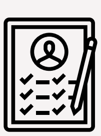
Though the driving mechanisms of solar PV adoption are not yet fully understood, it is generally believed that market diffusion follows a predictable, bell-curve pattern. Everett M. Rogers's 1962 Diffusion of Innovation Model provides one of the earliest understandings of market growth (Sahin, 2006). For a detailed schematic of Rogers's Diffusion of Innovation

Model, see Appendix 2A. Rogers's model suggests that market expansion is based on communication between individuals in a social system. That is, as more people adopt a technology, more communication about the technology takes place, leading to more rapid subsequent adoption. Decision to adopt, according to Rogers, depends on an individual's personal inclination to "innovate" (Sahin, 2006). Innovators, typically the first 2.5% of the adoption population, are individuals willing or able to take financial risks on new, uncertain technologies. Rogers's Innovation Diffusion Model is a macroeconomic describing overall market trends; it considers the impact of social networks, but it does not necessarily capture individual or local effects.

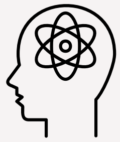
The Bass model, a 1969 derivative of Rogers Diffusion of Innovation model, has been used to model solar market expansion in multiple studies (Dong et al., 2014; Islam, 2013; Bollinger & Gillingham, 2012). The Bass model, similar to earlier diffusion models, assumes rates of adoption accelerate as more consumers embrace innovation. In Bass models, this phenomenon is called "social contagion" and is measured via the coefficient of imitation. Social contagion is a driving force behind accelerating adoption rates, but the overall estimate of contagion captures a variety of extra-social factors that influence technological diffusion (Bollinger & Gillingham, 2012). The Bass model groups consumers into two distinct categories: externally influenced "innovators" and internally motivated "imitators." All consumers fall into one of these two categories. As time progresses the number of new innovators adopting diminishes while the number of imitators increases, peaks, and dissipates. Externally influenced consumers decide to take up innovations without "social contagion" while internally influenced adopters (imitators) wait to see innovations used by peers (Tracy, 2019). See Appendix 2B for more information on Bass models of diffusion.

For solar market diffusion, in particular, studies have used the Bass model to predict consumer propensity for adoption at a given time based on certain consumer characteristics and market conditions. Islam (2014) suggests cost-benefit estimates and social pressures such as advertising campaigns are likely to influence the adoption of solar PV technology. The coefficient of innovation captures levels of awareness about the technology; attitudes towards energy conservation; and socio-demographics (Islam, 2014). How innovators communicate their beliefs will in turn determine the coefficient of imitation. Bollinger & Gillingham's 2012 Bass model for solar uptake considered consumer perceived net present value, costs of the panels, the incentives in place, electricity prices, and number of nearby rooftop installations in their coefficients of innovation and imitation (Bollinger & Gillingham, 2012).

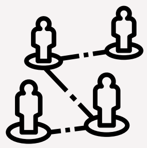
BOX 5: WHAT OUGHT TO BE CONSIDERED WHEN FORECASTING SOLAR ADOPTION?
Shakeel & Rajala, in their 2020 systemic review: Factors Influencing Households' Intention to Adopt Solar PV, identifies the factors, listed below, that have been instrumental to solar PV adoption to date.



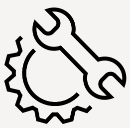
Demographic: individual's age, gender, education, occupation, income, marital status, house size, house type, number of residents, ownership status and condition of building.



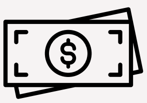
Personal: individual's attitude towards the environment, interest in environmental issues, level of motivation, expectations, perceived benefits, knowledge about the technology, willingness to adopt, intentions and perceived behavioral control.



Social: if the neighbors have installed solar PV at their houses, the overall installation in the locality as well as the effect of visibility and observability of the technology.



Technological complexity: consumers' perceived ease of use, their understanding of its usefulness, compatibility, relative advantage, risks associated with the use and after-sale repair and maintenance services are some of the major technical factors.



Economic (most important for adoption): The high cost of the technology, the amount needed to be paid up front, financing options, the return on investment, the saving it could yield during the life span of the technology and reduction in the energy bills are some of the factors have impact on the adoption.

External factors: market price of energy, subsidies, the regulations building owners needs to comply with and incentives on installation of energy generation.

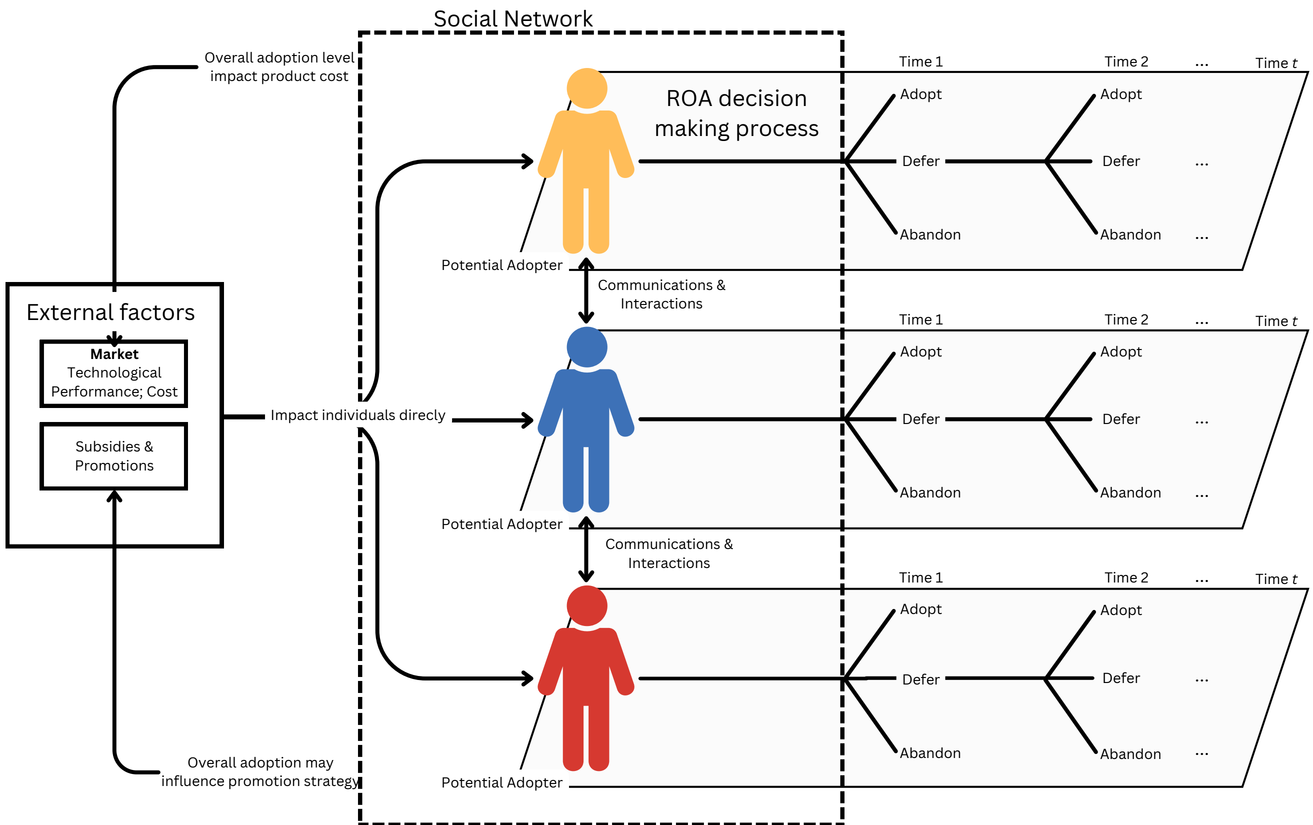
Novel Modeling For Solar Diffusion: Integrated Agent-Based Modeling

Zhang et al., in their 2018 study on diffusion of renewables, established a novel diffusion model that integrated Agent-Based modeling (ABM) to assess the propagation of renewable energy adoption. Their model incorporates individual risk preference and real option decision making into an individual consumer's willingness to invest in renewables. Risk preference is moreover variable based on interactions with peer networks. Using real-time residential PV diffusion in Singapore, authors validated the effectiveness of their model.

Their model claims macroeconomic models, such as the Bass Model or the Innovation Diffusion model, do not adequately consider peer networking or individual heterogeneity in market proliferation patterns. Especially in PV deployment, consumer behavior is dynamic depending on consumer preference, political ideology, how they communicate and obtain information, and diverse social networking experiences. Micro-level modeling, such as traditional ABM alone, overcomes macroeconomic obstacles, but is nevertheless inadequate in forecasting market proliferation for PV products. ABM alone says individuals base adoption decisions on the proposed decision rule: based on individual agent's heterogeneity and interpersonal communications. ABM diffusion, however, does not consider "real options," meaning temporal changes in product performance and price. Real Option Analysis (ROA) allows consumers to take a flexible strategy depending on how uncertainty about innovation performance evolves over time. ROA is particularly important for PV where upfront investment costs are high and the market is volatile/uncertain. The novel ABM model for PV adoption considers three supplementary considerations to traditional ABM models: 1) including ROA in decision making; 2) considering relationship diversity among different social interactions; and 3) examining the impact of external influences (e.g. government subsidies or increasing market performance) on the diffusion process.

Individuals within a social network make decisions based on multiple, dynamic conditions. One being the ROA integrated decision rule, where potential adopters are able to either adopt, defer, or abandon at each time period. Interpersonal communication, relationships within the larger social network, and external factors are also ongoing considerations in the consumer decision making process. The structure of Zhang et al.'s model is depicted in figure 5.

Figure 5 Proposed Integrated ABM for Solar Diffusion, Zhang et al., 2018



The proposed model shows how social network, external factors, and overall adoption influence individual decision making processes over time. Both market factors and interpersonal networks are dynamic over time. This model, therefore, shows ROA decision making is an iterative process over multiple time periods.

Conventionally, the rational decision-making model assumes that when project value is greater than capital cost, the investment is profitable for the adopter. For innovative technologies, consumers know the capital cost of their investment, but project value is uncertain. Adopters differ in their initial assumptions about the product's value, but perceptual uncertainty erodes as technology permeates the social network. Cost is similarly variable as government subsidies, rebate programs, and promotional deals decrease system costs. In short, adopters decide to invest in the innovative product only when their personal perceived project value of investing in the product outweighs the cost of the innovative product at a given time. Should value not outweigh costs, the consumer will defer their decision and reassess the technology iteratively as they gain more information about the product and market conditions change. Overall, this integrative model relies on multiple forms of modeling traditionally used in innovative market diffusion to more accurately forecast solar proliferation in a way that considers macroeconomic factors, peer effects, market development and volatility, as well as external intervention.

Social Contagion Quantified

"Social contagion," also referred to as word-of-mouth (WOM) effect, positive spillover effects, social network effects, peer-effect, etc., is a significant driver of solar adoption. Though the exact relationship between solar installation and the likelihood that a neighbor will adopt the technology is disputed, there is significant and resounding agreement among researchers that the positive peer-effect is a significant driver of solar adoption (Islam, 2014).

Bollinger and Gillingham (2012), for instance, estimate that a PV installation in a typical zip code increases the probability of an additional installation in that zip code by about 0.78 percentage points. This probability increases as the spatial scale gets smaller. At the street level, each installation increases the monthly probability of an additional installation by approximately 15 percentage points. These results provide evidence that the peer effect decreases with distance, with stronger peer effects at the street level (Bollinger and Gillingham, 2012). Bolligner and Gillinngham also found that zip codes with larger household sizes and a higher fraction of people with more than a 30-minute commute have a larger peer effect, whereas zip codes with higher median household income and more people who car-pool have a smaller peer effect. This implies that visibility is a driving force of peer effect– larger households and longer commutes both constitute increased visibility with more persons in proximity to solar installations and more driving time to see solar installations. The peer effect is also stronger among lower income households. Often installing solar is associated with too much risk for low income households to feel justified in making the upfront investment, so seeing the technology modeled successfully among peers is more influential for those weary of making the investment. These findings, though statistically significant for the study area and impactful for the industry at large, may vary in different regions. It's likely that the peer effects, though they will undoubtedly trend in the same direction, may not be of the same magnitude in West Virginia.

Operationalizing Peer-Effects: Solar Community Organizations (SCOs) (Noll et al., 2014)

Noll et al., 2014 describes the role of SCOs in catalyzing peer effects and other forms of information dissemination in the residential PV sector in the United States. SCOs, as defined by Noll et al., refer to formal or informal organizations or citizen groups– often non-profits– engaged in activities explicitly designed to encourage the adoption of residential rooftop solar PV. Their research studied the underlying channels of information flow, which provided insights for overcoming barriers to diffusion of Solar PV technologies. Figure 6 demonstrates the SCO-driven peer-effect process.

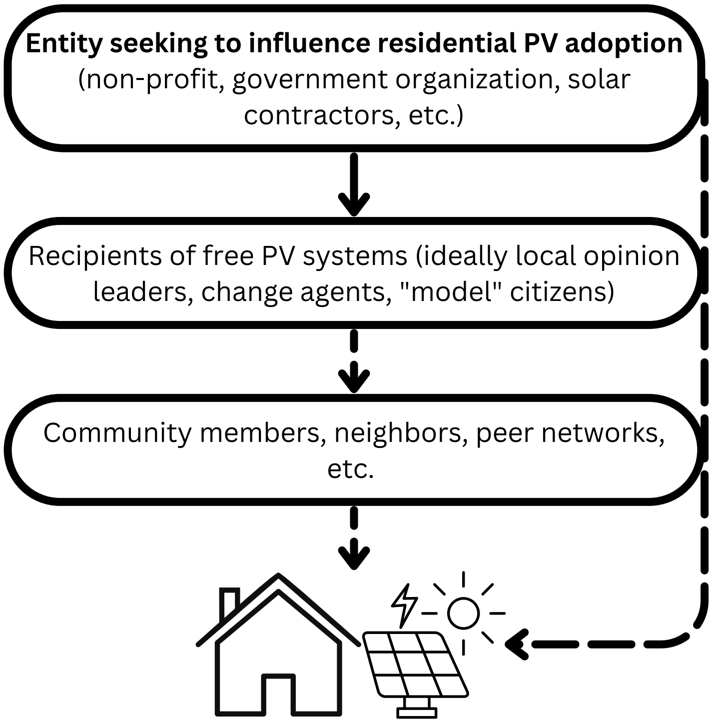


Figure 6 schematic diagram modeling the community-driven peer-effect process. Solid arrow represents direct provision from the influencing entity to community members. Dotted arrows show indirect provision, meaning at this stage technology spreads organically through peer-networks.

Based on their case studies, Noll et al. present three elements critical to the success of any solar campaign:

1) Involvement of a local champion(s)—a person(s) who is well connected, active and well known in the community—who is motivated to have his or her community go solar.

2) Existing networks; a well-connected community is more likely to succeed than a relatively disconnected or inactive community

3) Financial assistance; More consumers have been influenced to adopt solar when a local financial institution provides low (or no) interest loans for their solar system.

Subsidies & Overcoming Financial Barriers

Subsidies are the most common financial incentives offered to potential solar adopters. Solar subsidies typically pay solar system owners for each MW of power produced by their household system. Solar subsidies do not impact the upfront investment required of adopters, but they decrease the payback period, or how long it will take an individual solar installer to break-even on their investment based on offset utility costs. As with research on peer-effects, it is well understood that financial incentives drive adoption, but to what extent remains unclear.

A handful of case studies have investigated the impact of subsidy programs on solar PV adoption in specific localities, but these findings vary spatially and are not universally applicable. For example, Bollinger and Gillingham (2012) studied the California Solar Initiative (CSI), which provided $3.3 billion during a 10-year rebate program. Researchers found a lower adoption rate where the rebate scheme decreased. In another study, exploiting changes in actual rebate levels over time in California, Hughes and Podolefsky (2015) estimated that an increase in rebates from $5,600 to $6,070 would lead to a 10% increase in PV installations. Crago and Chernyakhovskiy (2017) studied county-level data of 13 US states over the period 2005-2012. Their findings suggest that when the rebate level increases by 1 dollar per generated watt, annual PV capacity increases by 47%. Recently Kattenberg et al. (2022), explored exogenous variation in subsidy provision to evaluate the effectiveness of a residential solar PV program in the Netherlands. Kattenberg et al. found that, within the group of households that applied for the €0.53 per kWh subsidy, its provision led to a 14.4 percent increase in the probability of adopting solar PV, a 33.2 percent larger installation, and a 1 year faster adoption.

Though not a perfectly transferrable study, the history of solar in the Netherlands reflects the current market conditions in West Virginia. The Netherlands has always been slow in its uptake of solar power possibilities, partly due to the historic reliance on their local natural gas resources (Kattenberg et al., 2022). In 2008, when Dutch solar energy was virtually non-existing, the EU Renewable Energy Directive set firm rules for the EU to achieve 20 percent renewables by 2020. Inspired and in part forced by the EU's broader shift, the Dutch government rolled out subsidies to kick-start solar adoption (Kattenberg et al., 2022). West Virginia is similarly reluctant to embrace the shift to renewables because of their ties to the incumbent energy market, but the nation as a whole is pushing towards renewables regardless.

Studies vary dramatically in their estimate of subsidy impacts– many of which operate on different temporal and geographical scales. For example, a study on global solar market expansion estimates that subsidies increased global solar adoption 49 percent over the period 2010-2015 (Gerarden, 2023). In the U.S. alone subsidies are estimated to account for 27% of demand increase over the 5 year period (Gerarden, 2023). All studies, however, point to positive feedback loops associated with subsidies. Subsidies increase uptake, and expedites market expansion then proceeds more rapidly.

An additional benefit of solar subsidies is that they induce technological innovation. As the market grows, firms look to reduce costs and improve their technology to remain competitive in an expanding market. This leads to R&D and investments in innovation that compounds market expansion generated by increased demand. The median technical efficiency of solar panels installed in the United States rose from 14.1% in 2010 to 17.0% in 2015 (Gerarden, 2023). These trends are in line with technological diffusion theories outlined previously.

BOX 6: UNCERTAINTY & UNDERESTIMATION

A small part of solar market expansion literature retroactively points to a history of widespread underestimation of the growth in PV deployment (Creutzig et al., 2017). In 2016 the U.S. Energy Information Administration (EIA) publicized that their own market forecasts dramatically underestimated the speed of market expansion. “[We] did not anticipate the sharp decline in solar PV costs seen over the past several years,” an EIA representative said in 2016 (EIA, 2016). This implies that solar market expansion transcends traditional modeling techniques and has thus far expanded at unprecedented, unexpected speeds. Researchers are still trying to disentangle all the mechanisms that induce solar market growth to better understand market development to date and properly forecast future deployment.

Marketing & Advertising

The direct-to-consumer solar market can target both costs and informational barriers to uptake. There is not a large body of literature on advertising as it directly pertains to solar market expansion, save for a handful of studies looking at Tesla's marketing strategy and brand proliferation (Almuzel et al., 2018 & Shashtri, 2023). That said, there is an abundance of research on the effect of advertising in adjacent consumer markets, namely supermarkets, which may be useful in expediting solar market saturation in West Virginia.

A 2018 study on the sales effectiveness of end-of-aisle promotional displays (endcaps) in supermarkets shows endcaps may increase brand sales by upwards of 400% (Tan et al., 2018). Endcaps, generally, are effective in increasing sales of a particular good because of conditioned consumer behavior, store structure and visual composition, and increased product exposure. Consumers have been conditioned over many years to associate endcaps with price discounts and deals. Now, whether endcaps offer discounts or not, consumers conflate endcap products with better value (Tan et al., 2018). Secondly, crowded stores with many brands, promotions, and options are often visually overwhelming for consumers– this same principle is why name-brand goods are kept at eye level (Tan et al., 2018). Endcaps, unlike in-aisle displays, only contain one product from one brand, thereby reducing the cognitive load for the consumer. Lastly, there is a predictable pattern in which shoppers navigate stores based on the commonality of supermarket layouts (and, similarly, Lowe's stores layouts). Endcaps are placed such that nearly all consumers will pass them while navigating the store, whether they are looking for the endcap product or not (Tan et al., 2018). This study, though it surveyed low price consumer goods such as chips and soft drinks rather than expensive, controversial goods such as solar panels, provides insight into the potential efficacy of targeted solar marketing in West Virginia stores.

Limitations in the Literature

Literature on solar market expansion, though comprehensive in some regards, is spatially, temporally, and mechanistically limited. Researchers have extensively studied California's solar market, the provision of subsidies, and the peer-effects in a select few locations. That said, there is little evidence about solar expansion, either historical or ongoing, in West Virginia or nearby Appalachian states; the impact of direct provision of panels as opposed to subsidies; or the effect of in-store advertising campaigns on solar uptake. The existing body of literature reveals definitive trends, positive spillover effects, and generally effective mechanisms for increasing solar uptake.

Alternatives & Policy Goals

The research reveals there are two major barriers to uptake of residential solar: (1) upfront purchasing and installation costs, and (2) perceived uncertainty about solar technology (Crago & Chernyakhovskiy, 2014; Shakeel & Rajala, 2020). The proposed alternatives, therefore, seek to alleviate the costs, both economic and social, of installing rooftop solar in West Virginia as well as disseminate reliable information through established local community networks. Both rely on a third party trusted by community members to distribute knowledge and dispel myths about solar panels. The first, a solar pilot program, would provide free solar panels directly to West Virginians. The recipients of free solar would become de facto solar advocates in their neighborhoods. The second, a partnership with Lowe's Home Improvement, would display rooftop solar information, discounts, and products in endcaps in West Virginia's brick and mortar Lowe's stores. Lowe's Home Improvement, one of The Nature Conservancy's largest corporate partners and international solar retailer, has the capacity to engage large portions of West Virginia's population who otherwise wouldn't be exposed to solar information. For TNC to achieve their goal of helping more West Virginians to understand and benefit from the solar opportunities available to them, it's important for them to thoughtfully co-opt existing stakeholder networks. Both alternatives will be analyzed on the basis of cost, reach, effectiveness, administrative feasibility, and cost effectiveness.

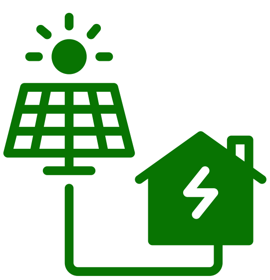
Policy Goals

COST

To calculate the cost of each program, I will total all direct costs including wages, implementation, ongoing administration, materials costs, and financial incentives/rebates used. Because TNC may offset costs with non-profit grant programs or share costs with corporate partners, multiple cost scenarios will be assessed depending on how much cost burden TNC will ultimately bear.

REACH

TNC's ultimate goal is improved community engagement aimed at increasing public support for their work in West Virginia. While increased residential solar adoption is a favorable outcome of effective community engagement, it is not the only proxy for success. Reach will measure how many people will be impacted by each alternative (e.g. how many customers may see a Lowe's endcap).



EFFECTIVENESS

Effectiveness will measure how many additional kW solar each alternative will contribute to West Virginia's renewables portfolio. Because some alternatives recommend TNC facilitate direct provision of solar panels, effectiveness will be measured as both direct and induced adoption.

ADMINISTRATIVE FEASIBILITY (PRECEDENCE)

Each alternative will receive a precedence score based on how many similar projects, if any, TNC WV has completed to date. Precedence, a tiered criteria, will be measured as follows:

0) entirely unprecedented: TNC has never completed a project of this scale, TNC has never worked with the proposed collaborators, and/or TNC has no experience with this particular mechanism

1) somewhat precedented: The scale of the proposed alternative is somewhat similar to TNC's previous work, TNC has worked with at least one proposed collaborators, and/or TNC has some prior experience with the proposed mechanism

2) precedented: The proposal is on par with TNC's previous/ongoing projects, TNC has worked with most or all of the proposed collaborators; and/or TNC has successfully completed similar projects in the past

3) entirely precedented: The proposal is smaller in scale than TNC's previous work, TNC regularly works with all proposed collaborators, and/or TNC has successfully completed larger & more complex projects in the past.

COST EFFECTIVENESS

Cost effectiveness will consider both the price per individual reached as well as price per additional kW solar installed (counting both direct and induced uptake). The measurement of cost effectiveness will be a ratio of the number of people impacted and total cost. The larger the ratio, the more efficient the alternative.

Current Policy

TNC currently does not have a comprehensive community engagement or residential solar uptake program. Each of these alternatives aims to promote face-to-face interaction with potential consumers within the spaces they're comfortable in– such as their own communities and local stores. The "current policy," or lack thereof, has a baseline cost of $0 and zero/negligible reach or potential adoption. Both alternatives will be compared to the baseline lack of existing policy.

Policy Alternatives

This analysis considers two policy alternatives: (1) a solar pilot program, in which TNC would provide free solar panels to a select few West Virginia homeowners, and (2) a corporate partnership with Lowe's home improvement. A description of each of these alternatives are as follows:

ALTERNATIVE 1 Showing Proof of Concept: Installing FREE Solar Systems

Joey James, senior strategist at West Virginia-based environmental consulting firm Downstream Strategies, was in 2021 the first in his community to install rooftop solar. Since then, others in his community have gone solar. "In a lot of communities," he said "what we're lacking is a good demonstration project to show that [solar] works" (James, 2023). Should more West Virginians see solar panels working in their own communities, it's likely that more residents would adopt rooftop solar themselves.

There is clear evidence that spreading information on rooftop solar organically through existing community networks would increase solar adoption. Providing free solar panels to homeowners would entirely eliminate financial barriers that limit potential buyers from entering the market. TNC, by providing a proof of concept for West Virginia homeowners, would initiate change from within existing social structures. Using residents as de facto rooftop solar advocates allows West Virginians to claim a sense of agency not afforded by government subsidies or otherwise regulatory policies. Independence and self-reliance are important West Virginian values; by helping West Virginians overcome financial barriers to change, TNC can catalyze micro-scale solar uptake led by community members.

This alternative relies on the power of social networks and peer-effects to kickstart adoption in otherwise reluctant communities. Because peer-effects are location specific with significantly higher impacts at the street level compared to the zip code level, I recommend two different models for this alternative: a diffuse model and a concentrated model. The diffuse model would provide one free 6.5 kW solar installation to one home in each of 20 zip codes. The concentrated model would allocate the same 20 homes across only five towns in three distinct phases. The concentrated model would also utilize a phase-down economic assistance model. The first home in each town would be 100% financed by TNC. The second two homes would then be 50% financed by TNC, and the final home only 25% financed by TNC. Many existing solar subsidies follow a phase-down model– large initial incentives reduce risk associated with adopting new, expensive, and unproven technologies, thus kickstarting early adoption (O'Shaughnessy, 2022). Early adoption, in turn, supports future market proliferation and learning-based market expansion. Moreover, the phase-down model ensures that incentives decline to avoid inefficient payments to free riders (O'Shaughnessy, 2022). Details for each plan are as follows:

Diffuse Model

Total Homes	20
Peer Effect	Fixed at 0.78 per home
Number of zip codes	20
Cost of each home	Fixed at ~$12,000

Concentrated Model

Total Homes	20
Peer Effect	Variable between 0.78 and 3.12 per cluster of homes
Number of zip codes	5
Cost of each home	Variable between $3,000 and $12,000

ALTERNATIVE 2 Leverage Global Corporate Partnerships: Lowe's Home Improvement x TNC Solar Partnership

A large body of literature confirms the efficacy of in-store advertising. Together, TNC and Lowe's Home Improvement can offer discounts on solar panels and installation as well as disseminate information about solar in Lowe's brick and mortar stores. There are 19 Lowe's locations throughout West Virginia. Lowe's, a global partner of TNC, financially supports TNC's work to "address mounting environmental and human health challenges facing the U.S. using the power of nature" (The Nature Conservancy, n.d.-b). Additionally, Lowe's is committed to revitalizing rural communities– in 2020, the Lowe's foundation donated $25 million to rural community development (Lowe's Corporate, 2020). Because solar expansion would benefit rural communities, this project would fit within the mission of the Lowe's Foundation, and TNC may be able to secure financial support from the Lowe's Foundation. Lowes has existing online guides for choosing solar panels and even DIY installation. This same information displayed in store endcaps, supplemented by TNC's vision for West Virginia's future, and accompanied by discounted Lowe's solar products would encourage West Virginians financially and dispel misconceptions about solar power.

Assessment of Alternatives

For a comprehensive list of assumptions used in the assessment of alternatives, additional considerations, as well as equations and models, see Appendix 3.

ALTERNATIVE 1 Showing Proof of Concept: Installing FREE Solar Systems

COST

Because many solar retailers advertise different prices and recommended system capacities for solar panels, it is unclear what exactly the cost of rooftop solar is in West Virginia. Suggested installation size ranges from 11kW to 5 kW, costing an estimated $29,040 and $14,400, respectively, without the 30% investment tax credit. For TNC to offer systems that offset half of annual energy consumption for the average consumer, each solar home would cost an estimated $12,012. For the diffuse model, panel and installation costs total $240,240. For the concentrated model, the phase-down pricing scheme brings panel and installation total to $135,135.

Based on previous large-scale solar projects completed by TNC, a team of five industry professionals would be needed to complete this project. For the first six months, the five-person task force would identify suitable homes; advertise the program; interface with homeowners, community members, and solar installers; determine program participants; and facilitate and oversee installation. Based on a $90,000 annual salary for five solar professionals across 6 months, this project would cost $450,000 in upfront personnel costs. Once established, however, this alternative will rely on community networks. The task force could then be dissolved and one remaining member would ensure the selected homeowners are advocating for solar in their communities in the intended way. Within the first year, personnel costs for showing proof of concept are estimated to be approximately $455,880.

TOTAL COST (OVER 1 YEAR)

$591,015 (concentrated program) – $696,120 (diffuse program)

REACH

Though peer-effects of solar are well researched, there is little available research about community connectivity or well-defined neighborhood characteristics for West Virginia. For these reasons, I will use the average size of Homeowners Associations (HOAs) in West Virginia, estimated 40 households as a proxy for reach (FCAR, 2021). I am using this estimate because HOAs make and enforce rules for residents– oftentimes visible design choices, such as external paint color or major renovations, are restricted by HOA membership. From this, it is therefore reasonable to assume that the average number of households belonging to a single HOA is a suitable measure of the reach of visible solar panels. If each of the twenty solar homes reaches 40 additional households, the total reach is estimated at 820 households or 2,025 individuals, including the recipients of the solar panels.

TOTAL REACH

2,025 individuals

EFFECTIVENESS (Direct and Induced Adoption)

Both iterations of this alternative will definitively increase the state's solar capacity by 130 kW. Induced adoption relies on the strength of peer effects. In the diffuse model, each additional home increases solar uptake by 0.78 percentage points. For ease of modeling, we will assume each zip code has 0 solar homes to begin with. Based on the siting process this may or may not be the case. State-wide, the diffuse model will increase the number of solar homes by approximately 15 households. Based on the average rooftop solar size of 5 kW, this would add 75 kW of solar to the state's renewables grid. For the concentrated model, we assume the second solar home will increase community-level adoption by 1.56 percentage points, the third home by 2.34 percentage points, and so on. Given the increasing peer-effect with the number of rooftop installations, the concentrated model would add 253.5 kW solar to the grid.

TOTAL EFFECTIVENESS

205 - 383.5 kW

ADMINISTRATIVE FEASIBILITY

The scale and technical expertise required of this project are not unprecedented; TNC has worked with professionals in the solar industry on much larger projects (e.g. Solar on Mine Lands). However, the community engagement mechanism is unprecedented. Therefore, this alternative is **somewhat precedented (2)**.

TOTAL ADMINISTRATIVE FEASIBILITY

2

COST EFFECTIVENESS (PER PERSON & PER MW SOLAR ADDED)

Diffuse Model

$343.76 per person

$3,395.71 per kW solar

Concentrated Model

$291.86 per person

$2,883 per kW solar

ALTERNATIVE 2 Leverage Global Corporate Partnerships: Lowe's Home Improvement x TNC Solar Partnership

COST

Based on the going rate for a marketing specialist within the environmental non-profit industry, hiring a temporary advertising specialist (or outsourcing a specialist from TNC's national team), would cost $71,000 annually. Marketing industry reports estimate that comprehensive marketing plans take up to 12-weeks to complete (Edge, 2017). After this 12-week planning stage, the marketing specialists would oversee implementation and track efficacy. Additionally, a 2021 report on non-profit advertising trends reports the average ad campaign requires 5 employees (Nonprofit Advertising Benchmark Study, 2021). Though this alternative does not propose a full-scale marketing campaign, it will require TNC conduct some level of marketing research to gauge the efficacy of their endcaps on solar uptake. Therefore, I propose TNC stick with this five-person team to oversee endcap installation and upkeep at all nineteen Lowe's locations. Though not all employees would be advertising specialists, I will use the $71,000 salary to estimate the total cost of a 5-person advertising team. Hiring costs, therefore, will total $355,000.

Each endcap itself (materials and design) is estimated cost an estimated $300 (Dube, 2021). Display fees range from $350-500 per display per store, and a "pay-to-stay" fee will be required when all of the products are purchased from the display (Trax, 2019). Based on expected uptake (i.e. product purchase), a 100 item display would be renewed approximately once per month. The total cost of the endcaps themselves would be $85,500 across all 19 stores for one year.

> **Discounted pricing model:** considering Lowe's philanthropic history with both TNC and West Virginia's communities, I also offer a discounted model in which Lowe's would not charge TNC for the advertising space. In this discounted model, TNC will pay for the endcaps, but not the display fees or the "pay-to-stay" fees. Under this model, endcap price is estimated to be only $5,700 for the year.

TOTAL COST (OVER 1 YEAR)
$360,700 – $440,500

REACH

For this alternative, I will only consider Lowe's DIY consumers (as opposed to professional customers). Lowe's relies on professional customers, mostly contractors and companies who make regular bulk purchases, for 75% of their sales (Jansen, 2022). Research on shopper behavior does not apply to large contractor transactions; therefore, I will focus on only the 25% of Lowe's shoppers who visit the store as individual consumers. Of those DIY customers, only 39% (on average) will actually engage with endcaps. The estimated number of West Virginains who would engage with solar endcaps is estimated to be 40,585.

TOTAL REACH
40,585 individuals

EFFECTIVENESS

This alternative has no direct effectiveness, but, based on endcap marketing studies, an estimated 1,176 consumers are expected to actually purchase solar products. This would lead to an expected increase of 5,885 kW

TOTAL EFFECTIVENESS

5,885 kW

ADMINISTRATIVE FEASIBILITY

The scale and mechanisms of this project are not entirely unprecedented, but they would require TNC WV operate in a way they are perhaps not used to. Advertising in brick-and-mortar stores and working with Lowe's are not in and of themselves unprecedented. However, TNC has not sold products in collaboration with a corporate partner in this way previously. Additionally, despite being a corporate partner of TNC's global mission, individual Lowe's stores in West Virginia are not necessarily partners of TNC's work. Generally, the scale and corporate partnerships are well within TNC's previous experience, but the exact nature of this collaboration earns this alternative a precedence score of **1, somewhat precedented**.

TOTAL ADMINISTRATIVE FEASIBILITY

1

COST EFFECTIVENESS

Full Price Model

$10.85 per person

$74.85 per kW solar

Discounted Model

$8.89 per person

$61.29 per kW solar

Assessment of Outcomes

Table 1 summarizes the conclusions drawn from the above assessment of the proposed alternatives. The preferred outcome for each criteria is highlighted in green. For cost, cost effectiveness, and administrative feasibility, the *lower* of the two alternatives is preferred. For reach and effectiveness, the *higher* of the two is preferred.

	Alternative 1: Showing Proof of Concept	Alternative 2: Leverage Global Corporate Partnership
Cost ($USD)	591,015 – 696,120	360,700 – 440,500
Reach (individuals)	2,025	40,585
Direct effectiveness (kW)	130	0
Induced effectiveness (kW)	75 – 253.5	5,885
Administrative Feasibility	2	1
Cost effectiveness ($USD/ individual)	291.86 – 343.76	8.89 – 10.85
Cost effectiveness ($USD/ kW installed)	2,883 – 3,395.71	61.29 – 74.85

Recommendation

Ultimately, I recommend TNC WV partner with local Lowe's Home Improvement stores to advertise solar products, disseminate information about solar systems and installation, and dispel myths about solar in general. Additionally, I propose TNC gather data on solar market proliferation at the household level to better understand growth to date and forecast future rates of adoption. Should TNC have the financial resources to do so, I recommend they pilot either model of the proof of concept alternative in one zip code. Otherwise, TNC ought to observe new rooftop solar installations and track peer effects within the zip code. It's likely that peer effects in West Virginia differ greatly from those estimated in previous studies, and understanding the consumer market will help TNC consider future stakeholder engagements programs.

Partnering with Lowe's home improvement is a great way for TNC to engage with West Virginians without forcing an explicitly pro-climate agenda onto consumers or scaring consumers off with their pro-climate mission. Lowe's has a history of partnering with TNC and helping West Virginia's communities, therefore it's reasonable to expect Lowe's stores would be open to this form of collaboration. Despite being slightly more challenging administratively, partnering with all 19 Lowe's Home Improvement stores is less expensive than piloting rooftop solar in select zip codes. Additionally, Lowe's home improvement has greater access to West Virginia residents than TNC alone, therefore partnering with Lowe's stores has a far greater expected reach and adoption than piloting rooftop solar.

Each endcap display, should effectiveness and cost assumptions pulled from adjacent market literature hold, is expected to engage over 2,000 West Virginians in conversations about rooftop solar and solar technology in general for only $4,500 annually. With Lowe's financial support, the annual cost drops to just $300 for each display. The cost effectiveness per person (when considering personnel costs), is approximately $10 for the full priced model and $8 for the discounted model. Though this type of consumer engagement is perhaps less intimate than peer networking through rooftop solar, when individuals are compelled to install rooftop solar because of Lowe's advertisements, peer networking effects will still take place. Therefore, there are additional positive spillover effects of solar uptake not included in this model, but expected from increased uptake.

Overall, a year-long advertising collaboration with Lowe's Home Improvement stores appears to be an incredible and impactful way for TNC to bring their messaging into the mainstream. Thousands of West Virginians shop at Lowe's stores each week; Lowe's has the technical, financial, and professional wherewithal to accomplish this project; and TNC will maximize their investment by working with Lowe's Home Improvement stores.

Implementation

The first step of implementing a Lowe's Home Improvement x TNC Solar Partnership would be to initiate contact with TNC's partners at Lowe's Corporate to ensure a partnership of this sort is feasible and appropriate for both entities. TNC should also seek to lower costs by engaging with the Lowe's Foundation, Lowe's charitable organization. The Lowe's foundation has worked with TNC in other cities (including on particular West Virginia projects as part of their "Hometowns" initiative) (Lowe's Hometowns, 2021; TNC, n.d.). Lowe's publicly supports TNC's work to "address mounting environmental and human health challenges facing the U.S. using the power of nature" both in press releases and via financial donations (TN, n.d.). Moreover, Lowe's is committed to revitalizing rural communities– in 2020, the Lowe's foundation donated $25 million to rural community development (Lowe's Corporate, 2020).

Once feasibility is confirmed and costs are negotiated (perhaps driving down total costs and improving cost efficiency), TNC can begin by either hiring a temporary marketing team or pulling from TNC's national location. While developing their marketing strategy and designing the in-store features, TNC should perform in-store surveys in all 19 Lowe's locations to confirm assumptions used to estimate community engagement capacity. This alternative's efficacy relies on its ability to engage thousands of residents annually; confirming consumer demographics and advertising efficacy will be the first step to confirming this is an appropriate course of action.

Should TNC's marketing and research team confirm that efficacy estimates are accurate, they can begin engaging with in-store teams to implement these changes. In-store teams should include store managers and stocking staff to ensure the proper placement and stocking of in-store displays and information. TNC can then create store-specific plans based on the findings of their in-store surveys and meetings with store teams.

The actual implementation– constructing and stocking endcaps– will be left up to Lowe's in-store sales associates. Once the displays are completed, TNC's marketing team will do a preliminary audit of each in-store display to confirm proper placement and successful completion. For the duration of this ad campaign, TNC's marketing team will check on each display monthly to ensure sales and information dissemination are proceeding according to plan.

While rolling out their new advertising campaign, TNC should also begin to track solar market growth throughout the state. TNC can estimate locality specific peer-effects, the impacts of different pricing models, and the strength of local peer networks to better inform future decisions on both solar deployment and stakeholder engagement.

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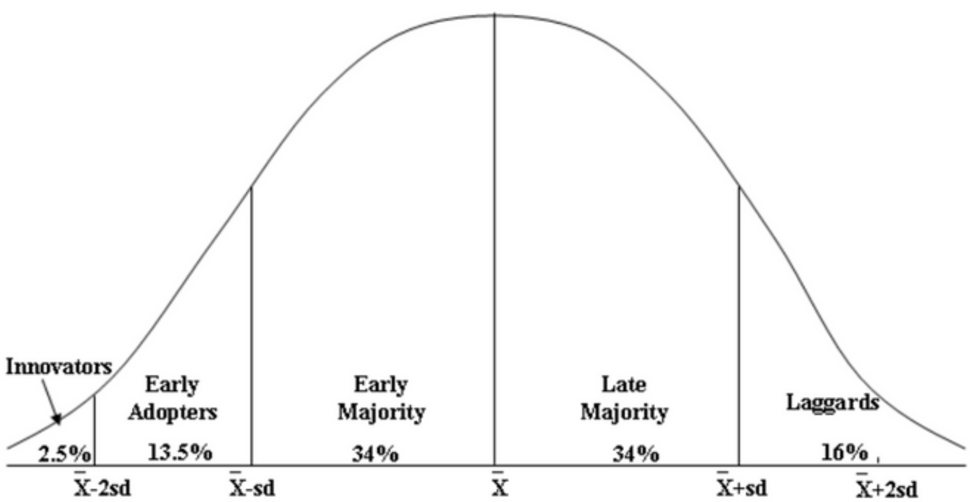
Appendix

1) A Timely Update on TNC's Work in Appalachia

Throughout our conversations about best practices for developing West Virginia's solar marketplace, Minney and TNC, as part of the "Appalachian Climate Technology" (ACT) Now coalition received a $63 million grant from the Economic Development Administration (EDA) as part of Biden's Build Back Better Regional Challenge. The $63 million will be matched by $29 million in private funding totaling $92 million to strengthen local economies, support energy industries and expand job opportunities through 8 projects in 21 counties across Southern West Virginia (EDA, 2022). The goal of ACT Now's "Just Transition" is to establish West Virginia as a global leader in climate resilience. Representatives of ACT Now emphasize the urgency with which we have to invest in the people, economy, and land of West Virginia as well as West Virginia's capacity for change (EDACommerce, 2022). Notably, they point to West Virginia's existing infrastructure that positions them to become global leaders in renewable energy production. West Virginia already has the energy infrastructure– from mine land to an intricate network of power lines– and the industrial workforce eager to apply their practical skills in the energy sector to transition seamlessly to a renewable energy economy (EDACommerce, 2022). The Nature Conservancy helped ACT Now secure EDA funding by emphasizing the importance of the Appalachian hardwoods to carbon capture and conservation.

2) Innovation Diffusion Models

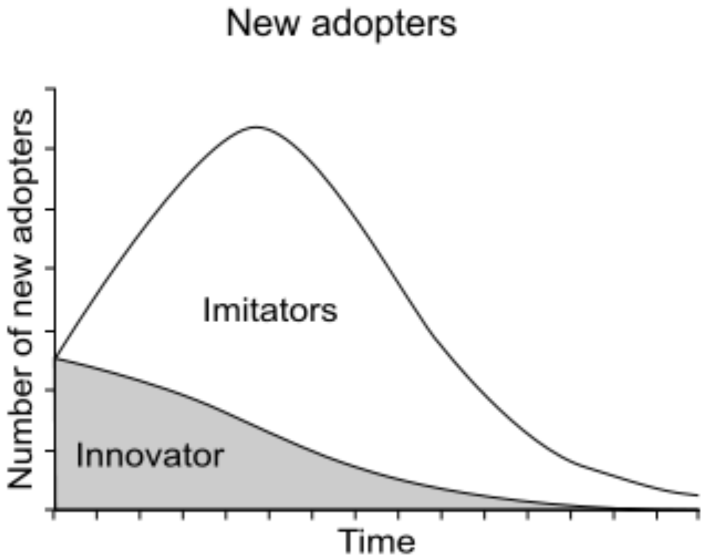
A) Rogers Innovation of Diffusion Model



Source: Sahin, 2006; Rogers' Diffusion Of Innovations Theory And Educational Technology-Related Studies Based On Rogers' Theory

Rogers defines adopter categories as "the classifications of members of a social system on the basis of innovativeness" (Sahin, 2006). His classification includes innovators, early adopters, early majority, late majority, and laggards. According to Rogers, "Innovativeness is the degree to which an individual or other unit of adoption is relatively earlier in adopting new ideas than other members of a system" (Rogers, 2003, p. 22). Innovativeness is relatively stable, socially constructed, and unique to each individual consumer. Innovativeness helps understand how consumer behavior changes as technological diffusion progresses. His model categorizes adopters based on innovativeness and the distribution of adopters is a normal distribution.

B) Bass Model of Diffusion



Source: Islam, 2014 Household level innovation diffusion model of photo-voltaic (PV) solar cells from stated preference data

Bass modeling suggests individuals are influenced by a desire to innovate (coefficient of innovation p) and a need to imitate others in the population (coefficient of imitation q). The probability that a potential adopter adopts at time t is driven by (p+qF(t)) where F(t) is the proportion of adopters at time t. In a pure innovation scenario (p > 0; q = 0) diffusion follows a modified exponential; in a pure imitation scenario (p = 0; q > 0), diffusion follows a logistic curve. p+q controls scale and q/p controls shape.

3) Additional assessment considerations, equations, and models

A) ALTERNATIVE 1: SHOWING PROOF OF CONCEPT

i. table of considerations & assumptions

ITEM	ESTIMATE
average residential price per kWh ($USD)	0.1281
average residential monthly electricity bill ($USD)	136.21
average household consumption (monthly) (kWh)	1,061
average household consumption (annual) (kWh)	12,740
Rooftop solar size for 100% offset (kW)	13
Rooftop solar size for 50% offset (program goal) (kW)	6.5
Average install size (expected per unit of induced adoption) (kW)	5
Panel cost per watt (including installation) ($USD)	2.64
Price of 6.5 kW system (with ITC) ($USD)	12,012
50% price of 6.5 kW system ($USD)	6,006
25% price of 6.5 kW system ($USD)	3,003
Annual salary, solar professional ($USD)	90,000
Customary TNC team size (industry professionals)	5
Number of HOAs in WV (HOAs)	<1,000
Number of WV homes belonging to HOA (homes)	40,192
Average HOA size WV (approximate) (homes)	40
Peer effect per home per zip code	0.78
Average persons per household (persons)	2.47

Sources: West Virginia Electricity Rates & Average Electricity Bills; Is Solar Worth It in West Virginia?; Solar Panel Cost West Virginia: Local prices & online estimator; West Virginia Community Associations – Economic Contributions & Value-Added Benefits; U.S. Census Bureau QuickFacts: West Virginia; Bollinger & Gillingham, 2012

ii. table of calculations (diffuse model)

Number of Installs	kW solar via direct adoption	Marginal Cost	Total Cost	Marginal Peer Effect	Net Peer Effect	Peer Effect Rounded to next lowest whole number	kW solar via induced adoption	# households reached	# individuals reached
1	6.5	$ 12,012.00	$ 12,012.00	0.78	0.78	0	0	40	98.8
2	13	$ 12,012.00	$ 24,024.00	0.78	1.56	1	5	80	197.6
3	19.5	$ 12,012.00	$ 36,036.00	0.78	2.34	2	10	120	296.4
4	26	$ 12,012.00	$ 48,048.00	0.78	3.12	3	15	160	395.2
5	32.5	$ 12,012.00	$ 60,060.00	0.78	3.9	3	15	200	494
6	39	$ 12,012.00	$ 72,072.00	0.78	4.68	4	20	240	592.8
7	45.5	$ 12,012.00	$ 84,084.00	0.78	5.46	5	25	280	691.6
8	52	$ 12,012.00	$ 96,096.00	0.78	6.24	6	30	320	790.4
9	58.5	$ 12,012.00	$ 108,108.00	0.78	7.02	7	35	360	889.2
10	65	$ 12,012.00	$ 120,120.00	0.78	7.8	7	35	400	988
11	71.5	$ 12,012.00	$ 132,132.00	0.78	8.58	8	40	440	1086.8
12	78	$ 12,012.00	$ 144,144.00	0.78	9.36	9	45	480	1185.6
13	84.5	$ 12,012.00	$ 156,156.00	0.78	10.14	10	50	520	1284.4
14	91	$ 12,012.00	$ 168,168.00	0.78	10.92	10	50	560	1383.2
15	97.5	$ 12,012.00	$ 180,180.00	0.78	11.7	11	55	600	1482
16	104	$ 12,012.00	$ 192,192.00	0.78	12.48	12	60	640	1580.8
17	110.5	$ 12,012.00	$ 204,204.00	0.78	13.26	13	65	680	1679.6
18	117	$ 12,012.00	$ 216,216.00	0.78	14.04	14	70	720	1778.4
19	123.5	$ 12,012.00	$ 228,228.00	0.78	14.82	14	70	760	1877.2
20	130	$ 12,012.00	$ 240,240.00	0.78	15.6	15	75	800	1976

iii. table of calculations (concentrated model)

Number of Installs	kW solar via direct adoption	Marginal Cost	Total Cost	Marginal Peer Effect	Net Peer Effect	Peer Effect Rounded to next lowest whole number	kW solar via induced adoption	# households reached	# individuals reached
1	6.5	$ 12,012.00	$ 12,012.00	0.78	0.78	0	0	40	98.8
2	13	$ 12,012.00	$ 24,024.00	0.78	1.56	1	5	80	197.6
3	19.5	$ 12,012.00	$ 36,036.00	0.78	2.34	2	10	120	296.4
4	26	$ 12,012.00	$ 48,048.00	0.78	3.12	3	15	160	395.2
5	32.5	$ 12,012.00	$ 60,060.00	0.78	3.9	3	15	200	494
6	39	$ 6,006.00	$ 66,066.00	1.56	5.46	5	25	240	592.8
7	45.5	$ 6,006.00	$ 72,072.00	1.56	7.02	7	35	280	691.6
8	52	$ 6,006.00	$ 78,078.00	1.56	8.58	8	40	320	790.4
9	58.5	$ 6,006.00	$ 84,084.00	1.56	10.14	10	50	360	889.2
10	65	$ 6,006.00	$ 90,090.00	1.56	11.7	11	55	400	988
11	71.5	$ 6,006.00	$ 96,096.00	2.34	14.04	14	70	440	1086.8
12	78	$ 6,006.00	$ 102,102.00	2.34	16.38	16	80	480	1185.6
13	84.5	$ 6,006.00	$ 108,108.00	2.34	18.72	18	90	520	1284.4
14	91	$ 6,006.00	$ 114,114.00	2.34	21.06	21	105	560	1383.2
15	97.5	$ 6,006.00	$ 120,120.00	2.34	23.4	23	115	600	1482
16	104	$ 3,003.00	$ 123,123.00	3.12	26.52	26	130	640	1580.8
17	110.5	$ 3,003.00	$ 126,126.00	3.12	29.64	29	145	680	1679.6
18	117	$ 3,003.00	$ 129,129.00	3.12	32.76	32	160	720	1778.4
19	123.5	$ 3,003.00	$ 132,132.00	3.12	35.88	35	175	760	1877.2
20	130	$ 3,003.00	$ 135,135.00	3.12	39	39	195	800	1976

B) ALTERNATIVE 2: LEVERAGE GLOBAL CORPORATE PARTNERSHIP

i. table of considerations & assumptions

ITEM	ESTIMATE
average ad campaign size (employees)	5
average ad campaign length (weeks)	12
advertising specialist annual salary ($USD)	71,000
Endcap materials cost ($USD)	300
Average display fee ($USD)	350
“Pay-to-stay” fee (monthly) ($USD)	350
“Pay-to-stay” fee (annual) ($USD)	4,200
Endcap size (number of items)	100
Number of Lowe’s stores	19
Total global weekly Lowe’s transactions (customers)	19,000,000
Total WV weekly transactions (customers)	95,798
Percentage of sales made by DIY customers	25%
West Virginia weekly DIY transactions	23,949
West Virginia annual DIY transactions	104,063
West Virginia annual unique DIY transactions (per store)	5,477
Average percent engagement with endcaps	39%
Average percent purchase rate from endcaps	2.9%

Sources: Tan et al., 2018; Home Depot pushes ahead of Lowe’s as it leans on pro customers. Retail Dive.; Lowe’s Home Improvement, Lowe's Corporate

ii. table of calculations

Number of stores	Marginal endcap cost	marginal annual display fee	total cost	Estimated annnual unique customer transactions	expected engagement with endcaps (reach)	expected endcap purchases	kW added
1	$ 300.00	$ 4,200.00	$ 4,500.00	5477	2136.03	62	310
2	$ 600.00	$ 8,400.00	$ 9,000.00	10954	4272.06	124	619
3	$ 900.00	$ 12,600.00	$ 13,500.00	16431	6408.09	186	929
4	$ 1,200.00	$ 16,800.00	$ 18,000.00	21908	8544.12	248	1239
5	$ 1,500.00	$ 21,000.00	$ 22,500.00	27385	10680.15	310	1549
6	$ 1,800.00	$ 25,200.00	$ 27,000.00	32862	12816.18	372	1858
7	$ 2,100.00	$ 29,400.00	$ 31,500.00	38339	14952.21	434	2168
8	$ 2,400.00	$ 33,600.00	$ 36,000.00	43816	17088.24	496	2478
9	$ 2,700.00	$ 37,800.00	$ 40,500.00	49293	19224.27	558	2788
10	$ 3,000.00	$ 42,000.00	$ 45,000.00	54770	21360.3	619	3097
11	$ 3,300.00	$ 46,200.00	$ 49,500.00	60247	23496.33	681	3407
12	$ 3,600.00	$ 50,400.00	$ 54,000.00	65724	25632.36	743	3717
13	$ 3,900.00	$ 54,600.00	$ 58,500.00	71201	27768.39	805	4026
14	$ 4,200.00	$ 58,800.00	$ 63,000.00	76678	29904.42	867	4336
15	$ 4,500.00	$ 63,000.00	$ 67,500.00	82155	32040.45	929	4646
16	$ 4,800.00	$ 67,200.00	$ 72,000.00	87632	34176.48	991	4956
17	$ 5,100.00	$ 71,400.00	$ 76,500.00	93109	36312.51	1053	5265
18	$ 5,400.00	$ 75,600.00	$ 81,000.00	98586	38448.54	1115	5575
19	$ 5,700.00	$ 79,800.00	$ 85,500.00	104063	40584.57	1177	5885