SOLAR PHOTOVOLTAICS (PV) DIFFUSION: DIMENSIONS OF COMMERCIAL AND INDUSTRIAL ENERGY CONSUMERS IN WISCONSIN

By

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Abstract

The scale of energy demand in the United States continues to increase in size and complexity without meaningful transformation, validating ongoing unsustainable energy consumption at multiple levels of society. In response, diffusion of solar photovoltaics (PV) as an alternative has been met with mixed levels of success, especially in Wisconsin. A literature review illustrates social, economic, and environmental factors that positively and negatively influence solar PV diffusion, as well as system and energy user behavioral dynamics. However, it is still unclear what specific factors are driving or inhibiting diffusion of different renewable energy technologies in commercial and industrial firms. For this study, we examine those factors that influence adoption of solar PV, as well as barriers and challenges encountered. We conducted mixed methods - an electronic survey methodology and multiple case study - to target key informants employed by corporate members of two salient energy transition programs and one renewable energy organization - Green Tier, Green Masters, and RENEW Wisconsin. Survey results indicate that solar PV adopters are significantly different from potential and non-adopter firms in 4 categorical ways: perceptions of external support, understanding of solar regulations and property rights, affordability, and investment risk and uncertainty. Case-study results demonstrate key dimensions of challenges and barriers including informal rate of return thresholds, stakeholder outreach and governance patterns, and internal innovativeness. We conclude that social and economic factors are crucial influences, and obstacles, in the knowledge and persuasion stages of solar PV diffusion. Further research on energy policy interventions could help cope with or remove barriers to market takeoff of solar PV in Wisconsin.

Keywords

Solar PV, commercial, industrial, diffusion, affordability

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List of Acronyms

BTUs:	British Thermal Units
C2P:	Consumer to Policy
DC and AC:	Direct and Alternating Current
FITs:	Feed-in Tariffs
GHGs:	Greenhouse gases
GT:	Grounded Theory
ITC and PTC:	Investment tax credit and Property Tax Credit
I, P, or MOU:	Investor, Public, or Municipal Owned Utility
kWh:	Kilowatt Hour
LCoE:	Levelized Cost of Electricity (or Energy)
MWh:	Megawatt Hour
PPAs:	Power Purchase Agreements
PSC or PUC:	Public Service Commission or Public Utilities Commission
RD&D/ R&D:	Research, development, and demonstration
RETs:	Renewable Energy Technologies
RECs:	Renewable energy credits
RPS:	Renewable Portfolio Standards
ROR:	Rate of Return
ROI:	Return on Investment
TRA and TPB:	Theory of Reasoned Action and Theory of Planned Behavior

CHAPTER 1: Introduction to the study

Factors pathogenic to the long-term stability of the planet – biotic, abiotic, or anthropogenic – are difficult to summarize. Some might be described as pollution, habitat fragmentation, plant and animal species disappearance, natural resource exploitation, land-use impacts, climate change, even overpopulation (Intergovernmental Panel on Climate Change, 2014). Many of these biophysical impacts are made possible by human beings; here we consider the provision of energy as a working example. Describing systems like these as "locked" is not an arbitrary finding, but supported through empirical evidence of social and psychological scientists and practitioners, and continues to be built upon today. Hardin (1968) remarked that "Freedom in a commons brings ruin to all" in his famous essay *Tragedy of the Commons* (Hardin, 1968), explaining how freedom to willingly exploit determines system-wide destruction to all actors. Furthermore, and more to the point of energy considerations, agency and marketing of the provision of energy is said to have produced an illusion or distortion, actively subsidizing and validating energy users as choosers, and not players (Wilhite citing Appadurai, 2008), synonymous with the characterization of locked. How then can we reinvent distributed generation and the grid infrastructure to produce and meet future energy demand, with minimal environmental impact, all while enhancing energy user understanding, shifting toward a culture of more informed actors? This is an unreasonably complex question with no clear answer(s), however, we explore the human dimensions of energy users under the purview of this complicated but motivating inquiry in this study.

At present, the planet continues to struggle with how to navigate and resolve complex biophysical stressors. One way is by unhinging from system-wide entrapment by understanding common pool resources (Ostrom, Burger, Field, Norgaard, & Policansky, 1999); another is by instilling deeper contextual thinking of how humans interact with the environment, emphasizing adaptation and transition intervention (Stern, 1993). The global extraction of raw resources for, and the infrastructural provision of, electricity, or energy, demands the scientific community to think and to study more inside the possibilities of innovation, and user behavior. Energy innovation (Chu & Majumdar, 2012) and market disruptors (Hart & Christensen, 2002) focus on possibilities through research, development, and demonstration (RD&D) and creativity incubation. These are the loci for future pathways toward energy security as well as adaptation and mitigation strategies for climate change.

Understanding of energy from local to global scales is largely disparate, difficult to measure, and difficult to change or initiate transition. From here on, we use transition and transformation interchangeably. Each of the pathways mentioned earlier illustrate elements shared between two paradigms that are useful to view the system of energy provision: energy transitions are sociotechnical (Sovacool, 2009; Geels & Schot, 2007), and energy transitions are social-ecological (Walker & Salt, 2012a, 2012b; Folke et al., 2010; Walker, Holling, Carpenter, & Kinzig, 2004). Avoiding getting caught up in an existential debate, these paradigms are loosely considered, but both help explain energy systems, and other systems in general whether ecological or human built, as seminal background information.

In the U.S., changes are necessary at both the supply side of energy, and the demand side, the latter being the focus of this study. A tool to help move change is policy. We consider existing energy policies to be diverse, complex, and focused or broad depending on the goal or expectations intended for those policies to achieve. In short, policies share elements that make them unidimensional, or multidimensional. Examples include standards and rules, regulations, and incentives that strive to control energy producers and user behavior. While commonly held energy policies are still well known today, such as renewable portfolio standards and investment or property tax credits, commonly unknown ones include feed-in tariffs (FITs), decoupling, and grant programs. Policies strive, or at the very least should continue to strive, to meet the energy security and demand expectations all users depend on the grid to provide, and to do so parsimoniously through equitable and fair rates, and expedient services during emergencies or service interruptions. However, policies cannot be relied upon to garner system-wide change regarding energy supply and demand. Perhaps this is why energy policies are diverse, and posit a number of distinct mechanisms, programs, and agencies for each situation. With this thinking, and in the scope of this study, the energy problems can be distilled down to a social issue toward energy users. In order to meet existing and future electricity demand anticipated against growth in human population, investment in sustainability, efficiency, and renewables, is more rational than the current mix of sustainable and unsustainable energy raw resources and infrastructural assets that the built environment haphazardly depends upon.

Wisconsin is an ideal example of a state facing such challenges, which is why it makes an ideal testbed for distributed generation technology diffusion such as solar PV.

Distributed generation refers to the establishment and production of electricity generating technologies near or at the point of consumptive activity, effectively negating the purpose of transmission or distribution lines, which are one of the largest sources of electron loss. Divesting from electricity produced from non-renewable fuels would make a dent in cost savings to all energy users in the state, and are increasingly cost competitive, making alternative choices more and more attractive. In addition, successful diffusion of solar PV is demonstrated by domestic adoption patterns and the growth of solar PV electric cooperatives particularly in the Western part of the state. We have identified a general gap in the literature, which is that human dimensions of domestic energy users is ahead of its counterpart, human dimensions of commercial and industrial energy users. We think research has made comprehensive strides toward integrating and explaining social, economic, and environmental factors involved in decision-making taking place at the domestic energy user level, and local energy producer level, as well as utilities and electric cooperatives. It has also made progress in the diffusion of sustainable business models through examination of corporate paradigm shifts taking place at both firm and niche market levels. But, there are several areas that have not garnered proportionate levels of scientific focus: (a) commercial and industrial energy user decision-making procedures, (b) linking commercial and industrial energy user behavior to challenges or barriers, or (c) identification of actionable opportunities from barrier recognition and removal. Landing on solar as one of the most competitive technologies to its fossil fuel competitors, our objective in this study is to explore and identify influential and non-influential determinants, as well as barriers, of solar PV technology diffusion in the

commercial and industrial energy user sectors of Wisconsin. These two component parts separate into our two main research questions:

1) What influential factors drive or inhibit the diffusion of solar PV technology in Wisconsin's commercial and industrial sectors?

2) What challenges and barriers do Wisconsin PV adopter and non-adopter firms encounter related to sustainable energy or energy efficiency?

Answers to these questions are driven by our hypotheses, which help address some of the inadequacies found in technology diffusion and energy consumer behavior research concerning solar PV. Our hypotheses are:

H_1: *On the basis of social, economic, and environmental influences and barriers, solar PV adopters, potential adopters, and non-adopters in commercial and industrial sectors do not differ.*

These three categories classify numerous behavioral attributes associated with decision-making. Teasing out the factors that help differentiate between adopter groupings is important throughout the entirety of this study.

H_2: *The influence of social, economic, and environmental dimensions is asymmetrical for predicting commercial and industrial solar PV adoption behavior.*

Differentiating between influential and non-influential factors plays a key role in this study, but this is the goal driving the first hypothesis. Here, we are striving to differentiate the influential factors further, particularly those that are strongly influential, and those that are more weakly influential. Strong influential factor(s) may be sufficient at predicting adoption behavior, but pooled together with other factors that assist in a weaker manner may enhance predictive indices of solar PV adoption.

H_3: *Independent psychosocial dimensions, between social, economic, and environmental groups, are not exclusive nor deterministic of solar PV adoption behavior.*

This study proceeds using several mixed methods and a diversity of relevant question items probing for user motivations and sources of behavior. The context of social, economic, and environmental variables are interlaced, suggesting that a mixture of items from the three categories have more explanatory power than independent items, static of one another. For example, non-adopters or potential adopters may be motivated by beliefs, attitudes, or values, to change adopter groupings because of one, but likely more than one, motivating factor.

This manuscript is organized into two distinct papers that together form the entirety of this research study. Each paper is given a chapter, thus Chapter 2 encapsulates the first paper, and Chapter 3 the second. This first paper uses the energy policy and literature review provided in the next section to inform the survey methods. Then, we provide the survey results and a discussion of the findings, which will then proceed into the second paper. The second paper covers emergent findings from a multiple case study organized in a similar fashion, providing its own literature review, methods, and findings followed by discussion, similar to the first. The concluding remarks (i.e. Chapter 4) in this manuscript, along with the background information here in Chapter 1, prior to the literature in this first paper, function together to introduce and conclude both of these papers as one all-inclusive study.

CHAPTER 2: Survey of Wisconsin solar PV adopter and non-adopter firms

2.1. Literature review

The aim of this section is to provide a sensible and comprehensive explication of energy policies and important legislation at global, federal, and WI state levels. An immersive understanding of energy policy and legislation should provide a valid step-by-step evolution of energy consumer behavior and challenges since the 1970's. Although the two main research questions in this study do not specifically examine the energy policy arrangement in today's energy economy, policies play a remarkably important role in governing both consumer behavior, and the diffusion of renewable energy technologies (RETs). Policies also continue to come under heavy scrutiny. Energy policies inculcate a plethora of ideas, objectives, and solutions, resulting in either desirable or undesirable outcomes. This is usually followed by illustrating plans, support packages, infrastructure, financial mechanisms and tools for evaluating success and effectiveness, as well as creative destruction of old or ineffective policies and programs. Broad objectives include pollution control, greenhouse gas emissions (GHGs) targets and caps (Yao & Chang, 2014), as well as more intelligible approaches to climate change adaptation and mitigation, land use, and most importantly, energy access, delivery, and behavior. By-and-large, studies continue to make concluding assertions toward an energy policy framework capable of shaping consumer behavior through an integrated, inclusive, and less centralized approach. Furthermore, according to Carillo-Hermosilla, del Río, & Könnölä's (2010), their study on diversity of eco-innovations illustrates a framework embracing incremental and radical interventions in two distinct arenas: 1) energy policy

and 2) management practices. These include promotion of user-led innovation capacity, strong relationships between users and suppliers, and increasing market acceptance and competition of eco-innovations (Carillo-Hermosilla, del Río, & Könnölä., 2010). Reported by Chen (2014), schema supersaturated with complex policies contribute to an incomprehensible, less meaningful, and sub-optimal outcomes. An energy policy arrangement must be one that explores optimal levels of incentive schemes and subsidies most attractive to consumer markets (Chen, 2014). Energy policies operate through an exhaustible number of tools, and include a number of different stakeholders. Consumers serve a critical component. Although an amalgam of local, state and federal agencies, regulators, advocates, institutions, and energy suppliers – including both renewable and fossil fuel suppliers – comprise the complex energy infrastructure that exists today, energy consumers are the facilitators and gate-keepers to a sustainable energy transition, and a less carbon dependent future. But the role of shaping energy transitions and market transformation – in fact, shaping energy security in general – depends on the behavior of energy consumers. All energy consumers are lumped into four categories: transportation, domestic/residential, commercial, and industrial, the latter duo being an increasingly relevant sector of interest.

State, federal, and international legislative action and cooperation speak to the evolutionary nature of addressing climate change, shifting toward smarter, and less carbon dependent energy supply and demand. While national and international legislative action establishes overarching goals – by outlining objectives, emissions targets and steps to take both short-term and long-term – state energy policies and programs tailor sustainability and carbon neutral efforts toward regional and local needs.

As it relates to investor owned utilities (IOUs), municipal utilities, or cooperative energy providers, sustainability programs go into complex details specifically targeting needs and attributes of local and regional energy consumer constituencies; among them are business and industrial energy consumers. Programs like the Green Tier program (by the Wisconsin Department of Natural Resources) and the Green Masters program (part of the Wisconsin Sustainable Business Council), cultivate investments in RETs and energy efficient products of many different types and sizes, through financial contracts, agreements, and mechanisms helping curb the burden of affordability.

What often gets misunderstood is that like all RETs and energy efficiency products, in order to realize the value in long-term investments, energy consumers must practice not just adoption of renewable energy products, but also those that are efficient. Benefits are achieved by receiving electricity produced from a renewable source, like solar photovoltaics, and lowering a household, business, or industry's energy demand profile with energy efficient behavior. This adoption behavior suggests a 'double-dividend' benefit (Keirstead, 2007). Maintaining the same energy consumption profile, including all respective RET's and energy consuming products, services, and peak demand over the course of the life of the system, inhabiting the same domestic household, or employed at the same business, renders some of the most influential RETs, such as solar PV, wind turbines, and biomass/biofuels, useless. Human behavior that embraces energy efficiency and energy conservation together, especially the 'double dividend' solar PV provides, is necessary to transform to a lower demand and less dependent energy behavior profile. Among business and industrial energy consumers across the state of Wisconsin, this is crucial for securing stable and sustainable profit

margins, employment, and growth. The future of Wisconsin's commercial and industrial sectors across the state depend on energy demand and expenditures. Although typologies of transition pathways are dynamic, imperfect, and for the most part not deterministic (Geels & Schot, 2007), the legislative and policy evolution toward modern day solar PV markets suggests a socio-technical mix designed to further integrate businesses and industry with solar PV technology. This part of the literature review demonstrates that the evolution of energy policy and legislation – operating in the context of business and industrial energy consumer behavior – has enhanced the complexity of energy user behavior. We highlight relevant federal and state energy policies concerning renewables like solar PV below.

2.1.1. Federal energy policy and legislation

Federal policies govern the way energy producers and consumers behave, and they have been doing so since the Public Utility Holding Company Act of 1935, which prohibited holding companies from engaging in unregulated utility business activities (Public Utility Holding Company Act, 1935). Since then, regulation still has been one of the most heavily scrutinized subjects covered in federal energy legislation. Some pieces of legislation are met with heavy disagreement on party lines, such as federal regulation and standards of carbon emissions and benchmarking in the Clean Power Plan (U.S. Environmental Protection Agency, 2015). The most important pieces of federal energy policy that still shapes energy generation and consumption in the United States include the Public Utility Regulatory Policies Act (PURPA), the Energy Policy Acts (EPA) of 1992 and 2005, the Energy Independence and Security Act (EISA) of 2007, and other incentives and cost targeting energy policies (see Appendix A). Beginning with PURPA,

this act focused on barrier removal and deregulation of the electric utility market, as well as standards in natural gas cogeneration, energy efficiency, and energy conservation. In short, PURPA lifted regulatory barriers creating a market for power (Public Utilities Regulatory Policies Act, 1978). Then, in the early 90's, energy utility infrastructure began to take a new shape. The EPA of 1992 set new power and rate making standards, including generation of wholesale power, which enhanced market competition between wholesale suppliers/generators. Furthermore, traditional "vertically integrated" systems – utility companies that own supply/generating plants, transmission, and distribution lines – shifted to competing sellers. The EPA of 1992 was also among the first pieces of federal legislation to illustrate standards and guidelines for energy efficient buildings, facilities, appliances, and promotion of demonstration projects for commercial renewable energy generation (Energy Policy Act, 1992). Up to now, federal policies concentrated on activities positively affecting market competition and generating capacity of energy suppliers. Then, federal policies shifted toward the augmentation of distributed generation and programs for business energy consumers as well as rural energy consumers. New policies began to focus on business production and investment tax credits (PTC and ITC) and loan guarantees, raw resource diversification, interconnection standards, increased net metering and smart metering capabilities, research and development of solar and wind technologies, and setting smart grid standards (Energy Policy Act, 2005; Energy Independence and Security Act, 2007). Some examples of these include clean renewable energy bonds (CREBs), qualified energy conservation bonds (QECBs), and the modified accelerated cost-recovery system (MACRS)

(American Recovery and Reinvestment Act, 2009; Database of State Incentives for Renewables & Efficiency [DSIRE], 2016).

2.1.2. State energy policy perspectives

There are three distinct types of electricity utilities: investor owned utilities (IOUs), public or municipal owned utilities (POUs or MOUs), and electric cooperatives or community shared solar (Coughlin et al., 2012), which are member owned and not for profit entities typically located in more rural areas of the country. For IOUs, what used to be traditionally monopolistic and vertically structured utilities, today has shifted, creating conglomerations of either/or ownership of one or many generation, transmission, and distribution infrastructures, all striving for wealth and competitive advantage in the energy market. An overwhelming majority of energy providers in today's energy infrastructure are privately owned. While the Federal Energy Regulatory Commission is in charge of monitoring electricity markets, and wholesale energy transactions at the interstate level, state governance models take the form of public utilities commission (PUCs). Sometimes referred to also as utility regulatory, public service commissions, or boards, PUCs, like Wisconsin Public Service Commission, regulate utility rates, and are in charge of provision of service and service prices, and construction of new energy infrastructures such as transmission lines, generating plants, oil and natural gas pipelines, water wells, and nuclear facility regulatory activities. Specifically pertaining to renewable energy generating capacity, state policy began to see changes in the early 1990's. Three important pieces of state legislation shifted energy policies and infrastructures, shaping today's existing energy infrastructure provisions. These are 1993 Wisconsin Act 414, 1999 Wisconsin Act 9, and 2005 Act 141 (see Appendix A).

Collectively, these acts serve a number of important functions such as promoting energy assistance to low-income households, and initiatives for energy efficient state facilities and private buildings, and providing a specific role of the PSC. Most importantly, these acts establish current and future renewable portfolio standards (RPSs), and programs to incentivize and fund distributed generation projects, like small-scale wind and solar, on public and private properties, called the Focus on Energy Program (Lovell, 2006; DSIRE, 2016).

RPSs are renewable energy percentage benchmarks, asserting that utilities increase their renewable energy generating capacities typically through a host of eligible technologies, and various requirements and compliance pathways. Some state's RPSs, including Wisconsin's, factor in renewable energy credits (RECs), and 'carve-outs' or 'set-asides,' to meet or exceed the RPS goal by the target year. RECs and carve-outs are not a new approach to utility compliance, but they employ slightly different approaches. RECs are 1MWh certificates that essentially monetize the energy produced from a distributed generation system and allow them to be exchanged in transactions from a utility that is exceeding compliance targets to a utility that is not, thus ensuring broader compliance behavior (DSIRE, 2016; Radloff & Dhungel, 2013). According to Schelly (2014a), the definition of carve-outs or set-asides illustrate how they target specific technologies such as expensive solar PV installations, seamlessly incentivizing and integrating solar power into each state's RPS mandate (Schelly, 2014a); even if these generators are located out of state but their market territories are located in Wisconsin, they count toward Wisconsin's RPS (DSIRE, 2016). Excluding the eight states that have 'renewable portfolio goals,' in the United States 29 states, including Washington D.C.

and 3 territories - Commonwealth of the Northern Mariana Islands, U.S. Virgin Islands, and Puerto Rico – have RPSs (DSIRE, 2016; Radloff & Dhungel, 2013). The RPS and Focus on Energy Program are crucial products of 1999 Wisconsin Act 9 because they govern and incentivize distributed generation, helping increase the rate of energy efficiency and energy conservation technology installs, competition, as well as system enhancements across the state.

While the 10% by 2015 RPS – with annual RE 'bump-ups' in each utility's percentage for each successive year (Radloff & Dhungel, 2013) – is praiseworthy for helping expedite the adoption process, compared with states such as Colorado, New York, Illinois, or California, Wisconsin's RPS is unambitious, and doesn't accurately reflect the progressive and forward-thinking compliance standards that other state-wide efforts are trailblazing. While Focus on Energy has been shown to be an invaluable resource for business and industrial energy consumers, circumstances surrounding the ability of Focus to provide support appear both encouraging and discouraging. It casts a wide net, reaching out to all business, industrial, and domestic energy consumers, especially farms, rural dwellings, hospitals, even schools and lodging services, offering tailored solutions, services and funding opportunities, the common theme being economic development. However, Focus needs a new theme, one that incorporates innovation, and RD&D. For example, the Emerging Technologies Program essentially turns private land and property into test beds for the latest energy efficient and renewable energy products. This is an encouraging aspect of the Focus on Energy program. More discouraging however was the revolving loan fund program that was recently discontinued, and Focus' annual budget is also showing signs of distress; what began as a $100M public benefits

fund from 2011 to 2013, has now dropped to $3.5M in 2016 (Focus on Energy, 2016; DSIRE, 2016; Radloff & Dhungel, 2013). Radloff and Dhungel (2013) report distinct strategies Focus on Energy can follow to be more innovative. Some examples include starting a success fund, modelled by states such as California, New York, and Massachusetts, removing the large energy consumer pay-in caps, strengthening data collection and monitoring technology enhancements, or establishing an energy investment and finance authority which uses dedicated funds to furnish smaller renewable 'start-ups' with private investors, and research universities (Radloff & Dhungel, 2013). It is rational to assume that programs integrating the power of voluntary agreements and capacity building are going to help spread the adoption of energy efficiency and renewable energy innovations and products more rapidly.

In terms of solar PV technologies, this can be seen today in domestic, industrial, and commercial properties as ground or roof mounted or racked arrays, or sometimes pole-mounted tracking systems. Coming in various types and sizes, the most successful and productive installations are well equipped and sited properly in south-facing orientations (unless tracking technology is installed) that receive as much sunlight as possible year-round without any obstructions from trees or other shade-creating structures. Sizes depend on load demand needs by the consumer, which is why all energy consumers considering solar PV technologies are encouraged to double-down through energy efficiency practices to get the most out of their solar panels while reducing costs as much as possible. This includes the initial cost of the solar array since fewer solar PV panels needed translates to a cheaper price. For solar PV, there are 4 types of installations: 1) PV Direct Utility, 2) Interactive (i.e. intertied or battery free), 3) Bimodal

(i.e. grid tied with battery backup), and 4) Stand-Alone (MREA, 2015). Altogether, distributed generation systems could not be possible without the establishment of solar access rights, rules and regulations, interconnection standards, net metering and FITs. These are umbrella principles for all energy consumers considering installing distributed generation systems such as wind, solar, and biomass/bio-digesters. They guarantee all IOUs and POUs will buy electricity produced by distributed generation systems – pertaining to both net metering and FITs – connect distributed generation systems to the grid, and retention of unobstructed access to sunlight and wind resources (DSIRE, 2016; MREA, 2015).

2.1.3. Net metering, feed-in tariffs, and decoupling

It is important to differentiate between state-wide policies such as net metering and FITs because these are the governing policies shared by utilities and distributed generation installations, but they are not identical. Since they dictate the exchange of financial capital, they are one of the most important stipulations in how energy consumers and utilities relate to one another. For those energy consumers without any distributed generating components, electric meters for all grid dependent households, businesses, and industrial facilities move in the "forward" direction, determining monthly demand and charges. Like most places in the United States and around the world, seasonal variability produces differentials in energy demand, with demand spikes concentrated around the hottest summer days and coldest winter nights due to necessary heating and cooling needs. Net metering – mandated by state governments – allows any owner of a distributed generation system like solar PV to sell electricity produced from said system back to the grid at retail rates, but in order to receive the financial pay-back

on any individual system, it only occurs during periods of system productivity exceeding consumption activity (sometimes referred to as net excess generation, when electricity meters "spin backwards"). Wisconsin's net metering laws limit systems to 20 kW capacity, crediting net excess generation back to consumers at retail rates or avoided cost rates, however these vary depending on the utility provider (DSIRE, 2016). A study by Kubert and Sinclair (2009) from the Clean Energy States Alliance provide an IOU perspective of net metering, arguing that independent distributed generators, like solar PV arrays or wind turbines, treat the grid as a free storage component, or a "free battery," creating a pattern of untimely electron delivery back to the grid when the utility doesn't need it, and drawing power from the grid when the system is not producing energy. The authors also criticize net metering as disadvantageous since it doesn't apply to electric cooperatives or MOUs, nor does interconnection standards. This is because these municipal or rural cooperatives are not in the jurisdiction of PUCs (Kubert & Sinclair, 2009). In short, net metering appears to be advantageous to some energy consumers, but recent research shows lack of uniform applicability across different utilities, expressing some discrimination toward energy consumers. This could be an opportunity to expand the rules and regulations of net metering and interconnection standards across all electricity providers – distributed or centralized – to provide uniform access to benefits for all different energy consumers in the near future.

FITs are slightly different from net metering policies. FITs – sometimes referred to as "standard offers," "advanced renewables tariffs," or in Wisconsin, sometimes "buy-back agreements" (Kubert & Sinclair, 2009; Schelly, 2014a) – were originally the energy policy basis in European models, and then spread to North America. All FIT schema

provide three important provisions to consumers with distributed generating capacity: a long-term contract, usually in the form of a Power Purchase Agreement (PPA) (Cory, Canavan, & Koenig, 2009), guaranteed grid connectivity, and a fixed price to help provide reasonable rate of return on investments. In Wisconsin, FITs are offered to consumers on a voluntary basis by IOUs (MREA, 2015). Under a FIT scheme, rather than wholesale exchange rates for excess power, FITs require consumers to buy electricity from their respective utilities at normal retail rates, but the upshot is that consumers get to sell their electricity to the grid at premium rates instead of wholesale exchange rates (see Appendix A) (Farrell, 2009). A plethora of research surrounds FITs, some of which explain crucial differences in frameworks from state to state (Institute for Electric Innovation, 2014; Kubert & Sinclair, 2009), and the positive ripple effects in United States' energy infrastructure and policy arrangement (Couture & Cory, 2009; Farrell, 2009). One study suggests FITs as having the momentum to transform the entire U.S. renewable energy market (Rickerson, Bennhold, & Bradbury 2008). As with any energy policy, FITs have advantages and disadvantages. Another study, which investigates the effects of FITs on upstream, midstream, and downstream private and state enterprise in China, found that FITs generated a multitude of benefits. Some of these include increased rate of inventory turnover and profit margins, increased participation by upstream – raw-resource extraction – industry in mid and downstream business opportunities, and ultimately midstream economic recovery (Wang, Zheng, Zhang, & Zhang, 2016). Scientists and scholars reciprocate similar advantages, adding strong investor confidence, low administrative costs, and wider participation, which ultimately illustrates principles of open-access leading to low social opposition.

Disadvantages include regulatory review and revisions, negligible support for up-front investments, and upward pressure on existing electricity rates due to larger scale and costlier technology projects such as solar PV. This is why FITs offered by several utilities in Wisconsin are advantageous for specific types of technologies – even though they must maintain technological neutrality – and not others, and come with caps on annual high-cost or innovative renewable energy projects (Couture & Cory, 2009; Kubert & Sinclair, 2009). While interactions of FITs with net metering, PTCs and ITCs is still not well known, together FITs and net metering perpetuate stability and innovation (Farrell, 2009), secure revenue streams and remove critical barriers from more rapid RET deployment (Couture & Cory, 2009).

Another policy mechanism operating in the context of energy consumer behavior is decoupling. The National Renewable Energy Laboratory defines decoupling policies as an automatic or regular rate adjustment mechanism that prevents utilities from over collecting on revenue streams from consumers in order to recover costs from generation and selling of electrical power, effectively bifurcating a link allowing IOUs to make unfair windfall profits (see Appendix A). Specific to fossil fuel generation, electrical power is generated at a specific capacity commensurate with demand and infrastructure to deliver it in each IOUs market territory. Then, rates are set to recover the costs (fixed and variable) (National Renewable Energy Laboratory, 2009). But it is complicated to estimate sales or anticipate energy behavior and consumption patterns. Actual revenue has tendencies to exceed or fall below sales expectations, which is how rate cases occur because energy prices control the flow of revenue. Therefore, a utility is incentivized to increase their sales either to meet or exceed sales goals (called a 'throughput incentive')

to collect a margin of profit (called a 'windfall profit'). A decoupling instrument allows regular evaluation and rate adjustments so fair prices allow lawful recovery of an "allowed revenue amount," negating the need for rate cases (National Renewable Energy Laboratory, 2009). It is unsurprising that decoupling policies are different around the United States by implementing utility, however decoupling policies offer a surprising insight into shifting frameworks and provisions for energy efficiency and renewable energy programs for all energy consumers. According to the "State Electric Efficiency Regulatory Frameworks" 2014 report, various utilities and states across the country that embrace decoupling mechanisms are indicative of supportive regulatory frameworks that can seamlessly integrate energy efficiency programs into their respective long-term investment plans. In Wisconsin, utilities like Wisconsin Public Service piloted and implement a decoupling mechanism and revenue stabilization mechanism, and Alliant Energy, another Wisconsin market territory utility, implements performance incentives through energy efficiency since 2008 (Institute for Electric Innovation, 2014). Not all utilities align with opportunity and benefits offered by decoupling, however Wisconsin's regulatory framework is advantageous toward utilities looking to integrate energy efficiency programs.

On the lifecycle spectrum of the energy industry, where energy consumers are grouped into downstream industry (graves), utilities – those entities controlling the generation, transmission, and distribution of energy – and the raw resources extractors, are grouped into midstream and upstream industry (cradles). The interaction between utilities and society is a point of contention from energy consumer perspectives, not to mention environmental advocates. The relationship and the transactions taking place

between IOUs and the energy consumer is not a simple exchange of financial capital for actual energy, maintenance, and services rendered. Creating electricity, whether through fossil fuels or renewable resources, is expensive, and requires stable revenue streams capable of recovering fixed costs for the infrastructure, and the variable/direct costs of the commodities used to generate electricity (NREL, 2009). Referring to the interwoven nature of energy infrastructure in society today, Goldthau (2014) characterizes these centralized energy provision systems as large technological systems, because they are strongly embedded in the surrounding environment (Goldthau citing Hughes, 2014). Energy consumers are often viewed as 'actors' in the big picture of centralized energy infrastructures – sometimes implying inclusive – but a more economic viewpoint suggests they are in fact cogs and gears, essentially enablers, of the large technological system. Consumers are the gatekeepers that maintain the revenue streams, as well as the windfall profits, for IOUs, but most importantly, they are more powerful and can affect more change than they are led to believe.

This literature explicating energy policy at these different scales illustrates that net metering, FITs, and decoupling policies are good. Although some people might motion to invest in electricity provided it comes from renewable resources solely on an environmental basis, others are constrained to make sensible choices that benefit the planet such as divesting from electricity produced from coal or other fossil fuels based on socioeconomic constraints. This is where policy can step in and positively inform and influence sensible investments and sustainable or environmental behavior that is sound. The capacity of these policies to provide necessary energy efficiency and renewable energy technology integration, innovation, and funding programs is essential for a

sustainable energy future for Wisconsin and the country's industrial and commercial economy.

2.1.4. Social, economic, and environmental determinants

Many scholars in interdisciplinary fields such as social and ecological science, psychology, energy policy, and economics, have written about the decision-making processes taking place as it relates to energy behavior. A deluge of studies specifically focus on social, economic, and environmental factors having varying characteristics and influential levels (Chen, 2014; Elkington, 2004; Goldthau, 2014; Hendrickson, Lindberg, Connelly, & Roseland, 2011; Schelly, 2014b; Sovacool, 2009; Vasseur & Kemp, 2015a Wang, Jing, Zhang, & Zhao, 2009). But these categories have been criticized for not being examined together; instead the literature reveals they've been exhausted often in isolation from one another (Høgevold et al., 2014). Understanding human dimensions of decision-making is particularly difficult, not because contextual circumstances are such that human beings are comprised of a complex number of distinct attributes, but that they are also compositions of more opaque or unknown attributes. These aspects are more or less influential towards a decision; say a decision to adopt or not adopt a solar photovoltaic installation at an individual's house or business. Observing and finding patterns of decision-making are advantageous in the context of a snapshot in time or of a particular system in the built environment, but even then, especially for studies taking place through time, are disadvantageous at exploring influential factors toward decision-making because they are constantly changing. These factors, largely organized into social, economic, and environmental categories, are not static, nor deterministic on their own. However, in greater numbers, droves of factors collectively can help reveal

determinism and intention to behave, which is why we refer to social, economic, and environmental factors as determinants. Identifying what specifically motivates commercial and industrial firms to adopt during decision-making processes, identifying barriers, and identifying the opportunities, are emphasized in this research, enhancing understanding of energy behavior outside of domestic consumers. Along with the energy policy review earlier, this literature review helps build three constructs that are salient to the adoption and diffusion of solar PV technologies among Wisconsin's commercial and industrial energy consumers: consumer to policy networks, affordability, and environmental stewardship.

2.1.5. Consumer to policy (C2P) networks as a social determinant

It is not surprising that energy policies attempt to be congruent with current scientific literature at implementing social, economic and environmental tools relating to the diffusion of solar PV technology. Solar PV technologies have tradeoffs, but the policies that shape the diffusion of these technologies envelope a host of desirable benefits through their respective consumers. These include supportive infrastructure, and networks of informed people and institutions. More specifically, solar installers, non-profits, advocacy groups, and other organizations, provide key data and technical information needed to help all energy consumers make informed decisions (i.e. social). Second, policies such as incentives, rebates and exemptions, rules and regulations, and market reforms, restructure costs and financing options toward making solar PV installations more affordable (i.e. economic). Third, environmental benefits help to instill values that speak to stewardship and accountability toward natural resources that are aquatic, terrestrial, and atmospheric in nature (i.e. environmental).

Communities of information are among one of the important determinants of solar PV adoption behavior (Schelly, 2014b). Previous studies employed strategies examining causes of decreasing civic and democratic engagement, by measuring social capital, institutional space, community service, and exploring potential root causes of the disappearing sense of commonwealth in society across the country (Boyte et al., conference proceedings, 2015; Boyte & Kari, 1996; Putnam 1995, 2000). Just like voters depend on state and federal candidates running for office that can speak to the issues they care about, determining the voter turnout and behavior, candidates depend on the voters in their respective constituencies. Candidates demonstrate policy platforms, programs, and vision through debates, protests, political rallies, and fundraisers. Essentially, voters interact with their candidates and amongst each other – on both sides of the political spectrum – cultivating support, shaping the dialogue through political efficacy, and participating in meaningful activities demonstrating civic engagement, behavior that bonds and bridges all would be voters (Levy & Zint, 2012). Similarly, trust has be cited as an important indicator of community involvement, however the links between trust, inequality and different forms of participation are complex (Uslaner & Brown, 2005). This is generally unsurprising; such is usually the underlying case, studying human dimensions of behavior.

Community participatory approaches are meaningful and effective strategies toward successful adoption of community-wide solar PV installations, but require tremendous amounts of time and patience (Menzel & Buchecker, 2013). There are many different attributes that characterize the planning, advocacy, and implementation steps within community participatory strategies toward solar PV adoption. Many are known to

be advantageous or disadvantageous to community inclusiveness in decision-making processes, and are rational areas employed in present and ongoing community-based research. These community and participatory attributes include governance regimes, dilemmas between the normative beliefs of different stakeholders (Howard, 2014), advocacy and legal frameworks (Luers, 2013), internal and external political efficacy and political interests (Levy & Zint, 2012), policy and institutional arrangements (Oteman, Wiering, & Helderman, 2014; Wirth, 2014), cultural and organizational capacities toward low-carbon transition (Middlemiss & Parrish, 2010), social orders (Streeck & Schmitter, 1985), and also interpreting decision-making processes and outcomes (Walker & Devine-Wright, 2008).

Relationships between energy consumers and information express oddly similar characteristics to the anecdote above. Klein and Coffey (2016) build on perspectives of community energy projects and sustainable energy transitions relating to different models of community interaction. Citing weaknesses such as transfer of information, context, or place-based lessons learned, the authors conclude that intermediaries (institutional infrastructures) can help alleviate these challenges by brokering partnerships between those with direct project involvement and external actors, collecting knowledge and data, providing advice and guidelines for support. In addition, this also helps build replicable models for community renewable energy development tailored to specific models, actors, and challenges in order to maximize benefits (Klein & Coffey, 2016). Two studies investigate solar PV adopters in the city of Groningen, the Netherlands; environmental problem awareness, informational and technical support, and social networks were critical toward faster solar PV diffusion (Jager, 2006). Less familiarity with the subsidy

and grant processes as well as lack of knowledge was attributed to failure for potential adopters to jump up to the adopter category (Vasseur & Kemp, 2015a). Furthermore, Schelly (2014b) confirms the relevance of social networks, stating that communities of information – defined as the context in which social networks are "meaningful and influential" – generate better quality information through trust, and correspond to stronger solar PV diffusion (Schelly, 2014b). In short, the evidence shows that connectedness of individuals to data, information, and technical support, positively influences adoption behavior. Therefore, insufficient connections to individuals who collect and interpret the data, as well as connections to the raw data itself, produce information gaps crucial for informed decision-making, especially for businesses looking to augment their existing energy systems and improve consumer behavior.

2.1.6. Affordability as an economic determinant

Energy policy is diverse, often difficult to interpret, and in a single pass hard to digest. This is especially true for policies targeting the affordability and financing of solar PV installations. The time period from 2007 to 2009 is marked as one of the worst financial-economic recessions in recent history, plagued by several market and policy failures. Sometimes called a "green industrial revolution" (Geels, 2013) or "green recovery" (Zenghelis, 2011), scholars anticipated financial-economic recovery particularly through private investment in renewable energy, energy efficiency, and carbon neutrality pending optimal price signals. From the energy consumer perspective, important circumstantial questions to ask might include options regarding availability of financing options, debt recovery tools, as well as risk and uncertainty in the adoption of distributed solar PV generators. Besides scholars, firms such as the National Renewable

Energy Laboratory (NREL) and the Organisation for Economic Co-operation and Development (OECD) are reliable resources for understanding macro-economic theory and debt-financing (Antal & van den Bergh, 2013), market barriers, conditions and impacts (Kaminker, Howarth, Kawanishi, Stewart, & Coldecott, 2013; Kaminker & Stewart, 2012), ITC/PTC extension implications (Mai, Cole, Lantz, Marcy, & Sigrin, 2016), tax equity (Mendelsohn & Harper, 2012), securitization, and financing projects through public capital vehicles (Mendelsohn & Feldman, 2013). But what NREL and OECD reveal is an agreement that costs, prices, and financing options through the lifetime of a solar PV installation constitute relevant information, and implications that are not well understood by investors and energy consumers. This problem is simple; if average energy consumers do not understand financing policies that would otherwise assist them in saving money on their electricity expenditures, because they lack the capacity to untangle them, then experts must step in and take corrective action. We think that there is huge opportunity to help grow the electricity and energy economics IQ of energy consumers everywhere who don't fully understand the implications reflected in their behavior and their bills, whether domestic, commercial, or industrial sectors.

Levelized cost of electricity (LCoE), a metric used to compare cost competitiveness, determining 'grid parity', decreasing system costs, and increasing performance standards of RET's like solar PV are leading to commercial energy infrastructure transformation as they compete better with their fossil fuel alternatives. Price forecasting models for solar PV revealed it to be among the highest cost generating technology at $270/MWh in 2015, dropping to $211/MWh in 2030; coal remained stable around $53/MWh in the 2015 and 2030 models, while Integrated Gasification Combined

Cycle (IGCC, pressurized syngas from coal) modelled $62/MWh to $57/MW (Tidball, Bluestein, Rodriguez, & Knoke, 2010). Although forecasts continue to predict substantial decreases in the price of solar PV power, utilities continue to see the difficulty in integrating commercial installations since it is still generally expensive by comparison. Moreover, solar PV installations are perceived as risky, and outcomes uncertain. Solar PV has a range of costs associated with adopting it, but relevant benefits as well. Costs include the actual PV module, building integration components (sometimes called the 'balance of systems,' including the inverter(s), cabling and wiring, batteries, fault protection devices, charging boxes, meters and other monitoring devices, overcurrent devices, and disconnect switches), building permits, labor, installation materials (mounting hardware), supply chain expenses, utility interconnectivity, and operation and maintenance. Benefits include environmental costs or emissions avoided, tax credits, RECs, discounts and rebates, increased reliability and more robust energy security (Eiffert & Thompson, 2000; Goodrich, James, & Woodhouse, 2012, MREA, 2015).

Along the same lines as average landowners, the average business or industrial establishment cannot always be expected to foot the bill for an entire solar PV installation. These situations often include an institutional investor to cover the capital needed to complete the project. Institutional investment requires large sums of financial capital, however, banking provisions for loans and various financing vehicles for long-term financing options are increasingly strict, and heavily regulated. The worst possible situation is when a large solar PV or wind project turns from cost recovery and profit generator to a stranded asset. This happens when defaults occur, inevitably leading to collapse. Businesses and industrial enterprises have fiduciary obligations to fulfill, which

means that a weighing of risk and reward takes place which either results in an adoption or non-adoption outcome. But some of the more difficult or unobservable moving pieces happening in the background are the unpredictable market distortions and imperfections, possibly failures, evidenced by international disagreements over border carbon adjustments. According to the authors, these mechanisms are supposed to curb carbon leakage, a pattern of increased GHG emissions caused by unregulated industries in another country compared to emissions reduced within country (Helm, Hepburn, & Ruta, 2012). The prudent decision-maker makes a risk adjustment, working to consider the stability of existing incentives, rebates, exemptions and subsidy environment. For the 20-25 year lifespan of most solar PV installations for example, an unfettered dependence on existing policies could prove disastrous if retroactive cuts to subsidies occur, putting a stop to much needed revenue streams (Kaminker et al., 2013; Kaminker & Stewart, 2012). Future PV owners must be cognizant of the price and policy signals, as well as risk and reward to themselves, policyholders, members, and beneficiaries. Institutional investors, as well as green banks, bonds and lenders, will not allocate financial capital if there is sufficient risk to profit making abilities. This is what happens when there is an asymmetrical level of information and understanding between investors and the potential distributed energy generation consumer (risk takers, solar PV developers), the latter tending to be less informed, and targets for the financial and legal consequences when failure (default) occurs. This is commonly known as moral hazard (Antal & van den Bergh, 2013).

Decarbonization – divestment from carbon energy resources – is seen as risky and uncertain by some investors, but pragmatic or realistic to others. Although solar PV

prices continue to decrease, solar PV adoption by utilities for commercial power generation is indeterminate, as it is still perceived as expensive compared to coal or natural gas resources. Distributed generation prices of solar PV installations, for domestic, commercial, and industrial sectors, are also getting cheaper, and represent an opportunity for investors to bid in the non-utility energy generating market. Investments and investment vehicles could be arbiters for market transformation, or barriers, but institutional investors are looking for asset classes that provide steady and stable revenue streams that link to inflation (Kaminker & Stewart, 2012). Moreover, while lucrative investors might see opportunity in risky business dealings with unstable circumstances, the well-informed, feasible, robust systems are a smarter pathway to take. This is disputably evident in non-utility markets such as commercial and industrial firms.

A study by Alafita and Pearce (2014) explored the feasibility of low cost financing options of solar PV asset backed securities. Findings indicated that securitization through PPAs helped bring down costs and perceived riskiness of investments, but understanding and measuring riskiness is a hard part of the adoption process; it is an inherent characteristic, but not easily untangled. One suggestion to overcome this hurdle is access to a database with information about power generation contracts and equipment performance data. This is especially important for solar PV developers who use PPAs or leases to purchase and secure solar PV assets (Alafita & Pearce, 2014). Another study by Antal and van den Bergh (2013) also motivates the importance of financial systems, stating their "core function" was to help those with little cash – the well-being of the system users – while at the same time providing broad coverage, appropriate prices, and ultimately affordable operating costs (Antal & van den

Bergh, 2013). These are not widely shared views, and are often conflicting views from the perspectives of energy system users and institutional investors. However, without the relationship between the two, distributed generation through solar PV in any energy consumer sector would not be possible, or where it is present day.

If sunshine is not available, then solar PV panels are not producing at desirable rates, extending the cost recovery period. The United States encapsulates broad variation in site suitability based on insolation – exposure of a specific area to solar radiation. Swift (2013)'s study confirms that installation location of distributed solar PV systems represent variations in costs and financial returns, especially relating back to local fossil fuel prices per kWh, but also state-wide solar PV incentives. When solar power reaches identical LCoE with its coal or natural gas competitor, solar is said to reach or beat grid parity. This shows that commercial utilities competing inside the state and federal energy policy systems disproportionately interact with costs and return on investment circumstances for existing or potential solar PV owners across the United States (Goodrich et al., 2012; Swift, 2013), further complicating the solar PV playing field state to state.

Simply put, limitless financial capital would suggest more freedom and flexibility of options with how best to allocate it, but businesses make fiscally conservative choices to maintain competitive edge and responsibility. Internal decision-making affects bottom line profit margins employees depend on for a living. It is rational to assume that affordability is a crucial component relating to investment patterns.

2.1.7. Environmental stewardship as an environmental determinant

Environmental stewardship and human behavior is a complex relationship not

easily explained. One of the most widely studied classes of human dimensions and human behavior are environmental indices. Many scholars are credited with being forerunners in fields such as social psychology and pro-environmental behavior. Paul Stern and Thomas Dietz specifically helped produce new theoretical research on forecasting pro-environmental behavior using value-belief-attitude-norm-behavior relationships. Taken holistically, all of these elements are viewed as dynamic, context dependent, and unpredictable. Individuals express environmental values through a spectrum of acceptance dynamics, motivated by complex and informal information acquisition processes like weighting and filtering. These expressions are indicative of value orientations; pro-environmental attitudes are typically observed in both biospheric and social-altruistic value orientations, but narrowly or inversely related with egoistic value orientations. In addition, Stern and Dietz (1994) postulated that these distinct value orientations strongly influence intention to behave, self, and social norm activation. Materialistic value orientations, like egoism, might function as "active filters" of consequential data that could be perceived as compromising or undesirably shifting an individual's value orientation, suggesting those individuals have tendencies to deny that human activities are harmful to natural resources (Stern & Dietz, 1994). Steg and Vlek (2009) also examined environmental dimensions, by examining the merits of environmental psychology's ability to shape and change specific behaviors to generate more desirable sustainable circumstances. Their study illustrated that human behavior does not depend on motivations alone; contextual factors may act as facilitators or limiters to environmental behavior, and influence individual motives. With regard to changing habitual environmental behavior, it is important to design interventions on the

basis that considers how those habits are formed, sustained and reinforced. However, unknotting context appeared to be a troublesome task, but important for determining environmental behavior under different conditions (Steg & Vlek, 2009). Both these findings leave a sense of insurmountable complexity, but also curiosity, not just to explore individual beliefs and attitudes toward the environment, but the behavior of an entire business or industry. Measures of environmental stewardship and sustainability are usually performed using criteria measuring social and environmental accountability (SEA), or corporate social responsibility (CSR). This is discussed more in detail in the literature review section of the second paper.

Interestingly, Fukukawa, Shafer, and Lee (2007) explored the influence of SEA principles not through those employed in private business or industry, but through the guise of Taiwanese Master of Business Administration (MBA) students pursuing careers in business. While these findings indicated support for SEA principles, for the sake of uniform standards, the authors concluded that governments should be pursuant of mandatory and enforceable reporting activities, and political action to bolster SEA values (Fukukawa, Shafer, & Lee, 2007). Indeed, nor is a convenience sample of students generalizable to the values and principles of all personnel in some specific business or industrial sector. However, SEA and CSR are potentially relevant components that might drive environmental stewardship principles. Altogether, environmental determinants represent significant potential toward sustainable energy strategies in commercial and industrial energy consuming sectors.

2.1.8. Innovation adoption, diffusion theory and perspectives

The nature of technology adoption and diffusion continues to be a salient area of

research to this day, performed in scientific research circles, as well as the private sector, and federal government. The reason it garners attention in many different fields besides scientific research is that understanding the mechanisms of successful or unsuccessful adoption and diffusion of innovations could lead to identifying several opportunities. These include: 1) policies to help encourage adoption of some innovations and discourage others, 2) innovation development needs, including sources of funding for research, demonstration, and scaling up for commercialization, 3) factors of the built environment that supplant or harm diffusion such as market volatility and price, and 4) attributes of consumers that influence rapid adoption and diffusion, effectively transforming markets and market behavior. Energy user attributes are the focus of this part of the study. From cell phones and gaming consoles, up to more idea-based innovations in fields such as agriculture, public health, or extension, tangible objects and intangible ideas are treated as innovations, and can be explored based on the rate and effectiveness of adoption and diffusion, with consumers as conduits. Not just scientific practitioners, but stakeholders ranging from students and interns to corporate officers, can find answers to questions regarding innovation adoption and diffusion first by understanding the different pieces underlying the conceptual framework. The Rogers Innovation-Decision Model demonstrates steps or "stages" decision-makers experience prior to and after an adoption decision. Specifically, the knowledge and persuasion stages represent an ideal starting point for exploring how social, economic, and environmental factors influence adoption behavior (Rogers, 2003). Figure 1 provides a visual adaptation of the Rogers Model of Innovation, and helps explain the general diffusion process of solar PV technology. In this paper, RETs like solar PV are often

referred to as innovations and technologies interchangeably not just because they are indisputably innovative, but that they express traits associated with innovations. During the Civil War, historians credit locomotives and Morse Code capabilities for the rapid and secure communication of battlefront conditions, resource depletion and needs, as well as the provision of battlefront ready troops, food and medical supplies, arms, and intelligence, ultimately leading to the victory of the Union over the Confederacy (Nye, 1997).

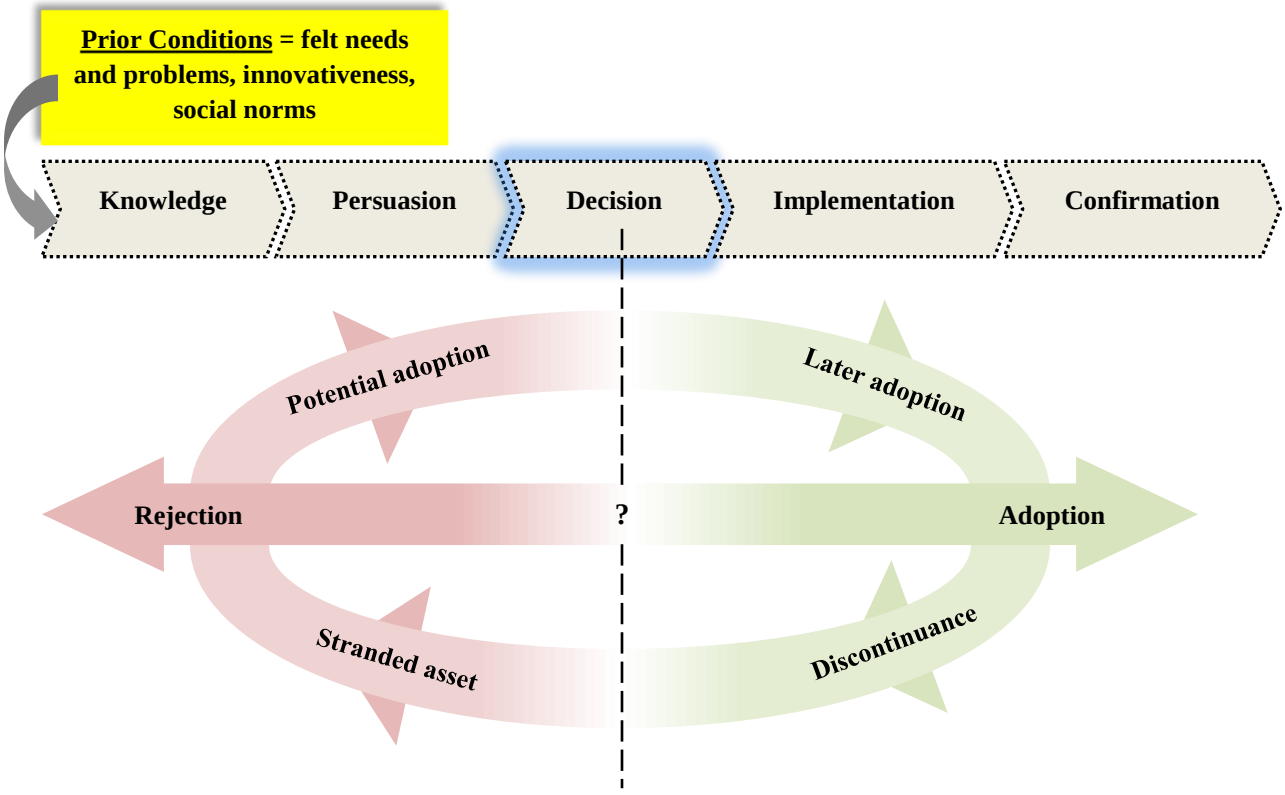

Figure 1. The Rogers Innovation-Decision Model

Note. These arrow tabs purposefully do not express clear or bounded stages or milestones to achieve before proceeding to the next. Often, for any decision-making unit, in reality these stages are initiated and carried out in a complex fashion to varying lengths of time. But, these stages are sequential; each subsequent stage must be sufficiently completed prior to the next.

Source: adapted from Rogers, E. M. (2003). Diffusion of Innovations (5th ed.): The Free Press, A Division of Simon and Schuster, Inc.

This anecdote tells us that innovations are not just novelties of goods providing services ahead of its time, but that they are also finite in context, refined, and built upon

later down the road; essentially, they are iterations of what is yet to become, creatively destroyed, then iterated upon again. We see presence of trains everywhere today, but they have progressed into bullet trains, light-rail systems, underground transportation such as The Tube, or elevated systems in Chicago. Even Morse Code is still taught in the military today, but humans communicate through radios, satellites and Global Positioning Systems, radar, sonar, cell phones, email, and social media. Solar PV technologies are not necessarily novel; they've been available in the market since the mid to late 1970's. But possibilities of integrating higher performing solar PV modules into businesses and industrial establishments is a benefit and service that is growing more and more innovative with each passing fiscal year. These might be regarded as niche-innovations because they are an imperfect and constantly evolving technology comprised of hardware and software components, associated with shrinking and swelling windows of time ripe for a market takeoff, and some would go further to speculate, regime transformation (Geels & Schot, 2007).

Using evidence from European models of energy consumption, Spaargaren (2003) draws upon the merits of Structuration Theory and the Social Practices Model by Anthony Giddens as more relevant and bigger picture strategy to understanding consumption behavior. For example, instead of using traditional attitude-behavior relationships, a shift takes place from exploring the individual consumer of energy intensive services, to exploring the actual energy intensive services, or social practices, as a function of the actor's lifestyle, and the system of provision (Spaargaren citing Giddens, 2003). More specifically, instead of the sources of attitudes and intentions to behave a certain way under given circumstances, the bigger picture of interest over

consumption behavior inspects the actual circumstances, what Spaargaren (2003) calls the "contextualization of norms and environmental behavior," moving away from individual sustainable behavior benchmarking to a more powerful "environmental sociology agenda" (Spaargaren, 2003). From this theoretical perspective, context of human consumption behavior rather than the psychological internal cognitions, is a powerful and more accurate depiction of issues surrounding the provisioning capacity of utilities and innovative technology.

2.1.9. Solar PV diffusion

Scientific research past and present continues to focus on domestic sector energy consumers, but a disproportionate amount of research reveals disparities between domestic and commercial or industrial energy consumers. We derive meaningful data and fundamental understanding from studies focusing on theories such as metabolic rift and ecological modernization theory (Schelly, 2015), domestic sector energy consumers (Bauner & Crago, 2015; Jager, 2006; Keirstead, 2007; Labay & Kinnear, 1981; Schelly, 2014b; Stern, 2014; Vasseur & Kemp, 2015a, 2015b), with others focusing on utility managers (Kaplan, 1999), renewable energy cooperatives (Yildiz et al., 2015; Yildiz, 2014), and environment and sustainability principles in students (Chen, 2014; Fukukawa et al., 2007). But, a rational course of action is to shift scientific exploits more towards commercial and industrial energy consumers.

According to the latest reports published by the U.S. Energy Information Administration, excluding motor-fuels and transportation sector consumer indices, Wisconsin's energy infrastructure continues to express heavy dependence on coal, natural gas, and nuclear materials for electricity, and in order to meet demand load, is a net

energy importer of these raw fossil fuels. Furthermore, domestic sector end use consumption in 2014 was 24.1%, industrial sector alone was almost 1/3rd at 31.7%, with commercial sector end use at more than 20%. Of the nearly 5,700 MWhs of electricity generated by Wisconsin in 2017, more than 60% of it is derived from coal. Fossil fuel sources comprised over 90% of electricity generated, whereas non-hydroelectric alternatives make up less than 5%, as shown in Table 1.

Table 1. 2017 Wisconsin electricity generation by fuel source

Fuel Type	Fuel source	Generation (MWhs)	Percent of total (Σ ~ 5678 MWhs)
Fossil	Coal-fired	3444	60.66
Fossil	Nuclear	897	15.80
Fossil	Natural Gas-fired	845	14.88
Sustainable	Hydroelectric	254	4.47
Sustainable	Other (wind, solar, biomass)	238	4.19

Source: adapted from U.S. Energy Information Administration. (2017). U.S. States: Wisconsin State Profile and Energy Estimates. Retrieved from U.S. Energy Information Administration (EIA): Washington, D.C., USA: http://www.eia.gov/state/?sid=WI#tabs-2

Together, commercial and industrial energy consumers comprise more than half of the state's energy end use, with the food, metals, and machinery manufacturers being the most energy intensive consumers (U.S. Energy Information Administration, 2016). The same state profile reports that at 103 BTUs per household, Wisconsin's average household uses 15% more onsite energy than the national average (U.S. Energy Information Administration, 2016). These figures show that although its presence is observable in Wisconsin's commercial and industrial sectors, its impact is negligible. In terms of scale, solar PV generates little electricity. By-and-large, the present day adoption behavior of large energy consumers of solar PV innovations is lethargic, but ripe for innovation, characterized by early stage diffusion. The big picture previous research studies demonstrate is that exploring renewable energy adoption and sector

specific challenges is promising in the commercial and industrial energy-consuming sector of society (Andrews & Johnson, 2016).

2.2. Methods

This research makes use of a mixed methods research strategy. By collecting data from survey, interview, and case study methods, this study is able to triangulate data in support of answers to both of the main research questions posed (Yin, 2009). This data source triangulation is depicted in Figure 2 below. This portion of the research focuses on the first main research question: What influential factors drive or inhibit the diffusion of solar PV technology in Wisconsin's commercial and industrial sectors? Using an electronic survey methodology (Dillman, Smyth, & Christian, 2014), we surveyed across solar PV adopter, potential adopter, and non-adopter groupings.

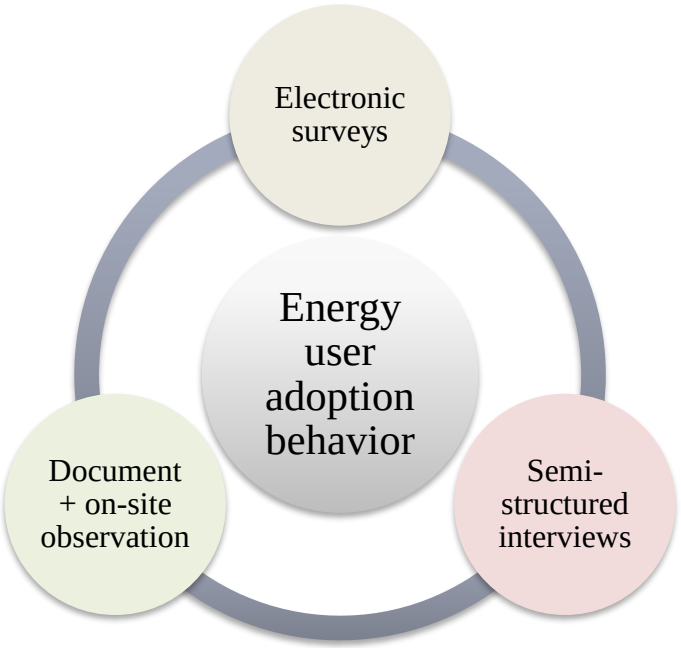

Figure 2. Data source triangulation

The main unit of analysis in this study are the individual commercial or industrial establishments in Wisconsin. Since this first question concerns influential determinants

of adoption and non-adoption, a binary response, the adopt/non-adopt decision attributed to individual business or industrial establishments characterizes the dependent variable in this study. To examine influential or non-influential determinants of this dichotomous decision, an electronic questionnaire is designed using question items grouped into three constructs mentioned earlier: consumer to policy networks, affordability, and environmental stewardship. Demographic items and construct items are each independent variables here.

Studies have thoroughly examined technology adopters exclusively, simply probing for reasons that influenced adopter behavior without gathering evidence from non-adopters. More research, and this research study here, urges that both adopters and non-adopters have the potential to provide insight into influential factors governing each group's decision-making process. However, the study by Schelly (2014b) demonstrates that finding meaningful data from innovation non-adopters is particularly challenging because questionnaires and interviews tend to frame the analysis around why participants/interviewees did not, or have yet to, choose to adopt a specific technology or innovation (Schelly, 2014b). We agree with the author's argument that this can be a particularly troublesome task. By exploring various businesses and industries nested in these energy and environmental sustainability programs, non-adopters of solar PV have in fact exercised a non-solar PV adoption – an alternative – decision-making path that demonstrates that firm's energy and environmental compliance differently. Solar PV innovations are indeed central to this research, but we acknowledge that other distributed generating systems and energy efficiency behavior, embracing sustainability too, are vital in navigating the sustainable energy transition. Determinants of these non-solar PV

innovations matter greatly, and they are covered in more detail in the next paper. While it would be reasonable to exclude solar PV non-adopters from this study, we confound the notion that the most useful and meaningful data come from adopters; we think non-adopters can provide an unfiltered perception of solar PV, helping furnish more unadulterated and unbiased data in our mixed methods here.

Surveying entire businesses – multiple employees of each individual firm – was impractical for this portion of the research, and might be a more pertinent strategy for a singular case study or case comparison research. Local economic development boards were another potential platform for survey-based research. Economic development firms such as the Wisconsin Economic Development Corporation, specialize in promoting healthy and competitive economic development, including minority businesses and early career entrepreneurs. In the scope of survey methodologies, authors often employ mail-based surveys through the United States Postal Service Computerized Delivery Sequence File (Dillman et al., 2014) and dual-pronged approaches that combine methods, such as Schelly (2014b)'s combination of solar PV installation firms and mail-based surveys from participant households in domestic solar tours (Schelly, 2014b). For business and industrial firms, the most rational course for recruitment is by using a Qualtrics survey platform (Qualtrics, Provo, Utah, USA), an internet-based program for questionnaire development and distribution.

Survey participants are essentially key informants capable of speaking for their respective employer's energy and environmental compliance efforts (O'Leary, 2010). Participant contact information was collected from public data available from two salient sustainable energy transition programs in the state of Wisconsin and one professional

advocacy organization on each of their webpages. Specifically, these include: 1) Green Tier program (a program of the Wisconsin Department of Natural Resources), 2) Green Masters program (a program of the Wisconsin Sustainable Business Council), and 3) RENEW Wisconsin, which is a state-wide organization that promotes education in renewable energy resources. RENEW Wisconsin spreads awareness through transparency, dissemination of information, and most importantly collaboration of stakeholders including solar PV companies, system owners and operators, the Wisconsin PSC, and a variety of electric utilities. We chose these organizations for their transparency in Wisconsin's business community, specifically by emphasizing high environmental compliance, standards, monitoring and reporting, and sustainable energy. In short, specifically for energy considerations, these three organizations emphasize energy transition behavior through efficiency and renewable resources, and are a reliable source for examining PV adopter and non-adopter firms. Our sample consists of businesses in both commercial and industrial energy user sectors in Wisconsin, comprised of both adopters and non-adopters of solar PV, and members or former members of the Green Masters and Green Tier programs, or recognized by RENEW Wisconsin. The diversity in adoption status, member status, and industries represented express a reliable vertical slice of the commercial and industrial energy user population of interest, but we are suspicious of sample size moving forward, and we must be cognizant of limitations that go along with sample size therein.

With limited survey, interview, and case-study research on commercial and industrial energy users available, we draw from domestic solar PV user research to help develop the conceptual framework for this study. The electronic questionnaire first asks

participants if they indeed implement sustainability practices, followed by how well they know and how well they are informed regarding their firm's energy consumption. Most importantly, they are asked whether they use, don't use, or are potentially considering a solar PV system, which measures adopter and non-adopter group recruitment (3 groups if excluding 'potentially considering' from 'non-adoption' as its own distinct group, as this can also be viewed the same as 'non-adoption').

2.2.1. Data collection

Illustrated in Appendix B-1, survey questions are organized into our three constructs, including short purpose statements explaining the importance of each. The survey concludes with demographic questions, followed by thank yous and motivation for their case study participation. Questions are positively and negatively worded in an alternating pattern, except for the environmental stewardship section, and are measured using a 5-point Likert scale (DeVellis, 2017). In addition, question items are worded such that the participant is asked to evaluate both the firm (items phrased with we or 'our firm') and self (question items sans 'we' or 'our firm,' or presence of the possessive 'I'). To the survey participants, this might seem confusing as the discrepancy between whether or not items ask to evaluate the firm or the self as the firm's key informant, is not clear. However, this blur between firm and self-evaluation is paramount. Question items, if dictating disproportionate 'firm only' or 'self only' measurement items, could belie the reality inside each distinct firm. As key informants, the roles of these individuals can be extended to change agents and opinion leaders (Rogers, 2003). Whether the extent of their duties, interests, power, and agendas is internal or external to the firm, we might run into the situation where key informant(s) might not be in

alignment with their respective employer. Asking an employee to expand up on her/his firm can be perceived as synonymous with explanation about their boss, supervisor, manager, or higher titled employee(s). Question items garner evaluation of firm and self, helping reduce potential pressure to produce biased agendas, interests, or other unwanted motivations. In short, governance structures and social networks – whether internal or external to the business or industrial establishment – are outside the scope of this research, but certainly a rational consideration for future innovation diffusion research. While this can be confusing to understand, we find it helpful to envision each distinct key informant as nested inside their respective business or industrial establishment (see Figure 3). This is a more accurate depiction of our main unit of analysis. For the consumer to policy networks and affordability sections, survey items are a mixture of previously researched measurement items deemed relevant (Vasseur & Kemp, 2015a) as well as items of our own conjuring, that are not yet replicated nor validated. We acknowledge this as an important limitation later. In the consumer to policy networks section of the questionnaire, we asked untried questions about clarity of economic benefits, property rights and regulations, as well as reliability of support from energy providers, availability of data, and overall presence of a community of information. For the affordability section, additional items measure riskiness of investment, cost to benefits weighting, return on investment, and acceptability of charges spelled out on utility bills. The environmental stewardship section of the questionnaire makes use of two relevant and validated scales: the Corporate Environmental Orientation Scale (CEOS), which corresponds to a business or industrial firm's level of corporate social responsibility (Banerjee, 2002), and the New Ecological Paradigm Scale (NEPS)

(Dunlap, Van Liere, Mertig, & Jones,2000). We believe together these two scales depict each participant firm's level of environmental stewardship reliably. Excluding semantic question items – firm name, case study interest, final comments, dissemination of research findings material – the questionnaire contains 76 distinct items.

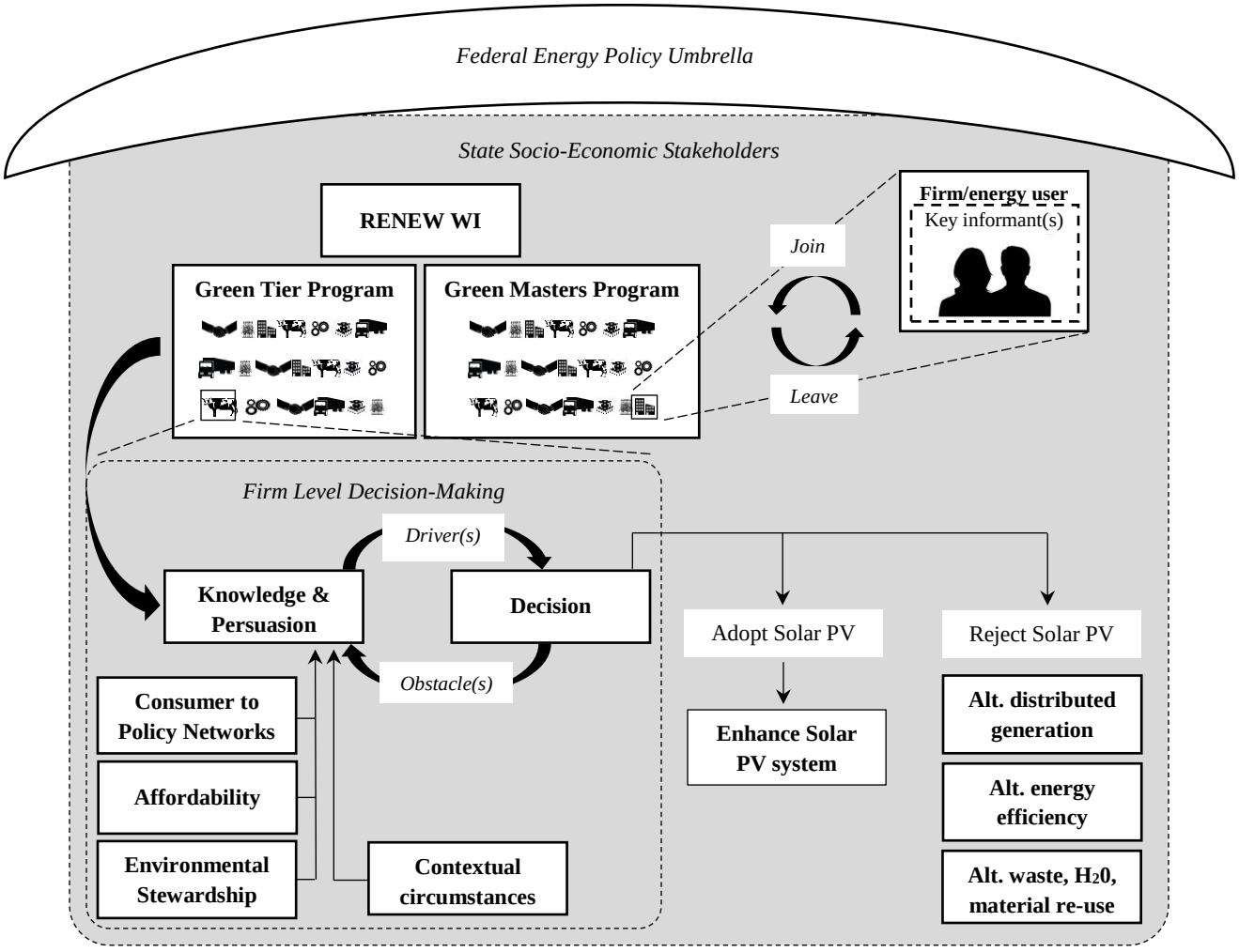

Figure 3. A conceptual framework for solar PV innovation diffusion
Source: adapted from Rogers, E. M. (2003). Diffusion of Innovations (5th ed.): The Free Press, A Division of Simon and Schuster, Inc.

The Dillman Method is a commonly used method for effectively recruiting survey participants and collecting data. This method can be used across technology media including mail, telephone, and electronic or web-based surveys. We are employing a

mixed mode design – primarily web-based but some telephone recruitment – for our survey due to some limitations of availability of email and contact information of several firms in the three programs mentioned earlier. First, known email addresses of key informants employed at these firms are collected, and an initial invitation explaining the purpose and merits of the research, along with benefits to participants, is delivered, followed by subsequent reminder emails. We encouraged that if the individual contacted is too busy or unable to complete the survey, to pass it along to another individual employed at their firm. A URL bringing participants to the survey introduction screen is contained in the invitation and reminders. Reminders are short and straight to the point, motivating research details, survey length, and thanking them for their help. Next, reminders are delivered to firms that have not yet completed the survey. Typically, the first and second waves of reminders are sent one week between each other, giving participants time to incubate the motion to take the survey. Finally, a third and fourth wave of reminders are sent to non-respondents after a two-week interval, followed by a final invitation and further thank yous.

Electronic-based surveys provide both benefits and setbacks. Using email to recruit participants in studies that employ surveys to collect data is generally cheap and it is easy to keep track of dates and times, making it easy to be systematic with timing of invitations and reminder waves. Moreover, email is a conventional tool that most businesses use to stay connected in a world generally shrunken by technology. However, congruent with the internet and social media platforms, email is an embedded feature within commercial and industrial firms, not to mention each other's lives. It is not uncommon for individuals to be inundated with unwanted email in perpetuity. Add in the

normal to abnormal distress employees experience in their professional lives, and email becomes a sort of exhaustive minefield. The recruitment process can be likened to a "hard sell," where principle investigators must spell out clearly and succinctly the purpose of the research, benefits for participating, and risk involved, packaged together in a single email. Those sampled may not even read through the email – not even the first few words – depending on the context surrounding participants sample. Therefore, generally short email messages are desirable. Further complicating things, firewalls and other security measures and settings on servers and/or individual computers may filter out email such as those seeking research participants from unknown or unwanted sources, similar to advertising and spam. The URLs that go along with the email invitations and reminders – linking the Qualtrics survey – could be targeted and filtered by computer security software. Finally, email addresses collected could be out of date, in which case the result is failure to send, in which case there are few options to resolve. Likelihood of the invitations and reminders gaining the eyes of potential participants then becomes unlikely. While there are pros and cons to email recruitment and electronic platforms, we proceeded with an electronic survey and email procedure for this part of the study.

Beginning late October and ending mid-January, data were collected from an electronic survey of 390 distinct business and industrial firms in Wisconsin. This is our population from which we sample from, broken down into three datasets corresponding to the Green Tier program, Green Masters program, and RENEW Wisconsin. These firms are comprised of mostly members of the Green Tier and Green Masters programs, or firms recognized by RENEW Wisconsin, but there are some former member firms too, specifically in our Green Masters data set. The Dillman Method is employed for the

roughly 95 firms in the Green Tier dataset, but the other two data sets presented novel challenges. For the 30 firms in our RENEW Wisconsin dataset, we recruited participants by calling the firms directly. We were not able to access member data in the Green Masters program, as this was private, and ultimately not accessible. Instead we teamed up with the program director to recruit from the 165 members and roughly 100 former members to generate as high a response rate as we could. Altogether, we collected 76 responses, achieving a response rate of just over 19%. More specifically, 23 indicated solar PV non-adopters, 25 indicated potential adopters, and 15 indicated adopters. Our sample size of 76 is not representative of our population in this part of the study. While this is not ideal, we are rather encouraged by the survey responses given that many of the current program members are obligated to take surveys. Specifically the Green Masters program members are required to take a survey, which determines their firm's distinction placement (e.g., Apprentice, Professional, and Master). More applicable to all, exceeding environmental compliance and performance standards demands routine, likely perfunctory, monitoring and reporting, not to mention energy or environmental system refinement and meeting deadlines. While business or industrial firms might view this survey as an opportunity, along the same line as domestic household or landowner surveys, surveying these businesses presented a challenge. This limitation is explained more in the following discussion section.

2.2.2. Data screening

For this part of the study, we analyze our data using factor analysis processes followed by regression analysis, specifically binary logistic and stepwise regression procedures. Data are screened prior to factor analysis steps. We eliminated four survey

responses because they were incomplete. Incomplete responses includes responses with mostly unanswered question items. Although some partial responses are included in our analysis, we cannot ignore the significant amount of unanswered questions items in these few responses. Consequently, they are omitted from our data, bringing our sample size n to 72 including 15 useful partial survey responses. In the next step, mean scores are produced for every one of our survey items across adopter groupings, including demographics, along with chi-square results. Pearson's chi-square tests for relationships between two variables, a dependent variable and an independent variable, and is a reliable tool for parsing surveys with many question items. Recall that the dependent variable is solar PV adoption grouping – solar PV adopters, potential adopters, and non-adopters – and each survey item and demographic attribute are independent variables. Mean scores and chi-square results are located in Appendix B-1. Third, negatively worded items for each of the four scales were reverse coded, and thus reverse scored. For the first scale, the C2P construct, high scores reveal positive perceptions toward connectedness, as well as presence of understanding and accessibility to data and energy policies. In short, respondents with higher scores tend to feel connected to energy policy and energy user data via social-networks and supportive firms external to their own, whereas lower scores align with the exact opposite, such as tendencies toward unreliable support or disconnectedness. The second scale, the affordability construct, is a little less complicated. High scores demonstrate solar PV systems as affordable, and low scores as unaffordable. We think economic attributes of distributed generators such as price signals, financing options, and perceptions of risk and uncertainty toward costs and benefits produce mixed feelings toward solar PV investments. Finally, the environmental

stewardship construct employs two validated scales mentioned earlier, indicating our third and fourth scale here. High scores demonstrate alignment with pro-corporate social responsibility and the ecological paradigm, and low scores demonstrate weaker alignment respectively. Another interpretation of this construct is using value orientations. Higher scores reveal strong orientations toward social-altruism and biospherism, and lower scores reveal weaker ones, or perhaps moderate to strong egoism (Stern & Dietz, 1994).

2.2.3. Exploratory factor analysis procedure

The factor analysis procedure occurs in two stages, an initial stage, followed by survey item observations and subsequent omission, and then a final stage. By means of an initial exploratory factor analysis with varimax rotation, we demonstrate both influential as well as non-influential solar PV adoption determinants by distilling each of our four scales down to smaller numbers of various survey items, or dimensions of each construct. Principle components analysis is used as the extraction method. Kaiser-Meyer-Olkin scores are observed for each of the scales, indicating suitability of each scale for the factor analysis procedure. Kaiser-Meyer-Olkin scores that achieved a score below 0.60 are regarded as poor; scores between 0.60 and 0.70 are acceptable; scores between 0.70 and 0.80 are moderate, and scores above 0.80 are considered excellent (Beavers et al., 2013). For each distinct factor produced, observations are made regarding items that did not achieve acceptable loadings; items with loadings below 0.50 were subsequently eliminated. Then, each factor is scored for reliability in SPSS using Cronbach's alpha. Following the reliability step in the procedure, for our factors extracted, no substantial increases in alpha would have been achieved with further item elimination; this concluded our reliability analysis. Factors with Cronbach's alpha scores below 0.70 not

reported in this analysis; these factors are observed to be unreliable in this part of the are study (Poortinga, Steg, & Vlek, 2004).

In the final stage, a final factor analysis including varimax rotation is performed on the remaining scale items, identical to the initial stage. Following another round of observation, item elimination, and reliability testing with Cronbach's alpha – to see if there were any significant changes from earlier. We satisfy those factors by reporting only those that demonstrate alpha scores above 0.70, along with the component loadings for each one. To illustrate differences across three solar PV adopter groupings, we performed a one-way analysis of variance (ANOVA). To do so, summated rating scales are generated for each factor, where components with high enough loadings were added together, and divided by the number of component items. This creates a mean score for that specific factor. Mean scores generated produced significant differences for some, but not all of our factors. This is explained in the results and the discussion.

The next section provides descriptive procedures for scale construction and item analysis including question items and demographics across solar PV adopter, potential adopter, and non-adopter groupings. We use SPSS v. 24 (IBM Corporation, Armonk, New York, USA) to conduct exploratory factor analysis and reliability analysis (Cronbach's alpha) to explore influential determinants of solar PV adoption and non-adopt behavior. In addition, we effort some regression modelling to further reinforce our findings, and estimate the predictive ability of our data. We think these survey findings can help motivate smarter energy policies at local and state levels, and motivate new research questions surrounding commercial and industrial energy consumers.

2.2.4. Scale construction

Starting with the C2P networks construct (see Table 2), five factors with eigenvalues greater than 1, the recommended value, were initially extracted. Factors one, two and three reported eigenvalues over 1.50 with factor one reporting the highest eigenvalue at 3.69. The three factors collectively explain almost 50% of the variance, while factors four and five explain less than 10% of the variance each. Factors one, two and three are interpreted and given the names External support presence, Clarity of solar regulations and property rights, and Understanding of FITs and RECs respectively. From the rotated component matrix, we observed that three items failed to achieve loadings above 0.50, which is a common metric that differentiates between acceptable and unacceptable levels. "Solar PV incentives" and "Solar PV subsidies" were initially omitted. Following the final stage of the exploratory factor analysis for this construct, "Enough data and information" achieved a loading of 0.45 on both External support presence and Property rights and regulations; it too was eliminated. Perceptions of clarity of solar PV incentives and subsidies as well as the amount of data and information available, do not appear to give significant meaning, nor explain the variance, in the factors reported in Table 2. Policies concerning FITs, RECs, property rights and regulations however play a central role in factors two and three. The data shows that various PV policies do not share a uniform level of clarity and understanding to energy users, indicating a knowledge gap among PV adopters and non-adopters. For internal consistency, we evaluate Cronbach's alphas above 0.70. Two factors, External support presence and Understanding of FITs and RECs, according to Table 6 achieved the alphas 0.73 and 0.74. Cronbach's alpha of 0.69 for Clarity of solar regulations and property rights was reported in these findings because: (a) an Eigenvalue of 1.69 was

demonstrated, which explains over 12% of the variance; and (b) although the alpha is less than 0.70, 0.69 is not sufficient enough to be eliminated from further analysis. We are curious to see how the 2-item factor performs across our three solar PV adopter groupings. This is the same motivation for one other factor in the affordability section. Factors four and five expressed poor internal consistency, demonstrated by alphas 0.58 and 0.29 respectively; they, along with their component items, are not analyzed any further. The Kaiser Meyer-Olkin score was initially reported at 0.72 for all 17 items prior to omission, indicating moderate suitability for factor analysis. Each scale's Kaiser score, alongside each factor's alpha and number of items, can be found in Table 6. The C2P construct, summarized in Table 2, illustrates the factor loadings of the remaining 10 items in the analysis, all of which show loadings above 0.50 for the three factors.

Table 2. Factor loadings for the 10 items in the C2P networks construct

	Factors		
Measurement Items (N respondents)	*1*	*2*	*3*
State-wide institutions and organizations provide reliable support when we need it (65)	0.76		
When our firm needs help with any energy technology we do not have trouble finding it (67)	0.73		
Our firm's energy provider provides unreliable support when we need it (62)	0.70		
At our firm, we do not feel a strong and supportive presence of a community of information regarding sustainable energy (61)	0.67		
Solar regulations are unclear (65)		0.82	
Solar property rights are clear (65)		0.68	
At our firm, we are not well informed on renewable energy policies (67)		0.54	
At our firm, we do not understand what feed-in tariffs are (67)			0.89
At our firm, we do not understand what renewable energy credits are (69)			0.75
Eigenvalue(s)	3.69	1.69	1.58
Variance explained (%)	26.36	12.07	11.27

Note. 5 factors extracted, 2 of which reported Cronbach's alpha << 0.70. These 2 factors are not reported further. 3 items, "Solar PV incentives," "Solar PV subsidies," and "Enough data and information" were eliminated for failing to achieve loadings > 0.50.

Next, the affordability construct, shown finalized in Table 3, initially reported six factors, however five factors were reported in the final stage, with both Kaiser-Meyer-Olkin scores above 0.70, indicating moderate suitability for factor analysis. 8 items loaded above 0.50 on factor one, 3 of which loaded strongly with loadings above 0.80. These included "Solar PV systems are affordable," "Solar energy will become cheaper than oil and natural gas," and "Solar PV benefits outweigh the costs." With more than 32% of the variance explained and an alpha above 0.89, this was the flagship factor in the affordability construct, and a reliable measure of perceptions regarding economic attributes of solar PV systems. The 8 components were clustered and interpreted together, and given the name Benefits of cheap renewable energy.

Table 3. Factor loadings for the 10 items in the affordability construct

	Factors	
Measurement Items (N respondents)	*1*	*2*
Solar energy will become cheaper than oil and natural gas (60)	0.83	
Solar PV systems are affordable (59)	0.81	
Solar PV is not the best available technology for our firm to be self-sufficient (60)	0.80	
Solar PV benefits outweigh the costs (60)	0.78	
The payback period on a solar PV system is too long (60)	0.77	
Increasing oil and gas prices support the use of solar PV (60)	0.64	
A solar energy system is not suitable for our firm's location (59)	0.59	
Solar PV investments are risky (60)	0.55	0.61
Financing a solar PV system is difficult to understand (60)		0.81
Outcomes of solar PV investments are largely uncertain (60)		0.72
Eigenvalue(s)	5.18	1.71
Variance Explained (%)	32.38	10.69

Note. 5 factors were extracted, 3 of which reported Cronbach's alpha << 0.70. These 3 factors are not reported further. 3 items, "The rate of return," "Utility-based energy prices," and "Our firm's energy bills" were eliminated for failing to achieve loadings > 0.50.

According to the rotated component matrix, 2 items, "Our firm's energy bills" and "Utility-based energy prices," failed to load meaningfully on all six of the initial factors, thus they were eliminated. Interestingly, the "The rate of return" item loaded at 0.79 on factor five initially, along with "Our firm is mindful about the monthly energy bill"

which had a loading of 0.57. However, in the final stage factor analysis, "The rate of return" item achieved a loading of 0.46 on factor two; this item was omitted for a poor loading. From this, we think commercial and industrial firms have a grasp on acceptable thresholds regarding rate of return, but it might also be that this item is poorly worded, and doesn't provide a reliable measure of rate of return. Compared to length of payback period, clarity of rate of return might be confusing to respondents since the item asks respondents to interpret the meaning of rate of return rather than a length of time (i.e. payback period). Therefore, this item does not contribute meaningfully here. Acceptability of electricity price, and the relationship between price and PV adoption, are also not reliable measures. They both do not contribute to the factor analysis. Price and perceptions of them are difficult measures; these might be poorly worded items. Another reason could be that stability of price and rates have not yet produced any negative or unsatisfying attitudes toward energy providers, indicating negligible presence of disparaging relationships between energy providers and users. Either way, not enough variables in this survey can make such claim with certainty. Factor two, which explains 10.69% of the variance, achieved a Cronbach's alpha of 0.69. Stated earlier, while this was indeed below the 0.70 threshold, the internal consistency of this factor is sufficient enough in this study for further analysis. Factor two includes 3 items, one which had a strong loading of 0.81; this item was "Financing a solar PV system is difficult to understand." This would have been 4 items if not for the unacceptable performance of the "The rate of return" item. The other 2 items, "Solar PV investments are risky" and "Outcomes of solar PV investments are largely uncertain," with loadings of 0.61 and 0.72 respectively, are interpreted to encircle this concept of Security of investment risk and

uncertainty. Factors one and two are illustrated in Table 3, while three, four and five are not because they achieved worse alpha scores, suppressing the original 19-item scale down to 10 items.

While the rotated component matrix in the NEPS scale (see Table 5) warranted item elimination and final stage factor analysis, the initial factor analysis in the CEOS scale (see Table 4) demonstrated loadings above 0.50 for each component. No items in the 14-item CEOS scale were eliminated, and internal consistency proceeded. Three factors were extracted, but only factor one achieved a Cronbach's alpha score above 0.70. Factor one, interpreted as Environmental preservation and protection, reported an excellent alpha of 0.88. This is the only factor reported in Table 4. The NEPS scale produced three factors that demonstrated excellent alphas alongside Environmental preservation and protection.

Table 4. Factor loadings for 8 items in the Corporate Environmental Orientation Scale (CEOS)

	Factors
Measurement Items (N respondents)	*1*
At our firm, we make a concerted effort to make every employee understand the importance of environmental preservation (60)	0.82
Environmental preservation is a high-priority activity in our firm (59)	0.79
Our firm has a clear policy statement urging environmental awareness in every area (60)	0.78
Preserving the environment is a central corporate value in our firm (59)	0.74
It is our firm's mission to be a leader in environmental protection in our industry (57)	0.71
In our firm, profits are more important than our environmental activities (58)	0.61
Our firm's responsibility to its customers, stockholders, and employees is more important than our responsibility toward environmental preservation (58)	0.60
Our firm has a responsibility to preserve the environment (59)	0.51
Eigenvalue(s)	5.73
Variance explained (%)	40.95

Note. 3 factors total were extracted, 2 of which reported Cronbach's alpha << 0.70. These 2 factors, along with their question items, are not reported further.

With a collective total variance explained of 65.32%, factors one, two and three produced the highest total variance explained among factors with above acceptable alphas. Excluding all other factors in this scale's factor analysis, factor one in the NEPS scale produced the largest eigenvalue at 6.41, and the largest variance explained at 45.78%. These three factors, summarized in Table 5, are interpreted as Recognizing environmental consequences, Recognizing social-ecological conflict, and Shift from human-centric perceptions.

Table 5. Factor loadings for 14 items in the New Ecological Paradigm Scale (NEPS)

	Factors		
Measurement Items (N respondents)	*1*	*2*	*3*
When humans interfere with nature it often produces disastrous consequences (55)	0.77		
The so-called "ecological crisis" facing humankind has been greatly exaggerated (56)	0.77		
If things continue on their present course, we will soon experience a major ecological catastrophe (56)	0.75		
The balance of nature is very delicate and easily upset (56)	0.70		
The earth is like a spaceship with very limited room and resources (54)	0.66		
Humans will eventually learn enough about how nature works to be able to control it (54)		0.72	
Human ingenuity will insure that we do NOT make the earth unlivable (56)		0.71	
The earth has plenty of natural resources if we just learn how to develop them (55)		0.69	
We are approaching the limit of the number of people the earth can support (55)		0.65	
Humans are severely abusing the environment (56)		0.62	
The balance of nature is strong enough to cope with the impacts of modern industrial nations (54)		0.54	
Humans were meant to rule over the rest of nature (52)			0.82
Humans have the right to modify the natural environment to suit their needs (55)			0.79
Plants and animals have as much right as humans to exist (54)			0.75
Eigenvalue(s)	6.41	1.44	1.29
Variance explained (%)	45.78	10.30	9.24

Note. "Despite our special abilities" was subsequently eliminated after failing to achieve loadings > 0.50. The initial 15-item scale is suppressed to 14 items.

Kaiser-Meyer-Olkin scores reported for the CEOS and NEPS scales are higher than the C2P networks and affordability constructs, at 0.83 and 0.86 respectively. This is not surprising seeing as both of these scales were replicated and validated in previous research studies, and employed in this study as trusted and reliable scales for measuring environmental stewardship dimensions of energy users.

2.2.5. Regression procedure

Regression analysis is a commonly used method following exploratory factor analysis. We use regression to help model and explain the influence of independent variables, which includes our survey construct items, demographics, and latent variables (i.e. factors), on our dependent variable, solar PV adoption behavior. Exploring the predictive abilities of these variables toward commercial and energy user adoption behavior may provide a future direction of research examining policies and pathways for solar PV or other technology market takeoff. Predicting actual human acceptance of various energy technologies like solar PV, and estimating motivating factors, is a difficult process, and there are limitations to regression models that purport influential predictors. Energy users also experience obstacles or challenges that prevent technology diffusion, coercing more acceptable alternatives rather than lucrative investments in renewable energy. These antithetical factors are also difficult to obtain. We employed two methods that probe for predictive models in our data: 1) binary logistic regression, and 2) stepwise regression.

2.3. Results

2.3.1. Exploratory factor analysis results

Table 6 summarizes descriptive statistics for each of the nine factors distilled

from the factor analysis procedure earlier. While these factors exemplify relevant dimensions of solar PV adopters, potential adopters, and non-adopters, they do not yet portray differences across these three groupings. To do so, new latent variables are developed by creating summated rating scales. Each factor has a specific selection and number of survey items; each factor has its own latent variable. In SPSS, the individual respondent scores to each survey item were added together, then divided by the number of items in each specific factor. These are composite scores, which generates a mean score for each survey response for each of the nine latent variables. Mean scores from Table 6 indicate above moderate alignment with each of our factors except for Clarity of solar regulations and property rights.

Table 6. Descriptive statistics of nine social, economic, and environmental factors

Factor interpretation	No. of items	All groups mean (SD)	Skewness	Cronbach's alpha
C2P construct (KMO score = 0.65)				
1 ~ External support presence	4	3.51 (0.67)	-0.95	0.73
2 ~ Clarity of solar regulations and property rights	3	2.91 (0.74)	0.22	0.69*
3 ~ Understanding of FITs and RECs	2	3.03 (0.96)	-0.22	0.74
Affordability construct (KMO score = 0.73)				
1 ~ Benefits of cheap renewable energy	8	3.13 (0.80)	-0.52	0.89
2 ~ Security of investment risk and uncertainty	3	3.21 (0.72)	-0.34	0.69*
CEOS (KMO score = 0.83)				
1 ~ Environmental preservation and protection	8	3.87 (0.67)	-0.29	0.88
NEPS (KMO score = 0.86)				
1 ~ Recognizing environmental consequences	5	3.60 (0.80)	-0.43	0.88
2 ~ Recognizing social-ecological conflict	6	3.41 (0.75)	-0.14	0.84
3 ~ Shift from human-centric perceptions	3	3.73 (0.82)	-0.82	0.80

*Cronbach's alpha < 0.70

Note. These latent variables are composites of two or more survey items. Scores range from 1 to 5. Rather than interpreting them on the 5-point Likert Scale, high scores represent strong alignment with the factor interpretation, low scores represent weaker alignment (5 = STRONG; 3 = MODERATE; 1 = WEAK).

None of the mean scores reveal strong alignment with any factor interpretation. Instead, these means are interpreted as passive results, and indicate surface level meaning. In addition, Understanding of FITs and RECs and Benefits of cheap renewable energy

achieved relatively moderate scores. Highest scores for all adopter groupings are found in the environmental construct. Together these means show that our respondents are generally above average in terms of their environmental consciousness and concern, but there is less agreeability regarding more social and economic dynamics of solar PV innovations. Each latent variable is carefully checked for homogeneity of variance and normality assumptions. Following tests of these assumptions, we conclude that these data are non-normal, however four of the nine variables pass the homogeneity of variance tests using Levene's and Welch's tests. Histograms of these latent variables can be found in Appendix B-2. We suspect that some scores in each of these nine latent variables are significantly different across the three solar PV adopter groupings. To test this, a one-way ANOVA was performed, and the mean scores across solar PV adopter groupings for each of the nine latent variables, with p-values for each one, are illustrated in Table 7.

Table 7. One-way ANOVA between solar PV adopters and non-adopters

	Adopters	*Non-adopters*		
Factor (N respondents)	Solar PV adopters	Solar PV potential adopters	Solar PV non-adopters	*p-value*
External support presence* (60)	3.86 (21)	3.36 (20)	3.28 (19)	*0.010*
Clarity of solar regulations and property rights* (65)	3.22 (22)	2.74 (22)	2.76 (21)	*0.047*
Understanding of FITs and RECs (67)	3.18 (22)	2.93 (23)	2.98 (22)	0.666
Benefits of cheap renewable energy** (58)	3.59 (21)	3.09 (21)	2.59 (16)	*0.000*
Security of investment risk and uncertainty* (60)	3.65 (21)	3.11 (22)	2.78 (17)	*0.000*
Environmental preservation and protection (56)	3.90 (20)	3.83 (19)	3.89 (17)	0.941
Recognizing environmental consequences (53)	3.60 (19)	3.73 (17)	3.48 (17)	0.673
Recognizing social-ecological conflict (52)	3.44 (18)	3.50 (18)	3.27 (16)	0.669
Shift from human-centric perceptions (51)	3.70 (18)	3.84 (17)	3.65 (16)	0.780

Note. The factors external support presence, clarity of regulation and property rights, benefits of cheap renewable energy, and security of investment risk and uncertainty are significant at the $p < 0.05$ level.
**Levene's test for homogeneity of variance: $p < 0.05$
*Welch test: $p < 0.05$

The one-way ANOVA results indicate that four latent variables – External support presence, Clarity of solar regulations and property rights, Benefits of cheap renewable

energy, and Security of investment risk and uncertainty – were significantly different. The Understanding of FITs and RECs factor, along with each of the factors in the Environmental Stewardship construct (i.e., CEOS and NEPS scales), indicated no significant differences between adopter grouping. Furthermore, PV adopters recognize the benefits of solar PV, finding solar PV distributed generation investments to be affordable, not risky and uncertain. Potential and non-adopters of solar PV are decreasingly influenced to adopt, and are significantly different from solar PV adopters across these four factors. Unsurprisingly, solar PV potential and non-adopters do not perceive investments to be affordable. PV distributed generation perhaps invites significant risk and uncertainty, determining alternative courses toward sustainable energy consumption among commercial and industrial users. Furthermore, potential and non-adopters weakly feel the presence of external support, and are not well informed of PV property rights, regulations, and policies.

Sociodemographic findings indicate no significant differences across adopter groupings. This includes age, gender, race, level of education, and number of employees at each establishment (see Appendix B-3). This result was expected and is not surprising due to the constraints brought by a small sample size. Nominally coded items measuring political ideology and industrial sector indicated proportionate political ideology across adopter groupings, but disproportionate industrial sector represented. There were insignificant differences found in the industrial sector variable between each adopter grouping, however, manufacturing stands alone as the most frequent industry indicated in the demographic portion of the survey; all others were represented only to a minor degree. Besides manufacturing, some of these minor representations include

professional, scientific or technical services, retail trade, and forestry, fishing, hunting or agricultural support. Industries represented, predominantly manufacturing sector, are indicative of the observable presence of manufacturing, dairy and agriculture, and science and technically skilled firms presently in business in Wisconsin's commercial and industrial sectors of the state-wide economy. These demographics are not, however, generalizable, to the entire commercial and industrial base in Wisconsin.

2.3.2. Regression analysis results

Rather than three adopter groupings, to simplify the logistic regression analysis, our solar PV adoption behavior is broken down into a dichotomous or binary adopt/non-adopt dependent variable (0 = NON-ADOPT; 1 = ADOPT). Proxies for this model are the nine factors extracted from the factor analysis earlier. Each is shown on Table 8.

Table 8. Correlation between solar PV adoption and nine composite factors

n	Variable	EPP	CONS†	RSEC†	SHUM†	BEN	INVRU†	ESP	CLAR†	FITR
72	SOLPV	.03	.00	.03	-.03	.43**	.46**	.38**	.31*	.11
56	EPP	1.00	.41**	.40**	.50**	.19	.24	.05	.15	-.02
53	CONS†		1.00	.66**	.51**	.28*	.04	-.03	.08	-.02
52	RSEC†			1.00	.49**	.22	.14	.01	.00	-.09
51	SHUM†				1.00	.28	.21	.03	.05	-.13
58	BEN					1.00	.59**	.20	.01	.00
60	INVRU†						1.00	.43**	.31*	.13
60	ESP							1.00	.41**	.20
65	CLAR†								1.00	.36**
67	FITR									1.00

**Significant at the $\alpha = 0.01$ level

*Significant at the $\alpha = 0.05$ level

†Item deleted from further regression analysis

Note. SOLPV = solar PV adoption behavior (0 = NON-ADOPT; 1 = ADOPT); EPP = environmental preservation and protection; CONS = recognizing environmental consequences; RSEC = recognizing social-ecological conflict; SHUM = shift from human-centric perceptions; BEN = benefits of cheap renewable energy; INVRU = security of investment risk and uncertainty; ESP = external support presence; CLAR = clarity of solar regulations and property rights; FITR = understanding of FITs and RECs.

We are interested if these composite factors indeed predict solar PV adoption behavior for commercial and industrial electricity consumers. We performed an initial correlation

of the dependent and independent variables (see Table 8). Before proceeding with the binary logistic analysis, we must first eliminate those variables with questionable intercorrelation (above .50), as multi-collinearity is not desirable. Through an iterative process, we eliminated five factors, landing on four potential predictors of SOLPV in this case. These are EPP, BEN, ESP, and FITR. Items eliminated from the model are indicated with daggers in Table 8 as well. Correlation between these four variables indicate acceptable levels of correlation for model fit. Results of the initial correlation suggest that BEN and INVRU positively correlate with SOLPV at a moderate level, reporting correlation scores of .43 and .46 respectively. This finding is synonymous with our factor analysis above. A positive correlation of .59 BEN and INVRU indicates collinearity. Similarly, SHUM and RSEC correlated with each other at .49, as does CONS and RSEC. Unacceptable intercorrelation between CONS, RSEC, SHUM, INVRU, led us to subsequently omit them from further analysis. The variable CLAR indicated some minor correlation with the variables FITR and INVRU. We conducted two logistic models, one that included CLAR, and one that did not. Since the model without resulted in an observably stronger Hosmer-Lemeshow test (.161 with CLAR, .841 excluding CLAR), we report our binary logistic model excluding CLAR, and including four predictor variables.

Results of the binary logistic regression, shown in Table 9, list each predictor variable, along with each's reported coefficient (B), significance (Sig.), and odds ratio (Exp(B)). The model indicates that two composite factor, BEN and ESP, are statistically significant predictors of solar PV adoption. The positive B values, 1.495 and 1.738, tells us that solar PV adopter firms (coded '1') scored higher than non-adopters (coded '0') on

the eight items embedded in the factor BEN, and the four items that comprise the factor ESP. Recall that the eight items in BEN include: 1) Solar energy will become cheaper than oil and natural gas, 2) Solar PV systems are affordable, 3) Solar PV is not the best available technology for our firm to be self-sufficient, 4) Solar PV benefits outweigh the costs, 5) The payback period on a solar PV system is too long, 6) Increasing oil and gas prices support the use of solar PV, 7) A solar energy system is not suitable for our firm's location, and 8) Solar PV investments are risky.

Table 9. Predictive influence of four composite factors on solar PV behavior using binary logistic regression (N = 72)

Predictor	B	Sig.	Exp(B)
Benefits of cheap renewable energy	1.495	.011*	4.458
External support presence	1.738	.023*	5.685
Environmental preservation and protection	-.312	.565	.732
Understanding of FITs and RECs	.099	.778	1.104

*Significant at the $\alpha = 0.05$ level

Note. Cox & Snell R^2 and Nagelkerke R^2 reported 0.28 and 0.38 respectively, indicating a range of 28% to 38% variation in the model. The Hosmer-Lemeshow goodness of fit test indicated a score of 0.841. This indicates a clear goodness of fit.

The four items in ESP include: 1) State-wide institutions and organizations provide reliable support when we need it, 2) When our firm needs help with any energy technology we do not have trouble finding it, 3) Our firm's energy provider provides unreliable support when we need it, and 4) At our firm, we do not feel a strong and supportive presence of a community of information regarding sustainable energy. The factors EPP and FITR did not report significantly in the model here, and are not considered predictors of solar PV adoption behavior with statistical certainty. Issues regarding solar PV system price, non-adoption alternative costs, payback period, site suitability, as well as costs vs. benefits weighting, are all necessary pre-conditions that must be estimated and resolved prior to acceptance of solar PV technology for

commercial and industrial firms in Wisconsin. Failing to visualize the benefits using these eight indicators as a measurement of behavior intention likely results in departure from considering solar PV technologies. In addition, reliable IOUs and organizational support, ease and access to assistance with technology, and felt presence of a community of information, also predict solar PV adoption behavior. Without the assistance and felt presence of external agencies and stakeholders in decision-making that concerns sustainability investments, negatively impacts acceptance of solar PV distributed generation. Although these two composite factors support our earlier findings, more research is needed on human dimensions of these factors to better explain social and economic drivers of solar PV diffusion. This might include policy and institutional arrangements, trust, price, or place-based thinking.

For the stepwise regression procedure, we started by pooling all 69 survey items and demographic questions together. These are the independent variables we are examining to predict solar PV adoption behavior, rather than composite factors. We carefully omitted question items that reported tolerance scores below 0.7, as this was the metric used in the analysis for estimating multi-collinearity. The result was a four-step model from a pool of 37 predictors, expressing low collinearity. No more than 4 independent variables comprise our stepwise regression models. From the correlation scores shown in Table 10, SOLPV moderately correlates with the variables RISK and JOY, RISK being the strongest between the two with a correlation of .538. Intercorrelation between independent variables is negligible in this case here. Table 11 contains each of the four steps in the regression model, where each step indicates the additive variable to those variable(s) from the previous step. In addition, R^2 and R^2

change values indicate the percentage of model variability explained from one model to the next, F_{Change} values indicate each independent variable's level of contribution to the model, and overall model significance is indicated in the far right column. Results of the stepwise regression shown in Table 11 indicate 4 potential models that predict SOLPV.

Table 10. Correlation between solar PV adoption and four predictors

n	Variable	RISK	JOY	EDU	SPRAC
72	SOLPV	.538**	.331**	.077	-.102
60	RISK	1.00	.040	-.189	-.037
59	JOY		1.00	-.256	.095
56	EDU			1.00	.239
68	SPRAC				1.00

**Significant at the $\alpha = 0.01$ level

*Significant at the $\alpha = 0.05$ level

Note. SOLPV = solar PV adoption behavior (0 = NON-ADOPT; 1 = POTENTIALLY ADOPT; 2 = ADOPT); RISK = solar PV investments are risky; JOY = I do not feel a sense of enjoyment with our firm's energy choices; EDU = what is your highest level of school you have completed or the highest degree you have received; SPRAC = does your firm regularly implement sustainability practices.

As the number of variables added to the model 'step' increase, so does the model variability explained. It follows then that F_{Change} values and model significance generally get smaller with each additional step. Selecting a 'parsimonious' model is the rational goal here, since the fewest number of predictors of the dependent variable is desirable.

Table 11. Predictive influence of four predictors on solar PV adoption behavior using stepwise regression analysis (N = 51)

Step	Predictor	R^2 / R^2 change	F_{Change}	Sig.
1	Solar PV investments are risky	.330 / .330	18.232	.000*
2	I do not feel a sense of enjoyment with our firm's energy choices	.444 / .114	7.394	.010*
3	What is your highest level of school you have completed or the highest degree you have received	.554 / .110	8.602	.006*
4	Does your firm regularly implement sustainability practices?	.617 / .063	5.587	.024*

*Significant at the $\alpha = 0.05$ level

A number of variable combinations, thus distinct models, are possible in multiple linear regression. The advantage of a stepwise procedure is that the procedure starts with the predictor with the largest F statistic. Then, in the forward process, the regression

eliminates variables with zero slope. Variables with strong partial F statistics are added to the model, refitting and eliminating at each step as the model(s) are built. B values are not reported yet because each step produces distinct coefficients for each model. Coefficients of each variable in each step showcase positive values predicting SOLPV by RISK, JOY, and EDU. However, only SPRAC indicated a negative value. We select the regression model at step 4 so that positive and negative relationships are visible in predicting SOLPV, and we regard this as our most parsimonious model, seen below.

Theoretical predictive model:

$$\textit{Solar PV YES Adopt} = \beta_0 + 0.630(RISK) + 0.398(JOY) + 0.283(EDU) - 1.004(SPRAC)$$

According to the theoretical model, RISK is the most powerful predictor of SOLPV, while JOY and EDU are more moderate. The negative coefficient in the predictor SPRAC indicates that the implementation of sustainability practices metric is a disincentive for predicting SOLPV. This tells us that diminishing perceived risk in solar PV investments is the coercive factor driving solar PV adoption. Higher education status also contributes to likelihood of adopting, but surprisingly sense of enjoyment in choice of energy strategy is a slightly stronger factor than level of education. How do solar PV adopters and non-adopters differ regarding perceptions and attitudes toward their own firm's energy strategies? The mean score reported by adopters to this "sense of enjoyment" question item indicated a 4.05, compared to potential and non-adopter group means of 3.10 and 3.24 (see Appendix B-1). Recall that this question item was negatively worded, and thus reverse scored, showing that adopters were above the level of 'agree' with this metric, and non-adopters were just above 'neutral.' We think internal perceptions and employee attitudes of their firm's energy behavior can be potentially

measured by using sense of enjoyment as a barometer. Adopters appear to be more satisfied by their firm's choices, compared to non-adopters who appear less satisfied. Regular implementation of sustainability practices is the only independent variable in the model to have a negative coefficient. The item "Regularly implement" is also a binary independent variable (0 = NO; 1 = YES). According to the raw survey data, two respondents, a solar PV adopter and potential adopter responded 'no,' while four respondents responded with 'maybe.' Of those, there were two non-adopters, one potential adopter, and one adopter. The original scale originally included a 'maybe' response, but these data were omitted because we cannot confirm with great certainty that the interval between 'no,' 'maybe,' and 'yes' are identical. We proceeded to transform this variable into a dichotomous variable. With the exception of 'maybe' and 'no' responses, all others answered 'yes' to this question item, adopters and non-adopters.

Generally, survey respondents are members of programs that promote commercial and industrial sustainability practices and extensive environmental standards. It shouldn't be surprising that an overwhelming majority of respondents indicated 'yes' to this question item. However, we think this variable might be masking the involuntary respondent interpretation of the meaning of sustainability. Not only does this term "sustainability" have a plethora of definitions, but it can be measured using any number of complicated criteria, not to mention actual behavior (Spaargaren, 2003). Owing much to those researchers and social-science practitioners in the sustainable community development field, human perceptions and attitudes of sustainability is an issue of disunity, and is more accurately estimated along a continuous scale or gradient, rather than a binary scale. Furthermore, these human dimensions of sustainability behavior are

also influenced by context and conditions of the setting. In this case, survey respondents employed by commercial and industrial firms are effected by various patterns and characteristics of the market economy. Typical measures of economic strength might include job and value creation, local and regional unemployment and poverty measures, even the size and scale of business operations and the number of new entrepreneurs. More complex ones include currency, inflation, even the price of oil. More to the point, the disunity in defining what sustainability practice exactly is per say, can be resolved by defining strong versus weak sustainability, and focusing on human dimensions of natural and non-natural capital, price, free and imperfect markets, policy regulation, tradeoffs, and scale and accessibility to public good (Hendrickson et al., 2011). Without explicit data on how respondents interpret and behave with respect to these conditions, we do not understand how sustainability is interpreted with enough certainty. Overall, the negative B might correlate with weak sustainability, as economic forces tend to coerce decision-making rather than social or environmental motivation, but more research needs to be done to begin to pull apart these complexities and diffuse understanding of them.

Of the two models in the regression analysis, we think the stepwise model has the most explanatory power at predicting solar PV adoption behavior for commercial and industrial firms. For a dichotomous dependent variable, binary logistic regression makes the most sense in terms of data input, but in comparison to the stepwise model, the logistic model doesn't have the level of meaning that the stepwise model possesses. However, it is vital to take caution with the stepwise model because it shows signs of overfitting and makes one too many assumption violations. Further research can help

illustrate more concrete findings by providing stronger data that either support or refine the model in this part of the study.

2.4. Discussion

The objective of this research is to explore those non-influential and influential determinants of solar PV adoption behavior, and to explore challenges and barriers from a conceptually broader scope of energy transition efforts, not exclusive to solar. From the findings earlier, what do they suggest and how do they contribute to understanding energy user behavior and technology diffusion? We think the findings in the C2P and Affordability constructs earlier are passive, and unsurprising. But they succeed at illustrating positive and negative social and economic influences on solar PV diffusion within commercial and industrial firms in Wisconsin. Differences between each adopter group do not appear to pertain to environmental factors. Perhaps this is due to the fact that the Green Tier and Green Masters programs, as well as the RENEW Wisconsin organization, emphasize – certainly they require – that all member firms conscientiously monitor and strive for high environmental compliance in their energy consumption, waste, and pollution mitigation efforts, independent of solar PV adoption status. Determinants of solar PV adoption behavior in this part of the study are not ecological, but rather social and economic in nature. Solar PV adopters appear to be influenced positively through external support, acknowledging clear solar PV property rights and regulation policies. The learning curves associated with each solar PV adoption step, not to mention external stakeholder resources and personnel, are necessary for successful adoption, solar installers being one necessary resource. It should not be surprising then that adopter perceptions and knowledge of upfront costs, risk and uncertainty in the

decision processes are more extensive, and optimistic, than potential or non-adopters, tending to be more pessimistic. External support structures – formal and informal – are necessary to deliver financing, technical, and policy information directly affecting solar PV owners, lessors and lessees, or potential adopters collecting data and information. Non-solar PV alternatives, such as lighting, heating and cooling, weather stripping and temperature regulation, building efficiency improvements, and other minor sustainability behaviors such as recycling and material re-use, might not require such extensive social networking, internal opposition and negotiation, or policy driven data in terms of cost-benefit implications, nor complexity. Non-solar PV alternatives are regarded simply as the "low hanging fruit" that produce measureable improvements that make sense and whose benefits are seen more immediately. These findings contribute to surface level understanding of solar PV diffusion, revealing some similarity with domestic energy users, but the data are less revealing of other non-solar PV efforts. These dimensions and barriers are discussed further in the second paper. The data appear to be consistent with previous work on domestic solar PV adoption behavior (Vasseur & Kemp, 2015a; Schelly, 2014b; Labay & Kinnear, 1981) and general innovation diffusion theory (Rogers, 2003); however more research is needed on solar and other distributed generator and energy efficiency technology diffusion, specifically toward demand-side management.

2.4.1. Hypothesis testing

H_1: *On the basis of social, economic, and environmental influences and barriers, solar PV adopters, potential adopters, and non-adopters in commercial and industrial sectors do not differ.*

Our findings demonstrate that adopters and non-adopters of solar PV differ on the

basis of a few social and economic factors, but not on environmental factors. Specifically, adopters and non-adopters can be differentiated by presence of external support, understanding of solar regulations and property rights, investment risk and uncertainty, and, most importantly, benefits of solar PV distributed generation. Environmental indicators such as preservation and protection, understanding of social-ecological conflict and environmental consequences, and shifting away from human-centric perceptions did not distinguish adopters and non-adopters. Thus, we partially reject this hypothesis.

H_2: *The influence of social, economic, and environmental dimensions is asymmetrical for predicting commercial and industrial solar PV adoption behavior.*

Factor and regression analysis demonstrate that social and economic factors influence solar PV adoption behavior more strongly than environmental motivators. However, even for a relatively long survey, the entire breadth of social and economic dimensions are not examined. Follow up analyses pursuing more on the economic and social dimensions side of actor behavior toward energy and sustainability can introduce more indicators to see how independent variables relate with one another. For now, we fail to reject this hypothesis, but on a partial basis.

H_3: *Independent psychosocial dimensions, between social, economic, and environmental groups, are not exclusive nor deterministic of solar PV adoption behavior.*

Factor and regression analysis appear to support asymmetrical influence on adoption behavior stated earlier, but do these different influences interact or are they exclusive? And, do they express determinism for predicting solar PV adoption behavior? This hypothesis is directly linked to the strength of prediction in the regression analyses, and how well assumptions and limitations are addressed in developing both logistic and

multiple linear regression models. Although we are conscious of variable independence, accounting for multi-collinearity, we believe these models are not deterministic of solar PV adoption behavior with statistical confidence. In addition, we do not feel these models meet minimum acceptable violations. These assumptions and limitations are explained further below. Therefore, we fail to reject this hypothesis.

2.4.2. Survey methodology limitations

It is important to not just demonstrate strengths of these findings here, but also weaknesses too, in the form of limitations and generalizability. We made three observations following collection and examination of our survey data: 1) proportionate numbers of solar PV adopters, potential adopters and non-adopters sampled, 2) satisfactory diversity of industries represented – although manufacturing was disproportionately dominant with minor contributions from other industries including retail trade, scientific and technical services, and forestry and agriculture – and 3) we were able to test, even include, some of our own survey items into the factor analysis, without overreliance on validated scales only. More specifically, replication and validation studies are necessary for testing and refining scales for various measurement tools and reliable question items towards complex human dimensions. Some of these include place-based thinking and trust. Developing new items and testing them not only refines the construct meaning, but expunges items that compromise the reliability of the indices. This last strength is encouraging; there might be a basis for novel scale development regarding affordability and energy user social networks using some of these question items outlined in Appendix B-1.

Weaknesses of these findings are summarized by data collection and data analysis stages. During the survey instrument development process, there is a risk taken when developing specific question items that have not been previously replicated and validated. Further research performing replication and validation of the social and economic constructs outlined in Appendix B-1 will help refine and strengthen the usefulness in future studies. Another challenge in the data collection stage occurred upon learning that accessibility to member information in both Green Masters and RENEW Wisconsin program datasets were limited; this limited our ability to recruit survey participants through a uniformly Dillman Method approach. To combat this, we recruited survey participants in the RENEW Wisconsin dataset by phone, and worked with the Green Masters program director to recruit participants for us via email. Green Tier member contact information was public, and therefore full Dillman Method was achieved. In addition, since some program member contact data was private and inaccessible, we have no reliable estimate of how large our population was. Complicating matters further, ongoing member recruitment, which is held annually, and unreliable estimates of members who opted out of the Green Masters program are also unknowns that we were unable to negotiate. These were unforeseen circumstances that we had to cope with as best as we could during the data collection stage.

Survey professionals are particularly bothered by how few published studies explain sources of error and strategies to account for them (Lindner, Murphy, & Briers, 2001). For this part of the study, it is important to avoid the pitfall that is a failure to discuss error associated with this survey data. There are four main sources of error found in survey data: coverage, measurement, sampling, and nonresponse error (Dillman et al.,

2014). Following screening, data indicate representation across solar PV adopter groupings. While question items reflect a mix of validated and invalidated scale items, factors reported include sufficient alphas, and scales include sufficient Kaiser-Meyer-Olkin scores, indicating minimum satisfactory measurement standards. Therefore, we are not suspicious of positive contributions to error from coverage and measurement. We are suspicious however of sampling error and nonresponse error. Pertaining to the study, sampling error suggests significant differences between estimates produced by a small sample of solar PV adopters and non-adopters, compared to a situation where all members of the population are sampled. Nonresponse error suggests that sampled survey respondents are different from those that did not respond (Dillman et al., 2014). Unfortunately, we cannot do anything about the sampling error in this part of the study; although we are encouraged by a more than 19% response rate, this is not sufficient. We have concerns that our data are not generalizable to the greater population of member firms in the Green Tier, Green Masters and RENEW Wisconsin organizations collectively. However, we can account for nonresponse error. There are a few strategies for handling nonresponse, such as using "days to respond" as a regression variable, or collecting a random sample of non-respondents and comparing to respondents; this is the most often used method, and some are used in combination. Instead, we used a simple extrapolation method, and compared early respondents to late respondents (Armstrong & Overton, 1977). The two assumptions here are 1) "early" and "late" respondents have operational definitions, and 2) "late" respondents are similar to non-respondents. We do this by applying a boundary, bifurcating our data into early and late respondents based on an arbitrary date, operationalizing early respondents from late respondents (Lindner et al.,

2001; Miller & Smith, 1983; Armstrong & Overton, 1977). We performed a one-way ANOVA across our early and late respondent groups. No significant differences are found between early and late respondents, reducing suspicion over the effect of nonresponse error on our findings. Also, we learned in the middle of survey data collection that Green Masters members – and non-members – are required to take a survey for placement in one of three tiers: apprentice, professional, and master. We learned that this was also a fairly long survey, similar to the instrument designed for this study. We calculated an average survey completion time, including the likelihood of leaving a cell phone or computer while the browser is still active – this is indicated by abnormally long survey completion times compared to the test pilots – at just over 30 minutes. Negative perceptions of this additional survey instrument for this study, alongside the length and additional reporting duties required by member firms, likely helps justify the uninspiring response rate achieved.

2.4.3. Regression limitations

Several limitations are important to highlight regarding our regression analysis steps taken earlier. These limitations are found in key assumptions required of both logistic and multiple linear regression models. Recall that the assumption of normality in our data was violated, and the assumption of homogeneity of variance was violated except for four of the nine composite factors extracted from the factor analysis. In addition, several important assumptions must be met for regression models, which include (a) independence of residuals, (b) considerations using continuous versus categorical data, and (c) linearity of data between the dependent variable and the independent variables in the model(s) (Quinn & Keough, 2002). To simplify this part of

the discussion, we break these assumption implications down between logistic and multiple linear regression models respectively.

In the binary logistic model earlier, assumption violations lead us to have increased suspicion of the predictive power of the model. First, according to Table 8, our nine composite factors illustrate some minor signs of correlation between each other, which is undesirable in this case. The worst is the significant correlation between CONS and RSEC which scored a .66. We dealt with these, and other variables with unacceptable correlation, by omitting factors with correlation above 0.50 according to the correlation matrix produced. Next, according to linearity diagnostics produced in SPSS, the four environmental factors appear to have a non-linear relationship to the dependent variable solar PV adoption, however, the five factors extracted from the social and economic constructs appear to be linear, but this relationship is weak. Violation of variable linearity is an important weakness we take notice of in the logistic modelling procedure. A binary logistic model is a rational next step following factor analysis as the independent variable in this case is dichotomous, and our independent variables can be either continuous or categorical. We observed two significant factors in the logistic model, BEN and ESP. As dual proxies for solar PV adoption behavior, this result was not surprising as these were demonstrated as influential factors earlier, showing that they differentiate adopters, potential adopters and non-adopters according to the one-way ANOVA. As an additional step in the regression, to help circumvent the poor predictive power this model seems to make, we moved on to a multiple linear regression procedure using a stepwise approach.

Rather than composite factors, we followed our logistic regression step with a stepwise regression analysis that models based on individual items from our survey. Residuals (i.e. error terms) plotted in the stepwise procedure indicated homoscedasticity, and a generally linear trend, but they do not appear to be normal. Similar to logistic regression, independent variables can be either continuous or categorical. But an important stipulation in multiple linear regression is that the dependent variable must be continuous. This raises some troubling barriers with the data collected. In the logistic model, a binary decision was used as the ordinal scale for the dependent variable. In the stepwise model, we treat the "potentially adopt" data as a distinct treatment making the scale more continuous. However, this should not be synonymous with stronger reliability, as the interval between non-adoption, potential adoption, and adoption, are not identical. Furthermore, assuming 5-point Likert scales – even 7 or 9-point Likert scales – as continuous rather than ordinal assumes that the variability of intervals between levels in each independent variable are approximately equal. But this is a tough assumption to make, and can only be made with a limited amount of certainty. In short, for our data in this part of the study, binary logistic regression makes more sense than does stepwise, but the predictive power between the two models helps gauge different levels of explanation they possibly provide on solar PV adoption behavior for corporate and industrial users. Rather than one single composite factor, four independent variables predict adoption behavior in the stepwise model. Table 10 shows no independent variables that are highly correlated with one another. But, the predictive power of a linear regression here could be compromised by variables that express multi-collinearity (Quinn & Keough, 2002). To account for this, independent variables reporting tolerances less than 0.70, indicating

signs of collinearity, were omitted from the model, leaving only predictors that are not highly correlated with one another. Based on a model using distinct question items, our stepwise model is held with suspicion as it violates a number of key assumptions.

Together, assumption violations, small sample sizes, and limited number of observations hamper the predictive power of both regression models here. We need a larger n to be more confident with the results produced from both models. We think that R^2 values reported in Tables 9 and 11 are unreliable estimates, as these values and effect sizes overestimate model variance explained, increasing the risk and suspicion for Type I errors (Algina & Olejnik, 2013; Knofczynski & Mundfrom, 2008). Overall, we think both models indicate overfitting; we interpret our regression findings as spurious (Babyak, 2004).

We must conclude that neither our binary logistic nor stepwise regression models have the level of reliability required to predict with solar PV adoption behavior accurately. Between the two models, we believe the stepwise regression model has slightly better explanatory power, as more than one independent variable was selected from the larger pool of independent variables in their capacity to predict solar PV adoption behavior. We are cautiously optimistic that this model demonstrates some explanation behind solar PV adoption behavior. The affordability and investment risk and uncertainty arguments are supported, but more data and research is needed on sustainability measurement tools and resources, emphasizing a more economics and market dimensions approach to understanding diffusions of distributed generation. Market forces and economic considerations affect investing in future economic performance through energy – addressing natural resource consumption and allocation –

but more understanding of these dimensions is needed, alongside reliable tools to measure and estimate these dimensions in actors and the built environment.

CHAPTER 3: Toward a grounded theory of solar PV technology diffusion

3.1. Literature review

We reiterate the complexity and difficulty in understanding human behavior and decision-making; energy consumers are disparate in their thinking, understanding, and values. Many scientists face difficulty attempting to make sense out of conscious decision-making, not to mention making quantitative and qualitative justifications in their findings. Earlier, we demonstrated that solar PV adoption behavior is largely attributed to social, economic, and environmental factors. However these are constructs enveloping a select group of factors that exercise different levels of influence and power in solar PV adoption behavior. There are unknowns that may inhibit or motivate decision-making. More specifically, these social, economic, and environmental factor groupings are just extensions that fit inside the purview of the more extensive context surrounding both the biotic and the built environment. This literature review specifically explores perspectives and stakeholder relationships in sustainability and energy transition behavior, and we regard the context surrounding human decision-making to foster relevant barriers to not just solar PV technology diffusion, but inflexibility of the context itself. The literature examines several attributes, perspectives, patterns, and barriers of the decision-making context, in the biotic and built environment. We review supporting literature that covers decentralization of the energy infrastructure and carbon lock-in, stakeholder theory and attitude-behavior relationships, sustainable business practices, and finally barriers and barrier removal in solar PV technology diffusion and adoption.

3.1.1. Decentralization and carbon lock-in

As mentioned earlier, energy policy represents the bulwark of legal frameworks and governance that dictate provisions and interventions of the energy infrastructure. This portrayal has been one of several central components of research exploring energy transitions at the macro- and micro-scale (Geels & Schot, 2007). Like many innovations, especially tangible technologies such as computers, motor-vehicles, military weapons, even television and the provision of entertainment services, successful innovations meet their end as a result of ongoing RD&D, innovation and market takeoff, and ultimately consumer divestment of the old, and investment in the new. The large and aging energy infrastructure known as the grid, is an innovation that continues to transcend generation after generation. The grid is the edifice of the provision of energy; by extension, the provision for the provision of services inherent in American lifestyles, sporting seemingly limitless electrical power serving both wants and needs in every consumer demand profile. In short, the provision of energy – the grid – and the provision of services – the innovations that are mechanical consumers of energy – alongside the consumers of the services – humans – are justifiably and seamlessly interlaced with one another. From this perspective, two important contextual properties can be expanded upon that explain energy consumer behavior and barriers therein: decentralization, and what is commonly known as "carbon lock-in."

Centralized and decentralized structures are different regarding ownership, in that centralized structures such as IOUs or MOUs are owned by investors, and decentralized structures such as electric cooperatives are owned by their community members. These aren't the only differences. The grid is a conglomeration of different IOUs, MOUs, and

electric cooperatives, expressing complex patterns of centralized and decentralized structures, whose geographic market territories, energy security, and energy consumers, are markedly different. Relating to the devolution of decision-making, governance taking place in decentralized systems tends to boost participatory activities of average community members (Howard, 2014). Demonstrated successfully in Germany (Yildiz et al., 2015; Yildiz, 2014), decentralized systems promote strong sustainability with more mobile and informed energy consumers, cooperative relationships serving needs and distributing benefits equally to all member-owners. Their success is based upon using mixes of raw resources for energy generation, emphasizing renewable resources such as wind and solar PV. These qualities express stability, resilience, and overall higher energy security compared to decentralized structures. It is important to note that while centralized systems express lower energy security by comparison. This evidence can be found in the lopsided dependence on fossil fuels, tendencies to unfairly distribute benefits to special interests and investors, and whose costs and externalities are socialized to consumers locked into patterns of behavior to supplant short-term profit margins of the energy enterprise. But evidence also shows that centralized structures are improving. Some parts of the grid are seeing improvements through more diverse mixes of energy resources, reduced costs and grid loss in transmission with smarter innovations, and integration of monitoring devices such as Phasor Measurement Units, which measure synchrophasors in the grid helping detect and prevent critical widespread faults and power outages. The context of the grid reveals that market conditions and policy landscapes are biased against decentralized systems, favoring established technologies like conventional fossil fuel fired power plants, and policies discourage decentralization,

essentially creating trade barriers, and contributing to the ongoing failure to internalize externalities resulting in market distortions (Yaqoot, Diwan, & Kandpal, 2016). Rogers (2003) agrees with these findings, adding differences such as higher levels of adaptation, peer-to-peer diffusion, and experimentation and reinvention by non-experts in more decentralized systems, compared to centralized systems that sees observably lower levels of adaptation and re-invention, and more formal, 'top-down,' command and control approaches decided by administrators rather than local social groups (Rogers, 2003).

Often, studies regard the grid as an impregnable system, one that is largely inflexible and incapable of being shaped by even the most mobile and informed energy consumers. Given the slow rate of change, decentralized structures have flourished, resulting in patterns of energy consumer divestment from large IOUs, and investment in local electric cooperatives that are more responsive to, and offering more tailored solutions to, local needs. These characterizations have led scientists and technical experts to refer to large utility-consumer relationships as carbon lock-in behavior (Goldthau, 2014; Radloff & Dhungel, 2013). In the context of energy consumption behavior at all levels, energy consumer behavior that is tied to investor owned utilities is essentially pre-disposed to be unlockable in the sense that behavior will not change since the coal, natural gas and nuclear power plants – not to mention permit extensions – leave consumers no choice but to remain customers to those utilities. Along the same lines as the provision of clean drinking water, sewage systems and storm drains, transportation, food supermarkets, restaurants, and brand-name enterprises, the modern energy infrastructure is embedded in society of developed worlds, omnipresent, and so heavily interwoven that in context, the relationship between large utilities and energy consumers

is co-dependent, or sometimes referred to as "stickiness" (Goldthau, 2014). Studies have explored niche innovation development – innovative technology incubators including wind turbines and solar PV – and transition pathways by using multi-level perspectives and policy vehicles to understand interactions, obstacles, and forecasting potential outcomes by exploring the nature of niche innovations to transition energy systems (Geels & Schot, 2007; Ratinen & Lund, 2015). Altogether, centralized IOUs are maintaining patterns of carbon lock-in among energy consumers, while decentralized energy systems are emerging as meaningful renewable alternatives. Could it be that decentralization is the key vehicle for barrier removal and freeing consumer carbon lock-in behavior? Decentralized energy infrastructures are innovative in their own right, but face difficulty in the context of conventional decision-making and consumer energy behavior in the present day built environment. In a world dominated by consumers unavoidably glued to centralized energy infrastructure, we are beginning to see more and more evidence highlighting the benefits of decentralized energy installations such as solar PV distributed generation, especially in Western Wisconsin.

3.1.2. Stakeholders and attitude-behavior relationships

While the central function of individual behavior is to form rational justifications to direct actions, the pre-dispositions and patterns of cognitions, forming the foundation of decision-making behavior, is especially crucial in decision-making. There are three theories that explain how to interpret and navigate human behavior relevant for review: stakeholder theory, Theory of Reasoned Action (TRA), and Theory of Planned Behavior (TPB).

So far, we have used the term 'stakeholder' loosely with negligible explanation of

what the term means, which has been an evolutionary subject of social science research. Early definitions were vague, but grew into distinctly wider and narrower views. The wider view capitulates that stakeholders are those groups or individuals affected by a firm's core objectives, and the narrow view argues that they are those groups or individuals capable of affecting the firm, and who the firm depends upon greatly (Freeman & Reed, 1983). This conceptually makes sense. In this scope, the narrow view targets the stakeholders as employees, investors, special interests, and policy-makers in the energy industry, with the energy consumers, community leaders, advocacy organizations, even the local government agencies on the periphery. By scale, unequal distribution of influence takes place, where heavy influence is relegated to few stakeholders in the narrow sense, and little influence to the majority of stakeholders, especially average energy consumers. These findings were criticized for their ambiguity, and further refined by Mitchell, Agle, and Wood (1997), adding dimensions such as power, urgency, and legitimacy of 'stake,' providing that these attributes are constructed socially, and constantly changing (Mitchell, Agle, and Wood, 1997). To this day, practitioners continue to ask questions about social orders and optimal arrangements of institutions, policies, markets, and industries, to achieve socially desirable outcomes rapidly and efficiently. This has vital implications for energy consumers, since efficient social networks disseminate data and lessons-learned, helping integrate carbon neutral solutions and effectively solve known problems, and protect against novel disturbances. This is called social-network analysis, employing strategies to examine stakeholders by measuring centrality, webs of strong and weak ties, and patterns of homophily and

heterophily which spells out similarities and dissimilarities in stakeholder attributes (Prell, Hubacek, & Reed, 2009; Rogers, 2003).

The works of Ajzen and Fishbein are invaluable resources that help paint the picture of how and why individuals behave the way they do. This partnership has produced countless studies on human behavior theories; among the most important are TRA and TPB, shown together in Figure 4. TRA stipulates that intention is the immediate determinant of overt behavior, which is determined by a person's attitude toward, and the subjective norm concerning, the behavior (Fishbein & Ajzen, 1975).

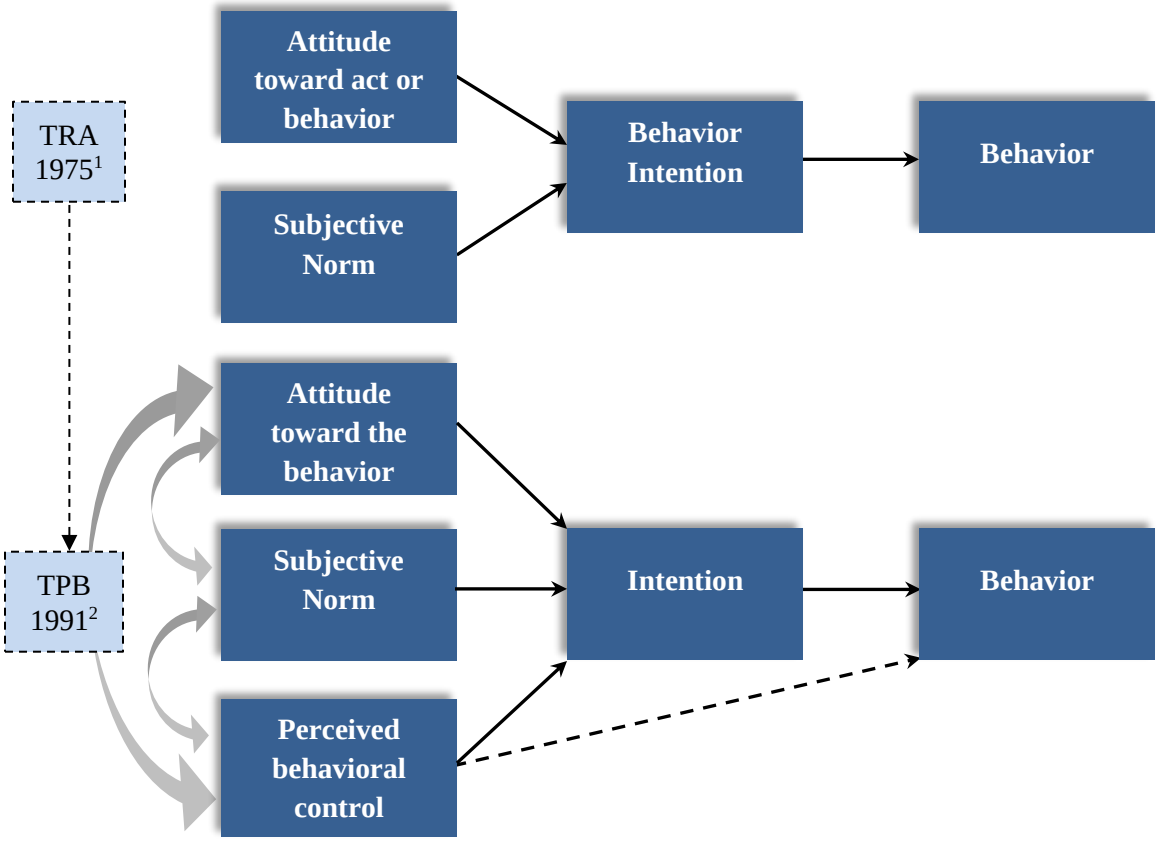

Figure 4. Theory of Reasoned Action and Theory of Planned Behavior

Note. Arrows represent influence and causal relationships.

Sources: [1]Ajzen, I. (1991). The Theory of Planned Behavior. *Organizational Behavior and Human Decision Processes, 50*(2), 179-211.

[2]Fishbein, M., & Ajzen, I. (1975). Belief, Attitude, Intention, and Behavior: *An Introduction to Theory and Research*. Reading, MA, USA: Addison-Wesley.

The authors clarified this by explaining behavior with four key elements: the action/behavior performed, the target of the action, the context in which it occurred, and the timeframe it took place, the latter two variables being the least understood (Ajzen & Fishbein, 1977).

TPB is an extension of TRA. However, TPB states that behavioral intention is attributed to three elements: attitude toward the behavior, subjective norms concerning the behavior, and perceived behavior control, which is a conscious judgment of the ease or difficulty in successfully acting out the behavior at hand (Ajzen, 1991). TPB traces attitudes, subjective norms, and perceived behavior controls back to an underlying foundation of beliefs, which collects, interprets, and guides action, or inaction. Along with behavior intention, each of these features is not just a core element in TPB, but they are also gateways or targets for attack in order to change behavior patterns (Ajzen, 1991). This can be particularly troublesome for social media consumers who are vulnerable to fake news or misinformation campaigns, commonly known as 'astroturf campaigns,' which intentionally disguise sources of information, therefore preying on the naivety of users. Consequentially, this contributes to abusive manipulation of user beliefs and attitudes on many issues in the social media sphere (Ferrara, 2015).

Since Ajzen and Fishbein's work, clarification on the context of attitude-behavior landscapes have investigated cognitive heuristics and risk evaluation of new attitude objects (Stern, Dietz, Kalof, & Guagnano 1995), environmental heuristics (Spaargaren, 2003), and a more specific environmental-based TPB and self-construal, which explores individual's schema toward the self, specifically variability, connectedness, and autonomy preferences (Mancha & Yoder, 2015). Consequently, theories like stakeholder

theory, TRA and TPB are explanatory in understanding social-psychological context of norm, behavior intention and actual behavior formation and roles, and the processes that shape individual cognitive landscapes. Although, countless interpretations, refinements, and reinventions of attitude behavior relationships leave readers with a sense of doubt on clarity of how to examine the internal landscapes of rational decision-makers, relating to a particular line of behavior, such as energy technology adoption. These complexities, however, are not the foci of this paper, but rather, we view these theories as important for exploring stakeholders and barriers in the decision-making processes, simply by asking directly what affects adoption behavior, and what challenges pertain to those processes. We believe some of those potential aspects fall into stakeholder and attitude-behavior camps of empirical evidence.

3.1.3. Sustainable business

Earlier, we illustrated that principles of SEA and CSR indicated socially acceptable and morally virtuous business practices, owing to benefits for the environment, the community, and the practicing business or industry at hand. As some of the most prolific energy consumers, the context of the decision-making unit internal to the business or industry establishment, whether it takes place in teams or by a select few, is an important dimension. It can affect any number of other departments, employees and officers, stockholders or other investors, not to mention bottom lines and profit making capacity in the near and long-term.

Sustainable business models are an attractive opportunity, ushering in both innovation, and challenges that go with it. Following exhaustive discussion, interpretation, and planning, there is need for immediate and obligatory action, alongside

monitoring and evaluation efforts, to treat communities and ecosystems with the highest levels of ethical and environmental standards. Elkington (2004) refers to this as the Triple Bottom Line framework – people, profits and planet – which coincides with social, economic, and environmental standards in the corporate context (Ekington, 2004). From a business or industrial establishment's perspective, this includes a number of different duties such as water conservation and discharge monitoring, waste management and material re-use, logistics and intelligent supply chains, pollution control, public health and emissions monitoring, employee training and job creation. Components more central to this paper include energy efficiency behavior and distributed renewable energy generation integration, such as solar PV. These are the general components that comprise a sustainable business model (Høgevold et al., 2014).

The study by Høgevold et al. (2014) investigated eight Norwegian business models by collecting interview data. These data demonstrate the evolution of five criterion in typical sustainable business models, two of which we regard as important to social-context: social boundaries, which consider the scope and size of a company's sustainability efforts, and organizational challenges, which help identify the extent of involvement from stakeholders. In the process of exceeding environmental compliance and social standards through sustainable business principles, these Norwegian companies revealed contextual change, shifting from internal organizational thinking and myopic challenges to a more external and holistic scope. Furthermore, this study also demonstrated that while the environmental by-products of sustainability were admirable, businesses were particularly proud of their efforts principally based on economic reasons, such as cost savings (Høgevold et al., 2014).

Energy efficiency measures are also an attractive opportunity. When comparing businesses and industries, it is important to note that no individual business or industrial establishment, or entire business or industrial sectors, have identical energy profiles and baseline energy demands. More simplified, think of businesses and industrial establishments in the scope of ancillary vs. auxiliary energy services and needs. Industrial establishments are commonly identified as manufacturers, machining and fabrication, chemical refining, and foundries. Besides intensive electricity needs, these industries require high heat energy input as well. This means that there must be a strong dependence on the energy utility to provide both heat and electricity to sustain operability. Renewable energy generators such as solar PV would have a negligible impact compared to energy efficiency measures, which would help dramatically by mitigating thermal loss and water loss – such as thermally and energy efficient boilers and conversion technologies – and encourage material and resource recovery through re-use and recycling programs (Doris, Cochran, & Vorum, 2009). In stark contrast, business establishments from hotels and lodging, to restaurants, coffee shops, multi-story business firms, office parks, even rural small-businesses, by scale have less demanding energy profiles compared to their industrial partners. The dialogue generally shifts from efficient processes to efficient buildings. Comparable to domestic building energy profiles, a commercial facility's energy expenditures go toward five specific energy services: heating, ventilation, and air conditioning (HVAC), lighting, electronic equipment, cooking and refrigeration/chilling equipment, and water heating (Lave et al., 2009). These services are flexible, and there is more room for effective impact with renewable energy generating capacity and energy efficiency, depending on the business.

In short, literature supports energy efficiency, predicting as much as 30% energy savings by the year 2030, with greatest gains from business and industrial sectors. Furthermore, investment in energy efficiency helps eliminate the need to expand current energy generating capacity in the U.S. However failure for present-day action and implementation of energy efficiency indicates a persistent market and even more persistent obstacles (Doris et al., 2009; Lave et al., 2009). Commercial enterprises and industries are energy intensive consumers, with distinct opportunities for energy efficiency in both systems and processes, and the actual facilities. While difficulties are hard to overcome, policies and programs promoting sustainable business principles and energy efficiency are helping high energy consumers strive to be more conscientious as community members and environmental stewards.

3.1.4. Solar PV barriers and barrier removal

More specific to the diffusion and adoption of solar PV, a rational approach to take is to inventory barriers. This often takes the form of direct barriers, or indirect, implying an interconnected entanglement of distinct barriers with varying degrees of relevance, but whose removal helps the adoption of solar PV move closer to a reality. Stock take of barriers in barrier removal investigations are also in the category of unsurprising studies, in that they are a rational strategy to take in order to achieve more socially desirable outcomes.

Like in many interdisciplinary research ventures, studies can take the form of meta-analyses of topical issues (Sovacool, 2014), replication and validation (Dunlap et al., 2000), or laboratory to field comparisons, something scientists can all agree on is often troublesome with any number of challenges. Investigating barriers and how to

remove them in many research studies is a rational objective toward achieving the more simplistic interpretation of measuring achievement, and is welcome in helping readers understand the big picture in the present day or near future. These studies (Yaqoot et al., 2016; Doris et al., 2009; Reddy & Painuly, 2004; Rogers, 2003; Painuly, 2001) offer a surprising amount of data, spanning market, economic and financial, technical, institutional, political, social and cultural spheres. The literature helps paint a complex picture of how many distinct factors and variables interact with one another, comprising a more holistic understanding of the circumstances and context of the issue. This is especially vital in understating the adoption, diffusion, and obstacles of RETs such as solar PV in circles such as commercial and industrial energy consumers.

3.2. Methods

This portion of the study focuses on the second main research question: What challenges and barriers do Wisconsin PV adopter and non-adopter firms encounter related to sustainable energy or energy efficiency? Following the second to last question item in the questionnaire measuring interest in seeing the results of the research study, the last question item provides a brief statement of purpose urging case study recruitment. A 'Yes' indication in the questionnaire builds the pool of potential cases. More specifically, a case in this study is defined as the individual key informant – implicitly, the distinct business or industrial establishment – that completed the survey. For our analyses, we employed a mixed methods data collection strategy. Where the survey methodology expresses the quantitative side, the case study methodology emphasizes the qualitative side. For this part of the study, we make use of a multiple case design (Yin, 2009). We collected data from three sources: interviews, direct observations, and

documents. Prior to the survey conclusion, we asked participants if they would be willing to participate further in the case-study portion of the study. 21 respondents replied that they would, and were subsequently shown a different informed consent; those that agreed left their contact information, and a pool of potential cases was generated. After an initial point of contact for the case study, we were able to recruit 7 firms for our case study. PV adoption status, programs, industry, level of knowledge, gender, and firm size were attributes examined for case selection. This helps select cases that were as diverse as possible from a limited number of willing participants, as well as cases with key informants who are capable of providing meaningful data and details. We achieved a cross section of firms representing diverse attributes, especially adoption status, industry, and firm size. Key informants held titles such as senior engineer, owner, environmental coordinator, and administrator. Multiple cases that enhanced diversity decreases our suspicion of data credibility for both adopter and non-adopter firms, and increases external validity. Examining cases with different theoretical characteristics and conditions, rather than uniform, reinforces the design, and garners more reliable data. Cases with too much similarity demonstrating the same patterns and results do not share the same depth and validity as cases with different attributes and patterns, producing contrasting results. This is the basis of our multiple case study replication logic (Yin, 2009). The map shown in Figure 5 depicts the location of each case study in this study, along with the University of Wisconsin – Stevens Point as a reference. For each case we conducted one-on-one (sometimes one-on-two and one-on-three) semi-structured interviews, as well as – to varying degrees – on-site observations led by the interviewees,

and document-based data collection which includes news stories, administrative reports, pamphlets, and web-based material (Yin, 2009).

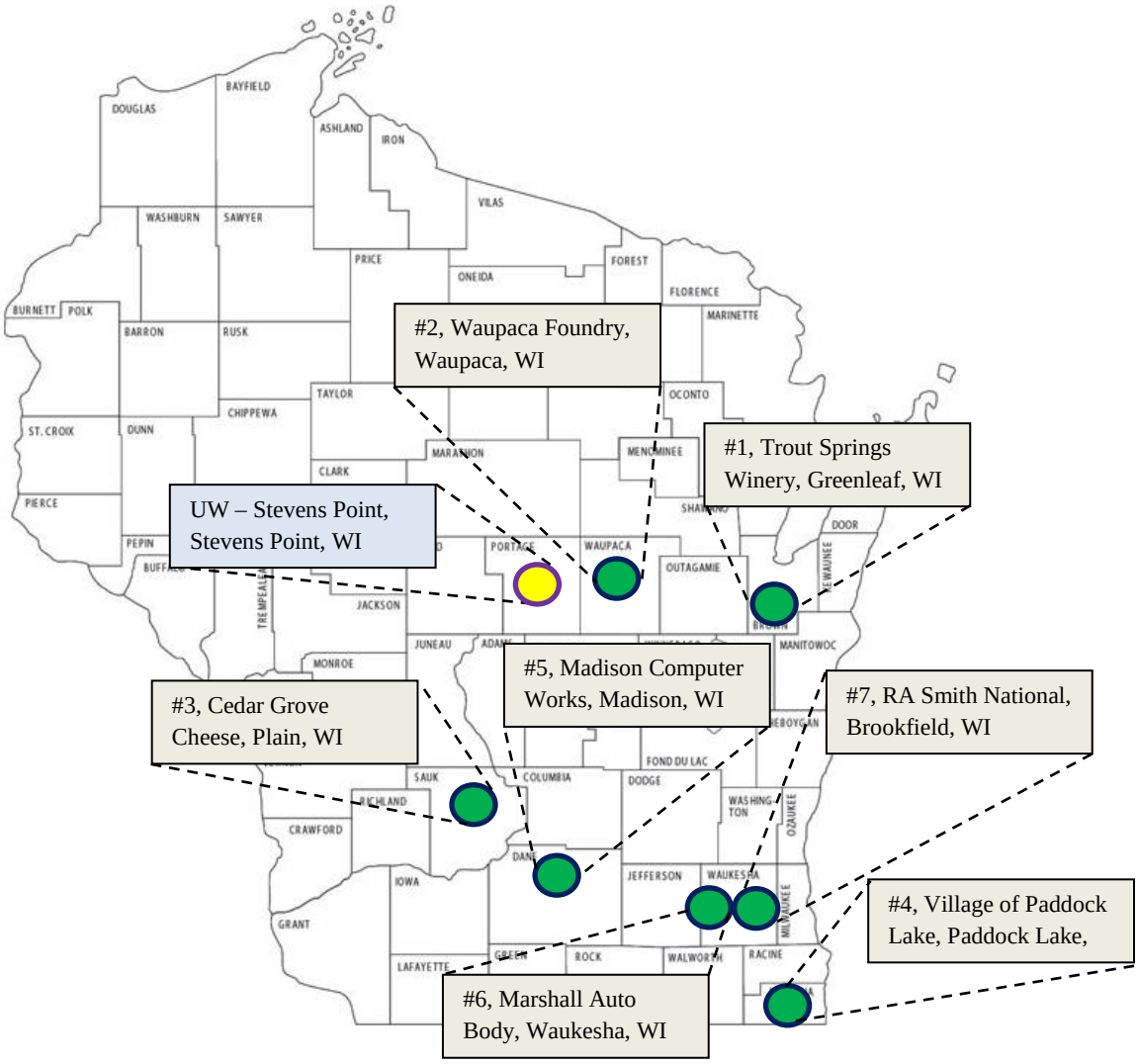

Figure 5. Case study firms in Wisconsin

3.2.1. Data collection

Interview questions were derived from Høgevold et al.'s study (Høgevold et al., 2014), as well as from our own conjuring. Interview discourse generated prolific emergent content from questions asked by the interviewer that were not structured prior to the interview taking place; these are outlined further in Appendix C. Unpacking the

"challenges and barriers" main research question, we sought to demonstrate emergent data of each distinct case study by asking questions in a semi-structured fashion (Yin, 2009).

It is reasonable to assume that each case's adoption or non-adoption decision-making process – including the contextual circumstances – are not identical to one another. It is reasonable to assume also that interviewees have varying abilities to trace their individual/firm milestone successes, challenges, and any other relevant events and details of such back in time, as it is easier to recall behavior that has taken place recently compared to long ago. This should not be confused with tracer studies, which are studies that trace a traditionally retrospective path technology and innovation take beginning from invention, through the innovation-development process, all the way up to successful market takeoff, creative destruction and replacement, or untimely failure. Although relevant in technology and innovation diffusion research, tracer studies possess weaknesses such as dependence on data and publication material limited in availability and explanatory power, and failure to integrate innovation diffusion and adoption behavior into the *a priori* timeline. Basically, technology and innovation tracer studies have produced incomplete timelines, and have not accounted for the unknown, novel, or accidental events that positively or negatively affected development, nor diffusion and adoption drivers and limiters (Rogers, 2003). While the collection of evidence is different from one innovation to the next, we find that solar PV is generally well studied, and continues to be well researched, particularly through qualitative research design methods that build in space for emergent data, capturing recollection – motivation – rather than biased justification for adoption behavior one way or another (Schelly citing

Vaisey, 2014b). Although a strength, a weakness to this approach is inaccuracy and limited recollection capabilities of interviewees to recall crucial events and details (Yin, 2009).

We conducted a single brief interview pilot with a local coffee shop, a solar PV adopter, helping not only gain some interviewing experience before data collection but also field test various questions to help anticipate potential pitfalls, cut down on unimportant question items, and emphasize more relevant questions to help furnish the highest quality data possible in a limited amount of time. This pilot interview lasted about 45 minutes, which is slightly shorter than most of the interviews we conducted. From there, we began our case study participant recruitment, scheduling 7 on-site interviews and site visits.

Up until now, our survey participants have received a synthetic and uninspiring experience interacting with a survey electronically. Helping quell these circumstances, in person interviews demonstrate a more personal and engaging experience and environment, and allowed us to make on-site observations and collect document-based records. Semi-structured interviews, and on-site observations and document collection form the second and third points in this research study's data sources triangulation. This is depicted earlier in Figure 2. Although the technology of interest in this part of the research is unsurprisingly solar PV, other energy, environmental, and sustainability technologies and innovations used by business and industrial firms – both adopters and non-adopters – help enrich these cases with meaningful and supportive data. Furthermore, cases selected represent distinctly different business and industrial categories in Wisconsin. Following the semi-structured interviews, using a pre-structured

case outline prior to case study data being collected (Miles, Huberman, & Saldaña, 2014), we were able to collect a diversity of case data. This includes a multitude of energy efficiency and renewable energy system technologies and processes, along with purposes and roles they serve in the context of the case, and other descriptive elements such as financial incentives, ownership, water and pollution control measures, governance and stakeholder connectedness, waste recycling, and material reuse efforts (Klein & Coffey, 2016). Challenges and barriers and additional findings are reported in the results section below.

For our data analysis methods, interviews were recorded with an integrated circuit (IC) voice recorder (Sony Electronics Inc., San Diego, California, USA) creating an audio file, then transcribed, and uploaded to NVivo Pro for Windows v. 11 (QSR International (Americas) Inc., Burlington, Massachusetts, USA). Web-based documents were uploaded and analyzed using NVivo too, while physical documents and field notes collected were not uploaded to Nvivo, but rather analyzed by hand. All the data collected are analyzed using a grounded theory approach. Following coding and thematic analyses – and ultimately the selection of core phenomena and selective coding procedure – on site observations and documents were analyzed. These data provide detailed background information and redundancy of case specific attributes and dimensions. This is important because redundancy is building each case and assists in strengthening relationships and supportive complementary data across cases as well. Discriminant sampling helps by enriching the data with solar PV adopters, potential adopters and non-adopters, such that we can achieve a comprehensive saturation of data. In the results section that follows,

core phenomena and theoretical dimensions of the second main research question are illustrated.

3.2.2. Grounded theory (GT) procedure

There are two types of GT analysis methods, the prescriptive or structured approach purported by Strauss and Corbin, or the constructivist approach in Charmaz's work. Charmaz's approach emphasizes dimensional characteristics of the interviewees, such as multiple realities, contextual complexity, and more of a purist emergent approach, forming postulations of depth and experience. The emergent nature of data conceptualized by Charmaz cannot be understated; it is a crucial component to GT. However, the focus of these interviews is on the context surrounding these diverse adoption processes, solar or non-solar, and the challenges and barriers therein. We must make the distinction between the importance of participant/interviewee experience, and dimensionality of the process. Prior to our interviews, although our interviewee's experiences and thoughtful dimensions on process are inherently connected, compared to dimensions, challenges, and barriers of the process, the experience is regarded as secondary. This is especially paramount in this part of the study. Therefore, we take the Strauss and Corbin approach as it is more applicable to our study here, emphasizing the adoption process of various energy and sustainability innovation not exclusively solar PV-based (Creswell, 2013).

The structured GT approach involves four steps: 1) open coding, 2) axial coding, 3) selective coding, and 4) memoing (Creswell, 2013). While the first three steps are followed sequentially, the memoing process occurs during the entire coding procedure from start to finish. A graphical representation of these steps together is shown in Figure

6. Memos, logs, and various notes, jottings, and sidebars are important steps in the GT procedure because they are the basis for developing, explaining, and visualizing the core phenomena, and organizing the author's thought processes and reflections. Memoing helps elucidate analytical meaning in the interview data by sifting out emergent data often taking the form of patterns, dimensions, attributes, concepts, and themes (Miles et al., 2014).

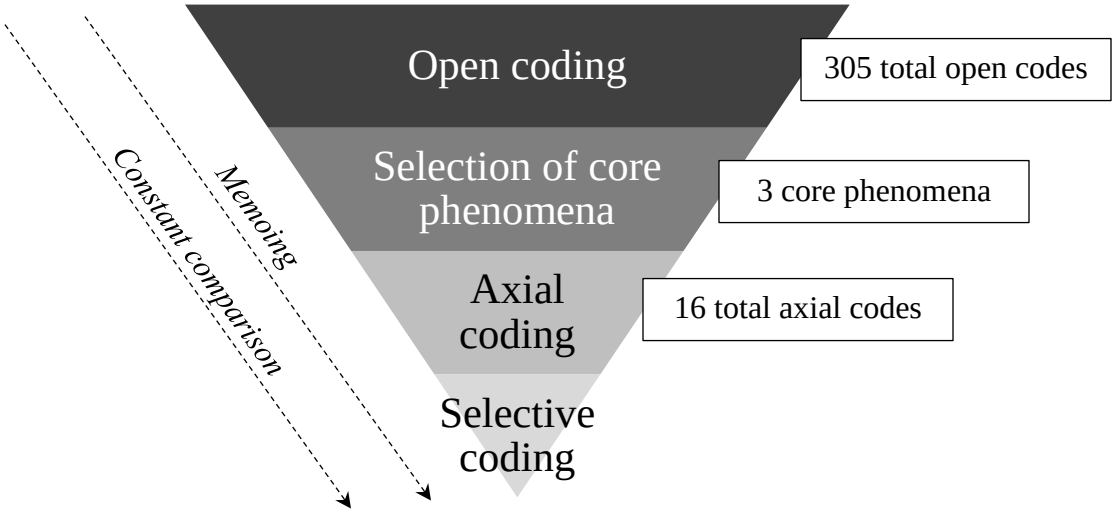

Figure 6. The structured GT procedure with coding schema findings
Source: adapted from Creswell, J. W. (2013). *Qualitative Inquiry & Research Design: Choosing Among Five Approaches* (3rd ed.). Los Angeles, CA, USA: Sage.

Strauss and Corbin's structured approach to GT is organized into four prescriptive axial coding categories: causal conditions, consequences, strategies, and intervening conditions (Creswell, 2013). Open coding is performed first prior axial coding; to do so, we began by organizing coding types before delving into the interview data; we did this so that our open codes roughly aligned with our axial codes. These different types of open codes included descriptive and in vivo (not to be confused with Nvivo), process, causation, and evaluation codes (Miles et al., 2014). We learned that Nvivo is a qualitative data analysis tool best suited for 'end of pipe' data completion, and is

incapable of organizing what could be an unknown, possibly extravagantly large, number of distinct open codes. We therefore printed our interview transcripts and proceeded with our open coding strategy using pen and paper. Besides various memos, jottings, and data harmonization taking place, we flagged meaningful quotes in the transcripts. These are great for adding directly into the results to boost the explanatory power of the findings.

Miles et al. (2014) refer to coding not just as literal analysis, but also as heuristic, a method of clustering and distilling data enumerated from any number of sources, sometimes referred to as subsuming or constant comparison (Creswell, 2013). From field notes, observations, and audio files of interviews, coding is a method of exploring and interpreting the meaning of the data (Miles et al., 2014). Each short phrase, sentence, or text chunk are not completely layered with codes attributed to each of our coding schemes, this would complicate the analysis. Some are depicted with layers of coding schema, as these are among the more enriching, dense, and emergent data. Once open coding reached completion, core phenomena were selected, and axial coding using the four prescribed categories stated earlier were used for data interpretation and presentation.

Following the selective coding process, as well as the end of our memoing process, we attempt to develop new substantive level theory as well as new hypotheses from the data, which infer relationships of commercial and industrial firms and key informants, with several other elements not exclusively contextual, but rather phenomena. We anticipate these findings to have less significance in terms of strength and relevance than larger and more complex theories. This is discussed more in the findings and the discussion sections.

3.3. Results

The results of the multiple case study are divided into three subsections corresponding to three core phenomena discussed below: 1) Financing and debt management dilemmas, 2) Stakeholder arrangements and governance, and 3) Internal innovation and resilience. Each subsection begins with a challenge statement, indicating the obstacle of interest for each phenomenon, followed by the coding and emergent evidence, and concludes with a proposition or assertion, and a graphical representation. Each challenge statement and propositions, along with the subsequent graphical representations are the selective coding procedure drawn from earlier steps in the GT methodology. To motivate future research in human dimensions of energy behavior using a qualitative design, these challenge statements may be regarded as potential main research questions, and propositions that follow may be regarded as potential hypotheses.

3.3.1. Financing and debt management dilemmas

Challenge: Why are bottom line thinking and rate of return hampering the diffusion of distributed generation and other process or system augmentations toward sustainability?

While waiting for federal and state energy policy landscapes to slowly evolve, not to mention utility initiatives and renewable energy programs, the provision of financial assistance helping would-be adopters negotiate up front cost burden produces mixed results. Potential and non-adopters universally stated the phrase "it's not there yet" or "doesn't make sense yet" to describe the insufficiency of solar PV upfront costs and rate of return, opting instead for alternative measures. This is unsurprising, as limited available capital would suggest tighter and less expensive options, but perhaps available capital isn't the only thing limiting the diffusion of solar PV. We think that "it's not there yet" is indicative of broader dimensions regarding fiduciary behavior and debt

management capacities extending beyond the availability of cash ready to spend. The causes of this phenomenon also include bottom line thinking as well as informal rules demarcating rate of return or return on investment thresholds. From our evidence, we think that the former is slightly easier to observe, rather than the latter, which is more difficult to perceive, as this was an emergent dimension unearthed from the data. From the Trout Springs Winery interview, this is what our interviewee had to say regarding bottom line thinking:

> "Caution? I mean, I guess what I would say is just do your due diligence. No matter what road you decide to go down as far as technology or alternative energy. Just do your due diligence, and look very closely at what you're getting for what your expenditure is. Does it make sense to you on your bottom line for doing what you're doing? Because some of these technologies are great! But, they don't give you much back, and so that's why we narrowed it down to what we did here. We didn't go down solar. To me, solar is a waste of money at this point. We didn't go down wind, we chose geothermal, and for us in our location, and what we're doing, that made the most sense for payback. I would caution people to not be caught up in the moment or buy into something that was not going to give them that payback in the end. Because let's face it, if your bottom line doesn't work, you're not going to be in business. You may want to do something for the good of nature or anything, but if the bottom line says it's going to break you and put you out of business, that's not the way to go either. So you have to be wise in what you choose to do. I guess I would caution people from being caught up in something that may not give them truly what they need."

This sort of bottom line thinking was evident to varying degrees in other cases too, but also, we were able to capture data that helped identify and explain rate of return regarding solar PV technology. Two of our non-adopter interviewees matched up closely regarding rate of return thresholds; the Village of Paddock Lake mentions a rate of return less than 5 years to be a desirable threshold. They remarked;

> "Here's the reason 5 years is one of the first milestones […] […] the majority of the municipality operates on a 5-year capital improvement budget […] […] they have equipment, (and a) sewer and water division, that lasts 20 (to) 25 (years), our

> water system warrant is big, lasting 30 (years), the majority of it (is) 30-40 years; they operate on multiple budgets. We have a 5-year capital improvement plan. We have a 10, and then a 20-year. That's specific to the utilities […] […] everybody has been trained to think 5 years; so two 5-year cycles for a piece of equipment to cycle out […] […] 5 years is really what they (the village board) want me to show, that we can start seeing profits, or cost benefit after 5 years. That's where we came up with that […] […] and I think it's kind of an industry standard […] […] in engineering things…for wastewater standards, give me maybe the 5 or 7 year standard and year […] […] it's been like that for a long time. When you're talking a capital costs […] […] it's hard to get people to buy into it. It's like you know we're going to have to spend this much money, and it's going to take 5, 6, 7 years back, people are okay with that, but once you start going beyond that, people start thinking 'do I really want to spend that money? Do I really want to do that?' […] […] we've all been programmed in that 5 to 10-year (payback), on anything!"

In our Waupaca Foundry interview, a similar "gold standard" is reported at a threshold of 2-year payback cycles. In this specific case, the foundry's management system is progressive enough to consider longer rates of return, mentioning a range of 3 to 7 years. Perhaps these payback thresholds are strongly influencing a culture or informal institution within these firms. Rate of return may be regarded as a linchpin criterion of energy or process sustainability improvements. Without sufficient rate of return, thus impeding the realization of any social, economic, or environmental benefits, future system improvements or enhancements cannot be expected to succeed until costs are cheaper. Figure 7 summarizes this financing and debt management dilemmas dimension.

Proposition: Within the firm, potential and non-adopters view distributed generation favorably, but bottom line thinking and rate of return are masking the principles-based knowledge necessary to implement them successfully long-term.

3.3.2. Stakeholder arrangements and governance

Challenge: Who, in what ways, and to what extent, are stakeholders – internal and

external to commercial and industrial firms – helping to achieve its goals?

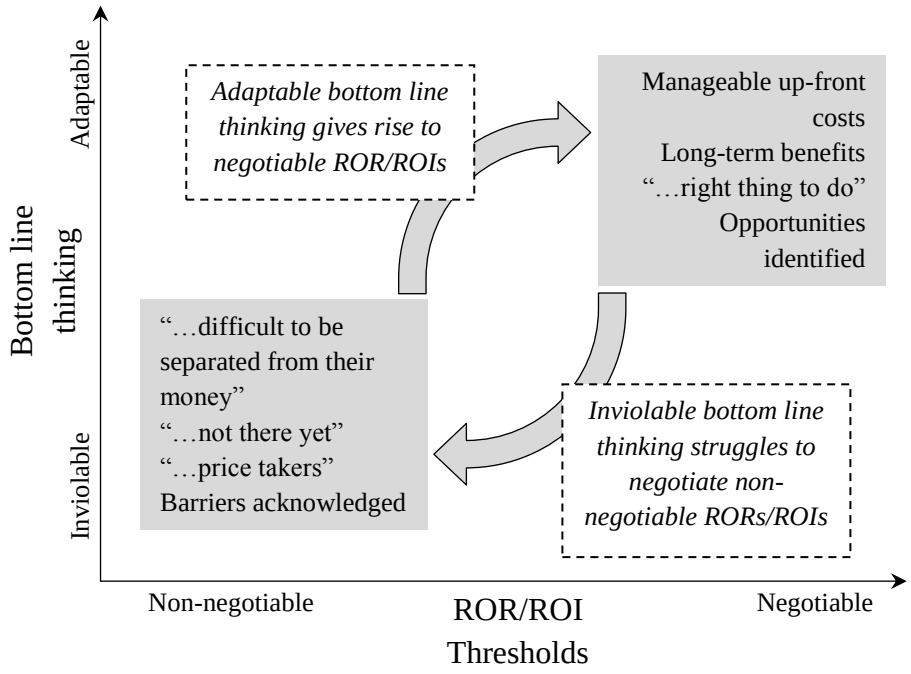

Figure 7. Conceptualization of bottom line thinking as a function of ROR/ROI thresholds

Rather than the economic and fiduciary obligations specified above, the main focus on this phenomenon is on the social structures internal and external to business and industry establishments. Goals are not specified with any degree of precision in the challenge statement above. This is because time bounded goals are assembled by single or multiple stakeholders, internal to the firm. They are then scoped and evaluated based upon their individual, or collective, psychosocial and behavioral landscapes. More important than identifying distinctions between short-term and long-term goals are the contextual circumstances underlying the decision-making behavior. Difficult to convey, a diversity of alignments and misalignments can be observed at the corporate level. Inherently, and under the guise of conventional corporate values, disparities in power, inclusion, and political clout inevitably lead to differentiation of stakeholders into two

broad and non-specific groups: a core group consisting of few but powerful individual(s) central to the decision-making process, and a peripheral group comprised of many, less powerful individuals, not central to the decision-making capabilities or needs of the corporation. This dichotomy is the basis of corporate governance behavior, and stakeholder arrangements here.

Strategies in response to this phenomenon are indicative of social network and behavior internal and external to the firm, as well as with their respective customer or client markets. From the semi-structured interviews in this study, we observed patterns specific toward industry leadership identity, and inclusion of external stakeholders through outreach and extension. Most importantly, we observed both agreement and disagreement in some governance behaviors, as well as the presence of apathetic, or otherwise unnoticing, clients and customers to these commercial and industrial establishments. These dilemmas are explained further with a few examples, first starting with Marshall Auto Body.

Boasting one of the larger solar PV arrays among our solar PV adopters in this part of the study, we were curious if Marshall's distributed generation system also generated any excitement or public acclaim; so we asked if our interviewees could explain the nature of any feedback they receive, or the absence of feedback, regarding the solar PV system:

> "Some of them like it I think , but this is a very conservative area, so a lot of them are mistrustful of it, and think that it's socialism maybe, or they're not sure, they don't know anything about it, and don't even know what it is […] […] so, it's not in their worldview, or if it is, it may be negative. But there's probably a substantial amount of people that like it, there's probably 25-30% (of) people here that look at it and go 'oh, that's okay.' […] […] and the employees are no different; we put that (kiosk) there so that they would see what we use for energy,

> and that it might have some effect, but it has very little effect. People are not, they've been trained to not pay attention to that I guess, I really don't know. […] […] there's people […] […] that would come in and think it's really great, but most people here just ignore that, they don't care."

A similar remark was made by Madison Computer Works, a computer and technical service business specializing in at-home office and business solutions. With two solar PV rooftop arrays coming in at under 20kW rated capacity total, the owners reported that their customers valued Madison Computer Works' reputation over the sustainability efforts. It appears that while positive promotion and marketing would seem like a beneficial byproduct to showcase to customers and clients, the value and benefits are internal to the corporation. Most made comments similar to Madison Computer Works, stating that these energy and sustainability efforts are simply "good business decisions."

Governance behavior was a surprising observation made between three of our interviews. One of our interviewees is an Environmental Coordinator with Waupaca Foundry. This interviewee mentioned how they were fortunate to have a management team that is "pretty progressive," adding later that they employ an on-site energy manager, identifying that the company's source of pride is indeed in the Green Tier program because of its strong capacity to act as "conduits," "connect with other people" and "be a positive force for good." Ultimately, this particular interviewee was proud that his company continues to strive for not just within industry leadership, but leadership across industries as well. Contrasting that with the engineer at RA Smith National, this interviewee's immediate boss was essentially a lone wolf who developed and imparted the solar PV and wind turbine projects upon the interviewee, in opposition to most of the other employees including the accountants and Chief Operating Officer. This indicates a hierarchical obstacle and misalignment in the governance aspect of corporations. In an

additional twist, a group of interviewees representing the Village of Paddock Lake represent a municipality rather than a business. Strictly speaking, rather than investors and shareholders, these people must be accountable to taxpayers and a village board of sorts. This introduces a political factor into the governance skunkworks, particularly in the municipality end of the non-domestic energy user spectrum. Collectively this evidence supports stronger need to untangle the complexity of stakeholders and governance structures, motivating future understanding of the operation and measurement of actual social-networking behavior and decision-making of corporations, both inside and out. While not the focus of the pre-structured outline for this multiple case approach, we think stakeholder arrangements and governance are two relevant factors helping explain barriers to energy transitions taking place at the corporate level. Figure 8 summarizes this stakeholders and governance dimension.

Proposition: Progressive thinking governance units and stakeholders help increase corporate leadership potential and goal achievement, while governance dilemmas stagnate it, effectively subsidizing status quo thinking.

3.3.3. Internal innovation and resilience

Challenge: How can businesses and industries be more competitive, more innovative and demonstrate innovation, on a budget?

Perhaps all commercial and industrial firms can be differentiated in terms of their evolution in innovation and creative thinking capacities through time. Breaking it down into sector, even sub-sector categories of industry, no single industry category is identical to one another, suggesting formalized industry standards, rules, and regulations, and

alignment of innovation and improvement patterns by industry group; these would be regarded as social norms or traditional operation, maintenance, and "business as usual"

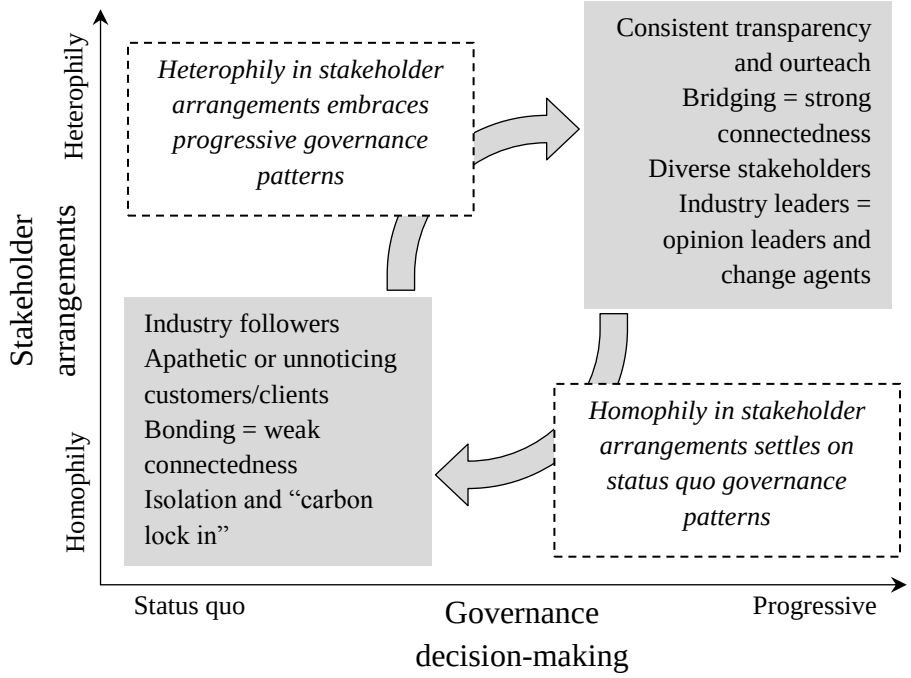

Figure 8. Conceptualization of stakeholder arrangements as a function of governance decision-making patterns

approaches, but are broadly defined as formal institutions. Even potential and non-adopters of solar PV are embracing a plethora of strategies besides the opportunities of distributed generation such as solar PV. These broad strategies include energy efficiency upgrades, material recycling and reuse, pollution control, and novel innovations. Even solar adopters are not so different, as they also employ many of these similar strategies, but the key difference with implementing a solar PV array, wind turbine, or other distributed generation system is that these firms are attacking wasteful spending and long-term debt through utility divestment measures, rather than purely investment measures in the above ways. Intervening conditions helping positively influence these strategies include long-term thinking and marketing, advocacy and promotion efforts.

Interestingly, excluding for a moment the existence of the value brought by Green Tier, Green Masters, and RENEW Wisconsin, two interviews specifically mentioned that they are "already doing some of these things (sustainability and process/system enhancements)." However, an important gap – an opportunity rather – was identified by the owners of Madison Computer Works regarding the potential of marketing, advocacy and promotion:

> "[…] small businesses are the ones doing it are doing it on their own, I don't think that there's anyone driving 'hey, have you considered doing PV on your building' as much. There was a little more outreach a couple years ago than there is currently, and I'm not sure that falls on the sustainability industry as a whole. […] […] It's really not as expensive as you'd think […] […] 'cause we didn't have any push! […] […] I think the people that I know who have done it have gone out on their own and sought it out […] […] not someone coming out and saying 'hey, you have a perfect building, have you thought about doing this?' […] […] there's people who helped us when we were looking into it to make the decision, but nobody is out there marketing; they need to increase the market outreach! […] […] but to promote this sort of thing, there should be good money in that. Whether it's with the recyclers who want the parts to make money off recycling, the (solar) installer […] […] or a private consultant who gets something from these different groups that they're helping, there should be a mechanism in place to promote it to small businesses […] […] the industry needs an outside sales force. To do the outreach. […] […] That's what I'm saying; they really do, otherwise there's going to be dribs and drabs and slow increase as opposed to the boom that it could be."

Correspondingly, firms like Waupaca Foundry regularly keep "shovel ready projects" in the hopper to be employed at a moment's notice. We think this is because innovation benefits and complexity, are seamlessly understood, compared to less modular innovations, which are more difficult. Cedar Grove cheese explained this modularity disparity between larger and smaller enterprises, stating:

> "[…] You need to go to the larger sources, and take care of the problems where they're really problems. You also need to work on technologies that are skilled,

> like, I think the money in technology is in big companies. Most people who are solving environmental problems are designing large machines, complicated kinds of systems, and it's not only in this (cheese making). It's basically all of our manufacturing, what's coming out is just designed for large operations […] […] so that puts sort of medium sized companies at a sort of disadvantage […]"

Circumstances in which various technologies – from energy efficient light bulbs and ballasts to larger systems such as pollution control eradication, wastewater treatment, "lean" processes and waste mitigation, even distributed generators – diffuse through commercial and industrial energy users could be deterministic of modularity attributes as well as normal innovativeness patterns perpetuated in those specific sectors or subsectors of industry. While marketing, advocacy and promotion of different technologies are laudable, overcoming that barrier, the threshold separating traditional innovation from novel innovation, is extensive. But it could be met with progressively innovative implementations – small "wins" – demonstrated through costs saved, and costs avoided. This includes mitigating GHGs, decarbonization, and landfill avoidance measures through material reuse and recycling. Demonstration of product or material life-cycle benchmarks, as well as milestone achievements, while retaining roughly the same capabilities for the provision of goods and services, seem to be, and should continue to be, a core corporate mission. This partners well with short-term and long-term resilience. Figure 9 summarizes this internal innovation and resilience dimension.

Proposition: Commercial and industrial firms fail to meet peak innovativeness capacities because of normalized and traditional approaches to energy and sustainability.

3.4. Discussion

The discussion in this part of the study is divided up into two subsections. First we discuss the contributions made from the findings, and where the research aligns with

previous studies, followed by assumptions and suggestions, and limitations to the case study approach conducted.

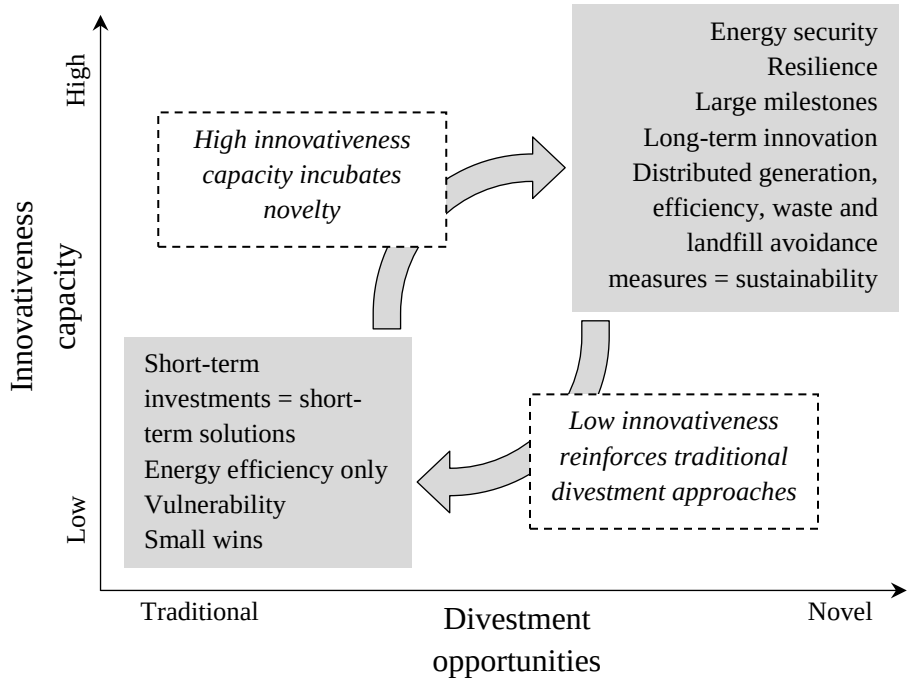

Figure 9. Conceptualization of innovativeness capacity as a function of divestment opportunities

3.4.1. Case dimensions and contributions

A diversity of commercial and industrial businesses call Wisconsin home. Of the four broad energy consuming sectors in the built environment – transportation, domestic, commercial and industrial – corporate establishments play a number of important roles. Besides the obvious provision of goods, services, jobs and jobs creation, businesses are places built from early beginnings on entrepreneurial spirit, ideas, and often few resources or clear directions. In a capitalist society, they can sustain or grow in size and personnel – crosscutting generations – or they may undergo cutbacks and shrink in size due to ripple effects of small or large-scale market failures or economic distortions. They may also suffer from other known or novel perturbations, resulting in creative

destruction, to be replaced by another business entity or community structure, or simply be abandoned. With energy and natural resources, the time and the manner in which people control and modify their internal systems and processes that keep their business and industries operable and resilient, are usually governed by social norms, stakeholder arrangements, policies, financial capital, and innovativeness capacities at multiple scales, to name a few elements. These dimensions are difficult to measure, but each one emerged and is supported with evidence gathered from our multiple case approach, helping answer our second main research question, which delves into challenges or barriers of a variety of innovative energy transition behaviors. Each case coincides with several obstacles, lessons learned, and future opportunities; these are depicted in Table 12.

Findings from the first paper suggest relatively weak alignment with previous studies on domestic sector solar PV diffusion. Here we find evidence of stronger relationships with previous studies, emphasizing the roles of diffusion networks and change agents, within organization innovativeness (Rogers, 2003), as well as sociotechnical and economic/financial barriers (Painuly, 2001; Reddy & Painuly, 2004). Starting with diffusion networks and change agents, several cases – RA Smith National, Waupaca Foundry, Village of Paddock Lake, and Trout Springs Winery – demonstrated the merits of reaching out and networking with stakeholders internal to industry and firm – sometimes referred to as near peers or industry "champions" (Rogers, 2003) – and external to industry and firm, demarcating stakeholder homophily and heterophily. Kaplan (1998) summarized solar PV diffusion as a combination of small wins, experimentation and groping along in the electric utility market (Kaplan, 1998). From

the perspective of a municipality, the Village of Paddock Lake case study shows remarkable similarities with Kaplan (1998), especially the importance of experimentation capacity and navigating for small wins. Furthermore, case data show evidence of role definition and role evolution from simple industry followers to change agents and opinion leaders, evidenced by Cedar Grove Cheese, Madison Computer Works, and Marshall Auto Body. As progressive members in the renewable energy and energy efficiency transition, key informants in these cases have made remarkable progress on each of their distinct learning curves in each of their industries respectively, demonstrating role shifting behavior not just towards industry leadership, but also broader industry change as change agents. These individuals are slowly shifting and even figuring out for themselves with the help of others, how to instill broader industry change while emphasizing their roles as sustainable business think tanks and practitioners. Figure 10 depicts the three core phenomena and their respective axial dimensions within the context of this case study.

Furthermore, our studies support the need for community inclusivity for distributed generation solar projects. The findings point out that normalized beliefs and industry practices are a source of both strength and weakness. Strengths can be found in competition for industry leadership, but weaknesses are found in stuck-thinking, unbendable processes and procedures, and little to negligible time or resources to innovate in house. Some evidence can be found in this study of individuals and firms that aim toward industry bar-setting through innovation, growth in partnerships and community involvement, and flexing the industry standards to achieve stronger resilience, breaking from dependent patterns of thinking and reliance. Evidence is

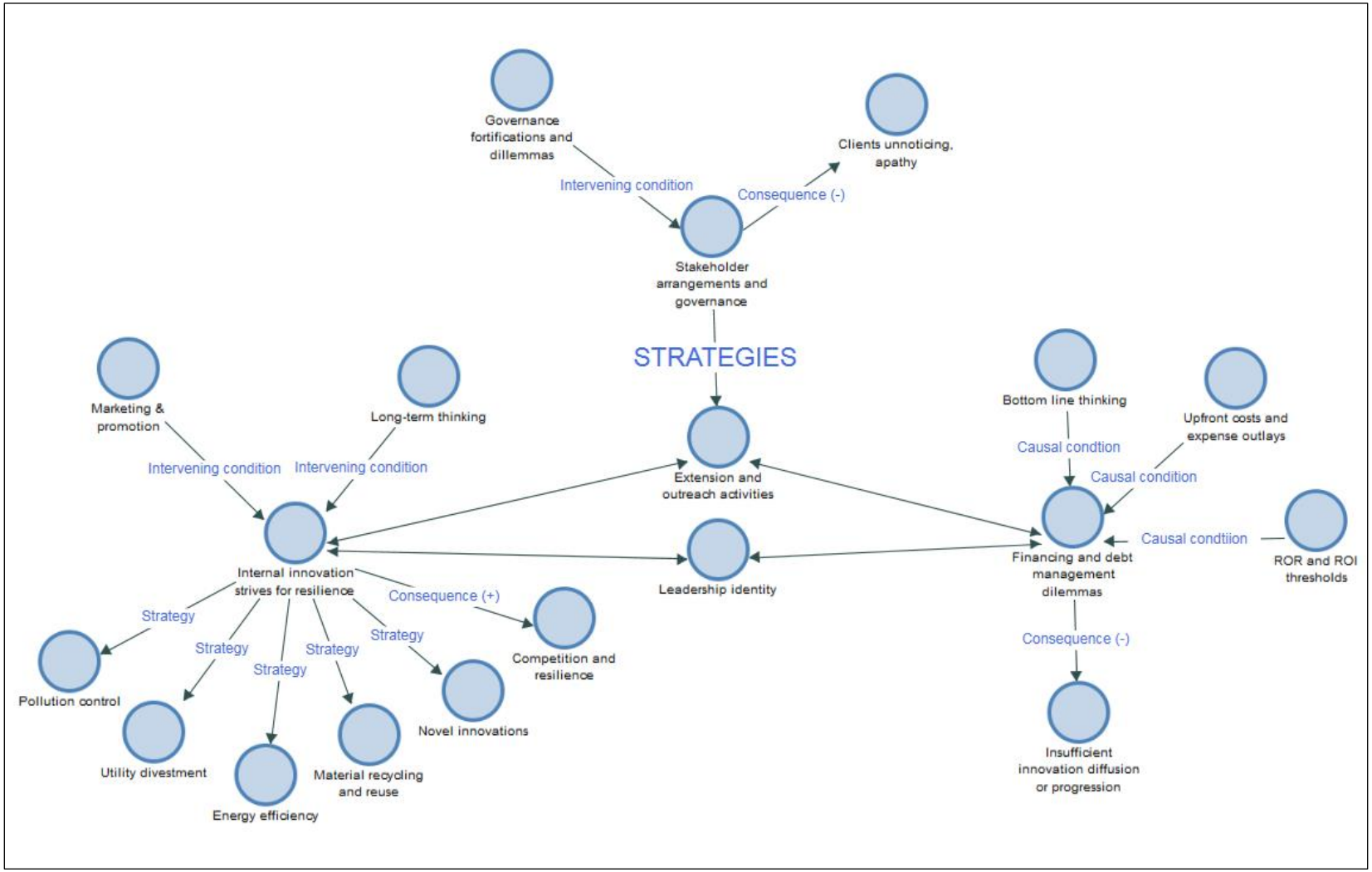

Figure 10. Thematic diagram of case study findings.

Note. Unique combinations of the four components surround the three core phenomena represented: 1) strategies, 2) intervening conditions, 3) causal conditions, and 4) consequences.

Table 12. Obstacles, milestones, lessons learned, and opportunities associated with sustainability behavior

Case firm	Obstacles	Milestones	Lessons learned	Opportunities
Trout Springs Winery Program: Green Masters Industry: Arts, entertainment and recreation Status: NON-ADOPTER	• Climatic conditions affect fish stock and grape crop loss • Time • Moving up the learning curve • **Enormity of expense outlay for wind and solar** • Pesticides, fertilizer, and insect control	• **Geothermal heat pumps** • Chickens as natural insect control agent and provides minor fertilizer input • No-till farming practices • Planting covered crops between rows	• **Consider site suitability when selecting technological enhancements** • **Perform due diligence** • Be willing to change and adapt • Do not be discouraged by failures • "Take caution from investing in what you truly don't need"	• **Tell your story and exercise outreach** • Currently working to establish a new entity: "Wisconsin Sustainable Wine Growing Alliance"
Waupaca Foundry Program: Green Tier Industry: Manufacturing Status: POTENTIAL ADOPTER	• **Thermal loss**[1, 2] • Air pollution • Payback costs • **Immediate versus long-term benefit delivery dilemmas** • Roof and property access restrictions	• Installation of LED lights and industrial fans • Energy efficient motors and air compression • Sand reclamation • **Use of thermally efficient cupolas rather than electric furnaces** • **Waste heat re-use and propylene glycol heat exchangers** • ISO 50001 certified facilities[1]	• **"Balance between process and trying to make improvements"** • **Technical feasibility will determine if different projects are "shovel ready" (i.e. project prioritization)** • Pollution control measures consume a lot of energy • Advanced specialized projects, requiring engineering and review procedures, require 3rd party	• **Involvement in Dept. of Energy Better Buildings, Better Plants Program** • Involvement in Carbon Disclosure Project (organization based in the UK) • **Consult with Focus on Energy** **Examine ways to cut down on coke use**[1, 2]**:** • Coke to melt ratio and developing perfect combustion process • Size of scrap metal affecting heat transfer • Installation of blast air dehumidification (need dry air in combustion, wet or humid ambient air drawn in is undesirable) • Keep the melting rate at 2500 tons of scrap per hour
Cedar Grove Cheese Program: former Green Masters Industry: Manufacturing Status: POTENTIAL ADOPTER	• **High upfront costs and payoff window** • Phosphorus discharge	• Devolution of management duties • **"Living Machine"** • rBGH (growth hormone) free milk • Organic certified	• Innovative technologies and other equipment is sometimes proprietary for large business and enterprise, rather than small business operations • DNR and EPA phosphorus standards based on ppm levels rather than poundage	• Involvement in Food Alliance (organization based in the US) • Regional and international outreach for new entrepreneurs and young cheese makers • Innovation development that's suitable for small business operations, not exclusively large businesses • Involvement in Wisconsin Artisan Cheesemaker Guild (an organization emphasizing partnership between artisan and farmstead cheese makers)
Village of Paddock Lake Program: Green Masters Industry: Utilities Status: NON-ADOPTER	• Energy inefficient sewer plant • **Unreliable wastewater treatment process, incapable of meeting future growth in the village** • Increased sewer user rates and feed to recover project debt, construction costs, and operational costs • **Local municipality political forces**	**New wastewater treatment plant and enhancements include:** • Screen room (landfill avoidance) • 2 new clarifiers • New oxidation ditch system • UV disinfection unit • Timers installed on pumps and effluent blowers Other improvements • **Chloride reduction plan** • Long-term taxpayer savings on service rates	• Pick low hanging fruit through energy efficiency measures • Understand Focus on Energy program stipulations (payback period requirements, implications of projects deemed 'custom') • **Understand utility stipulations regarding rates and system enhancements (rate structures may increase, IOU capital for improvements are limited by achieved efficiency and formulaic processes not well understood).**	• **Installation of hydroelectric water wheel** • Clean Water Fund (a cooperative organization in the US) • Partner with Wisconsin Rural Water Association (WRWA) and Wisconsin Wastewater Operators Association (WWOA) (organizations)

Table 12. *(continued)*

Madison Computer Works Program: Green Masters Industry: Professional, scientific or technical services Status: ADOPTER	• **Lack of marketing in distributed generation, especially toward small businesses** • "Vampire" charges	• **~ 20 kW roof rack PV system** • Purchased hybrid vehicles • Facility enhancements such as conversion to LCD displays, sensors and timers, and efficient lighting	• Federal tax credits, incentives, grants, and cost recovery (depreciation), help • Knowledge and success attained from the first solar PV make system enhancement decisions smoother • Issues with roofs for roof mounted systems need to be addressed	• **Need for solar panel replacement through proper buy-back and recycling processes (landfill avoidance)** • Need to replace policies that charge customers for sustainable behavior that helps the planet (and resolving rate cases) • Need for autonomous local storage options such as battery integration solutions to store electricity produced by distributed generators
Marshall Auto Body Program: Green Masters Industry: Transportation Status: ADOPTER	• Waste produced by collision repair processes including supply chain and procurement	• **LEAN process, adoption of a culture of waste avoidance and mitigation** • 72.4 kW roof-mounted PV array • Electric vehicle (EV) charging stations	• Greenwashing effects showcased by big polluters are simply a waste of time and money • Streamlined efficiency in the LEAN process is capable of repairing twice the number of vehicles using the same amount of resources	• **Within and cross industry information sharing and training with LEAN-based thinking (embraces "Heijunka" procedures, similar to "just in time" procedures)**
RA Smith National Program: Green Tier and Green Masters Industry: Manufacturing Status: ADOPTER	• Internal consternation toward wind and solar adoption decisions	• Installation of both solar PV and wind systems • Energy efficient boilers installed • Replaced lights with more energy efficient LED lights and tubes (also T8s)	• **Find answers by connecting with solar installer and those individuals or firms who have been through the adoption process** • DSIRE lists a lot of key policy information, but contractors or installers can help package these opportunities to save money together • Research, and strive for all possible sources of funding (timing of various policy and program deadlines is crucial) • Look closely at RORs and ROIs • Do something, start somewhere	• Partner with Waukesha Economic Development Commission (WEDC) • Partner with Wisconsin Manufacturing Extension Partnership (WMEP) • Work cooperatively to enhance awareness of and discuss greenwashing in commercial and industrial establishments

Note. Bolded bullet points generally express those findings that are emphasized in each case.

Sources: [1]Waupaca Foundry, Inc. (2015). *Economic, Environmental, and Social Performance and Impacts: 2015 Sustainability Report.* Waupaca, WI, USA: Waupaca Foundry, Inc. Retrieved from http://www.waupacafoundry.com/SiteCollectionDocuments/Sustainability/2015%20Waupaca%20Foundry%20Sustainability_Rpt_FNL.pdf

[2]Gigante, G. (2010). How Can We Become a Practical Green Foundry Industry?. *International Journal of Metalcasting*, *4*(3), 7-15. Retrieved from http://www.waupacafoundry.com/Documents/EN/2010hoyt.pdf

present, but at varying degrees, and certainly not a top priority, compared to competitive advantage and stable cash flow, but this is understandable, and must blend with opportunities for stronger innovation and outreach capacities, specifically with the community and solar potential.

On the issue of community inclusivity, one specific difficulty is in the diffusion and sharing of lessons learned, data and, and information, and transferring information to niche or regime levels in the modern day social order of things. Because of the presence of context dependent and location dependent (i.e. place-based) lessons, stakeholders aren't necessarily interested in sharing knowledge outside the local area (Klein & Coffey, 2016). This illustrates the difficulty of independent groups of stakeholders, such as businesses and communities, to cooperate with one another. In short, communities are relatively adamant with transferring lessons learned, operating sometimes in isolation from one another (Klein & Coffey, 2016), but public private partnerships are an opportunity not fully realized yet, and offer a pathway for change.

Howard (2014) reciprocates similar difficulties, adding that climate scholars and advocates reveal that one of the biggest hurdles to overcome regarding effective public participation is the segregation of policy areas, and fear of reform. Ultimately this failure to integrate effectively quarantines meaningful change, subsidizing disengagement. In addition, complex normative beliefs – bureaucratic and political – often conflicts with initiative for community engagement. Research covering international governance regimes shows that the power to set an agenda and determine content of any particular line of discourse is not a commonly shared characteristic of community engagement models, reinforcing the need for the inclusivity upstream of typical governance actor

arrangements (Howard citing Werksman and Foti, 2015). Resolve can be found in engaging personnel and resources in civic or non-governmental organizations (NGOs), as well as reforming and adopting legal frameworks and procedures emphasizing community member engagement. By enabling public participation, there is less of a need for specific substantive rights or laws. Procedural community involvement and devolution of legal activities to catalyze engagement is an innovative idea. There is identifiable need to embrace community legitimacy and accountability, strength of voice, and upstream mobility (Howard, 2015). Critics might arrive at a reasonable conclusion that this innovation produces an illusion of utopian community involvement. But we think brokering relationships that emphasize community engagement is a pathway toward greater economic and community resilience. Uniting behind community-based solar energy as a goal would be an attractive starting point, enhancing activity in cooperation with communities and private enterprise.

Navigating these complex efforts are not without barriers. Sociotechnical barriers define barriers having to do with internal stakeholder arrangements, individual stakeholder attributes, industry norms, and formal and informal institutions. For example, these components include firm level hierarchical arrangements, innovativeness capacities, formal rules, regulations, and standards normalized in the industry, and cultural behavior, all in the purview of corporate governance behavior. Not surprisingly, economic and financial barriers encircle the availability of financial capital, but the data reveal that in fact bottom line thinking and informal rules regarding rate of return thresholds are also significant economic obstacles blocking some of the more innovative energy enhancements possible. Perhaps these economic and financial barriers negatively

influence perceptions of RETs. Some of these factors might include site suitability and compatibility, lack of principles-based knowledge, risk and uncertainty, or few or non-existent cues to action (Painuly, 2001; Reddy & Painuly, 2004; Rogers, 2003). Furthermore, solar PV adopters and non-adopters demonstrated advanced knowledge, specifically how-to knowledge and awareness knowledge, and favorable perceptions and attitudes of RETs such as solar, but only the adopters completed the adoption stage for solar PV technology. This demonstrates higher principles-based knowledge, while non-adopters opted for alternative efforts, failing to complete the solar PV adoption stage. Roger's refers to this disconnection between favorable knowledge and attitudes, with adoption or "practice," as "KAP (knowledge, attitudes, practice) gaps" (Rogers, 2003). What does this mean, and how can this obstacle be removed? This is complicated, and difficult to answer within the scope of this research, but our assumptions here can shed some light on this complex barrier, and other barriers mentioned earlier.

3.4.2. Assumptions and suggestions

For this part of the study, we make three assumptions: 1) humans are cognizant and rational information processors, 2) the context of decision-making behavior share conceptual elements of both cognitive heuristics (Stern et al., 1995) and environmental heuristics (Spaargaren, 2003), and 3) stakeholders share non-identical, but some similarities in self-construal, governing stakeholder attribute differentiation, stakeholder conflicts, and unities of individuals, firms, and other stakeholders (Mancha & Yoder, 2015). Inherently, under the umbrella of these assumptions, there will always be obstacles to varying degrees, but identifying them is crucial, especially those that subsidize "carbon lock-in" behavior. Barriers can be removed, but they can also be

generated, reinforcing one-another. If commercial and industrial corporations can begin the process of removing this "carbon lock-in" obstacle, a more resilient and economically competitive state can be achieved. From our case study findings, two actionable suggestions help motivate realistic cues to action, and are supported by previous studies:

(1) Marketing campaigns through social networks: spread needed knowledge, awareness and data, especially those resources to help spur smarter solutions capable of negotiating high up-front cost burden, such as "pay as you save (PAYS)" mechanisms (Jager, 2006; Kubert & Sinclair, 2009).

(2) Reinvention: prices and price signals for RETs continue to grow cheaper, but the attitudes, thinking, and normalization of negative perspectives toward solar persist. It is time to reverse this thinking, and turn the argument on its head. Unprecedented accomplishments have been made across the globe, but the implications are not connected into businesses and industries. Opinion leaders and change agents can share these success stories, shifting toward industry leadership identity. Reinventing business as usual processes toward a culture of decarbonization is a new priority.

3.4.3. Limitations

For the multiple case study methods employed in this part of the study, several limitations are important to demonstrate. In person interviews alongside document and on-site observations complete the data source triangulation for this research, but it is vital to demonstrate potential pitfalls, affecting the credibility and bias of the research here. Four limitations associated with methodology and findings are explained; they are weaknesses of interview questions, introduced researcher bias, data saturation estimation

(Creswell, 2013), and incomplete case data from document and on-site observation collection.

First, following completion of all interviews, we observed during the analysis that our questions were weak to begin with, providing minimal explanatory power as well as taking tangential paths during conversation. We think these interviews develop a stylistic conversation between interviewer and interviewee. Most importantly, they provide a comfortable environment for both parties, which is needed to develop trust with the interviewee(s). Data follows a semi-structured format congruent with our methods, as well as allowing other questions and answers to emerge, but we were not able to extract useful data from all interview questions. In short, better questions generate better data.

Second, grounded theory introduces bias from the researcher. If another group of authors were to repeat the same grounded theory approach for the same audio-files for this study – investigator triangulation (Yin, 2009) – using the pen and paper method and Nvivo, each investigator would produce a unique method and interpretation of the data. This means hypothetically, their data management and treatments, voice to text transcriptions, open codes and axial codes, core phenomena, and selective coding findings, would not be identical. Each of their Nvivo project files might overlap in some places in the transcripts, but they would not be identical. While this might be fortuitous for an investigator triangulation driven methodology, as a single investigator here, our data are inherently subjective.

The remaining limitations, estimation of data saturation and extent of observation and document collection, go hand in hand. Observations and documents collected provide limited historical context due to limited extent of time to observe and document

data and information. Furthermore, documents can be time consuming to find, inaccessible, or non-existent, and those documents that do exist contain reporter bias, which must be taken into account as well. Observations are especially vital. The most enriching case studies contain countless hours of observation, often made by droves of researchers, volunteers, and other contributors (Yin, 2009). We must ask ourselves also "how do we know we've achieved data saturation?" Although this multiple case design is enhanced through observation and document-based data, limits due to short incubation time and bias from different sources have the potential to produce inaccurate and incomplete cases, causing the qualitative data to be vulnerable due to insufficient saturation.

We agree with Miles et al. (2014), characterizing qualitative data analysis as an "inescapably selective process" (Miles et al., 2014). Navigating the transition from a more quantitative and objective analysis to a qualitative and subjective one, we think these analyses and results do not water down or weaken the dimensions of our answers to our two main research questions. Rather, we think they strengthen the dimensions and explanatory power. Qualitative data analysis is never identical across researchers, but that is for investigator triangulation; data source triangulation invites less error as long as the author(s) achieve saturation of the data, which we believe we did through discriminant data collection by interviewing across our three adopter groupings. In addition, we think that we achieved saturation knowing that we were capable of providing structured phenomena that help explain the low-level theory behind this diffusion and technology adoption behavior across adopter groupings. Case studies themselves aren't without limitations, however we account for them by extracting the

maximum amount of explanatory power of each interview, observation event and document for each case through exhaustive analyses.

CHAPTER 4: Conclusion

This study explores solar PV technology diffusion by examining commercial and industrial energy users in Wisconsin. Research on domestic sector energy users continues to churn out findings and actionable items and policies to shift household energy use and a prolific rate. Our research here helps enhance commercial and industrial energy user dynamics as well, by addressing determinants and barriers of solar PV diffusion. We demonstrate positively and negatively influencing determinants of this process, and further contextual dimensions of individual firms, by employing mixed methods though survey and multiple case approaches. Social and economic constructs in our survey results indicated significant differences between solar PV adopters, potential adopters, and non-adopters. More specifically, they included perceptions of external support, solar PV regulations and property rights, perceptions of affordability and benefits, and investment risk and uncertainty. Following our multiple case study, three corporate dimensions were unearthed that justify broader challenges and barriers to navigating the sustainable energy transition. These included informal rate of return thresholds, stakeholder arrangements coupled with internal governance patterns, and innovativeness capacities.

The provision of energy from an aging grid may continue indefinitely, but the state of Wisconsin could be a leader in the diffusion of distributed generation such as solar PV, and commercial and industrial establishments could lead that change. Many corporations and firms in Wisconsin are already taking some initiative with these opportunities to reach carbon neutrality and mitigate environmental impact, but there are also opportunities to establish and grow a culture of reciprocity, social capital, and

market competition. These opportunities are more opaque, and difficult to perceive in a sociotechnical system of energy and utility provision, immovable and set in its ways. Pathways to help deliver changes might include establishing public-private partnerships, promoting decentralized electric cooperatives, and to reinvigorate the role of extension professionals. Insufficient external support structures warrant a reinvigoration, specifically to establish connections, and enrich and deliver trustworthy, unbiased, and technical "know-how," driven by scientific data. Private firms and the provision of energy takes on political flavors due to tensions between energy users and utilities, public service commissions, municipalities, community leaders, and institutional organizations. Focus on Energy, federal tax incentives and programs, even other private firms and solar or other distributed generator installers, are all important stakeholders helping deliver reliable data and information to all project ideas searching for funding. But those available financial resources for progressively larger and more innovative distributed generation systems on the bleeding edge of market takeoff are increasingly vulnerable due to state and federal budgetary priorities. The importance of state and federal energy offices, institutions, scientists, and extension and outreach professionals, has never been more vital than it is today.

This research lives under the energy policy and technology diffusion umbrella, and opens doors to more research areas that can further illustrate social, economic, and environmental dimensions of the provision of energy and evolution in thinking and infrastructure. Environmental and economic factors continue to bolster the need for change at the human and ecological nexus of energy demand, but the social playground, responsible for much of the decision-making hindrances and contextual situations,

struggles to positively shape the built environment. This ongoing failure to recast this nexus in a concept that permeates all energy users and producers, global to local in scale, is a motivating force to continue scientific research. Our study did not in great detail cover the following topics; these topics were either outside the scope of the study, or not sufficiently comprehensive. These include social network analyses and governance patterns, business sector specific energy behavior, the role of coercive and mimetic forces in decision-making logic (Andrews & Johnson, 2016), programs and attributes of energy providers including IOUs, MOUs, electric cooperatives and energy service companies, and community grass roots initiatives striving for sustainability. In addition, other topics not addressed that are vital to distributed generation diffusion include physical barriers such as site suitability, geographic location, and roof condition implications, and broader economic analyses interacting with energy providers and users. The latter component of what this research is not cannot be overstated. We regard economic modelling, policy formulation, and evaluation, to be significant sources of opportunity for future research endeavors. This includes legal frameworks, financial services including "green banks" and "green bonds," debt management policies and policy effectiveness, and ethical and regulatory attributes of stakeholders on the economics side of issuing financial capital support, loans and leases, and asset securitization. Furthermore, experts motivate the need for increased identification, understanding, and supporting research for macro and micro-scale energy infrastructure integrations, decentralization behavior, and shifting energy consumer behavior from passive to active (Engelken, Römer, Drescher, Welpe, & Picot, 2016). Overall, each of these previous topics are rational courses for further investigation.

This study explores two specific groups of energy users, commercial and industrial, and the energy behaviors and transition efforts within a social context. But according to other authors, this perspective that broadly compares and contrasts energy user behavior with social and psychological models, should shift toward actor-driven or energy services behavior, not focusing on energy consuming devices or technologies. More specifically, these authors suggest analyzing energy demand, and producer-user relationships, by studying the social practices model or "structuration theory" (Spaargaren citing Giddens, 2003), as well as distributed agency (Wilhite, 2008). Furthermore, studies suggest that thinking shift from the provision of energy – device centered approaches – to the provision of energy services, suggesting that human agents are in fact not energy consumers, but energy services consumers (Wilhite, Shove, Lutzenhiser, & Kempton, 2000). These articles here we regard as seminal material, and they provide guidance toward novel strands of research at the human-ecological nexus that is energy provision.

More specific to Midwestern or "heartland" states that have an economy in agricultural, future research can begin to take steps in understanding technology diffusion of anaerobic digesters, and their challenges and barriers to market takeoff. Divesting from utilities through "cow power" is still an emerging field. Other technologies worthy of future diffusion research might also include local storage options and battery integration potential with existing distributed generators, carbon capture and carbon sequestration technologies for utilities, and wind turbines. In addition, we think sub-sectors of domestic energy behavior could also be a rational course of research.

Specifically, this concerns multi-family and low-income housing options, policies, and programs relating to energy.

Do technologies shape society or does society shape technology? These two components are irrevocably connected, especially when applied to energy supply and demand dynamics. Innovation, whether they are tangible technologies or the less tangible "idea driven" innovations, should be embraced for their potential to provide meaningful change in developed and developing worlds. However, a growingly less natural society, headed towards the more perverse and material society, is increasingly more dependent on technology to do nothing but reliably provide. The grid is a key example. The grid is a large technological system; the infrastructure and its ubiquity is embedded everywhere we are in the developed world. We emphasize that transformation of existing energy infrastructure, and the provision of energy, is an impossible and aimless objective without first identifying a starting point. Those technologies whose price signals compete the best with fossil fuel alternatives right now, like solar PV, are a good place to look into. We are now seeing evidence of successful electric cooperatives based on solar PV, exemplifying the merits of decentralized, distributed, and sustainable generation, namely in Wisconsin. The spread of these micro-scale systems is also a good place to start. To that end, smarter energy policies that integrate or "harmonize," while eliminating disunity as much as possible, but also remaining adaptable and considerate of other interdisciplinary interactions such as energy and food, water, and waste, will help produce a more robust economy and state of energy security. Input from commercial and industrial enterprise, small and large, will be indelible in this pathway.

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APPENDIX A
Evolution of relevant energy policy and legislation in context of solar PV

Scale	Year & Name	Summary	Force & Effect
Global	**1987:** Brundtland Report: "Our Common Future"[1]	Promotion of sustainable economic development, equity and renewable energy. Energy agendas fall into [1] policies that explore environmental effects, and [2] policies that are the source of environmental impacts and degradation. *"[…] (energy) mix has been allowed to flow together haphazardly […] […] dictated by short-term pressures and short-term goals of governments, institutions, and companies. Energy is too important for its development to continue in such a random manner [...] [...] safe, environmentally sound, economically viable energy pathway that will sustain human progress into the distant future is clearly imperative [...]."* *"[…] we see a small and fragile ball (Earth) dominated not by human activity and edifice but by a pattern of clouds, oceans, greenery, and soils. Humanity's inability to fit its activities into that pattern is changing planetary systems fundamentally. [...] [...] These new realities, from which there is no escape, must be recognized and managed [...]."*	*Strong:* new global agenda focusing on course corrections that emphasize sustainable energy, smarter economic development, and global harmonization.
	1992: Conference on Environment & Development: Rio de Janeiro[2]	Reaffirms importance of global sustainable development, expands upon the major global players, finance, trade and economic instruments, mobilizing non-governmental groups such as private industries, farmers, and local authorities. Advocacy for vulnerable populations such as the poor, indigenous tribes and natives, women and children, and workers and trade unions. *"[…] cost of inaction could outweigh the financial costs of implementing Agenda 21. Inaction will narrow the choices of future generations […]." and "[…] funding […] […] provided in a way that maximizes the availability of new and additional resources [...] innovative financing [...] [...] various forms of debt relief [...] [...] feasibility of tradeable permits [...] fund-raising and voluntary contributions through private channels including non-governmental organizations [...]."* *"[…] primary goal of improved access to technology information is to enable informed choices, leading to access and transfer […] […] strengthening […] […] countries' own technological capabilities […]." and "[…] Multinational companies, as repositories of scarce technical skills needed for the protection and enhancement of the environment, have a special role and interest in promoting cooperation in and related to technology transfer, as they are important channels for such transfer, and for building a trained human resource pool and infrastructure [...]."*	*Moderate:* rehash of global sustainable development dialogue, but broader scope and details of distinct actors across developed and developing economy landscapes. Besides promotion of solar PV and other renewable energy infrastructure, financial mechanisms for implementation is also paramount.

Global (continued)	**2010:** UN SEforALL[3]	Universal access to conventional energy technology and services, double advancements and efforts in energy efficiency and share of renewables in the global energy portfolio. *"[…] sustained efforts […] […] integrated electrification planning, the creditworthiness of energy off-takers and immature markets […] […] issues of affordability for Strong upfront investments, whether LPG cylinder(s) and stove(s) for cooking or a solar home system [...]."*	*Moderate:* clear objectives, diversity of goals and implementation measures. Success hinges on the energy efficiency and renewable energyT scaling up procedures, and financial mechanisms. The relationship between developed and developing nations are often a point of contention due to international debt.
	2011: Conference of the Parties 17: Durban, South Africa[4]	Green Climate Fund established, measurement, reporting and verification (MRV) measures established, addition of "applicable to all parties," expunged "common but differentiated responsibilities" - affirming balanced responsibility and inclusion - and establishment of the Ad Hoc Working Group on Long-term Cooperative Action (AWG-LCA) charged with negotiation and brokering commitments and international agreement from 2012 (post-Durban) to 2015 (pre-Paris). → Launched protocol development process so that the outcomes have legal and binding force, and unification of all parties → "2 Degrees Celsius Goal" and discussion on 2050 global emissions reduction targets postponed	*Weak:* with the exception that it set the precedent for the Paris Agreement with legal and binding force, progress was hampered by circumstances over global emissions reduction targets, warming targets, and political disagreements over Kyoto (unbalanced because excludes commitments from developing countries).
	2015: Conference of the Parties 21: Paris, France[5]	2 degrees Celsius warming limit, emphasis on pursuing 1.5 degrees Celsius, flexible nationally determined contributions (NDCs), reaffirming adaptation efforts, compliance efforts that are "non-punitive" and "non-adversarial," allowance of carbon-market efforts and tradable carbon offsets. → $19B in financial support by developed countries to developing countries → Then Secretary of State John Kerry pledged $800M per year by 2020 for adaptation efforts, a 2X increase in annual support funds → Launch of several solar and renewable energy research programs: International Solar Alliance (India and France), Mission Innovation, Compact of Mayors (Mike Bloomberg: Mayor of New York City, and Anne Hidalgo: Mayor of Paris, France, coalition of 360+ cities), Breakthrough Energy Coalition (28 investors in 10 different countries, including Bill Gates, formerly of Microsoft)	*Strong:* ambitious global warming limit, largest financial contributions and future commitments, strongest level of international cooperation, successfully outlined future negotiations and evaluation action.

United States Federal Government	**1978:** PURPA[6]	Fair and equitable rates and rate-making standards, encourages energy conservation and energy efficiency in facilities used by electric utilities.	*Strong:* deregulation, shift to competing sellers-market, no more "vertical integration."
	1992: EPA[7]	New rate-making standards, energy efficiency standards for buildings, appliances, and industrial facilities, promotion of demonstration projects, boost in competitive economy through wholesale power market.	*Moderate:* with the promotion of wholesale energy, solar PV speaks mostly toward commercial feasibility, not distributed generation feasibility.
	2000, 2003: State solar interconnection standards, rules, rights[8]	Adopted by the WI PSC, IOUs and MOUs required to obey standards and provision for distributed generators.	*Weak:* systems greater than 20kW generating capacity do not qualify for net metering (Category 1 to Category 2 jump up), most only applicable to IOUs.
	2002: Corporate tax credits: ITC/PTC[8, 9]	System owners can take advantage of tax credits based on investment costs or a per kWh production. ITC and PTC may not be used together. → ITC extended, 30% through 2019, 26% in 2020, 21% in 2021, and 10% for every year after → Solar systems that are not on ITC can claim a production tax credit of $0.023/kWh	*Strong:* helps recover investment costs quickly, increases ROI, helps solar PV and other RETs reach grid parity.
	2002: MACRS[8]	Based on the IRS's classification of lives by classes of assets, distributed generator owners can take annual tax deductions for depreciation of property, allowing for larger deductions in the earliest years following installation, and progressively lower deductions afterward. → Many RETs including solar PV fall in to the 5-year property class	*Moderate:* helps recover investment costs quickly, increases ROI, some systems qualify for bonus depreciation.
	2002: USDA REAP[8]	USDA administers grants and loans to agricultural and small business establishments in rural America that wish to install renewable energy and energy efficient systems and enhancements. → Grants may not exceed 25% total cost for renewable energy project	*Moderate:* tailored solutions for rural establishments.
	2005: EPA[10]	Illustrates potential of concentrated solar power (CSP), solar PV and solar thermal, "passive" solar technology (daylighting), and solar water heaters and their research, development, and demonstration. Explores commercial viability, integration with public buildings and federal facilities, and adoption of interconnection and net metering standards.	*Moderate:* more broad-spectrum, promotes solar PV for rural or "insular" regions, public buildings, and federal facilities.

United States Federal Government (continued)	**2007:** EISA[11]	Programs and performance standards for energy efficient residential, commercial, federal, and industrial buildings. Accelerated solar technology research, appropriations for solar PV, thermal, CSP, and passive solar demonstrations. Small-business loans for RE and EE investments, electric utilities to promote EE investments and behavior in customers through programs and incentives (home energy audits, promotional and education campaigns, availability of affordable loans, and consider removal of "throughput incentives" (decoupling).	*Strong:* greater specialization in solar technologies including smart-grid and energy storage RD&D, huge push for energy efficiency and RETs besides solar (carbon storage and sequestration, HVAC, biofuel, and fuel-economy standards).
	2009: ARRA[12]	Appropriations in energy efficiency and renewable energy programs, loan guarantees, RD&D, transmission and grid infrastructure, and environmental clean-up efforts: $16.8B → $6B Innovative Technology and Loan Guarantee Program → $3.2B Energy Efficiency and Conservation Block Grants → $3.1B State Energy Programs (renewable energy and/or energy efficiency)	*Strong:* credited with post economic recession recovery, significant investments in renewable energy and energy efficiency.
State of Wisconsin	**1993:** Wisconsin Act 414[13]	To limit the out of state expenditures on non-renewable raw resources, this law instructs all energy users to energy efficiency and renewable energy adoption to the extent of cost-effectiveness and technical feasibility using a energy sources priority list. Applicable RETs include wind, hydroelectric, biomass and effluence, and solar (passive, PV).	*Weak:* stipulates guidelines to encourage energy efficiency and renewable energy adoption, not requirements.
	1999: Wisconsin Act 9[13]	Additional provision of assistance to low-income households. Created Wisconsin's RPS, and first Public Benefits Fund (known today as Focus on Energy), collected from [1] energy customer fees, and [2] electric utility "contributions" (essentially from the energy customer, but instead recovered through customer rates)	*Strong:* RPS and Focus on Energy largely illustrate the renewable energy umbrella and financing options for all energy users.
	2000: Biogas, Solar, and Wind Energy Equipment Exemption[8]	Solar PV systems that add value to property are exempt from property taxes.	*Weak:* minor cost savings, passive solar does not qualify.
	2000: RPS and RECs[8]	Target mixes of renewable and non-renewable energy sources, often achieved with the help of renewable energy credits (RECs)	*Strong:* encourages distributed generation and mandates renewables in energy provider portfolios.

State of Wisconsin (continued)	**2000:** Net Metering[8, 14, 15]	During periods of net excess generation, electricity delivered to the grid credited to the system owner at the utility's retail rate. System electricity offsets consumer needs (although for businesses or industrial establishments this is not usually the case, solar PV systems are essentially "peak shavers" since consumer needs > system production capacity).	*Moderate:* 20 kW system capacity limit, caps disincentivize larger system sizes, most only applicable to IOUs.
	2005: Wisconsin Act 141[13]	Establishes new RPSs, Focus on Energy (a state-wide program) restructured by replacing public benefits fund model with gas and electric IOU programs through contractual agreements with private program administrators (oversight by the PSC instead of Dept. of Administration) → IOUs (gas and electric) required to fund Focus on Energy providing 1.2% of their total annual operating revenue, or may provide their own, but WI PSC is prohibited from ordering programs (ex. WE Energies) → Pre-WI Act 141 saw Focus on Energy's 2005 funds grow to $62.9M (Strong watermarks achieved in the years 2011, 2012, and 2013 at $100M per year) → Focus on Energy 2015 and 2016 total: $8.5M	*Moderate:* more ambitious RPS, directs programs to address barriers and needs based on energy user sector (domestic, business, agriculture, institutional, industrial, and large energy consumers). Provision of funds poachable for budget cuts, progressively declining annual funds.
	2009: Renewable Energy Sales Tax Exemptions[8]	Solar PV systems 100% exempt from sales and use tax.	*Weak:* minor cost savings, eligible technologies must have the capacity to produce 200 watts AC or 600 BTUs daily to qualify.
	By utility: Feed-in Tariffs (FITs) [14, 15]	Grid-tied system owners purchase all power consumed from the grid at retail rates. All the power produced from distributed generating system is credited back at premium-rates, rather than retail.	*Strong:* encourages larger systems sizes, premium rates recover costs quickly, incentivizing enhancements to existing systems.
	By utility: Decoupling mechanism[16, 17]	Elimination of throughput incentives, and unfair windfall profits and rate-making by energy providers. Rates, total allowable revenue, and fixed charges are regulated by the PSC, but sometimes viewed as arbitrary. IOU-PSC proceedings tend to generate discord with some energy users, or sometimes entire neighborhoods or communities.	*Strong:* rate-making is contentious, empowers energy users to participate and scrutinize their energy providers to ensure a fair and just standard.

Focus on Energy	**2000:** Renewable Energy Competitive Incentive Program (RECIP)[8, 18]	Request for Proposal process takes place twice per year. Solar PV systems must meet the following criteria: [1] cannot exceed 125% of owner's annual energy consumed , [2] payback must be within 1.5 years following installation, [3] the payback period cannot exceed the system warranty period, and [5] system must be sited in a participating utility's market territory.	*Weak:* limited funding available, competitive RFP process.
	2002: Renewable Rewards Program[8, 18]	Eligible solar PV modules receive a $600/kW DC installed capacity. Eligible sizes between 0.5kW and 4kW (maximum incentive of $2400).	*Weak:* minor cost savings.

Note. Policies classified under 'weak' may be inaccurately qualified as 'ineffectual.' From an affordability perspective, these weaker policies may not be regarded with substantial cost savings opportunity alone. However, bundled together with other state and federal grant, finance, and other savings opportunities (usually put together by a representative of a private solar firm), they are salient "low hanging fruit" that collectively represent a substantial difference in opportunity to save money. Therefore, weak might also be interpreted as the low hanging fruit to potential distributed generation owners/operators.

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APPENDIX B-1

Mean scores distributed by adoption groupings in the Corporate Technology Diffusion of Wisconsin Businesses

Question Item		*Adopters* Solar PV adopters (N = 24)	*Non-adopters* Solar PV potential adopters (N = 25)	*Non-adopters* Solar PV non-adopters (N = 23)	Chi-square[b]	Total n (~answered items only)
Introduction						
[1] Does your firm regularly implement sustainability practices? (-1 = UNSURE; 0 = NO; 1 = MAYBE; 2 = YES)	Mean	1.88	1.88	1.91	1.54	(72)
	S.D.	0.45	0.44	0.29		
[2] How would you rate your level of knowledge regarding your firm's energy systems? (1 = Not knowledgeable; 5 = Extremely knowledgeable)	Mean	4.08	4.00	3.78	8.54	(72)
	S.D.	0.88	0.76	0.90		
[3] How frequently are you updated and informed regarding your firm's energy consuming activities? (1 = Never; 5 = Always)	Mean	4.29	4.24	4.17	2.90	(72)
	S.D.	0.75	0.93	0.98		
Consumer to Policy Networks[a]						
[5] There is not enough information available on solar energy to adopt it (- - -)[1]	Mean	4.00	3.52	3.30	21.64***	(70)
	S.D.	0.98	0.92	0.93		
[6] The application of a solar photovoltaic system is not hard (+++)[1]	Mean	3.91	3.28	3.17	13.69*	(70)
	S.D.	0.87	0.89	0.89		
[7] Solar PV incentives are unclear (- - -)[†, 1]	Mean	3.41	2.67	2.48	13.44*	(69)
	S.D.	0.80	1.13	1.04		
[8] Solar PV subsidies are clear (+++)[†, 1]	Mean	3.45	2.46	2.55	13.96*	(68)
	S.D.	0.91	0.98	1.01		
[9] The environmental benefits of a solar PV system to a business are unclear (- - -)[1]	Mean	3.64	3.88	2.91	15.41*	(69)
	S.D.	1.00	0.95	1.35		
[10] The economic benefits of a solar PV system to a business are clear (+++)	Mean	3.50	3.25	2.82	11.27	(68)
	S.D.	1.01	1.03	1.14		
[11] At our firm, we do not understand what renewable energy credits are (- - -)	Mean	3.68	3.42	3.57	7.19	(69)
	S.D.	1.04	1.02	1.12		
[12] At our firm, we care about how utilities determine rates for electricity (+++)	Mean	4.55	4.21	4.30	4.58	(69)
	S.D.	0.60	0.66	0.95		
[13] At our firm, we do not understand what feed-in tariffs are (- - -)	Mean	2.68	2.48	2.32	8.51	(67)
	S.D.	1.39	0.99	0.95		
[14] When our firm needs help with any energy technology, we do not have trouble finding it (+++)	Mean	4.00	3.30	3.82	10.46	(67)
	S.D.	0.54	1.11	0.85		
[15] At our firm, we are not well informed on renewable energy policies (- - -)	Mean	3.59	3.00	3.32	7.22	(67)
	S.D.	0.80	1.09	1.00		
[16] Solar property rights are clear (+++)	Mean	3.05	2.55	2.48	12.06	(65)
	S.D.	0.95	0.86	0.98		
[17] Solar regulations are unclear (- - -)	Mean	3.05	2.68	2.48	8.30	(65)
	S.D.	0.90	0.78	0.87		
[18] State-wide institutions and organizations provide reliable support when we need it (+++)	Mean	3.55	3.45	3.14	10.80	(65)
	S.D.	0.67	0.80	1.20		

[19] Our firm's energy provider provides unreliable support when we need it (- - -)	Mean	3.95	3.62	3.25	14.52*	(62)
	S.D.	0.74	0.87	1.02		
[20] Enough data and information are available for firms to adopt solar PV (+++)†	Mean	3.86	3.14	2.95	12.41	(63)
	S.D.	0.79	0.99	1.00		
[21] At our firm, we do not feel a strong and supportive presence of a community of information regarding sustainable energy (- - -)	Mean	3.90	3.05	2.79	20.51***	(61)
	S.D.	0.77	0.74	0.86		
Affordability[a]						
[22] Solar PV systems are affordable (+++)[1]	Mean	3.24	2.82	2.38	12.32	(59)
	S.D.	1.00	0.96	1.09		
[23] Solar PV is not the best available technology for our firm to be self-sufficient (- - -)[1]	Mean	3.05	2.68	2.18	13.05**	(60)
	S.D.	0.87	0.84	88.0		
[24] Increasing oil and gas prices support the use of solar PV (+++)[1]	Mean	3.76	3.59	3.24	11.85	(60)
	S.D.	0.89	0.91	1.25		
[25] Solar energy is not the most sustainable energy source (- - -)[1]	Mean	3.52	3.77	2.88	19.53**	(60)
	S.D.	1.08	0.61	1.27		
[26] Solar energy will become cheaper than oil and natural gas (+++)[1]	Mean	3.71	3.73	3.00	18.96**	(60)
	S.D.	1.01	0.55	1.17		
[27] A solar energy system is not suitable for our firm's location (- - -)	Mean	3.39	3.48	2.47	27.60***	(59)
	S.D.	1.18	0.81	1.23		
[28] An energy system focused on energy efficiency products are suitable for our firm's location (+++)	Mean	4.10	4.09	3.88	3.73	(60)
	S.D.	0.63	0.61	0.86		
[29] Solar PV investments are risky (- - -)	Mean	4.00	2.95	2.71	28.25***	(60)
	S.D.	0.63	0.79	1.05		
[30] Solar PV benefits outweigh the costs (+++)	Mean	3.86	2.91	2.65	23.21***	(60)
	S.D.	1.01	0.87	1.27		
[31] The payback period on a solar PV system is too long (- - -)	Mean	3.05	2.36	2.29	11.38	(60)
	S.D.	1.20	1.00	1.05		
[32] The rate of return on a solar PV system is clear (+++)†	Mean	3.14	3.23	3.47	11.20	(60)
	S.D.	1.01	0.92	1.07		
[33] Outcomes of solar PV investments are largely uncertain (- - -)	Mean	3.57	3.27	2.65	13.21**	(60)
	S.D.	0.87	0.83	0.79		
[34] Sufficient financial capital is the most important thing that determines if a firm will adopt a solar PV system (+++)	Mean	3.19	3.55	3.35	7.74	(60)
	S.D.	1.08	1.01	1.00		
[35] Financing a solar PV system is difficult to understand (- - -)	Mean	3.38	3.09	3.00	5.23	(60)
	S.D.	0.81	0.92	0.94		
[36] Our firm is mindful about the monthly energy bill (+++)	Mean	4.14	4.18	4.59	6.37	(60)
	S.D.	0.73	0.80	0.62		
[37] Utility-based energy prices do not support the shift toward solar PV (- - -)†	Mean	2.76	2.77	2.59	10.17	(60)
	S.D.	0.77	0.75	1.12		
[38] I am confident with our firm's energy strategy (+++)	Mean	4.19	3.18	3.71	17.48**	(60)
	S.D.	0.51	0.91	0.99		

[39] I do not feel a sense of enjoyment with our firm's energy choices (- - -)	Mean	4.05	3.10	3.24	15.13*	(59)
	S.D.	0.74	0.89	1.25		
[40] Our firm's energy bills reflect charges that are acceptable (+++)[†]	Mean	3.00	3.18	3.24	9.56	(60)
	S.D.	1.14	0.90	0.90		
***Corporate Environmental Orientation Scale*[a, 2]**						
[41] At our firm, we make a concerted effort to make every employee understand the importance of environmental preservation (+++)	Mean	4.14	3.86	4.06	4.31	(60)
	S.D.	0.66	0.83	0.97		
[42] Our firm has a clear policy statement urging environmental awareness in every area (+++)	Mean	3.95	3.82	4.00	1.46	(60)
	S.D.	0.87	0.96	1.00		
[43] Environmental preservation is a high-priority activity in our firm (+++)	Mean	4.05	3.82	3.94	2.49	(59)
	S.D.	0.83	0.96	0.97		
[44] Preserving the environment is a central corporate value in our firm (+++)	Mean	4.15	3.86	4.18	3.32	(59)
	S.D.	0.75	0.99	0.88		
[45] The financial well-being of our firm does not depend on the state of the natural environment (- - -)	Mean	3.50	3.77	3.88	13.91	(58)
	S.D.	1.05	1.19	1.11		
[46] Our firm has a responsibility to preserve the environment (+++)	Mean	4.30	4.36	4.53	3.33	(59)
	S.D.	0.57	0.49	0.51		
[47] Environmental preservation is vital to our firm's survival (+++)	Mean	3.25	3.77	4.12	12.54	(59)
	S.D.	1.25	0.81	1.17		
[48] Our firm's responsibility to its customers, stockholders, and employees is more important than our responsibility toward environmental preservation (- - -)	Mean	3.15	3.29	2.88	9.23	(58)
	S.D.	1.18	0.85	1.05		
[49] The natural environment does not currently affect our firm's business activity (- - -)	Mean	3.55	3.95	4.00	4.09	(59)
	S.D.	1.10	0.84	0.94		
[50] In our firm, environmental preservation is largely an issue of maintaining a good public image (- - -)	Mean	3.50	3.27	3.47	7.84	(59)
	S.D.	1.00	0.99	1.23		
[51] It is difficult for our firm to be successful and preserve the environment at the same time (- - -)	Mean	3.80	3.73	4.00	6.88	(59)
	S.D.	1.06	0.83	0.87		
[52] In our firm profits are more important than our environmental activities (- - -)	Mean	3.75	3.29	3.59	4.48	(58)
	S.D.	1.21	1.01	1.12		
[53] We evaluate our environmental efforts by their economic benefits to our firm (- - -)	Mean	3.20	2.70	2.82	3.98	(57)
	S.D.	1.01	0.92	1.07		
[54] It is our firm's mission to be a leader in environmental protection in our industry (+++)	Mean	3.70	3.90	3.94	7.55	(57)
	S.D.	1.03	0.91	1.09		
***New Ecological Paradigm Scale*[a, 3]**						
[55] We are approaching the limit of the number of people the earth can support (+++)	Mean	3.21	3.25	3.19	8.18	(55)
	S.D.	1.08	1.07	1.28		
[56] Humans have the right to modify the natural environment to suit their needs (- - -)	Mean	3.42	3.74	3.53	12.18	(55)
	S.D.	1.17	1.05	0.72		
[57] When humans interfere with nature it often produces disastrous consequences (+++)	Mean	3.25	3.78	3.47	5.03	(55)
	S.D.	1.12	0.73	1.13		

[58] Human ingenuity will insure that we do NOT make the earth unlivable (- - -)	Mean	2.89	2.95	2.94	9.88	(56)
	S.D.	0.94	1.10	1.20		
[59] Humans are severely abusing the environment (+++)	Mean	3.75	3.89	3.65	4.56	(56)
	S.D.	1.07	0.81	1.22		
[60] The earth has plenty of natural resources if we just learn how to develop them (- - -)	Mean	3.05	3.26	3.06	5.37	(55)
	S.D.	1.03	0.87	1.14		
[61] Plants and animals have as much right as humans to exist (+++)	Mean	3.63	3.67	3.71	2.82	(54)
	S.D.	1.07	1.14	1.05		
[62] The balance of nature is strong enough to cope with the impacts of modern industrial nations (- - -)	Mean	3.63	3.94	3.47	7.90	(54)
	S.D.	1.07	0.80	0.94		
[63] Despite our special abilities humans are still subject to the laws of nature (+++)[†]	Mean	4.25	4.25	4.18	0.25	(57)
	S.D.	0.55	0.55	0.53		
[64] The so-called "ecological crisis" facing humankind has been greatly exaggerated (- - -)	Mean	3.65	3.74	3.35	7.09	(56)
	S.D.	1.14	0.87	1.17		
[65] The earth is like a spaceship with very limited room and resources (+++)	Mean	3.53	3.67	3.76	2.63	(54)
	S.D.	0.91	0.77	0.97		
[66] Humans were meant to rule over the rest of nature (- - -)	Mean	3.83	3.89	3.69	5.64	(52)
	S.D.	0.92	1.02	0.79		
[67] The balance of nature is very delicate and easily upset (+++)	Mean	3.50	3.74	3.47	10.14	(56)
	S.D.	0.89	1.05	1.33		
[68] Humans will eventually learn enough about how nature works to be able to control it (- - -)	Mean	3.63	3.63	3.31	5.95	(54)
	S.D.	0.76	0.76	1.20		
[69] If things continue on their present course, we will soon experience a major ecological catastrophe (+++)	Mean	3.80	3.74	3.35	6.95	(56)
	S.D.	1.01	0.73	1.12		

***Significant at the $\alpha = 0.01$ level

**Significant at the $\alpha = 0.05$ level

*Significant at the $\alpha = 0.1$ level

[†]Item deleted from further factor analyses

Note. Items with the symbols (+++) or (- - -) indicate positively and negatively worded survey questions indicative of its scale respectively. Negatively worded items were reverse scored.

[a]5-point Likert Scale: (1 = Strongly disagree; 5 = Strongly agree), reverse coded: (1 = Strongly agree; 5 = Strongly disagree)

[b]Pearson's chi-square tests for differences between 2 variables. In this study, chi-square tests for differences between solar PV adoption (dependent variable) and each of our survey items including demographics (independent variable(s))

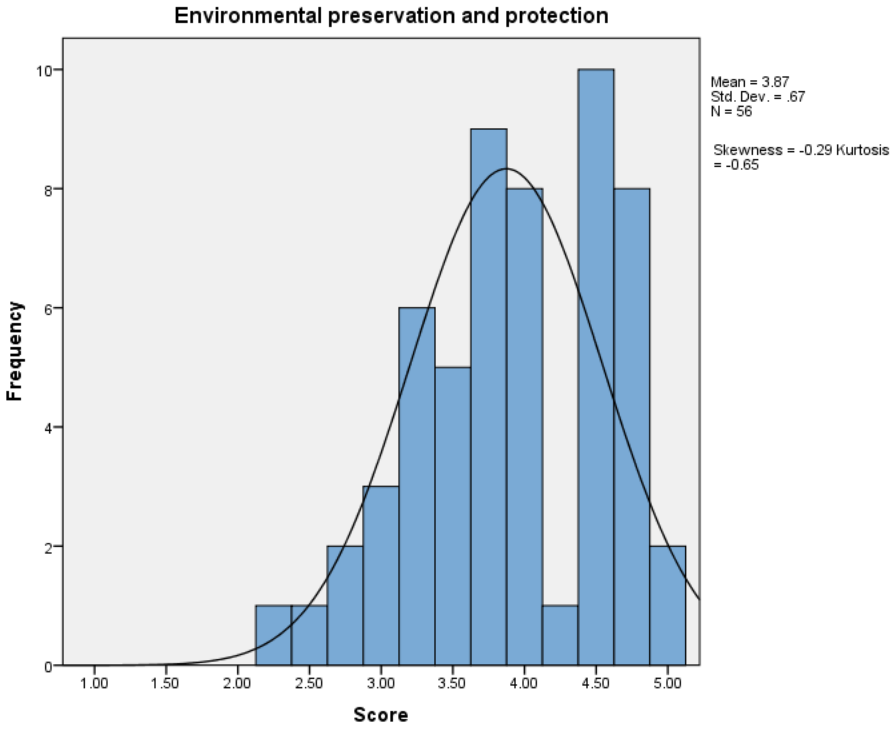
Sources: [1]Vasseur, V., & Kemp, R. (2015a). The adoption of PV in the Netherlands: A statistical analysis of adoption factors. Renewable and Sustainable Energy Reviews, 41, 483-494. doi:10.1016/j.rser.2014.08.020

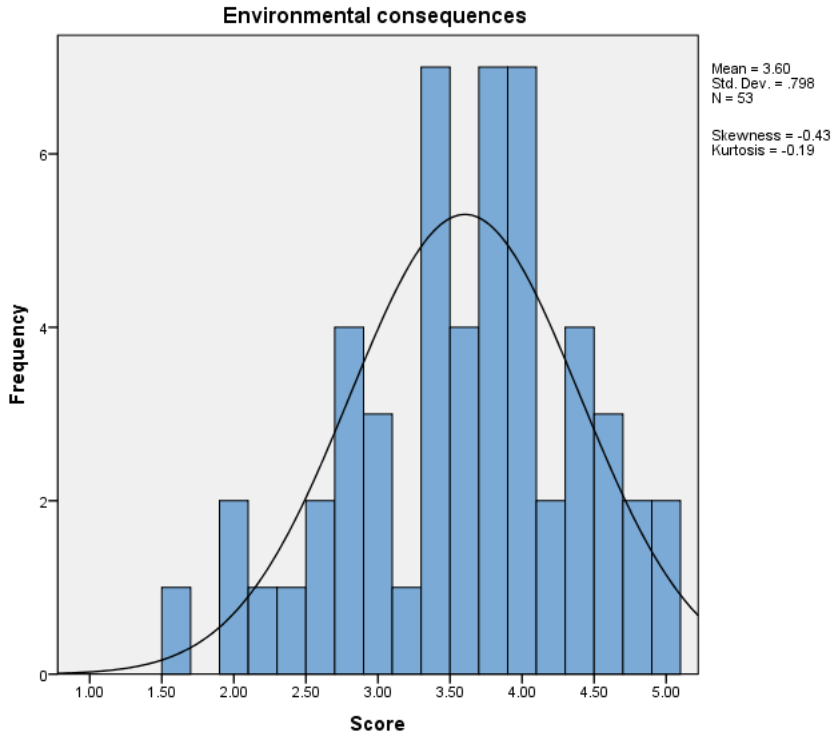
[2]bauner, S. B. (2002). Corporate environmentalism: The construct and its measurement. Journal of Business Research, 55(3), 177-191.

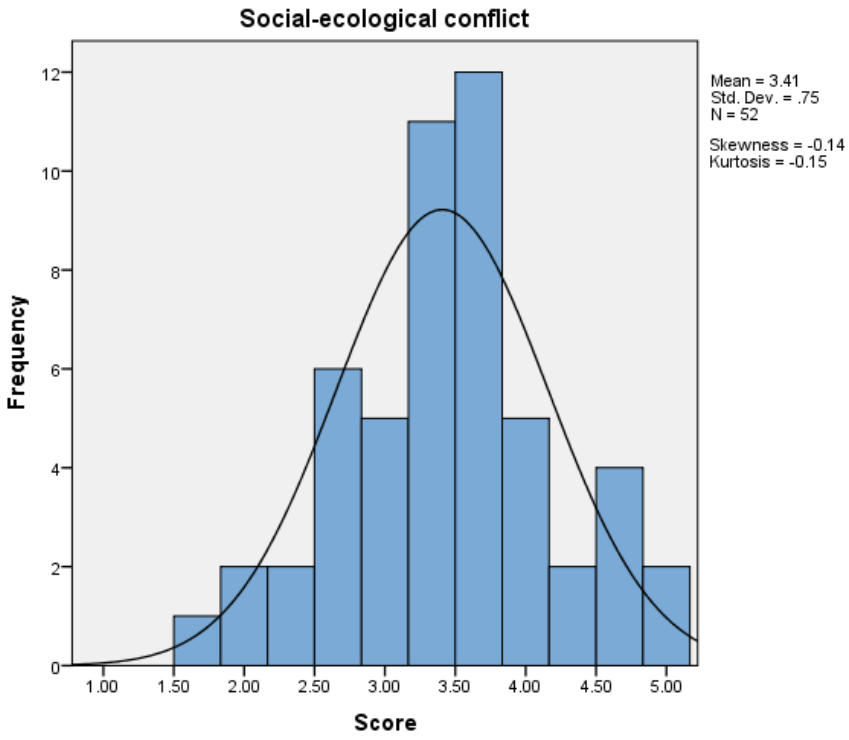
[3]Dunlap, R. E., Van Liere, K. D., Mertig, A. G., & Jones, R. E. (2000). Measuring Endorsement of the New Ecological Paradigm: A Revised NEP Scale. Journal of Social Issues, 56(3), 425-442.

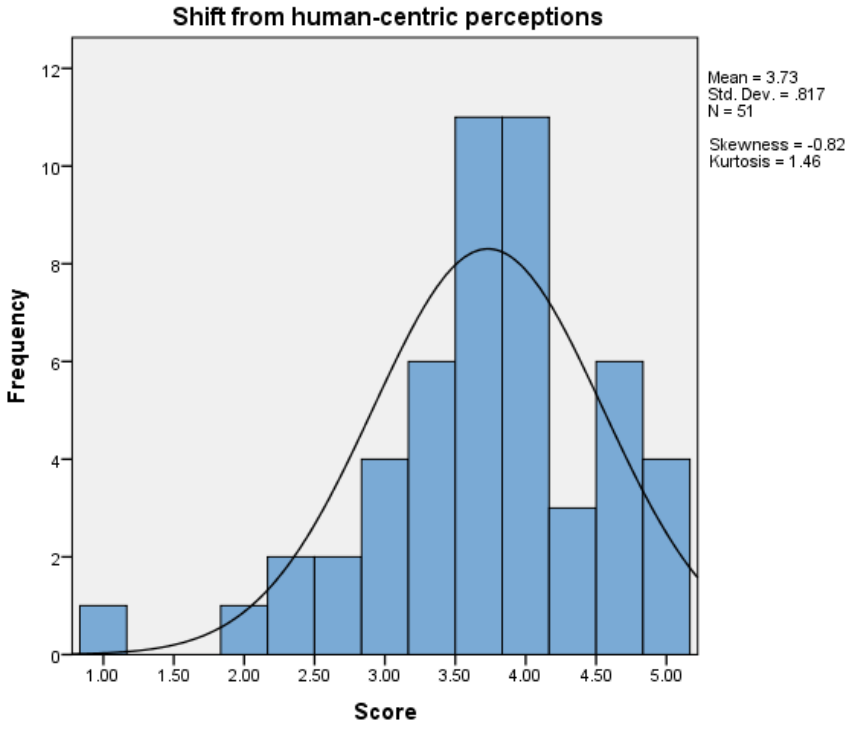
APPENDIX B-2

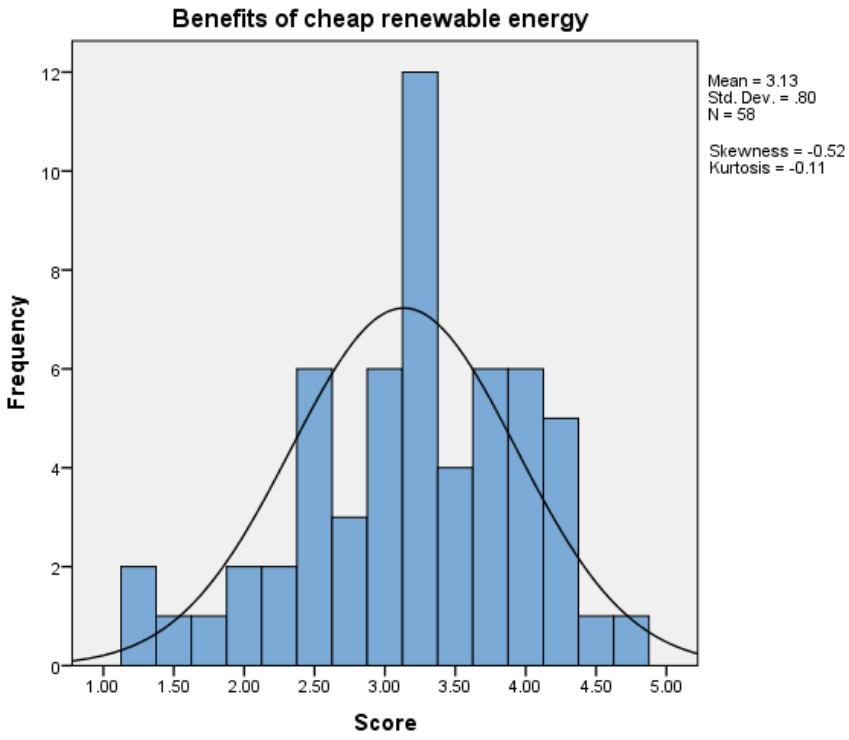
Histograms of 9 factors extracted from the consumer to policy networks and affordability constructs, and the CEOS and NEPS scales

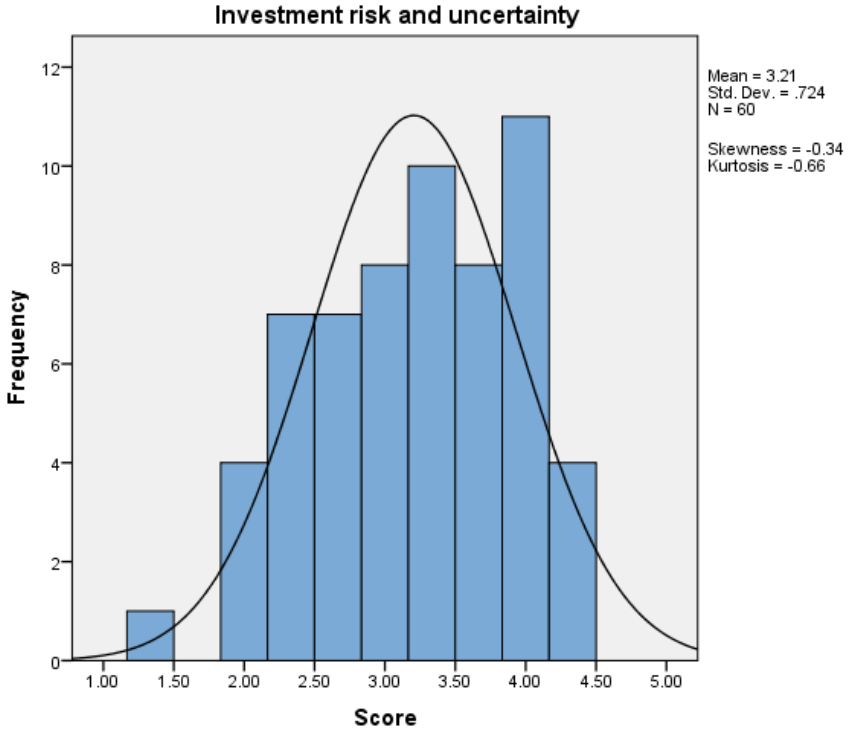

Environmental preservation and protection
Mean = 3.87
Std. Dev. = .67
N = 56
Skewness = -0.29 Kurtosis = -0.65
Frequency
Score

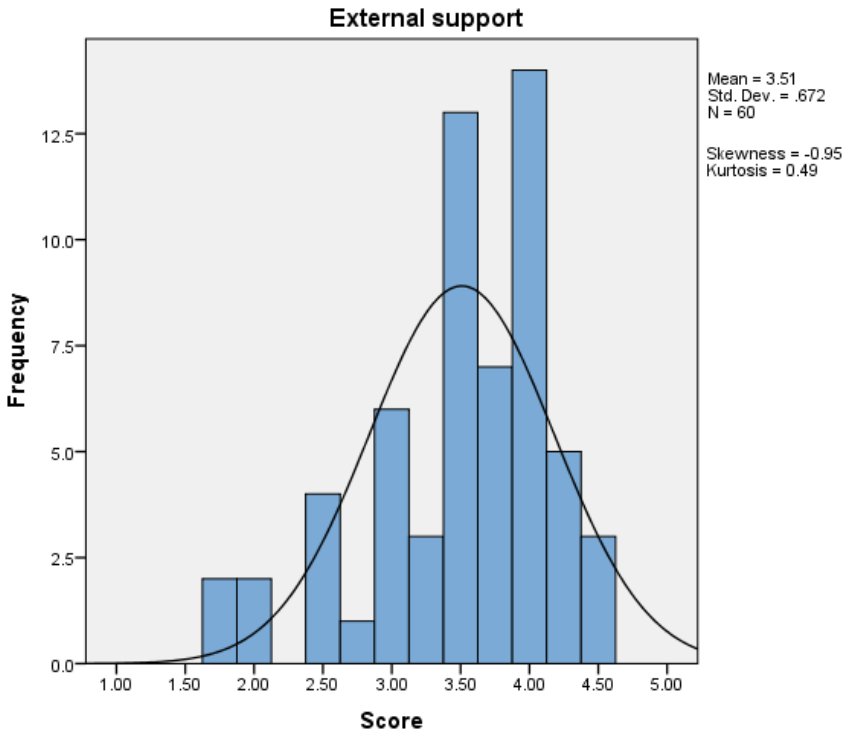

Environmental consequences
Mean = 3.60
Std. Dev. = .798
N = 53
Skewness = -0.43
Kurtosis = -0.19
Frequency
Score

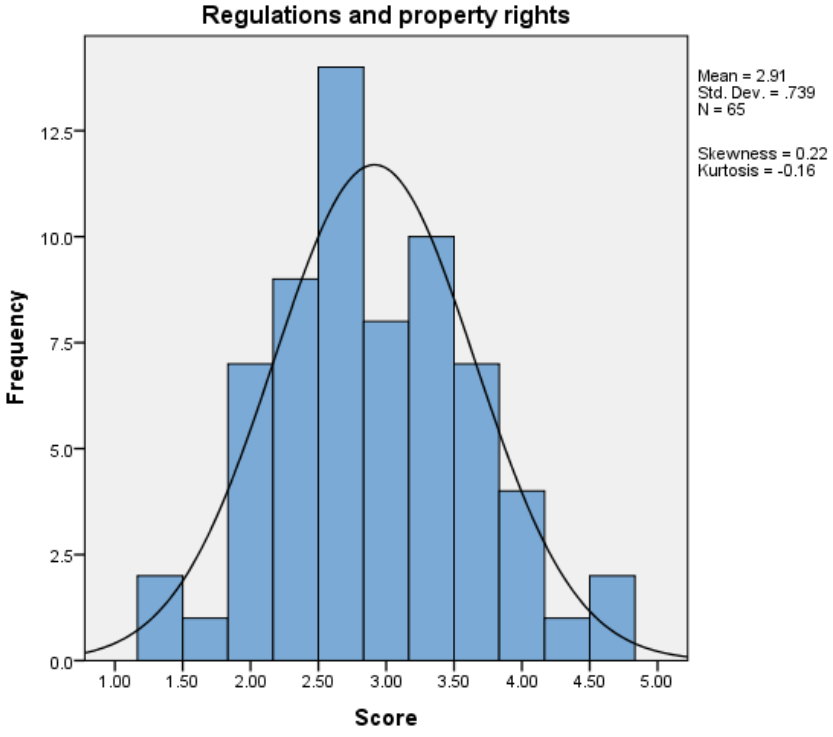

Social-ecological conflict
Mean = 3.41
Std. Dev. = .75
N = 52
Skewness = -0.14
Kurtosis = -0.15
Frequency
Score
0
2
4
6
8
10
12
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00

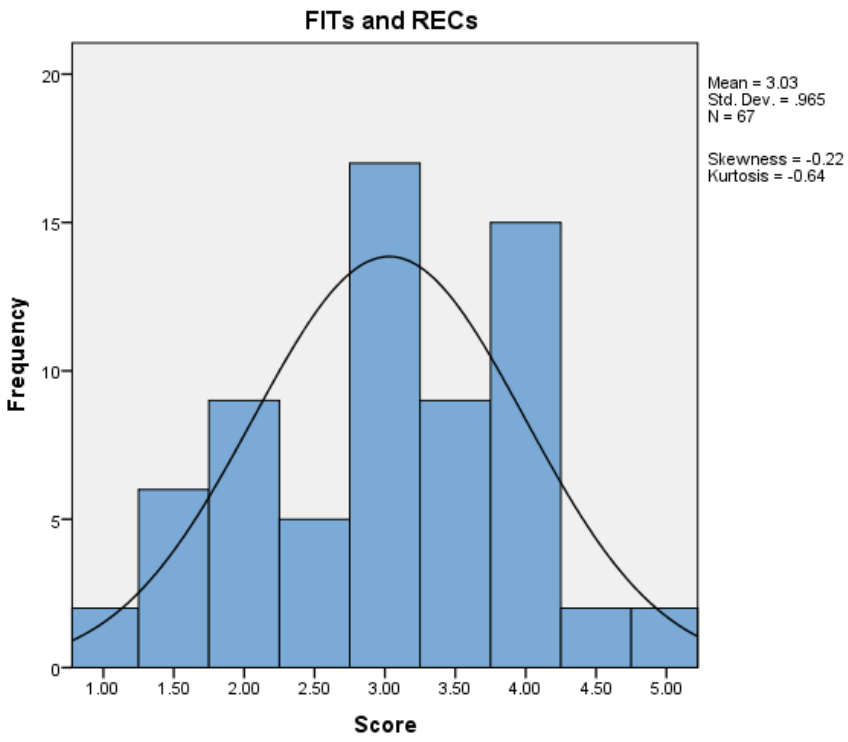

Shift from human-centric perceptions
Mean = 3.73
Std. Dev. = .817
N = 51
Skewness = -0.82
Kurtosis = 1.46
Frequency
Score
0
2
4
6
8
10
12
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00


Benefits of cheap renewable energy
Mean = 3.13
Std. Dev. = .80
N = 58
Skewness = -0.52
Kurtosis = -0.11
Frequency
Score
0
2
4
6
8
10
12
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00

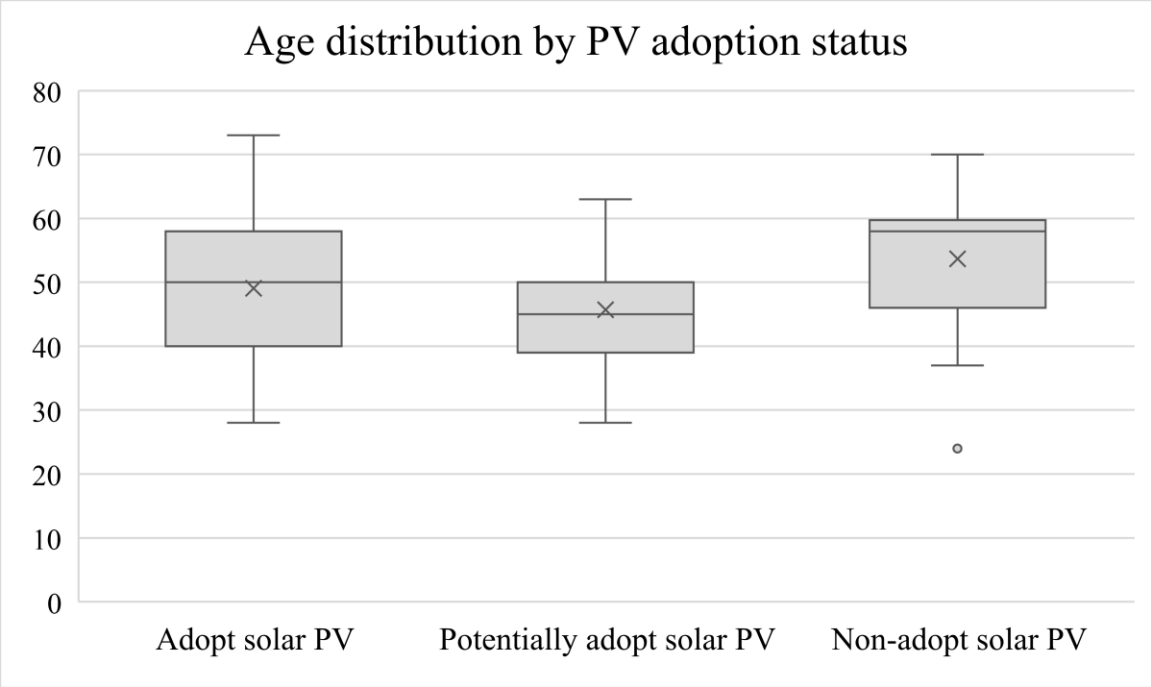

Investment risk and uncertainty
Mean = 3.21
Std. Dev. = .724
N = 60
Skewness = -0.34
Kurtosis = -0.66
Frequency
Score
0
2
4
6
8
10
12
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00


External support
Mean = 3.51
Std. Dev. = .672
N = 60
Skewness = -0.95
Kurtosis = 0.49
Frequency
0.0
2.5
5.0
7.5
10.0
12.5
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Score

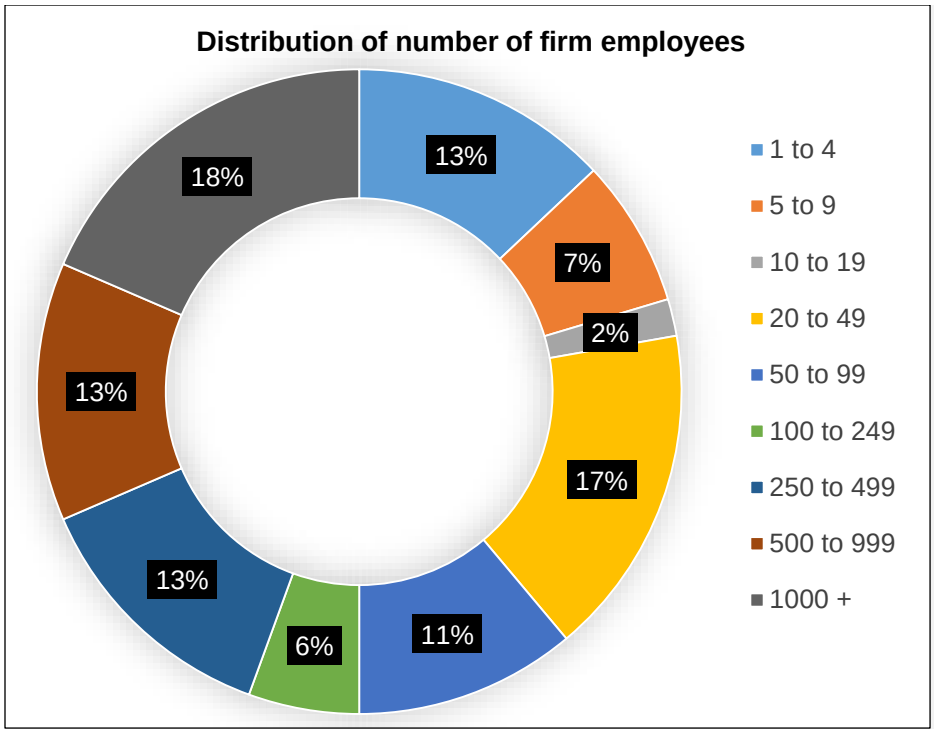

Regulations and property rights
Mean = 2.91
Std. Dev. = .739
N = 65
Skewness = 0.22
Kurtosis = -0.16
Frequency
0.0
2.5
5.0
7.5
10.0
12.5
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Score

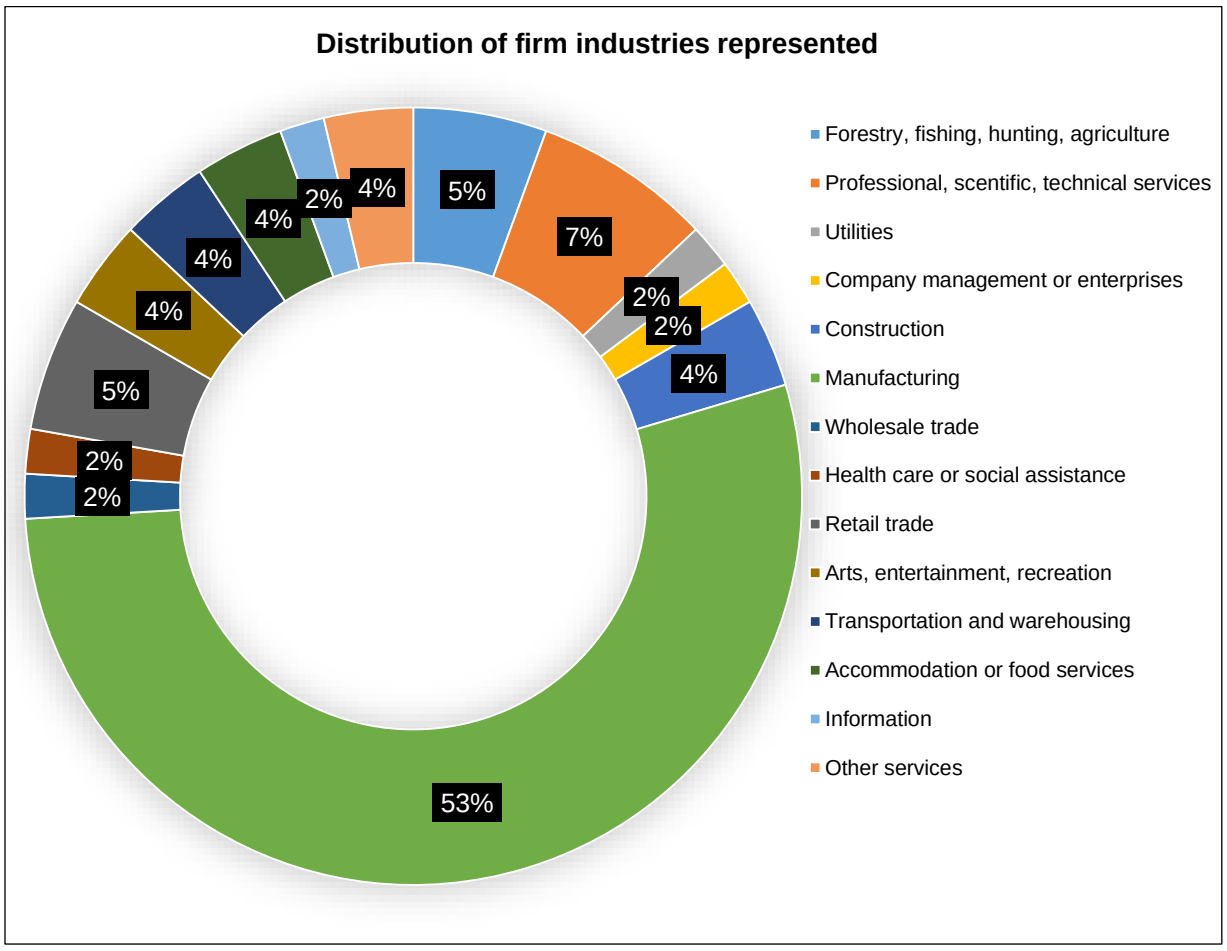

FITs and RECs
Mean = 3.03
Std. Dev. = .965
N = 67
Skewness = -0.22
Kurtosis = -0.64
Frequency
Score
0
5
10
15
20
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00

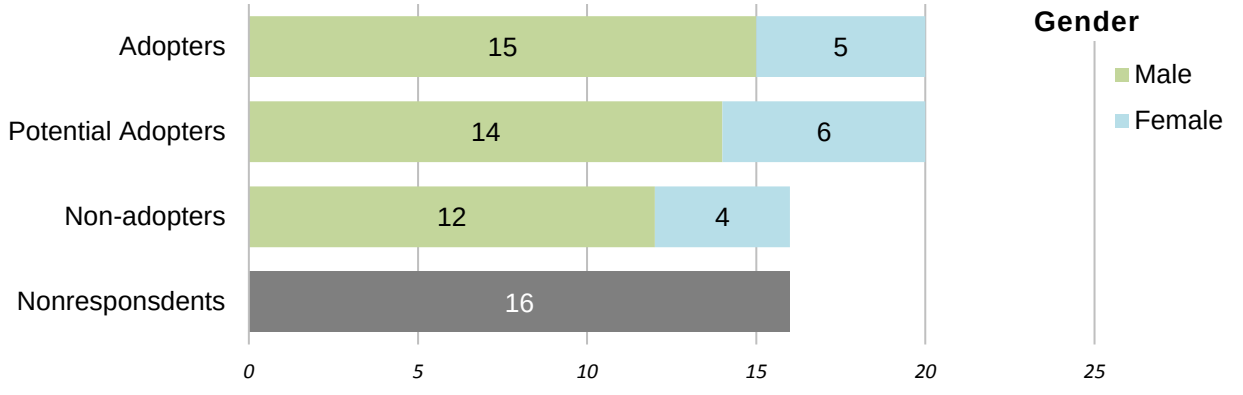
APPENDIX B-3
Demographic figures

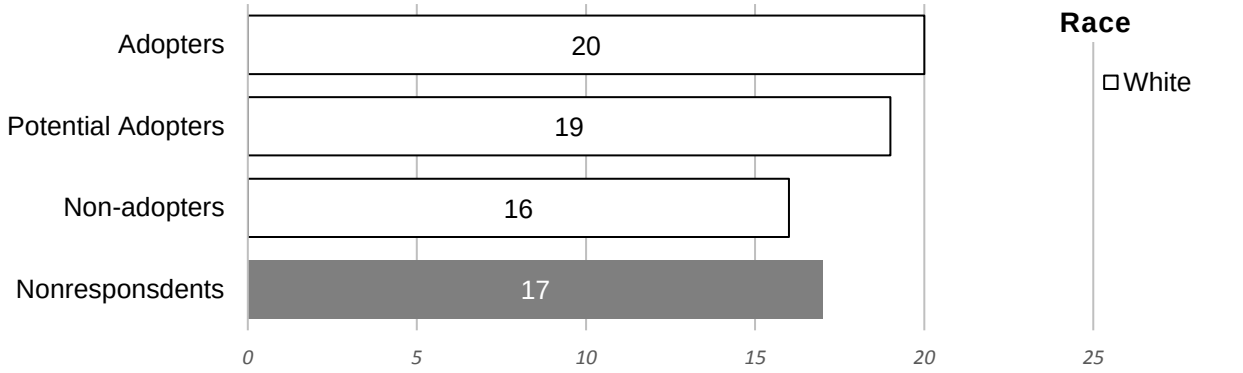


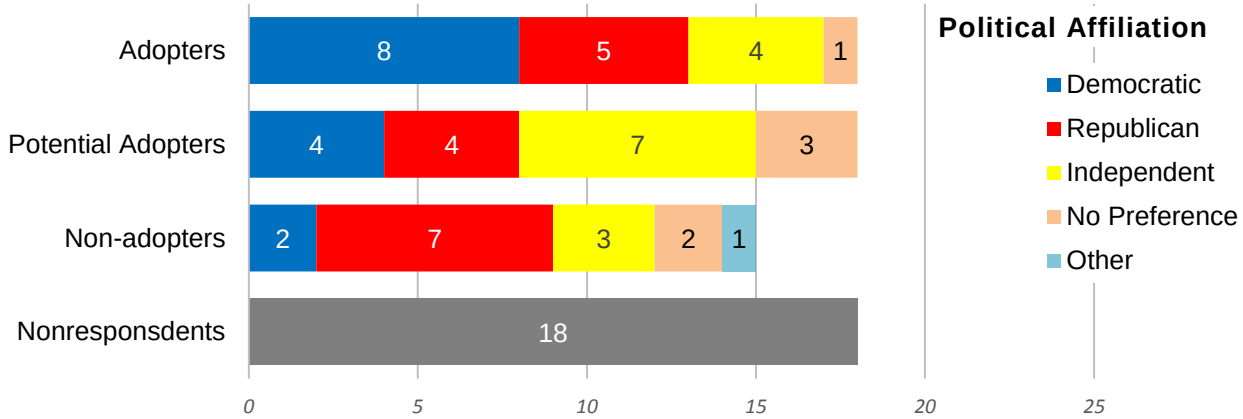
	Adopters	*Non-adopters*	
Descriptive statistics on age	Solar PV adopters	Solar PV potential adopters	Solar PV non-adopters
Sample size w/ incomplete responses	19 (5)	19 (4)	16 (7)
Mean	49.05	45.68	53.69
Median	50	45	58
Mode	37	39	46
Standard deviation	11.92	10.69	11.695
Sample Variance	142.16	114.34	136.76
Range	45	35	46
Minimum	28	28	24
Maximum	73	63	70


Distribution of number of firm employees
13%
7%
2%
17%
11%
6%
13%
13%
18%
1 to 4
5 to 9
10 to 19
20 to 49
50 to 99
100 to 249
250 to 499
500 to 999
1000 +


Distribution of firm industries represented
5%
7%
2%
2%
4%
53%
2%
2%
5%
4%
4%
4%
2%
4%
Forestry, fishing, hunting, agriculture
Professional, scentific, technical services
Utilities
Company management or enterprises
Construction
Manufacturing
Wholesale trade
Health care or social assistance
Retail trade
Arts, entertainment, recreation
Transportation and warehousing
Accommodation or food services
Information
Other services


Adopters
Potential Adopters
Non-adopters
Nonresponsdents
15
5
14
6
12
4
16
0
5
10
15
20
25
Gender
Male
Female


Adopters
Potential Adopters
Non-adopters
Nonresponsdents
20
19
16
17
0
5
10
15
20
25
Race
White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Potential Adopters
Non-adopters
Nonresponsdents
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Political Affiliation
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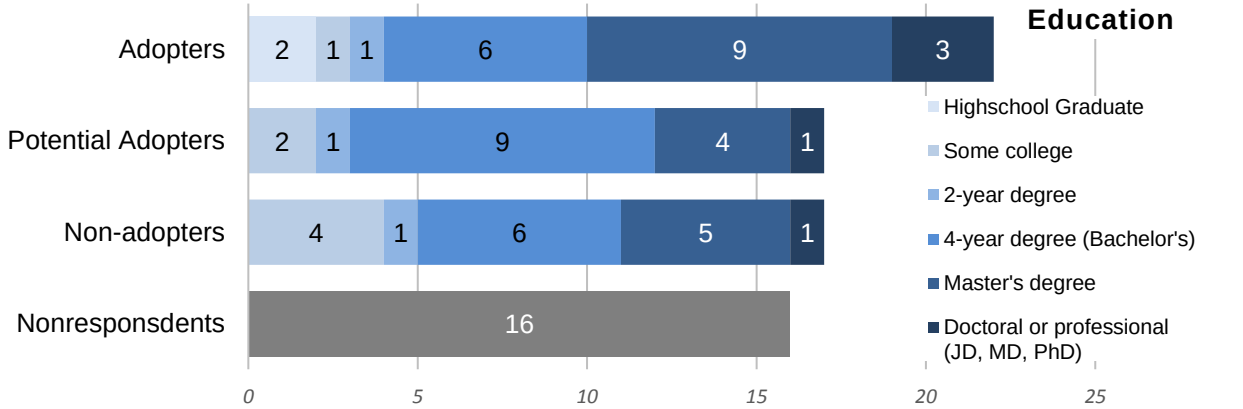
Republican
Independent
No Preference
Other


Adopters
Potential Adopters
Non-adopters
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16
0
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20
25
Education
Highschool Graduate
Some college
2-year degree
4-year degree (Bachelor's)
Master's degree
Doctoral or professional (JD, MD, PhD)

APPENDIX C
Semi-structured interview questions

(1) What does your firm do explicitly (providing a narrative)?

(1a) Please list your company's current and most important environmental and sustainability practices?[1]

(2) What does sustainability mean to your company?[1]

(3) When did your company become a member of _____ (Green Tier, RENEW WI, Green Masters programs)?

(3a) How did you hear about the Green Tier, Green Masters, or RENEW WI programs?

(4) To the best of your knowledge, how would you describe your firm's energy behavior and energy systems prior to program membership?

(5) At that time, what were the motivations for applying for membership?

(6) What motivates your company to implement sustainable practices today?[1]

(7) How would you describe the outcome of your company's sustainable practices?[1]

(8) For your firm's energy systems, who do you rely on to keep the lights on or keep the system in full operation (in other words, describe your community of information, both key informants in the firm's establishment, and those individuals or organizations outside the firm, that you rely on for support)?

(9) Is your firm implementing or exploring enhancements to your system?

(9a) Yes – Describe them.

(9b) No – Likelihood of enhancing in the near future?

(10) Implementing sustainable practices within a company's business and its network is complex and time sensitive. Could you please describe some of the challenges your company has experienced, whether they have been overcome or have not.[1]

(10a) For those that have been overcome, how were they overcome?

(10b) For those that haven't, how is your firm coping or managing them?[1]

(11) From your experiences at this firm, what are some of your milestone accomplishments? Challenges?

(12a) What do you think will bring your firm future success?

(12) What were the lessons learned throughout the whole process up until today?

(13) In the simplest sense of the word, can you identify and describe your firm's short-term goals?

(14) Long-term goals?

(15) For those firms that are not sustainability transition program members, what would you tell them that might urge them toward or caution them from applying?

(16) **(Just non-adopter firms):** Why non-adopt solar PV? What improvements or conditions might bring your firm into the potential adopter category for solar PV?

(17) **(Just adopter firms):** Why adopt solar PV? For those businesses that are potentially looking at adopting solar PV, what would you tell them that either influences or cautions their firm to adopt?

(18) What has been your relationship with your utility provider like?

(18a) How do you think energy users relate to their utility, whether it's natural gas or electricity?

(18b) Do you think in asking about these relationships that energy users take a fiscal perspective on it, such that energy prices are stable and affordable, then relationships will be positive?

(19) What would you think if there were a solar cooperative nearby, would you consider being a part of that?

(20) What were some of the obstacles in integrating these various system elements and enhancements?

(21) For any and all system enhancements, whether energy efficiency, distributed generation implementation, or various sustainability and pollution control efforts, if you could repeat the process over again, would you?

(21a) Whether you would or would not, what would you do differently?

(22) Do you receive feedback from your clients/customers?

(22a) What are they telling you about your firm's efforts? Do they notice and do they care about the green behaviors?

(23) Where do some of your environmental values stem from personally? Do you think that's an important thing in your profession?

(24) In terms of the internal decision-making here, how does the exchange process work? Who controls the decision-making procedures (governance)?

(25) Does your firm share information and experience with other firms that are looking for answers to their questions?

(25a) Is it easy to exchange the information?

25b) Are their rules to exchanging information? If so, what are they?

Note. Interview questions displayed here were not asked verbatim nor in order as they appear; on-site interviews with one or more than one interviewees took on stylistic conversation that was unique for each interaction. These questions summarize the core topics or dimensions covered, and include questions that were pre-structured, as well as the questions that emerged during interviews collectively. In total, these questions were not asked uniformly across interviews. Questions that emerged during these interview are displayed here in in italics.

Sources: [1]Høgevold, N. M., Svensson, G., Wagner, B., J. Petzer, D., Klopper, H. B., Carlos Sosa Varela, J., . . . Ferro, C. (2014). Sustainable business models. *Baltic Journal of Management, 9*(3), 357-380. doi:10.1108/bjm-09-2013-0147