HOUSEHOLD CHANGE AT THE FOOD-ENERGY-WATER NEXUS:
EXPANDING SOCIAL-BEHAVIORAL SCIENCE PERSPECTIVES

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ABSTRACT OF THE DISSERTATION

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This dissertation contributes to social and behavioral science perspectives that push forward vital energy transitions in the face of climate change. In its three analytical chapters, this dissertation achieves three central objectives: 1) accumulates findings on household behavior at the food-energy-water nexus across disciplines, 2) identifies social behavioral drivers of household green technology purchase, and 3) expands the focus of consumption research beyond the individual to consider how household social dynamics shape food, energy, and water use in the home.

Systematically reviewing published FEW intervention literature, Chapter 2 proposes a typology that characterizes household food, energy, and water conservation interventions as active, passive, or structural, and household-specific or non-specific, illustrating six distinct categories: information, tailored information, action, gamification, policy/price change, and material/technological provision. The review reveals four lessons for future intervention research: household non-specific information and tailored information appear to be more effective when used together, the impacts of feedback are reinforced when contact with participants is persistent,
price-based interventions are often ineffective, and material/technology provision has proven very effective in a limited number of studies.

Chapter 3 explores social and psychological determinants of green purchasing behavior in the US and Canada, motivated by the importance of efficient technology adoption to reach national emissions goals. This analysis establishes a causal chain from values to environmental concern to green lifestyle orientation, or the perception of importance of environmental action to one’s overall lifestyle, which predicts green purchase intentions for lightbulbs, appliances, and vehicles. Income also impacts purchase intentions in both US and Canadian samples, illustrating the pervasiveness of consumer lock-in that has potential to significantly slow green technology adoption. These findings stress the importance of exploring pro-environmental behavior not in isolation, but as interconnected with broader lifestyle circumstances.

Chapter 4 tests the effects of various household social dynamics on a variety of pro-environmental actions, in response to a “unit of analysis” problem, where intervention research often targets individuals despite much resource consumption happening in the context of multi-person households. Multiple linear regression models demonstrate that positive household dynamics, including enhancing and norming behaviors, predict variance in pro-environmental actions in the household. In addition, individual and household levels of environmental awareness predict variance in both positive and negative household social dynamics. These results support qualitative research efforts that emphasize the importance of household social dynamics to resource consumption, providing avenues for future quantitative research to take a practice-based approach.

Using multiple methods and drawing from a variety of theoretical bodies, this dissertation contributes to household behavior change literature that bridges disciplinary boundaries in the social sciences, providing paths forward for individual and household-level mitigation efforts.
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This dissertation contains material from two previously published works. While both papers are co-authored, I solely completed data analysis and writing. Co-authors engaged in project conceptualization, data collection, and manuscript revision, serving in advisory capacities.


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1 Introduction

1.1 Motivation

As climate change poses pressing ecological and social concerns, researchers aim to identify sources of greenhouse gas (GHG) emissions and the potential for emissions reductions. As major corporations and local, state, and national governments pledge to reach net-zero emissions by 2050 or sooner, consumer energy efficiency investments and use behavior change constitute a major pillar to support a nation-wide energy transition. Further, reaching net-zero emissions will positively impact community health and well-being with the creation of new economic opportunities and cumulative air quality benefits across the US (Larson et al., 2020).

While much of the literature focuses on demand-side energy management, there is also need to address resource consumption at the household level. Ivanova et al. (2016) found that households are responsible for more than 60% of direct and indirect global greenhouse gas emissions. Addressing behavior change, Dietz et al. (2009) identified the “behavioral wedge,” where addressing direct emissions through interventions at the household level could reduce US emissions levels by over 7%. Thus, targeting household resource consumption provides a significant opportunity to reduce global GHG emissions for climate change mitigation efforts.

1.2 Research Objectives

This dissertation examines household consumption at the Food-Energy-Water (FEW) nexus, seeking to advance the social-behavioral science concerned with the role of the household in mitigating the climate crisis. Following a three-paper model, each analytical chapter of this dissertation contains a distinct but related set of research questions and analysis. Through these analyses, this dissertation examines three dimensions of resource consumption behavior: existing, external behavior change efforts, individual-level behavioral determinants, and inter-personal behavioral determinants in the household setting.
Chapter 2, “Becoming FEW Conscious: A Conceptual Typology of Household Behavior Change Interventions Targeting the FEW Nexus” asks: (1) What intervention studies exist within the literature that study food, energy, and water resources, both individually and through a nexus approach? (2) What common strategies exist for targeting food, energy, and water conservation in household interventions? (3) What tools might facilitate the development of more comprehensive household FEW nexus studies?

Building on Chapter 2’s investigation of consumption behavior interventions, Chapter 3, “Explaining Green Technology Purchases by US and Canadian Households: The Role of Pro-Environmental Lifestyles, Values, and Environmental Concern” examines predictors of green technology purchasing behaviors in a large sample set, comparing US and Canadian consumers. Although this chapter focuses more explicitly on energy than it does food and water (though some efficient appliances do save water in addition to energy), it asks questions about how specific social and behavioral factors, including green lifestyle orientation, pro-environmental values, and environmental concern, influence the adoption of efficient technology.

While Chapter 3 looks at household green technology purchasing as an individual decision, Chapter 4 considers how social relationships and dynamics within the household shape decision-making. Chapter 4, “Green Roles at Home: Exploring the Impact of Household Social Dynamics on Consumption at the FEW Nexus,” asks two central questions: 1) Do household social dynamics hang together as unique constructs when measured quantitatively? 2) Do household social dynamics impact frequency of self-reported pro-environmental food, energy, and water actions?

In sum, this set of analyses aims to answer questions about drivers of both individual and household behavior, contributing to the body of literature that informs successful behavior change interventions and policy responses.
1.3 Research Approach

1.3.1 Consumption at the Food-Energy-Water Nexus

The Food-Energy-Water (FEW) nexus provides a critical framework for this dissertation. The FEW nexus emerged as a research field in the past ten years and is typically defined as “a systems-based perspective that explicitly recognizes water, energy, and food systems as both interconnected and interdependent” (Albrecht et al., 2018, p. 1). As the impacts of climate change pose massive threats to ecological and social systems, researchers across academic disciplines attempt to identify sources of GHG and ways to reduce these emissions. In the realm of households, past research focuses heavily on energy demand-side management (direct energy use), while more recent work focuses on emissions produced by individual households as a result of daily life and activities (indirect energy use and other sources of emissions beyond CO2) (Dietz et al., 2009; Ivanova et al., 2016; Jones & Kammen, 2011). To accurately capture a picture of household climate impacts, research must extend past direct energy use to consider the indirect energy embedded in other resource use.

More recently, scholars have explored the climate impacts of modern food production systems, considering factors such as emissions from deforestation and fossil fuels burned for fertilizer and transportation (Van Meerbeek & Svenning, 2018; White & Hall, 2018). The FEW nexus framework captures tensions, tradeoffs, and synergies within the household system, acknowledging the embedded energy and water use in food production, transport, and preparation, and the energy necessary to provide potable water for household consumption (Albrecht et al., 2018). Albrecht, Crootof & Scott advocate for increased social science presence in the FEW nexus field, citing in their review the lack of reproducible methods, failure to capture FEW interactions, limited qualitative work, and disciplinary silos in published nexus-focused literature. While studies measuring direct energy and water use are more prevalent in the literature, scholars have only recently targeted the climate impacts and overall environmental
sustainability of food consumption. Historically, health-related concerns drove food consumption studies, but emerging work examines changing food consumption around environmental motivations (Hartmann & Siegrist, 2017).

1.3.2 Interdisciplinary Behavioral Science Approach

Scholars in a wide range of social science disciplines have theorized the determinants of household decision-making. This dissertation aims to draw from a wide variety of disciplines that integrate behavioral science and climate mitigation, including public policy, sociology, social and cognitive psychology, and energy systems science. The concept of bridging gaps between disciplines is explored most explicitly in Chapter 2, noting the breadth of disciplines that design and test interventions to change consumption behavior. Schmidt & Weigt (2015) observe, “Despite the predominately socio-economic nature of energy demand, such interdisciplinary viewpoints – albeit on the rise – are still the minority within energy-related research” (p. 206). This dissertation aims to contribute to this call, building knowledge in the critical area of consumption and energy transitions.

1.3.3 Methodological Approach

This dissertation takes a multi-method approach to answering questions about changing consumption. Chapter 2 uses a systematic literature review to assess the state of intervention research targeting the FEW nexus, while Chapters 3 and 4 use quantitative data analysis techniques (structural equation modeling, exploratory factor analysis, and multiple linear regression) to uncover drivers of pro-environmental behavior. While the statistical techniques used in Chapters 3 and 4 quantitatively analyze self-reported data about consumption, they explore theories that have previously been primarily explained qualitatively, adding novelty and pushing forward new avenues for quantitative consumption behavior research.

Many of my research questions were motivated by a multi-university, interdisciplinary National Science Foundation Innovations in Food, Energy, and Water Systems (INFEWS) grant
for a project titled, “Reducing Household Food, Energy and Water Consumption: A Quantitative Analysis of Interventions and Impacts of Conservation.” Michigan Technological University leads this project in collaboration with Rutgers University, Penn State University, Arizona State University, University of Minnesota, and the U.S. Forest Service. The larger project focuses on three main research questions: 1) Which household consumption habits, if targeted with interventions, would result in the largest GHG emissions reductions associated with food, energy, and water use? 2) What types of information encourage household FEW conservation? And 3) What household characteristics influence FEW consumption and receptiveness to interventions? To answer these questions, the project has three phases of research over 5 years, including a computer-based role-playing game, a national survey, and a household intervention study. The full project, including data used in Chapter 4 of this dissertation, was approved by the Rutgers University IRB (Rutgers IRB # 2018002308).

1.4 Contribution

This dissertation contributes to the broad body of literature that explores changing household resource consumption in response to climate threats. Taken together, findings from each analytical chapter suggest that determinants of household consumption are complex, dynamic, and embedded within broader social, political, and institutional systems.

Chapter 2 synthesizes existing household resource consumption intervention research, noting distinctions between food, energy, and water research and suggesting avenues for future study to create impactful interventions. The proposed typology of behavior change interventions provides a framework for future studies and challenges researchers to think more holistically about food, energy, and water resource domains. Effective behavior change interventions have potential to incorporate both individual and social characteristics that drive consumption, motivating Chapters 3 and 4.
As Chapter 2 establishes characteristics of existing behavior change interventions, Chapter 3 examines individual behavioral determinants, focusing specifically on green technology purchasing behaviors. This chapter uncovers social-behavioral determinants of green technology purchases, highlighting the importance of “green lifestyle orientation”, or importance of environmental action to one’s overall lifestyle. The results suggest a relationship through which biospheric and altruistic values, environmental concern, and green lifestyle orientation predict green technology purchasing intention, noting the strong effect of income. The adoption of green technology, specifically electric vehicles, will prove essential to meeting national emissions goals (Larson et al., 2020).

Building on the findings from Chapter 3, establishing the importance of individual green lifestyle orientation to consumption behavior, Chapter 4 expands this view to capture social dynamics within the household. Chapter 4 aims to bridge the gap between the individual and the household in quantitative social science literature, situating the household as its own unit of analysis with unique internal social dynamics that influence decisions about resource consumption. The analysis finds that positive social dynamics act to encourage pro-environmental action in a small sample of households, testing scales that can be validated in future research with larger, nationally representative samples.

Using multiple methods and drawing from a variety of theoretical bodies, this dissertation makes a unique contribution to household behavior change literature that bridges disciplinary boundaries in the social sciences. Each chapter illustrates the complexities inherent in household pro-environmental decision-making, establishing a range of factors that drive consumption behavior from outside information to individual lifestyle orientation to household social life. While some behavioral determinants, like values, are relatively stable and unchanging, other factors like household income, household social relationships, and systems of provision are dynamic and change over time. Finally, each chapter illustrates the ways in which individual
decisions about consumption are often shaped by broader social, institutional, and political systems that determine what resources households have access to and the social and personal norms created around these resources in their households and communities. Ultimately, this project aims to inform efforts to move towards more sustainable ways of living, a task that grows increasingly urgent with our uncertain climate future.
2 A Conceptual Typology of Household Behavior Change Interventions Targeting the Food-Energy-Water (FEW) Nexus

2.1 Abstract

The food-energy-water (FEW) nexus presents an opportunity to rethink predominant approaches to household behavior change science. We link emerging FEW nexus research with existing literature examining household consumption and pro-environmental behaviors. While a large body of work examines the environmental impacts of household life and explores pathways to behavior change for sustainability, the literature lacks studies that test interventions in multiple FEW resource categories, leaving researchers unable to identify tensions and tradeoffs in the household system. To guide this developing field and accumulate findings on household behavior across disciplines, we propose a conceptual typology that synthesizes interdisciplinary analytic traditions to classify behavioral interventions targeting the household FEW nexus. The typology synthesizes behavioral interventions as active, passive, or structural, and household-specific or non-specific, illustrating six distinct categories: information, tailored information, action, gamification, policy/price change, and material/technology provision. A review of 40 studies that guided the typology identifies four significant lessons for future intervention research: household non-specific information and tailored information work better together; feedback is more effective when it is persistent; price-based interventions (information or incentives) are often ineffective; and material/technology provision is very effective but utilized in few household studies. To push forward household resource consumption science, we advocate for a holistic nexus focus that is rooted in interdisciplinarity, coalition building with stakeholders, and data reporting that facilitates knowledge accumulation.
2.2 Introduction and Background

A rapidly expanding area of study in sustainability sciences, the food-energy-water (FEW) nexus challenges previous understandings of household resource consumption. Creating questions about feedback systems, tradeoffs, and actual environmental impacts, the FEW nexus adds further complexity to our understanding of human-environment relationships. The human necessities of housing, sustenance, and transportation require growing supplies of FEW resources. Consuming these resources at our current rate results in air, land, water, and greenhouse gas (GHG) impacts (Shwom & Lorenzen, 2012; Villarroel Walker et al., 2014). These routine activities are also deeply personal, cultural, and create meaning in our lives. Despite increased attention to the interconnected nature of food, energy, and water consumption, it remains unclear how many household consumption intervention studies utilize the FEW nexus framework.

A large body of literature examines the environmental impacts of household life and explores pathways to behavior change for sustainability in the face of climate change. In 2016, Ivanova et al. modeled the environmental impact of household consumption globally, finding that it contributes to greater than 60% of GHG emissions and 81% of total freshwater resource worldwide (Ivanova et al., 2016). In 2009, Dietz et al. identified the “behavioral wedge” arguing that household behavioral changes could reduce 7% of US emissions (Dietz et al., 2009). More recently, Dubois et al. (2019) point to the three major components of household footprints in developed countries: car and plane travel, meat and dairy consumption, and heating, drawing increased attention to the relevance of a FEW focus (Dubois et al., 2019).

Initial studies on household conservation focused mainly on energy. Emerging in the 1970s, programs sought to help homeowners reduce their energy use during the energy crisis, and were institutionalized in various demand-side management programs for energy (Wilhite et al., 2003). Likewise, areas experiencing drought have sought to understand these dynamics to encourage household water conservation (Liang et al., 2018). More recently, two developments
have brought the idea of household conservation at the nexus of food, energy, and water to the forefront. Buzby, Wells, & Hyman (2014) found high levels of food waste, approximately 30%, at the retail and consumer level (Buzby et al., 2014). Additionally, novel research focused on the food, energy and water nexus highlights the GHG emissions and water consumption that result from food production and preparation (Heller & Keoleian, 2015; Jones & Kammen, 2011). The FEW nexus research domain requires considering connections and interdependencies between systems in efforts to solve complex global problems (Bazilian et al., 2011). Albrecht, Crootof, & Scott (2018) explain, “The nexus approach aims to identify tradeoffs and synergies of water energy, and food systems, internalize social and environmental impacts, and guide development of cross-sectoral policies” (Albrecht et al., 2018) (p. 1). These studies encourage researchers to think more critically about the interconnections between food, energy, and water resource systems at the household level. Thus, interventions have grown more complex and sophisticated, evolving to target the consumption of multiple resource categories simultaneously and draw attention to the ways that they connect within the household system. This paper seeks to link emerging FEW nexus research with existing literature examining household consumption and pro-environmental behaviors.

To guide this developing field, we propose a conceptual typology that synthesizes interdisciplinary analytic traditions to classify behavioral interventions targeting the household food, energy, and water (FEW) nexus. The development of a typology enables research on household consumption in the FEW nexus to accumulate findings across disciplines. A limited number of household behavioral intervention studies target consumption in all three resource categories, and to our knowledge, there are no reviews that highlight household consumption behavior at the FEW nexus. Emerging FEW research has primarily focused on changing production systems rather than consumption. Given this, it is unclear what intervention strategies generally work across all three resource domains, or even how to effectively track food, energy,
and water use in a single study. No one household functions precisely like another — household practices both shape and are shaped by the intricacies of individual and family life. Through this lens, our typology is structured to consider the position and function of the individual and household within the intervention. In the analysis that follows, characterizing interventions through these roles provides an alternative way of linking intervention technique to theoretical behavioral determinants. This paper advances past typologies and reviews by emphasizing the significance of the food, energy, and water nexus to household sustainability. Our objective is to look across interventions in the FEW resource domains and identify commonalities between intervention strategies and underlying frameworks as we move forward to address household resource consumption in an interconnected way. Specifically, we ask: What intervention studies exist within the literature that study food, energy, and water resources, both individually and through a nexus approach? What common strategies exist for targeting food, energy, and water conservation in household interventions? What tools might facilitate the development of more comprehensive household FEW nexus studies? We argue that more careful attention to FEW interconnections will advance household consumption research initiatives. Additionally, our understanding moves past individual consumer decision-making to consider structural constraints to behavior change, while drawing attention to how researchers are incorporating these barriers into existing intervention science.

2.1.1 Determinants of Household Behavior

Steg & Vlek (2009) provide a comprehensive review of pro-environmental behavior (PEB) determinants and argue for a systematic approach to future studies (Steg & Vlek, 2009). The review approaches PEB through an environmental psychology framework and identifies five factors that account for these behaviors: perceived costs and benefits, moral and normative concerns, affect, contextual factors, and habits. Within this framework, the consumer operates as
a result of either individual motivation or habit. This structure helps link theory to behavioral
determinants targeted in intervention studies.

Understandings of how perceived costs and benefits lead to action stem mainly from the
Theory of Reasoned Action (TRA) and Theory of Planned Behavior (TPB) (Ajzen, 1991;
on pro-environmental behavior, identifying TRA and TPB as the earliest theories to dispute that
there is a direct link between knowledge or attitude and behavior, identifying intention as a
mediator: “intentions are not only influenced by attitudes but also by social (‘normative’)
pressures” (Kollmuss & Agyeman, 2002) (p. 242). Both theories, however, maintain that the
individual makes choices rationally through the weighing of reasoned costs and benefits.

Moral and normative concerns, as outlined by Steg & Vlek (2009), focus on values, the
role of environmental concern, and moral obligation to engage in PEB (Steg & Vlek, 2009).
Value-based theories argue that hedonistic, egoistic, altruistic, and biospheric values contribute to
pro-environmental behavior (Steg et al., 2014). Environmental concern is most commonly
measured by the now widely used New Ecological Paradigm (NEP) scale (Dunlap et al., 2000;
Model (NAM) and the influence of social norms on behavior (Cialdini et al., 1990; S. H.
Schwartz, 1977). Theories including the value-belief-norm theory (VBN) and value-identity-
personal norm theory (VIN) bring together these understandings to explain that values may be
mediated by other variables such as beliefs, identity, and personal norms (van der Werff & Steg,
2016). The final individual behavioral determinant, affect and symbolic motives, is less
represented in the literature, and Steg & Vlek (2009) report that previous studies often relate these
variables to car purchase and use (Dittmar, 1992; Gatersleben & Appleton, 2007).

Moving past individual motivation-focused behavioral determinants, Steg & Vlek point
to the importance of understanding contextual and habitual factors for engaging in PEB.
Contextual factors are notably not included within the widely used theories outlined above. Political and economic elements such as “physical infrastructure, technical facilities, the availability of products, and product characteristics” may either directly affect behavior or contribute to attitudes and motivations (Steg & Vlek, 2009) (p. 312). Recent trends in FEW intervention studies have increased attention to material and technological factors – for example, Devaney & Davies (2017) provide participants in a food sustainability study with tools including food growing kits, organic food boxes, and fridge triage boxes as part of a comprehensive intervention package that holistically addresses sustainable food consumption, storage, preparation, and waste (Devaney & Davies, 2017).

Finally, understanding habit as a behavioral determinant goes beyond previous understandings that focus heavily on consumer reason and rationality in decision-making. Steg & Vlek describe habitual behavior as “guided by automated cognitive processes, rather than being preceded by elaborate reasoning” (Steg & Vlek, 2009) (p. 312). They point to Aarts & Dijksterhuis’ (2000) response-frequency measure of general habit strength as a promising methodological way forward (Aarts & Dijksterhuis, 2000). Social practice theory provides an alternative theoretical framework for understanding household consumption, understanding routine household life as comprised of practices that are socially, habitually, and contextually constituted (such as preparing food, bathing, and doing laundry) (Shove et al., 2012). Hargreaves (2011) explains, “social practice theory de-centres individuals from analyses, and turns attention instead towards the social and collective organization of practices — broad cultural entities that shape individuals’ perceptions, interpretations and actions within the world” (Hargreaves, 2011) (p. 79). Similarly, Røpke (2009) argues that practice theory may illuminate otherwise hidden or taken for granted aspects of consumption by understanding the consumer as a “practitioner” (Røpke, 2009).
2.1.2 Characterizing and Evaluating Behavioral Interventions

Researchers have dealt with the complexity of implementing and advancing behavioral interventions in the social sciences by defining and characterizing intervention techniques. Our proposed typology is informed by previous work in intervention classification, particularly research efforts aimed at health and energy behaviors. Geller et al. (1990) provide a conceptual framework for health interventions highlighting a taxonomy of 24 types of defined interventions (Geller et al., 1990). This taxonomy provides a starting point for understanding the scope and contents of previously tested behavioral change interventions in the context of injury control. Researchers have since worked to build upon this foundation and apply this framework to other areas of intervention research, including resource consumption and pro-environmental behavior.

The taxonomy organizes behavior change techniques into three categories: communication/education, activators, and consequences. Communication and education interventions include passive strategies (lectures and demonstrations) and active strategies (commitments and discussions). Activators include goals, competitions, or incentives targeted at an individual or group, occurring before the target behavior. Consequences occur after the target behavior, including feedback, rewards, or penalties. Each intervention type was evaluated based on seven characteristics: involvement, social support, response information, extrinsic control, immediate effects, intrinsic control, and long-term effects. Despite developing a comprehensive means of evaluating intervention studies, the paper notes that “it is extremely difficult to make comparisons across different behaviors and environmental contexts” (p. 134). More recently in health research, Michie et al. (2013) identify replication, implementation, evidence synthesis, and identifying active components as necessary information to include in health intervention study publications to enable knowledge creation and increased intervention efficacy (Michie et al., 2013).
Abrahamse, Steg, Vlek, & Rothengatter (2005) review household energy conservation intervention studies to characterize and assess intervention efficacy (Abrahamse et al., 2005). Following Geller et al.’s taxonomy, they classify interventions as either employing antecedent or consequence strategies. Antecedent strategies influence behavioral determinants before the behavior is performed in the household, while consequence interventions seek to influence behavior through known positive and negative consequences. The review finds that antecedent strategies’ effectiveness differs based on the specific type of intervention employed. Information, for example, tends to influence knowledge or attitude without a concrete link to behavior. By providing examples of targeted behaviors, modeling resulted in both increased knowledge and energy use reductions. As for consequence strategies, the review finds both feedback and rewards to be relatively successful for decreasing household energy consumption, with rewards resulting in notably short-lived behavior change. Additionally, the Steg & Vlek review that outlines PEB determinants divides interventions into informational strategies (information, persuasion, social support and role models, public participation) and structural strategies (availability of products and services, legal regulation, financial strategies) (Steg & Vlek, 2009). Our typology synthesizes and builds upon these classifications following recent developments in the field while focusing specifically on FEW resource consumption.

2.3 Methods

2.3.1 Article Selection Procedure

We selected articles for review used to create a typology from the Web of Science database. Search queries used include: water conserv* AND intervention AND (household OR residential); energy conserv* AND intervention AND (household OR residential); food consum* AND (sustainab* OR environment*) AND intervention AND (household OR residential); food conserv* AND intervention AND (household OR residential); food waste AND intervention AND (household OR residential).
For further review, papers had to be full-text and published since 1990 in peer-reviewed journals available in English. We conducted the search in fall 2018. Each article had to focus on a behavioral intervention study with an experimental or quasi-experimental design, including a treatment and control or comparison group. Each intervention had to focus on food, energy, or water consumption, or some combination of the three, and take place in the household. We excluded interventions that focused on other climate mitigation or adaptation behaviors, such as flood preparedness, water quality testing, or agricultural studies. Intervention studies that took place in dormitories, office buildings, or other similar settings were excluded, as motivations for behavior change may differ between settings (Carrico & Riemer, 2011; Greaves et al., 2013). After papers were determined to meet inclusion criteria based on their abstract, they were read fully and screened again.

We initially located six hundred and eighty-one studies via search and selected forty-nine after the first screening. Out of these studies, we selected forty for review based on the outlined criteria. We identified additional studies for food resources from reference lists of other included papers. The majority of the forty studies focused on energy (n=19), while eight centered on food, nine on water, and four looked at combined food, energy, and water or food and energy consumption. See Appendix A for the full list of studies.
2.3.2 Generating the Typology

We coded the articles that met the above inclusion criteria for: study design, dependent variable, sample size, target behaviors, intervention duration, study results, self-reported or objective data collection, country/geographical area of intervention study, guiding theories (if identified), mode of intervention delivery, and departments or disciplines of authors. We recorded this information for each paper and created the typology iteratively by analyzing and comparing the study design, intervention techniques, and guiding theories referenced.

Collier, LaPorte, & Seawright’s guidelines for “putting typologies to work” informed our processes. Specifically, we built the typology with attention to the ‘building blocks’ they propose: an overarching concept measured by the typology, row and column variables that articulate multiple dimensions of the main concept, a matrix component to “better organize the typology, tighten its coherence, and think through relations among different components”, and distinct cell types within the matrix (Collier et al., 2012) (p. 223).
2.4 An Updated Typology for FEW Behavior Interventions

Table 1 illustrates our proposed typology for FEW behavioral interventions. FEW behavioral interventions act as an overarching concept that the typology seeks to organize and synthesize. As described earlier in the paper, this concept advances past typologies and review papers by stressing the significance of the food, energy, and water nexus in household resource consumption science. The row variables are passive, active, or structural interventions. The distinction between passive and active builds on a characterization proposed by Geller et al. (1990) but applies here to intervention strategies outside of just communication (Geller et al., 1990). The added dimension of “structural context” interventions blurs boundaries between active and passive to classify studies that view the household less as a standalone actor and more as a unit within a complex structural system that makes decisions within the context of broader regulatory, political, and social networks. The column variables distinguish between household specific and non-specific interventions. This added dimension places emphasis on a more recent trend in intervention research that tailors treatments to the individual household. We see this in information tailored specifically to a household’s resource use, strategies that pinpoint specific actions that members of a household can take to reduce consumption or material and technology provision that considers what a particular household might need to reduce the resources consumed through routine practices. The arrangement of these row and column variables in a matrix illuminates the relationships between the intervention strategies highlighted within each cell type.
2.4.1 Justification for a New Typology

The proposed typology builds on the existing behavior change intervention syntheses described above and adds new dimensions based on a review of current intervention studies. While some scholars have regarded typologies as unsophisticated or less rigorous than quantitative analysis, Collier et al. argue that within a defined framework, typological analysis can be both creative and rigorous. They point to the usefulness of typologies for organizing theory and concepts, specifically when there is a need for the synthesis of complex traditions of analysis (Collier et al., 2012). The paper also asserts that the concepts typologies seek to organize may change and evolve. Our proposed typology aims to synthesize developments in intervention theory and practice across multiple disciplines.

2.4.2 Information

We describe information-based interventions as participant passive and household non-specific. Within information interventions, households often receive generalized information, not specific to their own household or resource use, including information about how to engage in a behavior (instructions, infographics), information about why they should engage in a behavior (behavior-environment link, environmental consequences, costs), or visual prompts or nudges to engage in a desired behavior. This category is distinct from what we deem tailored information,
where personalized information is provided based on features of a household or its past behavior. In the information category, providing information is intended to increase knowledge about the environmental impacts of resource overuse, or knowledge about how households can curb usage (Abrahamse et al., 2007). Abrahamse et al. point out findings by Geller (1981), where information provision generally resulted in increased knowledge, but not behavioral change or energy savings (Geller, 1981).

The ‘information deficit model’ assumes that imparting knowledge about the consequences unsustainable actions or consumption will alter attitudes, leading to changes in behavior (Burgess et al., 1998). Testing this model with regards to energy consumption, however, has repeatedly found that while providing information may lead to some changes in attitude, this rarely translates to behavioral change (Geller et al., 1990; Hargreaves et al., 2010). Owens & Driffill point to the criticism this model has received in academic work “both on epistemic grounds… and for its failure to take account of the social, cultural, and institutional contexts in which attitudes and behaviours are formed” (Owens & Driffill, 2008) (p. 4413). More recent resource consumption research expresses an awareness of the limitations of this approach, testing additional theoretical considerations that may better predict behavior change. In a literature review of intervention techniques, Thondhlana & Kua (2016) point to the importance of combining non-tailored information with other intervention strategies including tailored information or feedback about individual energy usage to affect behavior change (Thondhlana & Kua, 2016).

2.4.3 Tailored Information

Like information strategies, tailored information is a participant passive approach, but is household specific in its content and delivery. Tailored information considers the specific household or individual by customizing or tailoring information, often through real-time feedback, individual comparison, or social comparison. Real-time feedback has become
increasingly popular, featuring smart technology that continually observes consumption patterns and reports usage.

In contrast to solely providing information to fill a void, researchers often point to the necessity of creating meaningful ways of implementing feedback approaches in the household. Norms have been found to predict other pro-environmental behaviors, including recycling (Abbott et al., 2013; Cialdini et al., 1990; Viscusi et al., 2011). Hargreaves et al. (2010) consider the importance of social and cultural norms that affect household energy use: “Rather than being a neutral form of information provision, therefore, feedback on energy use acquires meaning through the discursive, interpretive lens of each household’s cultural practices” (Hargreaves et al., 2010) (p. 6112).

2.4.4 Gamification

From the two forms of information to gamification, we see a shift from passive strategies to active participant interventions. While gamification does not have one standard definition within the literature, in the context of behavior change, it refers to the incorporation of game-based elements into an intervention setting. While gamification aligns with action and experiential learning, its focus on competition and virtual learning distinguishes the category, as well as the fact that it is typically not tailored to an individual household. Gaming in the sphere of resource consumption research is relatively new and rapidly expanding. Before the emergence of video games in energy research, however, reward-based interventions have been found to reduce energy consumption, particularly in the short-term.

Ro et al. (2017) explain that gamification interventions can incorporate the elements of task absorption (or a “state of flow”), competition, normative influence, social diffusion, concrete information, habit formation, and choice (Ro et al., 2017). They note that reward-based interventions may not result in lasting behavior change, as participants focus on an incentive or prize rather than interest in performing a behavior in the long run. The authors recommend,
however, only offering relatively small rewards as one solution. Social diffusion refers to how ideas and behaviors are reproduced by example within a community. Social diffusion is essential to the realm of household consumption, as practices performed inside the home are otherwise private.

Despite the more recent popularity of digital gaming, Seaborn & Fels point to the historical significance of games, as they “are firmly entrenched in human culture, continuing to influence our social and leisure lives on a scale unprecedented and yet historically anticipated” (Seaborn & Fels, 2015) (p. 14). Seaborn & Fels review gamification as a behavior change tool, understanding it as the incorporation of game elements and mechanics into intervention strategies. The paper points to a wide variety of theoretical foundations for game-based interventions, including but not limited to self-determination theory, intrinsic and extrinsic motivation, and situational relevance.

2.4.5 Action

Action-based interventions require an individual or household to take part in an activity designed to teach a behavior, form a habit, reflect on old behaviors, or strategically plan new ones. These interventions are typically participant active and household-specific and stem from work in social psychology and experiential learning. Examples of action interventions include goal setting and personal pledges, peer support groups, self-monitoring with reflective writing, and rehearsal of target behaviors.

Action interventions like reflective writing and personal pledges have roots in self-affirmation theory. Walter, Demetriades, & Murphy (2017) argue for the use of self-affirmation through reflective writing in environmental behavior interventions, as individuals can assert self-value activities that remind them of their values and how “good they are” (Walter et al., 2017) (p. 1162). Behavior rehearsal is an intervention technique stemming from social cognitive theory and self-efficacy. Boudet et al. (2016) use action-based interventions, including behavioral rehearsal,
to promote behavior change by increasing participant confidence in their capacity to perform a targeted behavior and yield the intended result (Boudet et al., 2016). Action interventions can also take place in a group setting, such as peer support groups. Staats, Harland, & Wilke (2004) argue the importance of a supportive social environment to environmental behavior change, citing evidence for the effectiveness of discussion groups and other face-to-face interactions (Staats et al., 2004). While interventions in group environments may target norms in a similar way to tailored feedback, the act of discussing pros, cons, or barriers to enacting a behavior may have additional benefits.

2.4.6 Structural Barriers: Price/Policy and Material/Technological Interventions

Abrahamse et al. (2005) explain that interventions may target voluntary behavior change, or instead, address structural barriers that constrain household decision-makers (Abrahamse et al., 2005). We define structural barriers as those that require a more material change than social context: technological, material or regulatory changes may be necessary to facilitate behavior change in specific contexts. Within structural interventions, we distinguish between household non-specific strategies that address policy and price and household-specific strategies that target materials and technology.

Based on a review of household energy conservation interventions, Abrahamse et al. point to the overwhelming push towards voluntary behavior change as opposed to structural changes within energy consumption research (Abrahamse et al., 2005). Over a decade later, while research into changing macro-level resource consumption factors has progressed, most FEW intervention research also focuses on voluntary individual behavior change. As explained by Thondhlana & Kua (2016), “People’s engagement in energy saving behavior may be influenced by their ability. For example, it may be difficult for people to change their behavior if they have to buy expensive energy-saving technology as part of the energy-saving programmes, or if alternative energy-saving options are not available or feasible” (Thondhlana & Kua, 2016) (p.
Isenhour (2010) found that despite values, attitudes, and beliefs, Swedes faced barriers to sustainable lifestyles that were economic, political, and social (Isenhour, 2010). Addressing these structural constraints extends the discussion about consumption past the individual consumer and takes into account the market and social factors to household sustainability transitions. Røpke (2009) points to technology as a key motivator or barrier to practices, as “recent development of materials and equipment has reduced the need for traditional skills and enabled new groups of practitioners to perform tasks that were previously too demanding, thus illustrating that the boundary between the elements of material and competence is fluid and subject to change” (Røpke, 2009) (p. 2494). Adding a structural dimension makes our typology innovative by linking the concepts of agency and structure within the context of household decision-making.

2.5 Insights from Reviewed FEW Interventions

Out of the 40 studies reviewed, non-tailored information and tailored information were by far the most commonly used intervention techniques in food, energy, and water studies, most studies using both strategies. While researchers applied non-tailored information and tailored information strategies in 83% and 75% of studies respectively, they utilized action, gamification, and changing contexts in 20%, 5%, and 25% of studies. Gamification is an emerging intervention technique in resource consumption and behavior research, however, only 2 out of the 40 studies reviewed to generate this typology used the method.

Speaking to the complexity of intervention studies referenced by Geller et al. (1990) and Abrahamse et al. (2005), it is important to note that 75% of studies reviewed used at least two intervention types, with 25% of studies utilizing three or more (Abrahamse et al., 2005; Geller et al., 1990). While a combination of intervention strategies is likely to improve behavior change results, from a research perspective, these combinations contribute to difficulty isolating the specific effects of each approach. Less than half of the studies reviewed provided effect sizes for intervention results, making a meta-analysis unfeasible.
2.5.1 Food

We identified eight studies that tested interventions for sustainable food consumption or food waste behaviors. Focus on a wide variety of structural constraints throughout the interventions is notable and makes sense as linking food to climate impacts is a more recent development in environmental behavior literature.

Bernstad (2014) measures the effects of interventions on household food waste separation behavior, testing the impacts of providing written information and the installation of food separation equipment (Bernstad, 2014). While providing non-tailored information alone (one condition) to study participants did not result in significant changes, installing food sorting equipment in households increased the amount of separately collected food waste and the source-separation ratio. These results illustrate the importance of convenience to changing behavior in the household, as addressing structural constraints such as the ability to separate food waste had the greatest success. Results also showed that increasing convenience had long-term effects compared to information provision. Geislar (2017) also found that reducing barriers to recycling food waste by providing curbside carts and collection had significant positive results, but additionally, communicating social norms of food separation led to longer-lasting behavior change (Geislar, 2017).

Holistically addressing sustainable food consumption, storage, preparation, and waste, Devaney & Davies (2017) illustrate the success of combining a variety of intervention types in changing householder behaviors (Devaney & Davies, 2017). In efforts to support more sustainable eating practices in the home, the study provided participants with structural tools including food growing kits, organic food boxes, and fridge triage boxes, both tailored and non-tailored informational tools like carbon footprint graphs and portion control guides, and action-based components including a visit from a chef to inspire meal planning. Results showed that participant food waste overall decreased by 28%, with noted self-reported shifts towards
sustainable food purchasing, preparation, and storage. Devaney & Davies conclude, “Findings reinforce calls to connect, combine, and align product, regulatory, informational and motivational supports across the interdependent practices of eating (acquisition, storage and preparation, and waste recovery) to optimize transitions toward sustainability” (p. 823).

The additional five studies used tailored and non-tailored information interventions to target food waste behaviors. A study comparing written and oral non-tailored information provision showed a higher source-separation ratio and a lower ratio of incorrectly sorted material in the group that received oral information, but the effects notably decreased over time (Bernstad et al., 2013). Shearer, Gatersleben, Morse, Smyth, & Hunt (2017) found sticker prompts effective in increasing food waste separation, but it is important to note that infrastructure in the study area (England) was already equipped to collect curbside food waste separately (Shearer et al., 2017). Schmidt (2016) found that providing tailored recommendations to decrease food waste (for example: avoiding impulsive purchases or immediate discarding of expired but still edible food) improved self-reported behaviors, but the improvement was also observed pre and post-test in the control group (K. Schmidt, 2016). One selected intervention in a paper by Rohm et al. (2017) tested the effects of providing informational brochures and fridge magnets on consumer acceptance of “suboptimal” foods, and did not find any observable effects, but noted that respondents who said they visited an attached website with food waste information self-reported increased effects of both the brochure and magnet (Rohm et al., 2017). Finally, Nomura, John, & Cotterill (2011) found tailored information in the form of group feedback on recycling behavior to have a positive effect on food waste recycling, with an effect size of 2.8% compared to a control group (Nomura et al., 2011). The group feedback was presented at the street level compared to the neighborhood average, and interestingly, the shorter the street was, the more effective the feedback.
In the food intervention studies reviewed, information-based interventions were best suited for participants that already have the structural tools to collect and sort food waste, including designated bins and curbside collection. Only one study sought to impact more than food waste and included sustainable food consumption in targeted behaviors.

2.5.2 Energy

While tailored information interventions appeared most frequently in the nineteen reviewed studies, research in the energy consumption sphere often utilizes a wide variety of intervention techniques to affect behavior change. Digital home energy monitors were used in five studies (26%) and decreased energy usage in three. Fan, Macgill, & Sproul (2016) found that homes with energy monitors consumed 12.8% less energy than those without, and Grønhøj & Thøgersen (2011) saw an average electricity savings of 8.1% in their treatment group (Fan et al., 2015; Grønhøj & Thøgersen, 2011). Jessoe & Rapson (2014) used home energy monitors in combination with pricing events, a structural intervention, and found that energy prices became more meaningful when researchers also provided non-price information to participants (Jessoe & Rapson, 2014). Nilsson et al. (2014) however, found no significant effects from the home energy monitors, and van Dam, Bakker, & van Hal (2010) measured the usage of participants who decided to keep their energy monitors after a four-month trial period, finding no sustained energy-saving effects over time (Nilsson et al., 2014; van Dam et al., 2010).

Another method of tailored information is social or normative messaging and feedback. Two studies evaluate data from OPOWER Home Energy Report letters that compare homeowner electricity use with that of their neighbors (Allcott, 2011; Allcott & Rogers, 2014). The 2011 paper found an average 2% electricity consumption reduction, with households in the highest deciles of pretreatment consumption averaging more considerable savings. The 2014 report, however, investigates the persistence of effects post-treatment, finding immediate energy savings, relatively quick “backsliding” to pre-treatment levels after the intervention, and increased
persistence of intervention effectiveness over long periods. Schultz, Nolan, Cialdini, Goldstein, & Griskevicius (2007) also observed backsliding in response to normative messaging interventions (what they term the ‘boomerang effect’) but found that adding messaging conveying social approval or disapproval neutralized this effect (Schultz et al., 2007). Harries, Rettie, Studley, Burchell, & Chambers (2013) found that adding social norms information to other forms of electricity feedback increased consumer engagement with the feedback, but ultimately did not reduce energy consumption (Harries et al., 2013). Mizobuchi & Takeuchi (2013) found that financial incentives are more successful when combined with normative feedback (Mizobuchi & Takeuchi, 2013). Schultz, Estrada, Schmitt, Sokoloski, & Silva-Send (2015) tested a variety of feedback types using in-home electricity displays, finding normative framing to result in greater reductions than simple informational feedback or cost-framed feedback (Schultz et al., 2015).

Testing more than just feedback, Pellerano, Price, Puller, & Sánchez (2017) tested normative messaging along with extrinsic financial incentives on residential electricity consumption, finding that these incentives did not increase the strength of normative messages (Pellerano et al., 2017). In another cost-based intervention, McCoy & Lyons (2017) provided consumers with exposure to time-of-use tariffs, finding that this group of households did reduce overall and peak electricity consumption, but ended up reducing investments in other household energy efficiency measures (McCoy & Lyons, 2017).

Examining a more recent realm of energy research, Ro et al. (2017) tested a game-based intervention (Ro et al., 2017). They found reductions in household resource consumption up to six months after the game, with the most considerable reductions in the high-energy consumption group. Sudarshan (2017) also used a competition-based intervention in India, where one group of participants received monetary rewards based on the difference between their electricity consumption and the peer average (Sudarshan, 2017). In this study, weekly normative feedback
was successful at reducing energy consumption but was no longer effective when combined with rewards.

In the realm of energy interventions, feedback is a useful tool for reducing consumption, but the way it is framed and delivered has implications for intervention success. While digital home energy monitors can work to reduce consumption, the type of feedback they provide to consumers must be purposeful and persistent. Games for sustainability behavior show promise, but only one study used this approach and found significant results. While these studies seek to change energy consumption, they are only able to observe energy as electricity consumption, unable to account for the embedded energy in other resource use.

2.5.3 Water

While all water-focused studies included an information provision aspect, two studies also used action-based interventions. Walter et al. (2017) tested the effects of self-affirmation on self-reported water conservation behaviors (Walter et al., 2017). Participants receiving the self-affirmation condition completed a reflective writing activity about implementing values in their daily life, while the non-affirmation condition received information about droughts in California, the location of the study. Results showed that those who engaged in self-affirmation had higher self-reported water conservation scores that endured for a month post-treatment. In the second study with an action component, Tijs et al. (2017) aimed to decrease water consumption through changing showering habits (Tijs et al., 2017). The study had all participants engage with an activity booklet (including action items such as goal-setting and self-persuasion) over two weeks, but one condition received monetary information appeals, while the other received environmental information appeals. Based on self-reported information about shower length and frequency, the study found those in the environmental appeals group to reduce showering frequency, with no change in the monetary appeals group. While this study sheds some light onto the effectiveness of
different types of intervention provision, the lack of control group leaves questions about the effectiveness of the action-based intervention components.

The remaining seven studies all included the provision of tailored information, with four out of the seven including a non-tailored information aspect. Glenn, Endter-Wada, Kjelgren, & Neale (2015) sought to reduce landscape water usage at the household level through specifically tailored information: each household received a professional water check, including an evaluation of their sprinkler system and landscape, site-specific irrigation schedules, and tailored recommendations on conservation (Glenn et al., 2015). While the majority of participants who implemented recommendations made by the water check successfully conserved water, those who did not adopt the recommendations cited “time constraints, cost of implementing recommendations, lack of motivation, personal physical impediments of age or disability, and physical limitations of their sprinkler systems” (p. 87). The study found that while tailored information can be effective in reducing landscape water use, interventions should address contextual factors.

Two studies utilized visual display systems to present tailored information about water usage to participants. Davies, Doolan, van den Honert, & Shi (2014) found in-home displays effective (average reduction of 6.8% during the study period compared to the control group), with effects that endured over time (Davies et al., 2014). Stewart, Willis, Panuwatwanich, & Sahin (2013) used a visual display and alarm specific to showering and found a 27% mean reduction in shower volumes initially after display installation, but the effects did not last over time and reverted to pre-study levels after four months (Stewart et al., 2013).

Fielding et al. (2013) implemented three combinations of information provision: non-tailored information alone, non-tailored information with the addition of descriptive norms delivered via postcard, and non-tailored information combined with tailored end-user feedback (via postcard) (Fielding et al., 2013). Compared to the control group, all three conditions reduced
water consumption (with an average reduction of 11.3 Liters per person per day). The effects of all conditions, however, dissipated within one year of implementation. Liu et al. also provided water end-use data via paper report, and while they did not find a statistically significant difference between intervention and control groups, 38% of households in the intervention group self-reported intention to conserve water (Liu et al., 2016). Schultz et al. (2016) and Seyranian, Sinatra, & Polikoff (2015) both tested a combination of non-tailored information provision and varying types of normative feedback, each finding that providing normative information reduced water consumption (Schultz et al., 2016; Seyranian et al., 2015). While Seyranian et al. found that participants who had higher water consumption at baseline responded better to a social norm intervention than general information provision, Schultz et al. found that participants with already strong personal norms surrounding water consumption showed less of a change than those with low personal norms when provided with normative messages.

In the two studies with action components, action interventions such as reflective self-affirmation writing and goal setting were effective for reducing water consumption. Feedback, including visual home displays, was also effective, but the persistence of effects varied across studies. It is important to note that geography played a role in researchers’ decisions about where to study water consumption behaviors. Of the four studies conducted in the United States, three took place in California and one in Utah, all areas that are subject to frequent droughts. Of the five studies conducted outside of the US, four were in Australia and one in the Netherlands. Fielding et al. (2013) note that the study area in Australia had recently experienced their worst documented drought on record (Fielding et al., 2013). Here, researchers must consider local environmental and policy contexts and must craft interventions specific to the study population.

2.5.4 Combined Resource Interventions

Four interventions measured consumption in more than one resource category. Abrahamse et al. (2007) sought to affect energy consumption, but unlike many other energy
studies, was able to look at indirect energy use embedded in household resource consumption (Abrahamse et al., 2007). Tailored information, goal setting, and feedback strategies found savings in direct energy consumption, but no difference in indirect energy savings compared to a control group. Households in the intervention groups, however, exhibited increased knowledge about resource conservation compared to a control group. Kurz, Donaghue, & Walker (2005) studied water and energy consumption through information provision and social comparative feedback, neither producing significant results for either resource category (Kurz et al., 2005). This study had unique results, as the only intervention with significant positive effects was appliance labels, which led to a 23% reduction in water consumption.

The following two studies took novel approaches, seeking to create holistic packages of interventions to change resource consumption behavior. Staats et al. (2004) tested the EcoTeam Program intervention package, finding improvements on a wide range of household environmental behaviors that persisted two years post-study (Staats et al., 2004). Boudet et al. (2016) tested child-focused interventions targeting household energy and food-and-transport behaviors, finding positive results in both categories (Boudet et al., 2016). Both studies employed a variety of theory-based intervention techniques ranging across typology categories and targeted a wide range of household environmental behaviors spanning multiple resources.

### 2.6 Discussion

The review above resulted in four key takeaways about interventions utilized in FEW studies. Without effect sizes and additional quantitative data reporting, we could not directly compare intervention strategies, but could identify trends in the literature.

First, studies typically used household non-specific (or non-tailored) information in conjunction with household-specific (tailored) information/feedback, and this strategy shows promising results. For example, Bernstad et al. (2013) only used general information in a door-stepping campaign, which was ineffective in changing food waste behaviors (Bernstad et al.,
We see one exception to this trend in Kurz et al. (2005), where tailored information was ineffective, but appliance stickers led to a 23% reduction in water consumption (Kurz et al., 2005). This result might be because of the persistent, visible nudging offered by the stickers that became a part of water-intensive practices.

Second, feedback is most effective when persistently provided to participants. In the Nomura et al. (2011) study, the first feedback card had no significant effect, and the authors concluded that the cumulative effect of two feedback cards ultimately changed food waste behavior (Nomura et al., 2011). Studies with home energy monitors that displayed continuous feedback, including Fan et al. (2015), had promising results (Fan et al., 2015).

Third, providing pricing information or changing pricing structures through incentives was often ineffective. Pellerano et al. (2017) provide an example that warrants further study: adding economic incentives to normative messaging not only did not increase the efficacy of the messaging, but may have reduced it (Pellerano et al., 2017). Sudarshan (2017) offered similar results, as the nudge treatment group no longer reduced consumption with the addition of incentives (Sudarshan, 2017). Jessoe & Rapson had success with providing price information, but they concluded that it was more meaningful when interventions also provided non-price information to participants (Jessoe & Rapson, 2014).

Finally, providing materials or technology that facilitate behavior change worked 100% of the time, but only three studies used this strategy. While information was ineffective in Bernstad’s (2014) study, installing food waste sorting equipment in households sparked behavior change with long-lasting results (Bernstad, 2014). Devany & Davies saw food waste decrease by 28% with their holistic intervention package that included providing items like fridge triage boxes and kitchen caddies to assist with food waste separation (Devaney & Davies, 2017). Gieslar (2017) explicitly concluded, “Findings support that residents will begin to separate food waste if provided supportive infrastructure” (Geislar, 2017) (p. 577). One additional study (Shearer et al.
2017) points to the importance of material infrastructure for resource consumption behavior, as their sticker program led to increased inquiries about food waste recycling caddies in the community (Shearer et al., 2017).

Across FEW resource domains, household studies used various environmental behavior theories to guide their inquiries and design interventions. While each typology category might be implemented through multiple guiding theories, links were apparent between theory and practice in many intervention studies. Notably, messaging interventions using household-specific information are often guided by value and norm-based theories, including the norm activation model (NAM) and value belief norm (VBN) theory. Interventions that provided materials or technology, like Devany & Davies (2017), cited social practice theory as central to their approach (Devaney & Davies, 2017). Future research might further explore how theories of environmental behavior link to each category in our typology of intervention strategies.

2.6.1 Acknowledging the Limits of Household Consumption

As this review and typology explicitly focus on household-level consumption, it is appropriate to consider the limits of this approach. Lorenzen (2018) points out that consumers are often “locked-in” at the technological, organizational, industrial, institutional, and societal levels, leaving only so much room for long-term voluntary behavior change (Janet A. Lorenzen, 2018). Other scholars point to the many factors at play guiding consumption decisions that extend beyond personal attitudes and values, including political leadership, market forces, and social power structures (Isenhour, 2010; Schor, 2007). While aiming to change household behavior can potentially reduce greenhouse gas emissions, researchers must not lose sight of other mitigation tactics that target government actors and transnational corporations.

2.6.2 Bridging Gaps Between Disciplines

Organization of intervention techniques into typologies can ultimately facilitate more cross-disciplinary work, as terminology is explicitly defined. Interventions designed by
interdisciplinary teams may be more holistic, comprehensive, and draw from a broader range of theories surrounding resource consumption and environmental behavior, contributing to novel approaches to these complex problems. Boudet et al. (2016) is one example of an intervention study we reviewed in this paper that brings together researchers from a variety of disciplines including public policy, education, environmental studies, and medicine (Boudet et al., 2016). The study approached intervention design through social cognitive theory, a framework the researchers describe as notably being used in public health experiments but less utilized in environmental behavior research, contributing a novel approach and advancing our understanding of household consumption behavior.

Scholars in the past two decades have done a great deal of writing on the challenges of interdisciplinary research, including language barriers, publication struggles, and disciplinary expectations (Bracken & Oughton, 2006; Campbell, 2005; Rafols et al., 2012). In a review of FEW nexus studies, Albrecht, Crootof, & Scott (2018) found, “many nexus methods are confined to disciplinary silos—only about one-quarter combine methods from diverse disciplines and less than one-fifth utilize both quantitative and qualitative approaches” (Albrecht et al., 2018) (p. 1). The nexus approach highlights seemingly endless complexities, making household interventions substantially more challenging to design and execute.

2.6.3 Addressing Spillover and Moving Towards a Nexus Approach

In response to our finding that very few studies focus on the multiple components of the FEW nexus, we urge researchers to pursue this novel approach to household resource consumption. As researchers acknowledge interconnections that give rise to the FEW nexus, future intervention research must look across resource domains to gain better understandings of the complex ways that households consume food, energy, and water. In a comprehensive review of FEW nexus studies, Newell et al. (2019) find social science-based studies underrepresented in the literature (Newell et al., 2019). Bazilian et al. (2011) point to different vocabularies,
competing priorities, institutional capabilities, and regulatory regimes between the three systems as drivers of poor communication and ultimately suboptimal decision-making (Bazilian et al., 2011). A persisting problem in changing resource consumption behavior lies in the potential for “spillover” across resource categories (Maki et al., 2019). Behavioral spillover occurs when an intervention changes additional behaviors that were not directly targeted (Poortinga et al., 2013). Spillover can be both positive and negative, as Truelove et al. reviews evidence of pro-environmental behaviors both increasing and decreasing likelihood of performing an additional pro-environmental behavior (Truelove et al., 2014). From a FEW perspective, a study by Tiefenbeck, Staake, Roth, & Sachs (2013) found that weekly feedback decreased household water usage during the intervention, but increased electricity consumption compared to a control group (Tiefenbeck et al., 2013). Interventions monitoring only one resource domain will not capture changes or patterns developed within other domains. Designing interventions that consider the entirety of the FEW nexus can help address this issue while shedding light on emerging dynamics of consumption spillover. Additionally, interventions that attempt to capture the intersections of FEW behavior must address how to effectively communicate indirect and embedded energy use to consumers.

Moving towards a true nexus approach means having the tools and resources to accurately track food, energy, and water use in the household. As researchers can collect and manage larger amounts of data, intervention strategies can grow increasingly specific to the individual household. Sensor technology has revolutionized the ways industry and researchers can track household electricity use with fine grained data (Barbato et al., 2011; Marchiori et al., 2011; Pillarisetti et al., 2014; Ziekow et al., 2013). With the ability to model household energy use and the availability of big data, providing household specific tailored information about energy use has become a promising avenue for energy research, but is still often cost-prohibitive and difficult to implement. Technology for water tracking is also advancing, with end-use water
meters that can provide data on frequency and duration of household water use and identify leaks and inefficiencies (Jordán-Cuebas F. et al., 2018). Tracking household food consumption presents a much greater challenge, with researchers developing complex and labor-intensive food data collection protocols (French et al., 2009). Recent life-cycle analysis studies, however, provide promise for integrating food consumption data by estimating the impacts of various food items on greenhouse gas emissions (Hitaj et al., 2019).

2.6.4 Knowledge Accumulation

Ultimately, through a wide variety of behavioral interventions, researchers hope to gain insights into the determinants of resource consumption behavior. Without systematic logging and tracking of study design and results, however, academics and practitioners will continue to face the same challenges of synthesizing the vast amount of existing information. Wynes et al. (2018) provide an example of a better way to understand impacts across studies by quantifying their greenhouse gas emissions reductions (Wynes et al., 2018). Providing a weight in kilograms of carbon dioxide reduced goes a step further than effect sizes to measure intervention impacts. Wynes et al. found that most behavioral intervention studies they reviewed, however, were not suitable for quantifying emissions reductions. In a similar methodological problem, Albrecht et al. (2018) found that few nexus studies they reviewed (less than one third) used explicitly reproducible methods (Albrecht et al., 2018).

Logging the results of behavioral intervention studies on a publicly available database would further knowledge accumulation in the field. Studies like Wynes et al. (2018) would have a much larger pool of data to draw from in quantification analyses. Additionally, tracing unpublished interventions in the database may work to combat publication bias that favors positive results, much like the way clinical trials must be registered before they are completed (Carroll, 2018).
2.6.5 Crafting Purposeful Interventions

Through the studies described above in the realm of food, energy, and water resource consumption, researchers often cite content and framing of intervention techniques as a primary factor responsible for the success or failure of an intervention. Nuanced intervention design must take context into account - researchers must continue to think critically about geography and sample-specific factors when designing household interventions. It is notable that water resource studies more frequently took place in locations that have previously experienced drought, presenting both a geographical need and potential participant motivation for increased conservation behaviors. Further, we cannot ignore economic and environmental inequalities: most interventions reviewed in this paper took place in economically developed countries. Researchers must use alternative considerations when studying developing economies and economies in transition, which is worth exploring in future research. We must also direct attention toward resource disparities by gender, race, and class within the context of any country under study. Ellegård & Palm (2015) further warn of confusing the individual with the household as a unit of analysis: “Individually tailored information is often discussed, but equally important are information and policy instruments targeting households’ and household members’ combined energy consumption patterns as they are derived from the activity sequences written in the individuals’ time-diaries” (Ellegård & Palm, 2015) (p. 7633).

To move intervention science forward with evolving theory, researchers should think through embedding interventions across typology categories within existing household practices. Beyond seeing immediate or even post-study behavior change results, we must address the policy implications and practicality of proposed interventions. Social practice theory provides one possible framework through which to consider embedding interventions within daily household practices. While providing information can provide initial learning experiences and begin to change social contexts through normative messaging, current research design often continues to
lack structural and contextual focus. Action interventions can help to establish household practices, form habits, and create environmental identity. Practices that were previously difficult or constrained can change through structural interventions that affect local policy initiatives, like food waste collection or renewable energy assistance programs. Gamification can provide additional behavioral nudges that supplement information provision and provide a hands-on learning experience for participants in specific contexts. Within the proposed typology, the potential impacts of each intervention category are essential to consider in different geographical and political contexts.

2.7 Conclusion

To further advance the science of household resource consumption as a climate change mitigation strategy, interdisciplinary research that highlights the FEW nexus provides a promising approach. In this paper, we link emerging FEW nexus research with household consumption and pro-environmental behavior literature through an innovative typology that accounts for both behavioral and structural intervention research.

In addition to the generation of a typology and key findings outlined in the discussion, our review highlights the lack of studies that 1) address multiple FEW domains and 2) report effect sizes that allow comparison of intervention impacts across studies. Across FEW domains, we see different types of interventions used and varying results.

More food studies addressed structural constraints than any other resource category. Here, information provision was more effective when households already had structural tools to collect and sort food waste. Household food studies more often targeted food waste than food purchasing and other consumer behaviors.

Energy studies showed that feedback is generally effective for reducing household energy use, but the way it is framed has implications for success. Digital home energy monitors are
popular and effective, but the feedback they provide must be purposeful and persistent. Within these studies, energy is typically observed as electricity use and does not consider embedded energy in other resource use.

Within water studies, action interventions were successful, but only present in two studies. Feedback was effective, but persistence varies across studies (many did not include follow-ups). Researchers considered the effects of structural barriers when interventions were not effective. We also noted that geography was framed as important for context (e.g., drought frequency).

Multi-resource studies used intervention “packages” that used multiple strategies and targeted multiple behaviors. These comprehensive intervention packages seem to be effective and warrant further study.

Eventually, the focus must shift to policy: how can effective interventions be successfully implemented and imitated in policy contexts? In the spirit of interdisciplinarity, FEW nexus researchers must connect with broader policy audiences to engage in coalition-building and the development of science-backed policies on local and national levels. Coordinating complex and holistic interventions outside of research settings will take coordination between and buy-in from a wide variety of stakeholders, including local governments, utility companies, and consumers. As food, energy, and water systems interconnect across the globe, international cooperation and partnerships will also be essential to large-scale conservation efforts. Literature on the co-production of scientific knowledge and participatory research may help us overcome these hurdles (Bruckmeier, 2019; Peters & Besley, 2019). With a focus on building and strengthening relationships across sectors, we might create conditions in which policy changes are possible.
3 Explaining Green Technology Purchases by US and Canadian Households: The Role of Pro-Environmental Lifestyles, Values, and Environmental Concern

3.1 Abstract

Household energy consumption is a significant driver of greenhouse gas emissions associated with global climate change. Thus, identifying social and psychological determinants of household-level consumption warrants further study. Using nationally representative samples from Canada (N=1220) and the United States (N=1001), we examine the impact of three categories of behavioral antecedents on decision to purchase energy efficient technology: values, environmental concern, and lifestyle orientation. Green lifestyle orientation refers to the importance of environmental action to one’s overall lifestyle, a theory that has been primarily explained through qualitative methods. We report three key findings comparing US and Canadian green technology purchasing intentions. The results of three structural equation models suggest the presence of a relationship between biospheric and altruistic values, environmental concern, and green lifestyle orientation that predict green technology purchasing intention in both samples. Additionally, income has a strong effect on purchase intentions in both US and Canadian consumers. Other sociodemographic factors also influence potential purchases and identifying as female was positively related to electric vehicle purchase intention in the US sample, but this relationship did not hold in the Canadian sample. We suggest that future research continue to explore pro-environmental behaviors not in isolation, but as integrated within broader green lifestyle perceptions and contexts.

3.2 Introduction & Background

Globally, 72% of GHG emissions can be attributed to household consumption when accounting for both direct and embedded emissions (Hertwich & Peters, 2009). Thus, one strand of the climate change mitigation literature explores policy and interventions focusing on the
household (Dubois et al., 2019). This paper specifically explores antecedents of green purchasing behaviors, which offer large potential for household energy savings and emissions reductions. First, we review scholarship on household behavior change, green purchasing behaviors, and pro-environmental lifestyles. We then analyze the effect of pro-environmental lifestyles, environmental concern, values, and sociodemographic variables on three key purchasing behaviors: buying high-efficiency lightbulbs, buying energy efficient appliances, and buying an energy efficient vehicle. We conclude with implications of our findings and directions for future research.

3.2.1 The Potential for Household Behavior Change

About two-thirds of the world’s anthropogenic greenhouse-gas emissions are accounted for by energy production and consumption activities (IEA, 2015). Energy efficiency (EE) interventions are generally considered the lowest direct cost option for saving energy and addressing climate change (EPA, 2009; U.S. House Select Committee on Climate Crisis, 2020). In the US, 118.2 million total households account for 55% of all energy used in buildings (US Energy Information Administration, 2018). These households produce more than 5 gigatons of carbon equivalent emissions each year (Song et al., 2019). Similarly, residential consumption accounts for 54.5% of buildings’ energy use in Canada (US Energy Information Administration, 2015). Traditionally, EE policies and program interventions have mainly relied on technological upgrades and market instruments, largely overlooking the potential and importance of “non-price” based human factors (Allcott, 2011). However, much research focuses on the role of non-price factors as potential behavioral drivers.

To reduce household energy consumption, researchers focus on two types of voluntary actions: a) no-cost or low-cost behavior changes done repeatedly (like turning off lights or washing clothes with cold water) and b) behaviors that require an initial financial investment. The second category typically requires adopting energy efficient technology (Dieu-Hang et al., 2017).
Karlin and colleagues (2014) classify energy conservation behaviors into two distinct categories, ‘curtailment’ and ‘efficiency’ behaviors. They identify energy conservation activities, such as purchasing energy efficient products or structural changes of buildings that generally require an upfront investment without any loss of amenities, as efficient behaviors. On the other hand, activities such as turning off lights, unplugging or reducing appliances use that generally do not require investment but cut back on amenities or comforts are curtailment behaviors.

The GHG emissions reduction potential of household energy curtailment and efficiency behaviors in the U.S., known as the “behavioral wedge”, has been estimated at 7% reduction of total U.S. emissions (Dietz et al., 2009). Dietz and colleagues’ analysis breaks household energy saving actions into categories based on behavior: home weatherization and upgrades of heating and cooling equipment; more efficient vehicles and non-heating/cooling home equipment; equipment maintenance; equipment adjustments; and daily use behaviors. While the first two categories focus on adopting equipment, the last three target changing the ways consumers use the equipment. Here, the study calculates potential for GHG emissions reduction by the amount of emissions reduced per action times the estimated number of households likely to change behavior with effective interventions. Our analysis focuses specifically on actions which involve purchasing household technology that is energy efficient. Dietz et al. add that these actions have a high level of behavioral plasticity, suggesting that patterns of purchasing behavior can change with targeted interventions. By understanding the motivations and characteristics of green technology consumers, we can begin to better estimate this behavioral wedge, by understanding factors such as the number of consumers likely to increase pro-environmental behavior in response to interventions.

The majority of past studies on energy conservation behavior have focused on the causes and efficacies of curtailment behaviors despite the fact that the energy-saving potential of efficiency behaviors is considered greater than that of curtailment behaviors (Abrahamse et al.,
However, there appears to be no uniformity, consistency, and finality regarding efficacy of such behaviors and their underlying motivations, forming a critical gap in literature requiring further research (Karlin et al., 2014; McCoy & Lyons, 2017). A study conducted to find the determinants of green purchase behavior among EU customers found significant differences based on knowledge, subjective norms, and cultural dimensions (Liobikienė et al., 2016). Further, a comparative study on citizens from the US and Canada found significant similarities in each sample’s levels of environmental concern (Xiao & Dunlap, 2007). We are not aware, however, of any peer reviewed study that explores green purchase behaviors in the US and Canada for energy efficient appliances and vehicles.

In this paper, we explore three purchasing decisions that range in cost and potential energy savings: buying high-efficiency lightbulbs, buying energy efficient appliances, and buying an efficient vehicle based on representative samples of residents from the US and Canada. While focusing on habitual behaviors that show savings over time, like turning off the lights or adjusting a thermostat, is necessary for reducing overall household energy consumption, purchasing behaviors require a one-time action that often realizes high levels of savings over time.

3.2.2 Green Consumption

Green purchasing behavior entails consumer willingness to purchase environmentally friendly products or appliances (Joshi & Rahman, 2015). Pro-environmental or “green” purchasing behaviors occur when consumers choose environmentally friendly products or services instead of default or mainstream options. While many eco-friendly products require a larger up-front investment than comparable traditional products, they often realize financial savings over time through energy, water, or other operational savings. Pro-environmental behaviors are based on a complex combination of our emotions, morals, habits, social and normative factors and many theoretical models have been developed to explain and influence such behaviors (Martiskainen, 2007). While structural and contextual factors, such as economic
incentives (Endres & Rundshagen, 2010), federal and state policy (Hall & Helmers, 2013), availability, and ease of use of green technology (Stragier et al., 2010) are also important predictors of pro-environmental behaviors, we focus on individual-level behavioral predictors and return to potential policy considerations in our discussion.

The Theory of Reasoned Action (Fishbein & Ajzen, 1975) and the subsequent Theory of Planned Behavior (TPB) (Ajzen, 1991) are common starting points for empirical green purchasing behavior studies (Hua & Wang, 2019; Moser, 2015; Vazifehdoust et al., 2013). TPB explains that one’s attitude, subjective norms, and perceived behavioral control determine intention to act, and intention leads to behavior. Attitudes and other TPB constructs predict some pro-environmental behaviors including household recycling, waste composting, and water use (Steg & Vlek, 2009). Specific to green purchasing, Vazifehdoust et al. (2013) found that consumer attitudes towards green product choices resulted from environmental concern, product quality, and a combination of green advertising and labeling. Because pro-environmental behaviors vary widely in characteristics like time, effort, and cost and consumers have a range of priorities, it is unlikely that a single decision-making theory will ever apply universally. Many studies cite the persistent gap between environmental attitude and environmental behavior, leading scholars to look towards other theoretical motivators (Kollmuss & Agyeman, 2002; Peattie, 2010; Pickett-Baker & Ozaki, 2008; Schuitema & Groot, 2015).

Values, or the overarching guiding principles in one’s life, present an additional key theoretical predictor of pro-environmental behavior (Dietz et al., 2005). Values are understood to remain stable over time and impact pro-environmental behavior primarily indirectly, through beliefs, attitudes, or norms (Steg & De Groot, 2012; Stern et al., 1999). Stern et al.’s (1999) value-belief-norm theory (VBN) links value theory to norm-activation theory. In the case of supporting environmental movements, VBN theory states, “individuals who accept a movement’s basic values believe that valued objects are threatened and believe that their actions can help restore
those values experience an obligation (personal norm) for pro-movement action that creates a predisposition to provide support” (p. 81). *Biospheric values* prioritize the intrinsic value of the Earth and environment for its own sake, rather than for that of humans. Linked to historical understandings of environmental ethics, biospheric values have been found to influence a wide variety of PEBs, particularly green purchases despite perceived barriers (Ateş, 2020; Schuitema & Groot, 2015; van der Werff et al., 2013; van der Werff & Steg, 2016). Biospheric values are typically positively correlated with *altruistic values*, or those that prioritize the welfare of other people. Steg & De Groot (2012) note the importance of distinguishing these values despite their similar characterization as self-transcendent, prosocial values, as they are empirically distinct and activate different behavioral intentions. Biospheric and altruistic values have been found to directly or indirectly effect a variety of pro-environmental behaviors (Dietz et al., 2005; Klöckner, 2013; van der Werff & Steg, 2016).

Stern (2000), while advocating for the explanatory power of VBN theory, points to “contextual forces” as a causal variable for environmentally significant behavior. He provides an extensive list of these forces, including institutional factors like restrictions on occupants of rental housing, monetary incentives and costs, and capabilities and constraints of technology and the build environment. Income is generally associated with increased energy-efficiency investments (Dieu-Hang et al., 2017), although they are not always related (Barr et al., 2005; Ruderman et al., 1984). Dieu-Hang and colleagues (2017) also propose the idea that utility bills make up a smaller percentage of overall budget for higher income households, which could potentially be associated with lower energy efficiency investments. Other sociodemographic factors, including age and gender, influence green consumption patterns. The ways that age impacts energy-efficiency decisions is less clear, with many studies finding evidence that younger consumers may use newer, more efficient technology than older consumers (Carlsson-Kanyama et al., 2005; Nair et
al., 2010), and others arguing that older consumers have more time to devote to reducing energy consumption (Barr et al., 2005; Dieu-Hang et al., 2017).

3.2.3 Green Lifestyle Orientation

Sustainable or green lifestyles go beyond isolated pro-environmental behaviors and take shape when an individual engages in practices oriented around sustainable living, often in attempt to address environmental problems (Axon, 2017; Axsen et al., 2012; Lorenzen, 2012). Lifestyle encompasses one’s beliefs, values, identities, behavioral patterns and “practical and cultural commitments to certain practices of consumption” (Elf et al., 2019). Wrapped up in lifestyle is self-identity, or the way that one identifies their intentions and creates meaning out of the practices that make up their lifestyle. Explained by Lorenzen (2012):

“To change a lifestyle, people not only have to change their practices, but also the story they tell about their practices… Thus, a green lifestyle is a pattern of living that involves deliberation over the uncertain environmental impacts of everyday practices and a guiding narrative that makes that process personally meaningful” (p. 95).

Here, we refer to self-identified green lifestyle as ‘lifestyle orientation,’ where respondents identify how important environmental action is as a part of their overall lifestyle. This research attempts to quantitatively measure lifestyle orientation—a novel approach as many studies exploring green lifestyles employ qualitative methods to get at the rich complexity inherent in the subject (Axsen et al., 2012). While quantitative research will fail to capture the same nuance, we might begin to make more generalizable conclusions about the role of lifestyle orientation in pro-environmental behavior engagement. Theoretically, as part of an overarching identity, green lifestyle orientation should predict a wide range of pro-environmental behaviors that one enacts through practices in their daily life (Shove et al., 2012). We understand green lifestyle orientation as bound up with environmental identity, or the way that one sees themselves as an environmentally friendly person (Whitmarsh & O’Neill, 2010). Environmental identity is associated with a wide range of pro-environmental behaviors, including carbon offsetting
behaviors (Whitmarsh & O’Neill, 2010) and interest and participation in smart energy systems (van der Werff & Steg, 2016).

3.2.4 Comparing Samples in the US in Canada

This paper focuses specifically on the US and Canada, as they are among the highest emitting countries in the world per capita (World Bank, 2020). As outlined in section 1.1, significant potential exists for emissions reduction at the household level, and the widespread adoption of energy efficient technology in developed countries will help achieve climate mitigation goals.

To our knowledge, few existing studies compare individual-level environmental social-psychological variables in the US and Canada. Thus, more research is needed to uncover similarities and differences in individual-level environmental behavior in the neighboring countries. While we might assume North American industrialized nations would have very similar behavioral models, policy contexts related to climate change mitigation differ in each country, as Canada has set more ambitious goals at the federal level, including ratifying the Kyoto protocol in 2002 (Harrison, 2007).

Limited evidence suggests consumer attitudes and behavior might interact differently in these samples and more research is needed to uncover these relationships. While Xiao and Dunlap (2007) found consistency in environmental concern between US and Canadian samples, Hanson (2013) found key differences. In the Canadian sample, environmental concern was significantly related to green consumer attitudes, as hypothesized, while this relationship was weak in the US sample. In a study of high school aged students, Lin and Shi (2014) found Canadian students scored higher for environmental knowledge, awareness, and pro-environmental behaviors, suggesting higher overall levels of environmental literacy in part driven by instructional methods.
3.2.5 Research Objectives

The objective of this research is to better understand drivers of these green technology purchasing behaviors. To do this, we test five hypotheses in three structural equation models across two samples:

- H1: Green lifestyle orientation is positively related to green technology purchasing frequency.
- H2: Environmental concern is positively related to green lifestyle orientation, indirectly affecting green technology purchasing frequency.
- H3a: Biospheric values are positively related to environmental concern and green lifestyle orientation, indirectly affecting green technology purchasing frequency.
- H3b: Altruistic values are positively related to environmental concern and green lifestyle orientation, indirectly affecting green technology purchasing frequency.
- H4: Income is positively related to green technology purchasing frequency.

Theoretically, these hypotheses test similar relationships put forth by VBN theory, proposing a causal relationship between values, environmental concern, green lifestyle orientation, and green technology purchasing intention. This conceptual framework is illustrated in Figure 1. We explore each of these hypotheses in both samples (US and Canada) to facilitate comparison between samples and suggest more generalized conclusions. We expect similar results for both samples, following previous research on environmental attitudes and behavior in US and Canada (Steger et al., 1989; Xiao & Dunlap, 2007).

**Figure 3-1 Conceptual Framework Linking Values, Environmental Concern, Green Lifestyle Orientation, and Income to Green Technology Purchasing Intentions**
3.3 Methods

3.3.1 Participants and Procedure

The cross-sectional survey, administered by Decision Analyst market research in February 2013, was designed to investigate engagement in pro-environmental behavior. Respondents received $5 (US or CAD) for participation in the survey. US and Canadian samples were recruited in effort to represent each country’s population by age and gender. For the Canadian survey, more than 54,000 individuals received an invitation to participate in the study. Of the first 2,046 respondents, 534 were excluded based on demographic criteria and 292 did not finish the survey, resulting in a total sample size of 1220. The US survey invitation was sent to 14,000 individuals. 1,395 individuals initially responded and 240 did not meet demographic quotas, resulting in a total sample size of 1000 (Schmitt et al., 2018). See Schmitt et al. (2018) for more details on Canadian sampling procedures.

Table 1 provides sample distributions by gender, age, education, and household income in comparison to US and Canadian census data. Although both samples have small sampling biases (e.g. overrepresentation of males, underrepresentation of 19-24 age group), threats to generalizability are limited as the following regression analyses control for demographic characteristics (Babbie, 2013; Schmitt et al., 2018).

Table 3-1 Sample Demographic Characteristics Compared to Census Data
(adapted from Schmitt et al. 2018)

<table>
<thead>
<tr>
<th></th>
<th>United States</th>
<th>Canada</th>
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<tbody>
<tr>
<td></td>
<td>Survey&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Census&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Sex (%)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>39.9</td>
<td>50.8</td>
</tr>
<tr>
<td><strong>Age (%)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19-34 years old</td>
<td>19.5</td>
<td>29.3</td>
</tr>
<tr>
<td>(20-25 for census)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>35-54 years old</td>
<td>46.7</td>
<td>41.2</td>
</tr>
<tr>
<td>55 year and older</td>
<td>33.9</td>
<td>29.5</td>
</tr>
<tr>
<td><strong>Education level (%)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bachelor’s degree</td>
<td>38.3</td>
<td>20.0</td>
</tr>
<tr>
<td>Graduate degree</td>
<td>21.2</td>
<td>11.6</td>
</tr>
<tr>
<td><strong>Household income (%)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;$70k/year</td>
<td>57.2</td>
<td>62.4</td>
</tr>
<tr>
<td>$70-99k/year</td>
<td>19.6</td>
<td>15.1</td>
</tr>
<tr>
<td>$100k/year or more</td>
<td>23.2</td>
<td>22.5</td>
</tr>
</tbody>
</table>

<sup>a</sup> All survey respondents are 19 or older.

<sup>b</sup> U.S. age, sex and residence data are from 2010 census data, and income and education are from 2013 census data (www.census.gov).

<sup>c</sup> Canada income data are from 2006 census data, and age, sex, and education data are from 2011 census data (www.statcan.gc.ca).

<sup>d</sup> Age distributions for Canada and U.S.A. census are for the segment of the population that is aged 20 or older.

<sup>e</sup> Education figures for Canada and U.S.A. census are for the population aged 25 or older.

<sup>f</sup> Excluding respondents that did selected “prefer not to answer”, which was 4.7% of the U.S. sample and 10.0% of the Canada sample.

### 3.3.2 Demographic Controls

**Income**: Income was measured as pre-tax income category, also measured in classes (from 1=less than $10,000 and 13=greater than $150,000), where we used the natural log of the midpoint of each class.

**Sex**: Participants indicated sex by selecting male (coded as 0) or female (1). Information on gender identity was not collected in this survey.

**Age**: Age was measured in eight classes (19-24, 25-34, 35-44, 45-49, 50-54, 55-64, 65-74, 75 or older), and in the analysis coded as midpoints of each class (except for the last class, coded as 75). Eligible respondents were over the age of 19.
We also included dummy variables to indicate if a respondent rents or owns a home (0=rent, 1=own) or owns a vehicle (1=own, 0=does not own) to control for these factors when asking about appliances and vehicle. Renters may not have the opportunity to make appliance purchasing decisions, just as vehicle ownership is not relevant to non-drivers.

3.3.3 Measures

**Dependent variable – self-reported green technology purchasing frequency:** We measure the dependent variable with a scale that asks participants “How often do you engage in each of the following activities?” for the following three activities: buy high-efficiency lightbulbs, buy energy-efficient appliances, and buy an efficient vehicle. The scale includes never (1), rarely (2), occasionally (3), usually (4), and always (5). Participants had the option to indicate that they had no opportunity to engage in the behavior. Such responses were assigned never (1), and additional controls for vehicle and home ownership were added to regression models. In the following analysis, we use both the combined, averaged scale and the individual items as dependent variables. The scale was internally reliable (α = 0.73) (Tavakol & Dennick, 2011). When accounting for the full set of pro-environmental behavior questions in the survey, the scale had a higher reliability rating (α = 0.94).

**Values:** Biospheric and altruistic values were measured in this survey using scales from Stern et al. (1998). Respondents indicated the importance of each value as a guiding principle in their life from not important at all (1) to very important (4). Each value was measured with three items. Biospheric values include respecting the earth, harmony with other species; protecting the environment, preserving nature; and unity with nature, fitting into nature (internally reliable scale, α = 0.90). Altruistic values include equality, equal opportunity for all; social justice, correcting injustice, care for the weak; and a world at peace, free of war and conflict (internally reliable scale, α = 0.80). Principal Component Analysis (PCA) with varimax rotation was used to reduce the items and differentiate the two sets of values. Table 2 reports the results of the PCA including
factor coefficients and total variance explained (TVE) of each construct. Each factor loaded onto a single construct, excluding loadings less than 0.4. Results from the PCA were used to calculate Bartlett’s scores used to measure the two values in subsequent analyses. Bartlett’s scores provide unbiased estimates of the true factor score, and do not correlate with other factors (DiStefano et al., 2009).

**Table 3-2 Principal Component Analysis of Value Scales**

<table>
<thead>
<tr>
<th>Value Statements</th>
<th>Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Biospheric (TVE = 42.02%)</strong></td>
<td></td>
</tr>
<tr>
<td>Respecting the earth, harmony with other species</td>
<td>.900</td>
</tr>
<tr>
<td>Protecting the environment, preserving nature</td>
<td>.891</td>
</tr>
<tr>
<td>Unity with nature, fitting into nature</td>
<td>.800</td>
</tr>
<tr>
<td><strong>Altruistic (TVE = 36.1%)</strong></td>
<td></td>
</tr>
<tr>
<td>Equality, equal opportunity for all</td>
<td>.880</td>
</tr>
<tr>
<td>Social justice, correcting injustice, care for the weak</td>
<td>.860</td>
</tr>
<tr>
<td>A world at peace, free of war and conflict</td>
<td>.628</td>
</tr>
<tr>
<td><strong>Measures of fit</strong></td>
<td></td>
</tr>
<tr>
<td>Kaiser-Meyer-Olkin Sampling Adequacy = .833</td>
<td></td>
</tr>
<tr>
<td>Bartlett’s Test of Sphericity = p&lt;.001</td>
<td></td>
</tr>
</tbody>
</table>

**Environmental concern:** We measure environmental concern by asking respondents to rate their level of concern on two environmental issues and averaging these scores: climate change and air pollution. Response options included: it is not a problem and does not require any action (1); more research is needed before action is taken (2); it could be a serious problem, and we should take some action now (3); and it is a seriously problem, and immediate action is necessary (4). Respondents could indicate that they did not know about the issue, and these responses were coded as missing values. These two items formed an internally reliable scale ($\alpha = 0.71$).

**Green lifestyle orientation:** To measure green lifestyle orientation, we asked how participants see their overall lifestyle. Response choices included: not green, environmental activities are not a priority (1); light green, environmental activities are sometimes a priority (2);
medium green, environmental activities are generally a priority (3) and; dark green, environmental activities are a main lifestyle priority (4).

### Table 3-3 Descriptive Statistics for Key Measures

<table>
<thead>
<tr>
<th>Values</th>
<th>United States</th>
<th>Canada</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min, Max</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Biospheric</td>
<td>3, 12</td>
<td>9.67</td>
</tr>
<tr>
<td>Altruistic</td>
<td>3, 12</td>
<td>10.43</td>
</tr>
<tr>
<td>Environmental concern</td>
<td>1, 4</td>
<td>3.07</td>
</tr>
<tr>
<td>Green lifestyle orientation</td>
<td>1, 4</td>
<td>2.27</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Purchase intentions</th>
<th>United States</th>
<th>Canada</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lightbulbs</td>
<td>1, 5</td>
<td>3.43</td>
</tr>
<tr>
<td>Appliances</td>
<td>1, 5</td>
<td>3.30</td>
</tr>
<tr>
<td>Vehicles</td>
<td>1, 5</td>
<td>2.51</td>
</tr>
</tbody>
</table>

#### 3.4 Results

To test the research hypotheses, we used structural equation modeling (SEM) with AMOS software version 26. We ran three multi-group SEMs to compare US and Canadian samples for each purchasing frequency variable. Figure 2 displays the SEM diagram used in all three models, with each purchase frequency variable. Estimation of the lightbulb purchasing model yielded the following statistics: chi-square = 172.569, df = 16 (p<.0001); IFI = .910; CFI = .907; TLI = .583; RMSEA = .066. Estimation of the appliance purchasing model yielded: chi-square = 193.310, df = 26 (p<.0001); IFI = .926; CFI = .924; TLI = .736; RMSEA = .054. Estimation of the vehicle purchasing model yielded: chi-square = 190.915, df = 28 (p<.0001); IFI = .918; CFI = .916; TLI = .730; RMSEA = .051. Following Hooper et al. (2008), these statistics indicate acceptable model fit, with the exception of chi-square which is sensitive to sample size.

To determine significance of indirect effects, we used the Test of Joint Significance (TJS) following Leth-Steensen and Gallitto (2016). Table 4 outlines results of the three SEMs, including direct effects. Although the conceptual framework does not call for investigation of direct effects on purchasing intention from values and environmental concern, we test these relationships to understand the salience of these variables in explaining purchase behavior on
their own, as research finds some evidence of their direct causal effects on pro-environmental behavior (de Groot & Thøgersen, 2018). Table 5 outlines indirect effects of key variables.

**Figure 3-2 Structural Equation Model Diagram**
Table 3-4 Structural Equation Model Results

<table>
<thead>
<tr>
<th>Path</th>
<th>USA (Group A)</th>
<th>Canada (Group B)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Item 1:</td>
<td>Item 2:</td>
</tr>
<tr>
<td>Bio</td>
<td>0.82</td>
<td>1.23</td>
</tr>
<tr>
<td>Bio</td>
<td>1.45</td>
<td>2.34</td>
</tr>
<tr>
<td>Soc</td>
<td>0.98</td>
<td>1.89</td>
</tr>
<tr>
<td>Soc</td>
<td>2.34</td>
<td>3.25</td>
</tr>
<tr>
<td>Age</td>
<td>0.89</td>
<td>1.78</td>
</tr>
<tr>
<td>Age</td>
<td>1.78</td>
<td>2.67</td>
</tr>
<tr>
<td>Inc</td>
<td>0.78</td>
<td>1.67</td>
</tr>
<tr>
<td>Inc</td>
<td>1.67</td>
<td>2.56</td>
</tr>
</tbody>
</table>

**p < .001, *p < .01, *p < .05**
H1 predicted that green lifestyle orientation is positively related to green purchasing frequency. The results support this hypothesis, as the coefficient is positive and significant across models in both US and Canadian samples. Green lifestyle orientation is positively related to lightbulb purchasing frequency in the US model 1a (b=.238, p<.01) and Canada model 1b (b=.154, p<.001), appliance purchasing frequency in the US model 2a (b=.172, p<.001) and Canada model 2b (b=.140, p<.001), and vehicle purchasing in the US model 3a (b=.182, p<.001) and Canada model 3b (b=.032, p<.001).

H2 predicted that environmental concern is positively related to green lifestyle orientation, indirectly affecting green technology purchasing frequency. Green lifestyle orientation is positively related to green technology purchasing frequency across models: 1a (b=.279, p<.001), 1b (b=.194, p<.001), 2a (b=.279, p<.001), 2b (b=.193, p<.001), 3a (b=.279, p<.001), and 3b (b=.193, p<.001). Environmental concern also indirectly effects green technology purchase frequency across models, determined by TJS, as both direct paths are positively related and statistically significant across models. In models 1a, 1b, and 2b, the effect is partially mediated, as concern has a statistically significant positive direct effect on purchase in addition to lifestyle (1a: b=.085, p<.05); (1b: .146, p<.001); (2b: .078, p<.01). In models 2a, 3a, and 3b, the effect is fully mediated, as concern does not have a statistically significant effect on purchase, but lifestyle does.

H3a predicted that biospheric values are positively related to environmental concern and green lifestyle orientation. The results support this hypothesis across models. Biospheric values are positively related to environmental concern in model 1a (b=.421, p<.001), model 1b (b=.364, p<.001), model 2a (b=.421, p<.001), model 2b (b=.364, p<.001), model 3a (b=.421, p<.001), and model 3b (b=.364, p<.001). Additionally, biospheric values are positively related to green lifestyle orientation in model 1a (b=.331, p<.001), model 1b (b=.340, p<.001), model 2a (b=.331, p<.001), model 2b (b=.341, p<.001), model 3a (b=.331, p<.001), and model 3b (b=.341, p<.001).
Further, the model provides evidence that biospheric values indirectly effect green technology purchasing frequency, as the TJS indicates that each piece of the causal pathway is positive and significant across models (biospheric values are positively related to environmental concern, environmental concern is positively related to green lifestyle orientation, and green lifestyle orientation is positively related to green technology purchase frequency.

H3b predicted that altruistic values are positively related to environmental concern and green lifestyle orientation. This hypothesis is partially supported by the SEM. The results indicate that altruistic values are consistently positively related to environmental concern across models: 1a (b=.358, p<.001), 1b (b=.222, p<.001), 2a (b=.358, p<.001), 2b (b=.222, p<.001), 3a (b=.358, p<.001), and 3b (b=.222, p<.001). Altruistic values, however, are only positively related to green lifestyle orientation in the Canadian sample (b=.054, p<.05). This relationship does not hold in the US sample. Indirect effects, however, track altruistic values along the causal path from values to concern to lifestyle to purchase frequency, and thus have statistically significant positive indirect effects on purchase frequency across all three models in both samples.

H4 predicted that income is positively related to green technology purchasing frequency, and this hypothesis is supported by our results across models. Income is positively and statistically significantly related to green technology purchase frequency in model 1a (b=.154, p<.001), model 1b (b=.125, p<.001), model 2a (b=.175, p<.001), model 2b (b=.126, p<.001), model 3a (b=.216, p<.001), and model 3b (b=.122, p<.001).
Table 3-5 Standardized Indirect Effects of DVs on Purchase Frequency

<table>
<thead>
<tr>
<th></th>
<th>US (Group A)</th>
<th>Canada (Group B)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lightbulb</td>
<td>Appliance</td>
</tr>
<tr>
<td></td>
<td>(1a)</td>
<td>(2a)</td>
</tr>
<tr>
<td>Biospheric Values</td>
<td>.143*</td>
<td>.087*</td>
</tr>
<tr>
<td>Altruistic Values</td>
<td>.060*</td>
<td>.030*</td>
</tr>
<tr>
<td>Environmental</td>
<td>.067*</td>
<td>.048*</td>
</tr>
<tr>
<td>Concern</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Determined statistically significant through TJS (Leth-Steensen & Gallitto, 2016)

3.5 Discussion

Across samples, our hypotheses hold when tested in a series of SEMs, linking biospheric and altruistic values to environmental concern, concern to green lifestyle orientation, and lifestyle to green technology purchasing frequency. Additionally, income and contextual factors (home ownership and vehicle ownership) predict variance in green technology purchasing across models. Our findings align with other studies that find value-based theories successful in predicting a range of pro-environmental behaviors, but our conceptual framework is unique in its focus on green lifestyle orientation, rather than personal norms, as a behavioral determinant of green purchasing intention.

Our findings suggest the relevance of green lifestyle as a behavioral determinant, particularly in the case of efficiency purchasing behaviors. Green lifestyle orientation is positively related to green technology purchasing intention across models, including lightbulb, appliance, and vehicle purchasing intention across US and Canadian samples. This finding reinforces the idea that individual pro-environmental behaviors are embedded in one’s overall lifestyle and cannot be viewed as isolated actions. Whitmarsh and O’Neill (2010) note that shopping for material objects is a type of “conspicuous” or visible form of consumption and thus often an expression of identity, which we understand as a component of lifestyle orientation. The
way we see our overall lifestyle in the context of environmentalism drives the way we make decisions, and purchases are particularly wrapped up in perceptions of lifestyle and identity.

Comparing across purchase types, the direct effect of lifestyle orientation on purchase intention appears to decrease (based on standardized beta coefficient size) as the cost of purchases increases. In the US sample, the relationship between lifestyle and lightbulb purchase intention has a larger standardized coefficient (b=.238) than appliance (b=.172) or vehicle (b=.182) purchase. In the Canadian sample, this relationship also holds, as lifestyle appears to have a greater impact on lightbulb purchase intention (b=.154) than appliance purchase intention (b=.140) or vehicle purchase intention (b=.032). One explanation for this finding is the fact that efficiency behaviors explored here have an associated upfront cost that may dampen the impact of psychological variables, following the ‘low-cost hypothesis’ that predicts the strength of effects of attitudinal variables decrease with increasing behavioral costs (Diekmann & Preisendörfer, 2003). Stern (2000) also finds that attitudinal variables explain less variance than contextual factors and personal capabilities in behaviors that are expensive or difficult to accomplish. Additionally, policy context differs in the US and Canada – for example, Canada phased out incandescent bulbs in 2007, while they are still available to purchase in the US (Ivanco et al., 2007).

Following this point, we observe the clear strong effect of income and contextual factors on purchasing intentions. In accordance with the ‘low-cost hypothesis,’ the opposite holds true for income which effects strengthen as cost rises in contrast to attitudinal variables. Household income was statistically significant and positively related to all purchasing behaviors in both samples. In the US sample, the standardized beta coefficient for income grew larger as the purchase measured became more expensive, from lightbulbs to cars. This pattern did not hold in the Canadian sample, but coefficients remained close in size across models. Dummy variables for home ownership and vehicle ownership were positively related and statistically significant in all
models in which they were included, illustrating the reality that consumers cannot make the choice to purchase efficient appliances if they do not own their own home or efficient vehicles if they do not own a car. Carpooling, biking, taking public transit, and other alternative modes of transportation reduce more emissions than driving even the most fuel-efficient vehicle.

Other sociodemographic variables also played a role in predicting purchasing intention, but a smaller one than income. Respondent gender was significant in all behaviors except appliance purchases in the US sample, and no behaviors in the Canadian sample, with a positive relationship indicating that identifying as female is tied to green purchasing behaviors. The US results follow consistent findings that women are more likely to be environmentally concerned and purchase green products (Fisher et al., 2012; Laroche et al., 2001; Subiza-Pérez et al., 2020). Finally, age was positively associated with all green purchasing behaviors in the US sample and only appliance purchases in the Canadian sample. Older respondents are likely to have had more opportunities to make big purchases such as appliances or vehicles. While Fisher et al. (2012) notes mixed results on age and environmentally friendly behavior in multiple studies, our results align with a meta-analysis by Wiernik et al. (2013) that found small but significant relationships between older age and various environmental attitudes and behaviors.

3.5.1 Limitations

It is important to note that the data were collected in 2013 and thus may not represent the precise current state of public opinion and behavior on sustainability in 2020. Additionally, the survey sample was recruited to be representative, but is not perfectly representative of US and Canadian populations. These data are still useful for investigating relationships between variables, testing hypotheses, and building theory. Controlling for socio-demographic factors through linear regression allows us to isolate these variables. This dataset is particularly useful as it collects data on a large number and wide variety of pro-environmental behaviors.
Additionally, it is unclear how these green technology purchases interact with savings or use behaviors. Specific to appliances, the way an individual uses the appliance often determines actual energy or water savings, and these savings can vary significantly (Sekar et al., 2019). Many scholars have pointed to the potential for “rebound effect” as an unintended consequence of increased energy efficiency – the idea that consumers will buy an energy efficient product, but in turn use it more frequently (Herring, 2006; Orea et al., 2015; Saunders, 2013). While studies have found empirical evidence for the rebound effect, researchers generally conclude that the effects are too minor to outweigh energy savings from efficiency measures (Gillingham et al., 2013).

Finally, there are other possible ways to measure the dependent variable of self-reported purchasing behaviors that may result in less potential for measurement error. The measures we use ask how often the respondent purchases efficient lightbulbs, appliances, and vehicles, which may be an inefficient way of measuring infrequent purchases. The survey asked about a larger list of 45 pro-environmental behaviors, using a Likert-type scale to measure frequency. Heterogeneity in the responses, however, suggests that many participants understood the intent of the survey questions.

3.5.2 Implications

Our research suggests the importance of green lifestyle orientation, environmental concern, values, and sociodemographic variables, to green technology purchasing behavior in US and Canadian consumers. Theoretically, this research contributes to a growing body of work that understands consumption as embedded in daily life, and green lifestyles as the long-term process of prioritizing environmentally conscious consumption (Lubowiecki-Vikuk et al., 2021). Purchasing green technology is just one piece of a broader pro-environmental lifestyle, shaped by material, social, and economic constraints. To echo Whitmarsh and O’Neill (2010), our findings reinforce the idea that how we think about ourselves can impact our pro-environmental intentions and behaviors.
The practical implications of our findings are twofold. Lifestyle orientation as a predictor of green technology purchases suggests opportunity for better communication practices to this segment of the population to encourage efficient technology adoption. The strong impact of household income, home ownership, and vehicle ownership in our models, on the other hand, point to areas of structural lock-in that demand institutional change. While we recognize broad structural and institutional level changes are necessary for rapid decarbonization, we believe there is value in the “dichotomizing of strategies (cultures versus structures and individual versus institutions)” to push forward (Boucher, 2016).

If the way one sees their overall lifestyle impacts what kind of purchases they make, how can researchers, industry, and policymakers better communicate with green consumers? Longo et al. (2019) describe how overwhelming amounts of information can lead to paralysis and even dread in green consumers, as factors outside of their control inhibit true sustainable consumption. The study recommends a wide variety of approaches to combat this barrier, including top-down regulations on manufacturing and bottom-up community-stakeholder partnerships to disseminate trustworthy information. In contrast to this sense of dread, Bukchin and Kerret (2020) find that higher levels of hope and motivation are significant predictors of early green technology adoption. Future research should consider these facets of identity and lifestyle orientation to craft messaging that speaks to the way consumers see themselves and understand their motivations. Further, future research might integrate lifestyle orientation with the norm-activation aspect of VBN theory, considering if green lifestyle orientation is consistent with the activation of pro-environmental norms when making green purchasing decisions (Blamey, 1998; Van Liere & Dunlap, 1978).

Dietz et al. (2009) suggest a variety of interventions to encourage energy efficient technology adoption including financial incentives for both households to purchase green technology and industry to produce and sell it. Our finding that income is linked to frequency of
energy efficient purchasing speaks to the need for increased financial incentives, particularly for purchases with higher up-front costs. Additionally, implementation of energy efficiency policies targeting the household sector have been linked to increased number of patented energy-efficiency inventions, a measure of innovation (Girod et al., 2017). A large body of research evaluates emission reductions and energy savings as a result of energy efficiency policies and programs, and these results are largely mixed – one recent comprehensive review found that introducing product standards and financial incentives have higher energy savings potential than behavioral and informational programs, although often subject to misevaluation that overestimates savings (Gillingham et al., 2018).

Critiques of household consumption research have long acknowledged that individual action can only move us so far towards rapid emissions reductions. Increased income is linked with greater individual emissions, despite levels of environmental concern (Boucher, 2016; Csutora, 2012; Gatersleben et al., 2002; Wilson et al., 2013). Wilson et al. (2013) found additionally that even respondents who reported energy efficient behaviors did not have significant differences in GHG emissions. Our findings, linking higher income to greater frequency of green technology purchases, complicates this relationship, suggesting that even if high income consumers are consuming more efficiently, they are still likely consuming at higher rates than low-income households. Boucher (2016) suggests, “rather than thinking of income as a medium for buying and disposing of products, energy, and emissions, it could be thought of as a proxy for a set of normative, socially positioned behaviors – an income lifestyle, a class culture” (p. 69, emphasis in original). High income consumers presumably have the most disposable income to spend on upgrading to efficient technology and higher levels of household emissions to reduce, positioning them as ideal targets for both behavioral and structural policy programs.
3.6 Conclusion

The purpose of this research is to investigate social-psychological factors associated with frequency of green technology purchasing in US and Canadian consumers. The results of three structural equation models across two samples suggest the presence of a relationship between biospheric and altruistic values, environmental concern, and green lifestyle orientation that predict green technology purchasing intention. Additionally, income has a strong effect on purchase intentions across samples. Other sociodemographic factors also influence potential purchases. Identifying as female was positively related to electric vehicle purchase intention in the US sample, but this relationship did not hold in the Canadian sample. As cultural and political shifts persist, future research should continue to monitor the ways in which consumers perform environmental identity and lifestyle through purchases. Beyond individual attitudes, behavior, and choices, existing institutions including government and industry must provide affordable, reliable, and equitable green technology to consumers.
4 Green Roles at Home: Exploring the Impact of Household Social Dynamics on Consumption at the Food-Energy-Water Nexus

4.1 Abstract

Capturing social dynamics between household members that work to shape consumption patterns presents a complex problem for studies of food, energy, and water resource conservation for climate change mitigation. To bridge the gap between the individual and household, we propose and test a series of quantitative measures of household social dynamics. Based on previous qualitative research, we develop and test three distinct dynamics that either encourage or deter household-level pro-environmental action: enhancing, norming, and constraining. In a sample of suburban Illinois, USA households (n=114), we find that enhancing dynamics and positive household norms positively predict variance in frequency of food, energy, and water conserving pro-environmental actions. Pro-environmental orientation of the individual respondent, in turn, explains variance in all three household dynamics, and perception of environmental awareness of the whole household is associated with greater prevalence of household norms. These findings suggest that internal social dynamics influence household decision-making around resource consumption, supporting qualitative research that illustrates consumption as embedded within the relationships that form residential life. We suggest ways forward for quantitative social science researchers to explore consumption through a practice-based approach.

4.2 Introduction

To significantly reduce emissions associated with global climate change on a short timescale, many scholars stress the importance of targeting greenhouse gas (GHG) intensive individual and household consumption. To this end, recent behavioral science research explores the social drivers of consumption to facilitate sustainability transitions through household change.
This paper contributes to this body of research by exploring how social dynamics within the household influence household consumption at the food-energy-water (FEW) nexus. We focus on two central questions: 1) Can we measure household dynamics quantitatively? and 2) Are household social dynamics correlated with frequency of self-reported pro-environmental food, energy, and water actions?

While other existing research on household dynamics primarily collects qualitative data to capture detailed snapshots of household life, we look quantitatively at prevalence of specific social dynamic processes, as perceived by a main respondent, in a larger sample of households. We measure the household social dynamic processes of norming, enhancing, and constraining resource consumption behavior (characterized by Lytle et al. 2021) as they relate to household practices that require food, energy, and water use. Our analysis measures the impact of these household dynamics on frequency of self-reported resource consumption behaviors. By measuring the influence of household social dynamics on consumption, we can inform future interventions that aim to curb household emissions.

4.2.1 Household Consumption at the FEW Nexus

Responsible for 60% of direct and indirect global greenhouse gas emissions, household consumption plays a key role in climate mitigation efforts (Ivanova et al., 2016). The food-energy-water (FEW) nexus concept aims to capture a broader picture of household consumption, considering embedded energy and water use and capturing tensions and trade-offs between systems (Albrecht et al., 2018). While household consumption change research has aimed to capture these systems, few intervention studies address all components of the nexus in an integrated way (Berman et al., 2019). Thus, exploring determinants of household consumption at the FEW nexus warrants further study.
4.2.2 Quantitatively Capturing Household Social Practices

To account for variance in decision-making less shaped by individual attitudes and values, a large body of work explores the infrastructural and social factors that shape consumption and pro-environmental behavior. Theories of social practice present a multi-scalar approach to studying consumption, framed as a series of everyday practices shaped by the relationships between people and material technologies (Bell et al., 2015; Shove et al., 2012). One understanding of practices characterizes them as “constellations of actions,” with social life comprised of a wide range of practices (Schatzki, 2002). Hargreaves (2011) attempts to integrate practice theory with the predominant focus on behavior, interpreting behavior change through a ‘practice lens,’ although Shove argues that practice theory, as put forth by Giddens (1984), is not behavioral. Shove’s framework stands in contrast to that which focuses on behaviors themselves, which act as the building blocks of practices and are often studied in isolation from the context that practice theory affords. Understanding consumption as a collection of practices that inherently require resource consumption, Røpke (2009) suggests that theories of practice might shift blame away from the individual consumer and encourage the consideration of collective action for sustainability. Understanding consumption as a series of “practices” rather than “behaviors” broadens the subject of inquiry beyond the individual, acknowledging that external factors, including social dynamics, work to shape and reshape practices. To study social practices in their residential context, however, researchers typically use qualitative methods to capture nuance, detail, and often otherwise unpredicted findings (Schelly, 2016). Thus, this research integrates theories of social practice with attitudinal variables more typically used in quantitative household consumption research (see Steg and Vlek 2009), offering a novel perspective.

4.2.3 The Household in Consumption Research

Existing research has failed to address what Jorgensen et al. (2020) deem a level-of-analysis problem: household consumption studies typically apply theories that predict individual
behavior to environmentally impactful actions that take place within the household, which often consists of groups of people. While many psychological and economic theories are useful for exploring determinants of household behavior, applying individual-level theories to group-level phenomena “leads to erroneous empirical results and conclusions, and thereby less effective policy and management actions” (Jorgensen et al., 2020, p. 1). Lack of focus on the household as a socially constituted unit may also contribute to the often cited gap between intention and action (Kollmuss & Agyeman, 2002). Jorgensen et al. conclude, “until appropriate household-level theories of resource consumption are developed, researchers are likely to continue to draw upon the wrong theories and develop incomplete or incorrect conclusions which in turn limit the effectiveness of household targeted resource management programs” (p. 2). Hargreaves and Middlemiss (2020) argue that the narrow focus of individual energy demand obscures energy use in places like homes, workplaces, and communities that predominantly feature complex webs of social relations.

Motivated by the absence of social relations in household consumption studies, our research seeks to bridge this conceptual gap by understanding household behavior as embedded within residential life and shaped by social dynamics. Hargreaves & Middlemiss (2020) show that previous research thoroughly documents the importance of social dynamics in shaping energy demand more broadly outside of the home. They identify three types of significant social relationships that shape this demand: those with family and friends, with agencies and communities, and those associated with social identities. Prevalent in the household context, relationships between friends and family impact energy demand in multiple ways including learning and shaping practices, sharing energy services, and energy consumption advice. The review argues, “it is through the enactment of these relations, for example, that people become socialized into particular ways of thinking about and using energy and thus that cultural
conventions with associated levels of service expectation become normalized or reinforced, stigmatized and challenged” (p. 197).

Other research, primarily qualitative, has documented various inter-household dynamics that appear to shape resource consumption. Papers as early as 2006 have called for increased focus on the household following findings that family decision-making shapes practices around food, energy, water, waste, and transport (Grønhøj, 2006). Bell et al. (2015) describe households as sites of negotiation between members in efforts to coordinate practices around resource consumption to minimize conflict. Through in-depth interviews, they uncover the complex impacts of social dynamics around gender, age generation, and household change on electricity consumption. Similar processes serve to socialize children into the process of electricity consumption, shaping consciousness about resource use and behavior (Aguirre-Bielschowsky et al., 2018).

Social norms provide another framework to explain group behavior. Kleinschafer & Morrison (2014) identify various drivers of norms that shape energy consumption in the household, including the role of a ‘champion’ that encourages efficiency behavior and the passing down of intergenerational norms between parents and children. One quantitative study focused on adolescents found that their environmental decision-making was heavily influenced by family norms (Grønhøj & Thøgersen, 2012). A comprehensive survey study that collected data from multiple household members found positive mental, physical, and life satisfaction impacts across household members in ‘greener’ households that collectively engage in more pro-environmental behaviors (Netuveli & Watts, 2020).

Additionally, studies have explored the role of conflict, particularly around energy consumption. For example, relationships between landlords and tenants often hinder sustainable building renovation (Ástmarsson et al., 2013). Other studies have examined conflicts around thermal comfort (adjusting thermostats) that drive household energy use, suggesting gendered
differences in resident interactions with home energy technology, perceived control, and negotiation (Sintov et al., 2019). Household thermal conflicts take place within a “socio-material environment” that includes both material factors like heating fuels and technologies and social factors like control, convenience, monitoring, and dependence (Sovacool et al., 2020).

Scott et al. (2015) developed a conceptual framework for the adoption of pro-environmental actions with the household as a unit of analysis, pointing to the decision-making strategies of experience, legitimate, coalition, emotion, and bargaining (drawn from Kwai-Choi Lee and Collins 2000). Household members 1) use experience as a source of information to influence decisions; 2) legitimate by emphasizing a particular role to gain influence; 3) form a coalition with two or more household members; 4) use emotion both verbally and non-verbally to persuade others in the household; and 5) bargain by giving in on one occasion in return for a favorable outcome on a different occasion. These strategies illuminate the various ways social dynamics can play out in real time to determine resource use outcomes.

To further understand how household decision-making processes shape food, energy, and water consumption, Lytle et al. (2021) conducted a series of exploratory qualitative interviews (n=44) with residential dwellers in the Midwestern United States. These interviews revealed that in addition to being driven by individual attitudes or values, decisions about consumption were largely embedded within the dynamic of social relationships that constitute the household. The results point to five social dynamic processes related to household consumption: enhancing, norming, constraining, preferring, and allocating (see Table 4-1). Enhancing occurs when certain members of the household support other members’ efforts to engage in sustainable consumption, while constraining refers to the inverse, deterring other members’ pro-environmental behavior. Norming represents the social norms of a household that enforce individual behaviors. Constraining occurs when some members deter other members’ efforts to engage in sustainable consumption. Preferring indicates individual preferences or requirements that determine
consumption patterns for the rest of the household. Allocating occurs when one member typically makes decisions for the entirety of the household (for example, food shopping might be allocated to one member of the household, while another exclusively waters the garden). These qualitative findings support the argument that researchers must consider the entirety of the household when studying consumptive practices that take place in the home, acknowledging the salience of social dynamics that shape resource use. This research selects three household social dynamics to investigate via survey: enhancing, constraining, and norming. Although Lytle et al. (2021) explain that norming can have both positive or negative consequences for sustainable resource consumption, this research considers only the positive aspects of norming that drive pro-environmental behaviors.

Table 4-1 Social Dynamic Processes Influencing Household Consumption, adapted from (Lytle et al., 2021)

<table>
<thead>
<tr>
<th>Process</th>
<th>Description</th>
<th>Example Quotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enhancing*</td>
<td>Enhancing or supporting other members’ efforts to be more sustainable</td>
<td>“I am trying to like vegetables. My wife loves them, she makes a lot of salads but I am not that fond of it, but I am trying to.”</td>
</tr>
<tr>
<td>Norming*</td>
<td>Internal family social norms insulate individual behaviors</td>
<td>“I have three other people in this family who like to sit in a tub or take a long hot shower. Can I talk them out of it?”</td>
</tr>
<tr>
<td>Constraining*</td>
<td>Constraining or deterring other members’ efforts to be more sustainable</td>
<td>“I don’t think we need to wash the clothes as much as we do but my sister has a habit of just washing them.”</td>
</tr>
<tr>
<td>Preferring</td>
<td>Individual preferences or requirements dictate group behavior</td>
<td>“My wife has allergies and you can’t leave the window open.”</td>
</tr>
<tr>
<td>Allocating</td>
<td>Decision-making or practices are allocated to another member of the household</td>
<td>“The easiest [thing we do to conserve resources at home’, and this is going to sound goofy, is I do everybody’s laundry.”</td>
</tr>
</tbody>
</table>

*Used in following analysis
4.2.4 Research Objectives

To address the gap in the literature that addresses quantitative approaches to uncovering household social dynamics, this research asks two central questions: 1) Can household social dynamics be measured quantitatively? 2) Are household social dynamics correlated with frequency of self-reported pro-environmental food, energy, and water actions?

4.3 Methods

4.3.1 Participants and Procedure

This research was conducted as part of a larger, multi-university, interdisciplinary study examining household food, energy, and water consumption and testing interventions to reduce climate and environmental impacts (FEWCON). This study recruited single-family homeowners in Lake County, Illinois in the Midwestern United States. Requirements to participate in the study included continued residence in Lake County, internet connection, completion of web-based surveys tracking socio-demographic profiles and household composition, and sharing food, energy, and water consumption data with the research team. Participants were compensated monetarily using a graduated compensation scheme to encourage continued participation. A total of $599 USD was disbursed to study participants in four installments upon completion of pre-specified benchmarks. Survey participants were given the option to refuse to answer questions or to withdraw from the study at any time without consequence. The study was reviewed and approved by the Rutgers University Institutional Review board, along with review and approval form other participating universities’ IRBs (Rutgers IRB # 2018002308).

Study participants were recruited in late 2019 and early 2020 using multiple recruitment approaches, including direct e-mail invitation with addresses gleaned from publicly available online educational and government resources, requests on Lake County Facebook groups, in-person presentations to community groups, and the web-based Qualtrics survey tool panel. We then took a snowball approach, requesting volunteers to nominate additional participants they
knew in the area. This mixed methods approach to recruitment renders calculating a specific response rate unfeasible. With an initial enrollment of 404 participants in late January 2020, the number of participants dropped to 299 and 273 in the two-part enrollment surveys conducted in February-March 2020. Due to the emergence of the COVID-19 pandemic, the originally planned intervention testing study could not be carried out. Stay-at-home orders in the area were instituted March 21, 2020 in response to the pandemic. Despite this, the team continued to run monthly surveys for enrolled participants beginning March-April 2020, shifting focus to study other aspects of consumption, and as of May 2021 the intervention study is in progress. This specific research uses data from the initial enrollment survey (February-March 2020) and the third survey wave (June-July 2020) for a total of 150 participants. The resulting sample size includes households with more than one member in the home and provided data points for each variable (n=114). It is important to note that study requirements requested one adult household member consistently respond to surveys although we were not able to confirm that this was the case.

Table 4-2 displays the socio-demographic profile of respondents including sex, age, education level, and political ideology of the respondent for the household. Additionally, Table 4-2 reports household income, number of household members, and presence of children in the household. The 2019 American Community Survey (ACS) reports 265,519 households in Lake County, IL and a population estimate of 696,535. These households contain approximately 165,842 children. The child dependency ratio is 38.9 (number of children aged 0-14 per 100 persons aged 15-64), lower than the US average of 59.1.

Females are overrepresented in our sample as main respondents (per ACS, 50.3% of the Lake County adult population identifies as female). We note that participants were asked “with which gender do you most identify?”, with options for female, male, non-binary/third gender, prefer to self-describe, and prefer not to answer. Respondents in this sample of 114 exclusively identified as male or female. The median age in Lake County is 38.7. The population median
household income is $92,511 and mean income $129,550. Thus, our sample overrepresents higher income households. 45.3% of adults over 25 in Lake County have a bachelor’s degree, showing an overrepresentation of highly educated main respondents in our sample (U.S Census Bureau, 2019). The sample is largely moderate or liberal, with very few conservatives, suggesting potential predispositions toward sustainability.

**Table 4-2 Sample Sociodemographic Characteristics**

<table>
<thead>
<tr>
<th>Sex (%)</th>
<th>70.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (%)</td>
<td></td>
</tr>
<tr>
<td>Under 25 years old</td>
<td>0</td>
</tr>
<tr>
<td>25-34 years old</td>
<td>13.3</td>
</tr>
<tr>
<td>35-44 years old</td>
<td>42.6</td>
</tr>
<tr>
<td>45-54 years old</td>
<td>27.3</td>
</tr>
<tr>
<td>55-64 years old</td>
<td>14.1</td>
</tr>
<tr>
<td>65 and older</td>
<td>2.7</td>
</tr>
<tr>
<td>Education level (%)</td>
<td></td>
</tr>
<tr>
<td>Some college/Associates degree</td>
<td>9.6</td>
</tr>
<tr>
<td>Bachelor’s degree</td>
<td>28.1</td>
</tr>
<tr>
<td>Master’s degree</td>
<td>47.4</td>
</tr>
<tr>
<td>Professional degree</td>
<td>2.6</td>
</tr>
<tr>
<td>Doctorate</td>
<td>12.3</td>
</tr>
<tr>
<td>Household income (%)</td>
<td></td>
</tr>
<tr>
<td>Less than $74,999k/year</td>
<td>16.7</td>
</tr>
<tr>
<td>$75-94,999k/year</td>
<td>11.4</td>
</tr>
<tr>
<td>$95-114,999k/year</td>
<td>17.5</td>
</tr>
<tr>
<td>$115-144,999k/year</td>
<td>21.9</td>
</tr>
<tr>
<td>$145-199,999k/year</td>
<td>21.9</td>
</tr>
<tr>
<td>$200k/year or more</td>
<td>20.5</td>
</tr>
<tr>
<td>Political ideology (%)</td>
<td></td>
</tr>
<tr>
<td>Very conservative</td>
<td>0</td>
</tr>
<tr>
<td>Conservative</td>
<td>9.8</td>
</tr>
<tr>
<td>Moderate</td>
<td>39.2</td>
</tr>
<tr>
<td>Liberal</td>
<td>38.2</td>
</tr>
<tr>
<td>Very Liberal</td>
<td>12.7</td>
</tr>
<tr>
<td>Number of household members</td>
<td></td>
</tr>
<tr>
<td>Two</td>
<td>27.2</td>
</tr>
<tr>
<td>Three</td>
<td>24.6</td>
</tr>
<tr>
<td>Four</td>
<td>35.1</td>
</tr>
<tr>
<td>Five</td>
<td>9.6</td>
</tr>
<tr>
<td>Six</td>
<td>3.5</td>
</tr>
<tr>
<td>Children in household</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>70.2</td>
</tr>
<tr>
<td>No</td>
<td>29.8</td>
</tr>
</tbody>
</table>
Household dynamics: Household dynamics scales were developed based on findings from Lytle et al. (2021), suggesting that household members enable and constrain each other’s efforts at pro-environmental consumption behavior, as well as establish and enforce household norms around consumption. We used 12 items to measure enhancing, norming, and constraining dynamics around food, energy, and water consumption behaviors (outlined in Table 4-3). Respondents indicated agreement with items on a seven-point scale ranging from 1 (strongly disagree) to 7 (strongly agree). We did not collect responses for this scale from respondents that reported living alone. These constructs were measured in the third survey wave and appeared in three separate sections of the survey grouped as questions about food, energy, and water consumption (rather than organized by theorized household dynamics). Section 4.4.1 details the computation of factor scores for these measures.

New Ecological Paradigm (NEP): We used a shortened, eight-item version of the new ecological paradigm (NEP) scale (Dunlap et al., 2000) to measure pro-environmental orientation of the respondent. This scale contains five items for which agreement indicates a pro-ecological view (When humans interfere with nature, it often produces disastrous consequences; The balance of nature is very delicate and easily upset; Humans are severely abusing the environment; If things continue on their present course, we will soon experience a major ecological catastrophe; Plants and animals have as much a right as humans to exist). For three items, disagreement indicates a pro-ecological view (The so-called “ecological crisis” facing humankind has been greatly exaggerated; Humans have the right to modify the natural environment to suit their needs; Humans were meant to rule over the rest of nature). Respondents indicated agreement with items on a five-point scale ranging from 1 (strongly disagree) to 5 (strongly agree). After
reverse coding the second set of items, we computed a variable with the mean of the eight-item scale ($\alpha=0.80, M=3.92, SD=.72$).

*Resident Environmental Awareness:* As NEP score was used to measure the pro-environmental orientation of the respondent, we used another variable to measure environmental awareness of other members in the household. As we only surveyed one household member for the duration of the study, we asked them to rate other household members by asking “How environmentally aware would you say (name) is?” for each member of their household. Respondents answered for each of their household members on a four-point scale ranging from 1 (not aware at all) to 4 (very aware). We computed a variable by taking the average of each household’s scores ($M=2.84, SD=.74$).

*Pro-environmental FEW consumption:* To measure pro-environmental food, energy, and water consumption, we asked respondents to indicate how often they undertake 20 different actions, measured on a seven-point scale ranging from 1 (never) to 7 (always) with an option to indicate if an action was not applicable. Food actions included: eating meals without any kind of animal meat, composting food waste, planning food preparation and portions carefully to avoid waste, eating meals without any kind of animal meat and without any kind of dairy (vegan), eating leftovers, growing your own food, shopping from local farms or farmers markets for food, and talking to friends or family members about the impacts of our food choices. Energy actions included: programming the thermostat, setting heat to a lower temperature in the winter, setting the air-conditioner to a higher temperature in the summer, drying clothes on a rack or line, turning off lights when I leave a room, washing clothes in cold water, talking to friends or family members about the impacts of our energy choices, turning off computers when not using, and turning off televisions when not watching. Water actions included: wearing clothes more than once, taking showers less than five minutes, running dishwasher only when full, and watering lawn only when needed.
4.3.3 Analysis

Data analysis was conducted with de-identified survey data using SPSS Statistics Version 27. Our results section organizes analysis by research objectives. To accomplish research objective 1, exploring the underlying structure of household dynamics, we used exploratory factor analysis (EFA). Following the creation of factor scores, outlined below, we conducted one multiple linear regression to measure the effects of variables of interest on pro-environmental action, and three additional multiple linear regression analyses to measure the effects of NEP score and household environmental awareness score on the three different household dynamics.

4.4 Results

4.4.1 Research Objective 1: Exploratory Factor Analysis to Determine Quantitative Household Dynamics Measures

First, we used factor analysis to explore the underlying structure of the set of 12 household dynamics scales. Here, exploratory factor analysis allows us to examine if the data hang together in ways that describe distinct household dynamics. We ran the analysis with an oblique rotation (promax) that assumes the factors are correlated and an orthogonal rotation (varimax), assuming no correlation between factors, and determined the latter was appropriate as none of the factors were strongly correlated (Tabachnick et al. 2007). Thus, we used Principal Axis Factoring with varimax rotation and Kaiser normalization in SPSS 27. The model met the assumptions of independent sampling, normality, and linear relationships between pairs of variables. To determine the appropriate number of factors, we considered eigenvalues greater than one, scree plot test, and assessment and interpretability of factors based on the exploratory nature of the analysis, deciding on a three-factor solution (Costello & Osborne, 2005). After rotation, the first factor accounted for 19.98% of the variance, the second factor accounted for 17.55%, and the third factor accounted for 16.17%. All three factors account for 53.7% of the
Table 4-3 includes the survey items and factor loadings for the rotated factors, with loadings less than .40 excluded (Matsunaga, 2010).

**Table 4-3 Factor Loadings from Principal Axis Factoring with Varimax Rotation for a Three-Factor Solution for Household Dynamics Questions**

<table>
<thead>
<tr>
<th>Item</th>
<th>Factor loading</th>
<th>Communality</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Some members of my household encourage other members to conserve energy (M=6.05, SD=1.11)</td>
<td>.747</td>
<td>.595</td>
</tr>
<tr>
<td>2. There is one member of our household who often takes the role of making sure we do not waste energy (M=5.58, SD=1.46)</td>
<td>.698</td>
<td>.594</td>
</tr>
<tr>
<td>3. Some members of my household encourage other members not to waste food (M=5.98, SD=1.00)</td>
<td>.620</td>
<td>.529</td>
</tr>
<tr>
<td>4. There is one member of our household who often takes the role of making sure we do not waste food (M=5.39, SD=1.49)</td>
<td>.569</td>
<td>.382</td>
</tr>
<tr>
<td>5. There is one member of our household who often takes the role of making sure we do not waste water (M=4.83, SD=1.71)</td>
<td>.528</td>
<td>.443</td>
</tr>
<tr>
<td>6. Some members of my household encourage other members to conserve water (M=5.45, SD=1.52)</td>
<td>.497</td>
<td>.552</td>
</tr>
<tr>
<td>7. In our household, it is expected that we all make an effort to conserve water (M=5.31, SD=1.49)</td>
<td>.872</td>
<td>.648</td>
</tr>
<tr>
<td>8. In our household, it is expected that we all make an effort to conserve energy (M=5.65, SD=1.21)</td>
<td>.600</td>
<td>.646</td>
</tr>
<tr>
<td>9. In our household, it is expected that we all make an effort to reduce food waste (M=5.54, SD=1.37)</td>
<td>.581</td>
<td>.563</td>
</tr>
<tr>
<td>10. Some members of my household hamper other members’ efforts to conserve water (M=3.53, SD=1.84)</td>
<td>.805</td>
<td>.648</td>
</tr>
<tr>
<td>11. Some members of my household hamper other members’ efforts to conserve food (M=3.18, SD=1.77)</td>
<td>.722</td>
<td>.486</td>
</tr>
<tr>
<td>12. Some members of my household hamper other members’ efforts to conserve energy (M=3.81, SD=1.92)</td>
<td>.628</td>
<td>.544</td>
</tr>
</tbody>
</table>

**Eigenvalues**

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.397</td>
<td>2.106</td>
<td>1.941</td>
<td></td>
</tr>
</tbody>
</table>

**% variance after rotation**

<table>
<thead>
<tr>
<th></th>
<th>19.977</th>
<th>17.553</th>
<th>16.172</th>
</tr>
</thead>
</table>

Note: Loadings <.40 are omitted.

Each factor appears to indicate a different household dynamic. The first factor indicates enhancing dynamics. Each item in this factor has a strong positive loading, with items 5 and 6 cross-loading onto the second factor. Item 5 loaded higher onto the first factor. Item 6, although loading highly onto both factors, loaded higher onto factor 2 but theoretically hangs in factor 1.
(Matsunaga, 2010). The second factor appears to index norming dynamics, considering the high loadings of items 7, 8, and 9. Items 10, 11, and 12 all load highly onto factor 3 which indexes constraining dynamics. This exploratory factor analysis confirms that the survey items hang together in terms of household social dynamics, as opposed to resource domains. This analysis shows the scales can be interpreted as three constructs, and we can use these constructs as variables in the following analyses.

Following the factor analysis, we created factor scores by averaging the values for each scale item on a factor. In the following analysis, we used three variables derived from the factor scores: enhancing (M=5.55, SD=1.01), norming (M=5.50, SD=1.16), and constraining (M=3.49, SD=1.55). We chose this method of creating factor scores for multiple reasons: average scores allow for easy interpretation and comparison between factors and preserves the variation of the original data. Although less sophisticated than refined procedures for generating factor scores, DiStefano et al. (2009) suggest this method for exploratory research with previously untested scales. In creating average scores, each item on the factor is given equal weight regardless of high or low factor loading. Each of the three factors, however, have relatively high loadings for each item. Dealing with cross-loading items presents one complication (items 5 and 6). The factor scores correspond with the factors described in Table 4, with both cross-loading items contributing to factor 1. DiStefano et al. (2009) warn that even in orthogonal solutions, non-refined methods may produce correlated factor scores. After calculating the factor scores, we ran a correlation analysis and found that none of the three scores were highly correlated (>0.7), satisfying the assumption of collinearity in regression models. Factor 1 (enhancing) was positively correlated with factor 2 (norming), \( r(112) = .51, p < .001 \). Additionally, factor 2 (norming) was negatively correlated with factor 3 (constraining), \( r(112) = -.24, p < .01 \).
4.4.2 Research Objective 2: Multiple Linear Regression Analysis to Measure Correlation of Household Dynamics with Pro-Environmental Actions

After creating variables with the household dynamics factor scores, we ran a multiple linear regression model regressing self-reported frequency of pro-environmental behavior on household dynamics, NEP scores, and demographic control variables. Using exploratory factor analysis, we determined that food, energy, and water actions in this sample do not hang together as distinct constructs that could be reduced to three unique scales. Thus, for this analysis, we use the average of the 20 items to compute a score for each respondent (α=0.77, M=4.36, SD=.72).

We ran the appropriate tests to determine that the data met the required assumptions for linear regression. Analysis of standard residuals showed that the data contained no outliers. Tolerance (all > .3) and VIF statistics (all < 3) indicated that the data met the assumption of non-collinearity (Hair et al., 2009). The Durbin-Watson statistic (2.095) indicated that each model met the assumption of independent errors (Field, 2013). A histogram of standardized residuals indicated that the data contained approximately normally distributed errors, as did the normal P-P plot of standardized residuals. A scatterplots of standardized residuals showed that the data met assumptions of homogeneity of variance and linearity.

Table 4-4 Pearson Correlations

<table>
<thead>
<tr>
<th></th>
<th>Env. Action</th>
<th>Enhancing</th>
<th>Norming</th>
<th>Constraining</th>
<th>NEP Score</th>
<th>Res. Env Aware</th>
<th>Education</th>
<th>Gender</th>
<th>Income</th>
<th># Residents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enhancing</td>
<td>.488***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Norming</td>
<td>.581***</td>
<td>.506***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constraining</td>
<td>-.155*</td>
<td>.063</td>
<td>-.274**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NEP Score</td>
<td>.317***</td>
<td>.270**</td>
<td>.437***</td>
<td>-.254**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Res. Env. Aware</td>
<td>.306***</td>
<td>.070</td>
<td>.396***</td>
<td>-.198**</td>
<td>.175**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td>.034</td>
<td>-.171*</td>
<td>-.229**</td>
<td>-.028</td>
<td>-.118</td>
<td>-.088</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>.121</td>
<td>.234**</td>
<td>.055</td>
<td>.033</td>
<td>.187***</td>
<td>-.054</td>
<td>-.305***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Income</td>
<td>-.102</td>
<td>-.156*</td>
<td>-.208*</td>
<td>.036</td>
<td>-.045</td>
<td>.059</td>
<td>.420***</td>
<td>.156*</td>
<td></td>
<td></td>
</tr>
<tr>
<td># Residents</td>
<td>-.227**</td>
<td>-.022</td>
<td>-.225**</td>
<td>.351***</td>
<td>-.179**</td>
<td>-.304***</td>
<td>-.093</td>
<td>.018</td>
<td>.007</td>
<td></td>
</tr>
<tr>
<td>Children (dummy)</td>
<td>-.155*</td>
<td>.074</td>
<td>-.149</td>
<td>.245**</td>
<td>.013</td>
<td>-.336***</td>
<td>.001</td>
<td>.101</td>
<td>-.075</td>
<td>.738***</td>
</tr>
</tbody>
</table>

* sig < .05 ** sig < .01 *** sig < .001
Pearson correlations illustrate relationships between variables of interest. The dependent variable, pro-environmental action, is significantly positively correlated with enhancing dynamics ($r(112) = .49, p < .001$), norming dynamics ($r(112) = .58, p < .001$), NEP score ($r(112) = .32, p < .001$), resident environmental awareness ($r(112) = .31, p < .001$). The DV is significantly negatively correlated with constraining dynamics ($r(112) = -.165, p < .05$), number of residents in the home ($r(112) = -.23, p < .01$), and presence of children in the home ($r(112) = -.16, p < .05$).

Table 4-5 Multiple Linear Regression, DV: Pro-environmental Action Frequency

Table 4-5 describes the model statistically significantly predicted pro-environmental action frequency ($F(10, 103) = 8.814, p=.000$), explaining 46.1% of the variance in the dependent variable, a large effect. The individual predictors were examined further and indicated that enhancing dynamics ($t=3.142, p=.002$) norming dynamics ($t=3.684, p=.000$) and education ($t=2.899, p=.005$) were significant predictors in the model. Though not statistically significant in the model, constraining household dynamics have a negative regression coefficient, which is suggestive of the hypothesized negative relationship between constraining dynamics and pro-environmental action.
As NEP score and household environmental awareness score were not statistically significant predictors of pro-environmental action in the MLR, we suspected that these measures may have direct impacts on household dynamics, indirectly impacting pro-environmental action frequency. To test this, we ran a series of linear regression models measuring the effect of NEP and household environmental awareness on each of the three household dynamics (Table 4-6).

Table 4-6 Linear Regression of Household Dynamics on NEP Score & Household Environmental Awareness

<table>
<thead>
<tr>
<th>DV: Enhancing</th>
<th>B</th>
<th>SE_B</th>
<th>β</th>
<th>t</th>
<th>R²</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEP</td>
<td>.311</td>
<td>.147</td>
<td>.207</td>
<td>2.110*</td>
<td>.131</td>
<td>2.281</td>
<td>.033</td>
</tr>
<tr>
<td>Household Env. Awareness</td>
<td>.080</td>
<td>.124</td>
<td>.064</td>
<td>.650</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DV: Norming</th>
<th>B</th>
<th>SE_B</th>
<th>β</th>
<th>t</th>
<th>R²</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEP</td>
<td>.683</td>
<td>.161</td>
<td>.358</td>
<td>4.248***</td>
<td>.355</td>
<td>8.328</td>
<td>.000</td>
</tr>
<tr>
<td>Household Env. Awareness</td>
<td>.488</td>
<td>.135</td>
<td>.308</td>
<td>3.620***</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DV: Constraining</th>
<th>B</th>
<th>SE_B</th>
<th>β</th>
<th>t</th>
<th>R²</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEP</td>
<td>-.521</td>
<td>.243</td>
<td>-.205</td>
<td>-2.144*</td>
<td>.172</td>
<td>3.150</td>
<td>.005</td>
</tr>
<tr>
<td>Household Env. Awareness</td>
<td>-.159</td>
<td>.204</td>
<td>-.075</td>
<td>-.780</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

B=unstandardized regression coefficient, SE_B=standard error of the coefficient, β=standardized coefficient
* sig < .05 ** sig < .01 *** sig < .001
Note: Each models included controls for education, gender, household income, household size, and children in the home (dummy). None were statistically significant where p < .05

Table 4-6 describes results of three linear regression models that test the effects of NEP and household environmental awareness on enhancing, norming, and constraining household dynamics. In each model, NEP is a statistically significant predictor of household dynamics. Household environmental awareness explains variation in norming household dynamics but is not a statistically significant predictor of enhancing or constraining dynamics. Both NEP and household environmental awareness appear to have stronger impacts on norming than enhancing and constraining dynamics.
4.5 Discussion

First, this analysis provides one way to measure household social dynamics (as perceived by one main respondent) quantitatively, a novel empirical step for household consumption research. By measuring these dynamics quantitatively, we begin to develop a broader picture of the ways these interactions impact consumption practices. Our findings illustrate that household dynamics hang together as distinct constructs that follow findings from qualitative interviews in the same population (Lytle et al., 2021). Including these measures in a multiple linear regression analysis shows that enhancing and norming dynamics act to encourage pro-environmental actions in our sample. Further, these dynamics may be in part driven by individual pro-environmental attitudes.

4.5.1 Impacts of Positive vs. Negative Social Dynamics

It is interesting to note that the positively framed household dynamics, enhancing and norming, were positively and statistically significantly associated with pro-environmental action in the model while constraining was not. Although not reaching the threshold for statistical significance where \( p < .05 \), constraining was negatively associated with the dependent variable, following the hypothesized relationship. It is not clear if these results will remain consistent when reproduced in a larger, more representative sample.

Some research has considered how conflict arises in the household in response to resource consumption or conservation. One recent study finds evidence that smart thermal technology (heating and cooling) drives a variety of different types of household conflicts, including those between parents and children, hosts and guests, roommates, couples, and landlords and tenants (Sovacool et al., 2020). Other studies have similarly focused on conflict and constraining aspects of interpersonal relationships, with fewer exploring the ways household members can and do encourage each other to make pro-environmental decisions about consumption (Aguirre-Bielschowsky et al., 2018; Ástmarsson et al., 2013; Dillahunt et al., 2010;
L. Schmidt et al., 2014). Respondent gender may also play a role in our findings, as one study found (counter to our results) that women more frequently reported conflicts over thermostat adjustment, while men more often referred to compromises and agreements (Sintov et al., 2019). To further tease apart these complex relationships, household resource consumption might be explored through the social-psychological lens of family and household decision-making and consumer research. There is room for research to explore both positive and negative social dynamics across specific types of relationships, such as those between family members, landlords and tenants, and communities build specific sets of practices that drive consumption (Hargreaves & Middlemiss, 2020).

4.5.2 Effects of Sociodemographic Variables

It is important to note that the limited variability in some sociodemographic characteristics was intentional in this specific sample, which was originally recruited to take part in a 12-month messaging intervention study. In choosing the study area, the team considered likely homogeneity in characteristics like household income and education based on available Census data that suggests these variables are higher in Lake County, IL than for the average American (U.S Census Bureau, 2019). By choosing this specific study area, these variables are already controlled for to some degree, so their lack of statistical significance in our model is not unexpected or reflective of results in larger, nationally representative samples. In our model, however, education was positively and statistically significantly associated with frequency of pro-environmental action, which follows established trends (Meyer, 2015).

4.5.3 Limitations

As with most exploratory research, this project is not without limitations. The household dynamics scales were newly crafted based on qualitative data analysis in this particular population (Lake County, IL) and are not nationally representative, nor representative of the geographic area (Lytle et al., 2021). We believe, however, that they provide novel insight into the
relationships that shape household consumption and should be explored both qualitatively and quantitatively in more diverse, representative, and larger samples to contribute to future research efforts.

With regards to study design, we were only able to collect data from a single respondent serving as a representative for the household. Thus, the representative household member in some cases answered questions on behalf of other members (household environmental awareness). The accuracy of our data could be improved if each member of the household were surveyed (similarly to the methodology employed by Netuveli & Watts, 2020). One alternative explanation for the exploratory factor analysis results might be that respondents responded similarly to questions that shared the same wording and sentence structure. To attempt to avoid this, the household dynamics questions appeared in three separate sections of the survey grouped as questions about food, energy, and water consumption (rather than organized by theorized household dynamics). Finally, this research focuses on three of the five household social dynamics identified by Lytle et al. (2021). We do not investigate preferring and allocating, partially because these dynamics typically involve specific contexts that do not come across clearly in broad survey questions. Future research might attempt to capture these dynamics quantitatively, hopefully pilot tested with focus groups to ensure the scales are clearly understood by participants.

During the study and when our third survey wave was deployed, stay-at-home orders took effect as a result of the COVID-19 pandemic in our study area. This changed both our study and household consumption broadly in drastic ways. Presumably as a result of the pandemic, the study lost participants by the June-July 2020 survey wave, resulting in a smaller sample size. More significantly, stay-at-home orders changed daily household life in significant ways, including working and attending school from home. These changes shifted some consumption that would have likely taken place outside of the home before the stay-at-home orders (e.g.
running the air conditioning all day while previously household members would be working from an office or school). Additionally, household social dynamics may have shifted in response to spending more time in the same space. This research, however, acknowledges that household social dynamics are fluid and likely change over time and in specific situations.

4.5.4 Implications and Future Research

Our findings suggest the importance of interdisciplinary collaboration in the field of household resource consumption, blending disciplinary traditions to answer questions about the diverse set of factors that drive decision-making. Attitudinal variables like NEP typically come out of social psychology (Dunlap et al., 2000), while social practice theories are commonly utilized in anthropology and sociology (Rouse, 2007). A central debate in climate mitigation research considers focus on individual behaviors vs. political, structural, and cultural constraints, arguing either that focus on the former obscures the latter or that too much focus on the latter disengages individual sense of responsibility (Lorenzen, 2014; Maniates, 2001; Shove, 2010). Here, we view a social practice based approach as able to center the household without placing the full burden of responsibility on the individual, as acknowledging complex systems of provision highlights social structure (Spaargaren, 2011). Crossing disciplinary boundaries encourages novel research design and findings, as we gather quantitative data for questions previously explored through qualitative methodologies.

Carrying the FEW nexus thread through, looking at the intersections between these resource systems gives researchers a more holistic picture of household consumption practices. As the larger FEWCON project that supports this research collects objective food, energy, and water consumption data through utility providers and shopping receipts, future research can test the impacts of household dynamics on more concrete dependent variables.

As the purpose of this research is to explore new survey scales to measure household social dynamics, future research will refine these scales and aim to test them in nationally
representative samples. Based on our findings in this study, scales should be refined to achieve simple structure in a factor solution if they do not when tested in a larger sample. We suspect that enhancing and norming dynamics might need revision to reflect more distinct constructs. Additionally, scales might be tested that capture preferring and allocating dynamics.

Further, this study used multiple linear regression to test effects of social dynamics on frequency of pro-environmental actions, finding that the effects of NEP score and household environmental awareness were washed out. Thus, we conducted a second series of regression models to test if these variables predicted variance in household social dynamics, finding that to be the case. Future research in larger samples should use more sophisticated statistical techniques to model casual pathways between these variables, potentially structural equation modeling. Other social psychological variables also might better predict household social dynamics around resource consumption. Further, these models might use more sophisticated tests to uncover mediating relationships between NEP, household environmental awareness, and pro-environmental action.

Finally, the larger FEWCON study will develop and test interventions aimed at reducing household consumption. These findings might aid in the development of future intervention research, as we learn more about the composition of households and the ways in which this facilitates or constrains pro-environmental decision-making. Intervention messages might be tailored towards specific household dynamics, encouraging communication among household members. Robust interventions will target household decision-makers while reaching the entire household. Some research has shown that children influence environmental decision-making (Boudet et al., 2016), and this should be explored with attention to household social dynamics and power dynamics. Future research might also consider household composition and milestone events that shape household dynamics and behavior. Family births and deaths, marriages and
divorces, and retirements, for example, all have potential to impact patterns around household resource consumption.

4.6 Conclusion

To explore influences on resource consumption that have potential to drive climate mitigation efforts, this study developed and tested a novel set of scales to measure household social dynamics. We found that positive dynamics, including enhancing and norming, predict variance in self-reported pro-environmental actions in the household. Further, environmental attitudes predict variance in positive and negative household social dynamics. This research extends the scope of household consumption research at the FEW nexus, offering opportunities for researchers to think about consumption in ways that consider the intersection between the individual and the household. It is our hope that this work encourages future intervention research that crosses disciplinary boundaries to facilitate climate mitigation efforts.
5 Summary and Conclusion

5.1 Summary & Contribution

In sum, this dissertation contributes to social and behavioral science perspectives that push forward necessary energy transitions in the face of climate change. I explore three dimensions of resource consumption behavior: external drivers of behavior change captured by existing intervention studies, individual-level characteristics that motivate pro-environmental behavior, and inter-personal dynamics that shape household consumption behavior. In three analytical chapters, I achieve three central objectives: 1) accumulate findings on household behavior at the FEW nexus across disciplines, 2) identify social behavioral drivers of green technology adoption, and 3) expand the focus of consumption research beyond the individual to consider the ways dynamic household relationships impact resource use. These three analyses reveal the complex, dynamic, and structurally embedded nature of household resource consumption. These characteristics complicate efforts to bolster sustainable consumption but can inform robust research and policy interventions that take a holistic focus.

The second chapter identifies gaps in the literature that, if addressed, will bolster efforts to develop impactful interventions to reduce consumption. Systematically reviewing published FEW intervention literature, I develop a typology that characterizes household interventions as active, passive, or structural, and household-specific or non-specific, illustrating six distinct categories: information, tailored information, action, gamification, policy/price change, and material/technological provision. Further, the review uncovers four lessons for future intervention research: household non-specific information and tailored information appear to be more effective when used together, the impacts of feedback are strengthened when contact with participants is persistent, price-based interventions are often ineffective, despite expectations rooted in theory, and material/technology provision has proven very effective in a limited number
of studies. Few studies address direct and indirect emissions through the FEW nexus framework and incorporating these considerations will likely improve intervention outcomes and advance knowledge in the field of household consumption.

Motivated by the importance of green technology adoption for national emissions reduction goals, the third chapter explores social and psychological determinants of green purchasing behavior. This chapter analyzes the impact of values, environmental concern, green lifestyle orientation, and socio-demographic variables on self-reported green technology purchasing intentions. This analysis establishes a causal chain from values to environmental concern to green lifestyle orientation, or the perception of importance of environmental action to one’s overall lifestyle, that predicts green purchase intentions for lightbulbs, appliances, and vehicles. Income also has a strong effect on purchase intentions in both US and Canadian samples, illustrating the pervasiveness of consumer lock-in that has potential to significantly slow green technology adoption. These findings stress the importance of exploring pro-environmental behavior not as a series of isolated actions, but as intertwined with broader lifestyle perceptions and contexts.

To further contribute to gaps in the literature around household consumption interventions, drawing from findings in Chapter 2, Chapter 4 develops and tests scales that measure household social dynamics. In response to a “unit of analysis” problem, where intervention research often targets individuals despite much resource consumption happening in the context of multi-person households, Chapter 4 tests the effects of various household social dynamics on a variety of pro-environmental actions. Multiple linear regression models illustrate that positive household dynamics, including enhancing and norming behaviors, predict variance in pro-environmental actions in the household. Further, individual and household levels of environmental awareness predict variance in both positive and negative household social dynamics. These findings support qualitative research efforts that stress the importance of
household social dynamics to resource consumption, providing avenues for future quantitative research to take a practice-based approach.

Taken together, these chapters examine three dimensions of resource consumption behavior: attempts to externally change behavior through research and policy interventions, individual-level drivers of decision-making, and inter-personal social dynamics that shape consumption in the household. Four findings from Chapter 2 reveal both best practices and shortcomings of existing FEW intervention research, which speak to insights from Chapters 3 and 4. The first finding stresses the importance of information tailored towards the unique characteristics of individual households in conjunction with non-specific information, typically about environmental impacts. The second finding suggests that this information should be delivered persistently, rather than as a one-off message. Chapter 3 illustrates how interventions might leverage self-perception of “green lifestyle” to deliver tailored information, suggesting that the way individuals understand and characterize their lifestyle matters for decisions about resource consumption, specifically green technology purchases. Chapter 4 demonstrates that existing social dynamics within households also shape resource consumption practices, and intervention messages can be tailored to households with attention to their composition, working to leverage existing social norms and build new ones to foster sustainable consumption.

The third takeaway from Chapter 2 explains that price-based interventions, both informational and with financial incentives, are often ineffective. Chapter 3 finds that income is an important predictor of green technology purchase behaviors, specifically when the purchases require a steep up-front cost. Given this finding, it is surprising Chapter 2 found price-based interventions to be generally ineffective. More research is needed to untangle this relationship, but it is possible that small financial incentives are simply not sufficient to alleviate financial hardship from initial upfront costs, specifically if decision-making considers yearly income as opposed to a one-time payment. Perhaps price-based interventions that change long-term
economy policies would see different results. With this in mind, the fourth finding from Chapter 2 finds material and technology provision to have effective results in intervention studies, though it is infrequently utilized. Taken literally, this finding says that if you provide households with efficient or sustainable materials and technology, like smart meters, compost pickup, or water-saving appliances, individuals and households will adapt to the new technology and use it over the long-term. Though these interventions are the costliest to implement, they help to overcome the income barrier to green technology purchases illustrated in Chapter 3. It is possible that providing new materials and technologies can shift household practices, helping to establish green lifestyle orientation at the individual level as people begin to see themselves as “green” consumers (Chapter 3), and can foster positive conservation dynamics, like social norms, in the household if embraced by some household members (Chapter 4). It is likely that many resource-intensive technologies will eventually be phased out by industry best-practices and regulatory changes (for example, vehicle emissions regulations). Thus, these findings about individual and household consumption drivers might help ease transitions.

5.2 Implications

5.2.1 Critiques of the Household Consumption Focus

Household consumption, though contributing a significant amount of GHG emissions, has been critiqued as too narrow of a focus to make real strides in climate change mitigation, and individual mitigation research has been critiqued for concealing the impacts of broader social and institutional forces. Shove's (2010) critique of the attitude-behavior-choice approach considers this “a political and not just a theoretical position in that it obscures the extent to which governments sustain unsustainable economic institutions and ways of life” (p. 1274). Other scholars also raise questions about the effectiveness and equity of placing the burden of mitigation on the individual or household consumer. Outlining the limits of household change, Lorenzen (2018) argues that consumers are “locked-in” at the technological, organizational,
industrial, institutional, and societal levels, making strategies like information provision and education that assume consumer sovereignty ineffective. Shove (2010) highlights food, water, and energy as systems of provision, through which “certain forms of demand are unavoidably inscribed” (p. 1278).

These ideas are in line with those that problematize the heavy focus on values and attitudes in consumption research when socio-demographic variables, including income, household size, and age are often more predictive of pro-environmental behavior (Abrahamse & Steg, 2011 as cited in Lorenzen, 2014). This follows arguments put forth by some sociologists and anthropologists that consider barriers to green consumption that deal with the larger structural forces of political leadership, market forces, and power structures. Schor (2007) points to the growing political power of transnational corporations and their impact on individual consumption, circling back to historical models (Veblen’s (1899/1994) model of status consumption as we see growing wealth inequality, Adorno & Horkheimer’s (1944/1972) focus on both production and consumption, and Gailbraith’s (1958) incorporation of materialism into the theories of consumption). Isenhour (2010) uses current trends in Swedish consumption to highlight the importance of large-scale structural trends, historical patterns, and political leadership: “It is imperative that we recognize that ‘consumer culture’ is more complex than aggregated individual choice. Our cultures are products of history and context. They rise out of, reflect, and simultaneously structure our material realities, productive systems, methods of exchange, social organizations, and political structures” (p. 466). These arguments de-center the individual as the unit of analysis in consumption research, placing more focus on societal structure, change, and context as determinants of consumption behavior.

Downey (2015) highlights structural constraints (like the inability for most US consumers to stop driving cars) while also addressing economic arguments that consumers should vote with their dollar. Downey argues that incorporating the social and environmental “costs” of a product
into their market price will not work as it sounds in theory – instead, it glosses over the initial causes of the social and environmental problems it seeks to address, while disproportionately burdening low-income families. This finding evokes questions of equity of household-level intervention, as political and economic forces often shift the burden of change onto already vulnerable populations.

Scholars like Maniates (2001) argue that a focus on individual consumption eclipses the role of the political: “When responsibility for environmental problems is individualized, there is little room to ponder institutions, the nature and exercise of political power, or ways of collectively changing the distribution of power and influence in society—to, in other words, ‘think institutionally.’” (p. 33). Willis & Schor (2012), however, found that conscious consumption was significantly and positively related to political action, linking the two activities and pushing forward the concept of “environmental lifestyles” that rely on individual identity and are constituted by a variety of environmentally friendly practices. Lorenzen (2018) suggests shifting the narrative that “every little bit counts” from everyday consumption to supporting environmentally friendly candidates and policies. Additionally, even in aggregate, the accumulation of household actions yields minimal tangible impacts in terms of quantifiable GHG emissions.

Researchers studying household resource consumption must consider critiques that focus on social, political, and other structural issues in addition to theories that center individual decision-making determinants and consumer agency in order to contribute to the discourse on practical and equitable policy solutions. In their response to Shove’s (2010) critique of the ABC model which calls for a paradigm overhaul, Whitmarsh, O’Neill, & Lorenzoni (2011) argue against a “move too far in the other direction - towards a situation where individuals are excluded from societal decision making and participation in enacting change” (p. 259). While Shove’s critique does call for a large-scale revisioning of consumption research, moving past the
individual-level variables of attitude, behavior, and choice does not require limiting individual participation in transitions towards sustainability. It is possible that consumption research does not have to exclusively target either the individual or institution – many thoughtfully crafted research efforts address intersections between the two. Acknowledging this duality, and the ongoing struggle to balance essential systems-level change with individual behavior, is a central goal of this dissertation. Although the research objectives of each analytical chapter center individual and household consumption, conclusions point to solutions that draw on systems-level change. For example, findings from Chapter 3 illustrate both the importance of green lifestyle orientation but also household income to green technology purchasing decisions. In this context, increasing wealth inequality will hold back individual transitions to sustainable ways of living that require high upfront costs. Chapter 4 demonstrates how social norms in the household shape consumption behavior. These norms, however, are not only formed in the household, but shift with cultural and societal expectations and understandings of appropriate consumption. Thus, individuals’ consumptive practices are shaped by broader social forces, but individuals also shift social norms through their visible choices around resource consumption.

5.2.2 Policy Implications

Specific policy implications for each analysis are laid out in Chapters 2, 3, and 4, but the overarching policy implication of this dissertation is that policymakers can leverage behavioral science tools to help meet emissions goals in addition to other robust climate policy measures that push forward a clean energy transition. Yoeli et al., (2017) outline 13 lessons from recent research in the behavioral science field that meet four objectives: capturing people’s attention, leveraging their desire to contribute to social good, making complicated information about energy and the environment more accessible, and facilitating accurate risk, cost, and benefit assessments. These tools include: “1) provide timely feedback and reminders, 2) reach out during transitions, 3) use intuitive metrics to express information, 4) choose the most meaningful time frame, 5) use
multiple modes of communication, 6) make information easy to access, 7) reframe consequences in terms people care about, 8) reduce up-front costs by spreading them over time, 9) present fewer options, choosing the most relevant ones, 10) increase observability of behavior and provide recognition, 11) communicate a norm, 12) obtain a commitment, 13) set the proper default” (p. 71). The authors caution that these tools are not meant to be used in isolation, but as a complement to other regulatory and market-based policies.

These 13 tools follow findings from Chapter 2, specifically around timely and persistent feedback. Tool 8, reducing up-front costs, is particularly relevant to findings from Chapter 3 that show the effect of income on purchasing behaviors. Long-term, no, or low interest loans for energy efficiency upgrades is one example of a policy measure to help lower income households purchase efficient technology and realize savings over time. Considering the finding in Chapter 3 that ties green lifestyle orientation to purchase intention, increasing observability of behaviors and providing recognition (tool 10) is also relevant. Increasing observability and tool 11, communicating norms, tie directly to Chapter 4 findings, as the positive social dynamics of enhancing and norming positively impact frequency of household pro-environmental actions.

These tools capture many of the findings in this dissertation, but I suggest two additional takeaways: 1) expand from focus on the individual to consider dynamics in the household (or school, workplace, community), and 2) explicitly link individual actions to broader social change. The first point directly follows findings in Chapter 4 and urges behavioral scientists and policymakers to leverage existing social dynamics that encourage conservation behavior. The second point is intended to be similar to communicating a norm (tool 11) but will engage those with a broader green lifestyle orientation (Chapter 3) in a way that clearly illuminates the links between individual behavior and systems change. While many see the limits to individual behavior change, fewer are aware of the institutional change that their individual behavior can reinforce.
5.3 Future Work

A key goal of this dissertation is to guide the developing field of resource consumption interventions, thus opening doors for future research to implement my findings. This work has sparked ideas about creative variables to include in future quantitative research. For example, based on Chapter 4, how might we quantitatively capture household transitions and milestone events that shape consumption? Additional longitudinal surveys might capture how households change in composition over time, and how these changes impact resource consumption behavior. Further, this research made use of behavioral intentions as dependent variables. It is important to consider how these intentions compare to objective measures of resource consumption, and if these are consistent with outcomes. This work largely used linear statistical models based on theorized relationships. Some variables, such as age, however, may in fact be non-monotonic and other non-linear models may more fully capture existing relationships.

At the time I am writing this dissertation, the larger FEWCON study is bringing interventions into the field as the COVID-19 pandemic seems to be easing in the United States and household behavior is returning to “normal”, or more similar to pre-pandemic behavior. Findings from Chapter 2 helped to guide the development of FEWCON interventions, specifically as the study provides participants with persistent feedback using an interactive online platform, HomeTracker. Future research should continue to leverage these findings to shape interventions with attention to sociodemographic differences across samples.

Though the FEWCON study was not originally planned around the COVID-19 pandemic, it quickly adapted to ask research questions related to changes in consumption in response to stay-at-home orders and risk perceptions. Now in the field, the intervention study will have the unique opportunity to take advantage of the second behavioral science tool discussed above, “reach out during transitions.” As household life changes once again in response to increased vaccination rates and reopened schools, stores, and workplaces, we will have the opportunity to
test if individuals and households sustain positive consumption changes adopted during the quarantine period under new circumstances. Recent writing illuminates the interconnections between COVID-19 and the climate crisis (Bashir et al., 2020; Botzen et al., 2021; S. A. Schwartz, 2020). With regards to consumption research and individual and household-level mitigation efforts, scholars must take particular care to communicate climate impacts realistically in the wake of COVID-19 economic impacts. Results from one study show that framing climate change as a “back seat” issue to COVID-19 reduces both concern about climate change and support for mitigation efforts (Ecker et al., 2020). These two very different crises share an important characteristic – they each require both individual-level behavior change and broader systems-level governance to avert further devastating impacts.

Further, both the COVID-19 pandemic and the climate crisis highlight issues of resource inequity and social injustice. Often, marginalized populations are exceptionally vulnerable to both crises at once. For example, one study found air quality to be significantly correlated with the number of COVID-19 cases in New York (Bashir et al., 2020). Here, existing environmental racism that makes marginalized groups more likely to live in places with polluted air makes these same groups suffer adverse health outcomes. Following this thread, future research that focuses on individual and household-level consumption for climate mitigation must acknowledge these issues of injustice that make minority, low-income, and other marginalized groups more vulnerable to climate impacts and have less capacity for behavior change, specifically when it requires up-front costs. As illustrated in Chapter 3, income is a significant determinant of decision to adopt green technology, illustrating the pervasive nature of consumer lock-in that prevents pro-environmental behavior change. To mitigate the impacts of consumer lock-in, we must advocate for smart economic and social policy that makes the energy transition realistic for all members of the public, despite socio-economic status.
Finally, future work targeting individual and household-level emissions must continue to integrate this research into broader conversations about the governance shifts required to reach a clean energy transition. While many continue to debate the relationship between individual and structural change, this dissertation articulates that the severity of the climate crisis necessitates a “both/and” approach as opposed to “either/or”.

Bibliography


van der Werff, E., & Steg, L. (2016). The psychology of participation and interest in smart energy
systems: Comparing the value-belief-norm theory and the value-identity-personal norm

relationship between biospheric values, environmental self-identity and environmental

Application of Schwartz’s Norm-Activation Model to Yard Burning. *Journal of Applied

Van Meerbeek, K., & Svenning, J.-C. (2018). Causing confusion in the debate about the
transition toward a more plant-based diet. *Proceedings of the National Academy of
Sciences, 115*(8), E1701–E1702. https://doi.org/10.1073/pnas.1720738115

become greener: Factors influence consumers’ green purchasing behavior. *Management
Science Letters, 3*(9), 2489–2500.

energy-water-food nexus: Strategic analysis of technologies for transforming the urban


Self-Affirmation Be the Solution to California’s Drought? *Health Communication, 32*(9),
1161–1170. https://doi.org/10.1080/10410236.2016.1217451

White, R. R., & Hall, M. B. (2018). Reply to Van Meerbeek and Svenning, Emery, and
Springmann et al.: Clarifying assumptions and objectives in evaluating effects of food
system shifts on human diets. *Proceedings of the National Academy of Sciences, 115*(8),
E1706–E1708. https://doi.org/10.1073/pnas.1720895115

self-identity in determining consistency across diverse pro-environmental behaviours.

within, amongst, and beyond Disciplines. *Environment and Planning A: Economy and
Space, 43*(2), 258–261. https://doi.org/10.1068/a43359


Wilhite, H., Shove, E., Lutzenhiser, L., & Kempton, W. (2003). The Legacy of Twenty Years of
Energy Demand Management: We know more about Individual Behaviour but next to
Nothing about Demand. In E. Jochem, J. Sathaye, & D. Bouille (Eds.), *Society,*


Appendices

Appendix A Studies Reviewed for FEW Behavioral Typology

Table A1 alphabetically lists the studies included in the typology by the first author. F/E/W refers to food, energy, and water studies. The fourth column lists if interventions were effective or not, without providing information about magnitude. If there was a positive treatment effect, the study was marked ‘yes’. If there was no treatment effect or a negative effect, studies were marked ‘no’. The fifth column lists notes that provide some context and help understand the characteristics of the results.

Table A1 Studies Reviewed for Generation of FEW Behavior Intervention Typology

<table>
<thead>
<tr>
<th>Author/Year</th>
<th>F/E/W</th>
<th>Typology Category</th>
<th>Intervention Effective?</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abrahamse et al. 2007</td>
<td>E (FW indirect)</td>
<td>Info, T Info, Action</td>
<td>yes (all treatment conditions)</td>
<td></td>
</tr>
<tr>
<td>Allcott &amp; Rodgers 2014</td>
<td>E</td>
<td>Info, T Info</td>
<td>yes</td>
<td>Effects initially steep but level off over time</td>
</tr>
<tr>
<td>Allcott 2011</td>
<td>E</td>
<td>Info, T Info</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Bernstad 2014</td>
<td>F</td>
<td>Info, Material</td>
<td>no (info), yes</td>
<td></td>
</tr>
<tr>
<td>Bernstad et al. 2013</td>
<td>F</td>
<td>Info</td>
<td>no</td>
<td></td>
</tr>
<tr>
<td>Boudet et al. 2016</td>
<td>E/F</td>
<td>Info, T Info, Action</td>
<td>yes (for energy, no for food component)</td>
<td>More effective for children than parents</td>
</tr>
<tr>
<td>Davies et al. 2014</td>
<td>W</td>
<td>T Info</td>
<td>yes</td>
<td>Effects maintained over time</td>
</tr>
<tr>
<td>Fan et al. 2015</td>
<td>E</td>
<td>T Info</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Fielding et al. 2013</td>
<td>W</td>
<td>Info, T Info</td>
<td>yes</td>
<td>In all treatment groups, water use reduction, leveled-off, returning to baseline levels after approx. 12 months. Information provision alone was just as effective as other conditions</td>
</tr>
<tr>
<td>Author(s)</td>
<td>Year</td>
<td>Type</td>
<td>Intervention</td>
<td>Tailored?</td>
</tr>
<tr>
<td>-----------</td>
<td>------</td>
<td>------</td>
<td>--------------</td>
<td>----------</td>
</tr>
<tr>
<td>Gieslar et al. 2017</td>
<td>F</td>
<td>Info, T Info, Material</td>
<td>yes</td>
<td>“Findings support that residents will begin to separate food waste if provided supportive infrastructure”</td>
</tr>
<tr>
<td>Glenn et al. 2015</td>
<td>W</td>
<td>T Info</td>
<td>yes</td>
<td>“Our finding suggest that water check programs can be effective in promoting water conservation when the information provided is tailored to meet participants' knowledge and skill levels”</td>
</tr>
<tr>
<td>Goodhew et al. 2015</td>
<td>E</td>
<td>Info, T Info</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Gronhoj &amp; Thogerson 2011</td>
<td>E</td>
<td>T Info, Action</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Harries et al. 2013</td>
<td>E</td>
<td>Info, T Info</td>
<td>no</td>
<td></td>
</tr>
<tr>
<td>Iwafune et al. 2017</td>
<td>E</td>
<td>T Info</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Jessoe &amp; Rapson 2014</td>
<td>E</td>
<td>Info, T Info, Price</td>
<td>yes</td>
<td>Price info more meaningful when non-price information is provided</td>
</tr>
<tr>
<td>Kua &amp; Wong 2012</td>
<td>E</td>
<td>Info, T Info, Action</td>
<td>yes</td>
<td>Face-to-face interaction had the highest correlation with action scores</td>
</tr>
<tr>
<td>Kurz et al. 2005</td>
<td>E/W</td>
<td>Info, T Info</td>
<td>yes (appliance labels for water); no (T info/energy)</td>
<td>Appliance labels led to 23% reduction in water consumption</td>
</tr>
<tr>
<td>Liu et al. 2016</td>
<td>W</td>
<td>Info, T Info</td>
<td>no</td>
<td>While 38% of households reported changing their behavior, there were no measureable effects</td>
</tr>
<tr>
<td>McCoy &amp; Lyons 2017</td>
<td>E</td>
<td>Info, T Info, Price</td>
<td>yes</td>
<td>Relative to control, treatment groups reduced energy use by 2.5% but were less likely to adopt energy saving measures during the trial</td>
</tr>
<tr>
<td>Mizobuchi &amp; Takeuchi 2013</td>
<td>E</td>
<td>Info, Price</td>
<td>yes</td>
<td>Households with high NEP score more likely to respond to the reward program and save electricity than those who do not</td>
</tr>
<tr>
<td>Nilsson et al. 2014</td>
<td>E</td>
<td>Info, T Info</td>
<td>no</td>
<td></td>
</tr>
<tr>
<td>Nomura et al. 2011</td>
<td>F</td>
<td>Info, T Info</td>
<td>yes</td>
<td>The first card had no significant effect and it was the cumulative effect of two feedback cards that had a significant impact of household participation in recycling food waste</td>
</tr>
<tr>
<td>Pellerano et al. 2017</td>
<td>E</td>
<td>Info, T Info, Price</td>
<td>yes (info, T info), no (price)</td>
<td>Addition of financial incentives did not significantly enhance conservation; Adding economic incentives to normative messages not only does not strengthen the effect of the latter but may reduce it</td>
</tr>
<tr>
<td>Ro et al. 2017</td>
<td>E</td>
<td>Game, Price</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Authors</td>
<td>Region</td>
<td>Type</td>
<td>Info</td>
<td>T Info</td>
</tr>
<tr>
<td>-------------------------</td>
<td>--------</td>
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<td>--------</td>
</tr>
<tr>
<td>Rohm et al. 2017</td>
<td>F</td>
<td>Info</td>
<td>no</td>
<td></td>
</tr>
<tr>
<td>Schmidt 2016</td>
<td>F</td>
<td>T Info</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Schultz et al. 2007</td>
<td>E</td>
<td>T Info</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Schultz et al. 2015</td>
<td>E</td>
<td>Info, T Info, Price</td>
<td>yes (normative message), no (simple feedback, info, price)</td>
<td></td>
</tr>
<tr>
<td>Schultz et al. 2016</td>
<td>W</td>
<td>Info, T Info</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Seyranian et al. 2015</td>
<td>W</td>
<td>Info, T Info</td>
<td>yes</td>
<td></td>
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<tr>
<td>Shearer et al. 2017</td>
<td>F</td>
<td>Info</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Staats et al. 2004</td>
<td>FEW</td>
<td>Info, T Info, Action</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Stewart et al. 2013</td>
<td>W</td>
<td>T Info</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Sudarshan 2017</td>
<td>E</td>
<td>Info, T Info, Game, Price</td>
<td>yes (nudge); no (price)</td>
<td></td>
</tr>
<tr>
<td>Study</td>
<td>Region</td>
<td>Communication</td>
<td>Participation</td>
<td>Findings</td>
</tr>
<tr>
<td>----------------------------</td>
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<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Thondhlane et al. 2016</td>
<td>E</td>
<td>Info, T Info</td>
<td>yes</td>
<td>Households who rec’d a combination of the treatment measures (FT group) recorded greater energy-savings than those who did not</td>
</tr>
<tr>
<td>Tijs et al. 2017</td>
<td>W</td>
<td>Info, Action</td>
<td>yes</td>
<td>Environmental appeal, but not the monetary appeal, effective in reducing showering frequency</td>
</tr>
<tr>
<td>Von dam et al. 2010</td>
<td>E</td>
<td>Info, T Info</td>
<td>no</td>
<td></td>
</tr>
<tr>
<td>Walter et al. 2017</td>
<td>W</td>
<td>Info, Action</td>
<td>yes</td>
<td></td>
</tr>
</tbody>
</table>