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Residential Demand Side Management: Strategies for Increasing Electric Utility Profitability

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This is to certify that the doctoral study by

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Abstract

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Doctoral Study Submitted in Partial Fulfillment

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Abstract

Some electric utility leaders lack effective strategies to reduce demand billing charges. Utility leaders are concerned with lowering demand billing charges, as failure to do so can negatively affect profitability. Guided by the operations management theory, the purpose of this qualitative multiple case study was to explore strategies that distribution electric utility managers use to reduce demand billing chargers from their power providers. The participants were three electric utility leaders working in the Midwest United States who used successful residential demand-side management (DSM) strategies. Data were collected using semistructured interviews and utility documents to address the research question. The collected data were analyzed using Yin's five-step data analysis, which included compiling, disassembling, reassembling, interpreting data, and concluding the findings. Three key themes emerged: residential demand billing is used to promote peak-shaving, education is used to make demand billing more acceptable to consumers, and incentive structures are tailored to ensure utility company costs are reduced or recouped. A key recommendation is for leaders of distribution electric utility companies to reduce demand billing charges from their power providers while making demand billing more acceptable to consumers and ensuring that utility company costs are reduced or recouped. The implications for positive social change include the potential to implement new strategies for improving DSM practices for benefiting residential applications. With the improvement of DSM, consumers' total electric consumption can be decreased, which can increase disposable income for consumers.

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Dedication

To my family for their support and encouragement. Thank you to my husband, Tyler, and my daughters Addie and Lainie. You are the inspiration behind everything I do and you support me and love me through everything I set my mind to.

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Section 1: Foundation of the Study

Projections indicate a substantial climb in energy use over the next several decades (Chu et al., 2016). In 2012, the global energy consumption totaled 549 Quadrillion British thermal units, or Quad BTUs, with the number expected to increase to 813 Quad BTUs by 2040. Similarly, 1975 global carbon dioxide (CO_2) emissions reportedly doubled by 2015, with projections estimating a tripling of CO_2 emissions by the year 2040 (Chu et al., 2016). Conversely, a U.S. Department of Energy (2019) report indicated CO_2 emissions might remain constant or slightly drop by 2040 primarily due to expected changes in the industrial sector and advancements in electric power systems. Even so, strategies to optimize energy usage are needed to mitigate the changing climate and provide future energy needs as well as maintain sustainability for electric utilities (Owusu & Asumadu-Sarkodie, 2016).

Background of the Problem

Demand-side management (DSM) includes programs and strategies to influence the use of electricity and gas by consumers in ways to encourage the desired changes, meaning cost-effective electricity without power interruptions or compromised residential comfort (Potter et al., 2018). The integrated DSM (IDSM) concept takes the desired changes one step further by providing consumer-centric strategies that also benefit the utility provider in controlling base and peak load energy demands (Potter et al. 2018). Lack of DSM strategies in the electric utility industry have negatively impacted profitability and consumer costs while increasing peak load demands by almost 38% (Javaid et al., 2018). Although effective DSM strategies remain a focus of the U.S.

electric utility industry, the United States and other countries worldwide continue to experience challenges in the development and implementation of such programs (Javaid et al., 2018). For example, renewable energy sources are often unpredictable and unreliable due to varying weather conditions, power grid fluctuations caused by differences in traditional and smart home energy usage, and continued use of older appliances with different energy patterns than newer energy-efficient, smart, and controllable appliances. Moreover, consumer participation in DSM strategies is necessary to manage peak load energy demands effectively, yet many consumers have not participated (Javaid et al., 2018).

As the demand for electricity in the residential sector continues to increase, effective DSM programs are needed. But managers in the distribution electric utility industry lack or underutilize DSM strategies that can impact costs involved with generating and transmitting electricity. The lack of DSM strategies adversely affects the industry's potential to reduce demand billing charges, generate revenue, address the need for renewable energy sources, and compromises consumer participation in the generation and transmission of utilities in a cost-effective manner.

Further, energy research contains substantial information on topics related to DSM strategies and the importance of advancing renewable energy sources. Still, the need for further research is evident. For instance, Owusu and Asumadu-Sarkodie (2016) indicated the importance of continued research into developing energy-efficient programs, strategies, and technologies applicable to the residential sector. Study findings and limitations identified by Potter et al. (2018) also suggested further research to explore

DSM strategies that may provide the capacity to combine services for optimal end-user energy consumption. Additionally, Carvallo et al. (2018) encouraged research into the disconnect between load forecasting and integrated resource planning. Corbett et al. (2018) also recommended exploring individual factors, technological solutions, and the role of consumers in DSM strategy implementation in various utility provider jurisdictions. Similarly, Gazafroudi et al. (2019) suggested future study into DSM strategies introduced by power utilities specific to smart devices used in communities, individual residences, and building complexes. The purpose of this qualitative multiple case study was to explore strategies distribution electric utility managers use to reduce demand billing charges from their generation and transmission utilities.

Problem Statement

Lack of DSM practices in the electric utility industry can lead to higher infrastructure costs and increase the peak load (Javaid et al., 2018). Global electrical demand in the residential sector is projected to increase by 1.4% annually until the year 2040 (Corbett et al., 2018). The general business problem was that DSM practices for residential applications are underutilized in the electric utility industry, which can adversely affect the potential for the industry to reduce costs and increase profitability. The specific business problem was that some distribution managers in the electric utility industry lack strategies to reduce demand billing charges from their power providers.

Purpose Statement

The purpose of this qualitative multiple case study was to explore strategies that distribution electric utility managers use to reduce demand billing charges from their power providers. The targeted population was comprised of three general managers of electric distribution utility companies in the Midwestern United States who have demonstrated success in implementing DSM at their utility. The implications for positive social change include the potential to reduce electric rates for distribution utilities from the electrical providers, resulting in cost savings for consumers. Additionally, expanding DSM practices might reduce the overall electric load for the electric generation system, which might lead to reduced fossil fuel generation during peak load periods as well as the lessened potential for an electric rate increase for the consumers. Burning less fossil fuel can be beneficial to the environment and keep electric rates stable, providing savings and increased disposable income for consumers of electricity.

Nature of the Study

A qualitative method was chosen for this study. Qualitative researchers explore questions related to a social phenomenon (Yin, 2017). Since I planned to explore a social phenomenon and gain insight into complex business practices, a qualitative research method was appropriate. In contrast, a quantitative study involves the use of statistical data to test a hypothesis about a variable's characteristics or variables' relationships (Taguchi, 2018). But I did not use statistical hypothesis testing to identify and explore DSM strategies; therefore, a quantitative method was not appropriate for my study. With a mixed-methods approach, researchers combine qualitative and quantitative methods through an analysis of statistical data (Cameron & Molina-Azorin, 2014). Since I did not analyze extensive statistical data, a mixed-methods approach was also not appropriate for my study.

For a study design, I chose a qualitative multiple case study. Researchers use the case study design to review multiple types of data to explore real-life situations (Petty et al., 2012). I used multiple resources to explore a variety of experiences and perspectives related to the phenomenon under study; therefore, a case study design was most appropriate for my study. In contrast, ethnographic researchers seek to understand the beliefs, language, and behaviors of a group by immersing in the group's culture (Yin, 2018). Since the purpose of my study was not to immerse myself in a culture, an ethnographic design was not appropriate. Additionally, phenomenological researcher explores the personal meanings of a population's lived experiences (Saunders et al., 2015). However, because I did not intend to explore the personal meanings of the lived experiences of the participants in a population, a phenomenological design was not appropriate for my study.

Research Question

What strategies do distribution electric utility managers use to reduce demand billing charges from their power providers?

Interview Questions

1. What are your organization's specific strategies used for sustaining residential DSM?
2. What key challenges did the company face in strategizing implementing residential DSM practices?
3. How did your organization address the key challenges to implementing residential DSM practices?

4. How does your organization assess the success of its strategies for implementing residential DSM practices?
5. Based on your organization's experience, how successful are the DSM strategies you are using concerning reducing your peak electrical load?
6. Based upon your organization's experience, what strategies do you have for enhancing your current DSM strategies in the future?
7. What, if anything, would you change in your company's approach to residential DSM utilization?
8. What additional information would you add regarding your organization's residential DSM strategies and practices?

Conceptual Framework

The operations management theory (OMT) was the conceptual framework for this study. Meredith (1998) developed OMT, describing it as a procedure for business managers to use limited resources to meet customers' needs. OMT involves managing how raw materials and energy are converted to create goods (Meredith, 1998). The principles of OMT are divided into four elements: (a) development of true management science, (b) scientific selection of an effective and efficient worker, (c) education and development of workers, and (d) intimate cooperation between management and staff (Voss, 1995). Many managers use problem-solving and operational management analysis methods based on the principles of OMT (Voss, 1995).

OMT can be considered foundational in DSM in the electric industry because both the customer and the utility must work together to make energy-efficient decisions to avoid rate increases (Corbett et al., 2018). OMT applied to my study because the integration of OMT with the power system can enable utility customers to participate actively in DSM. Using OMT, researchers can understand the management of the demand side of an industry, such as the case for electrical energy usage (Voss, 1995). Business managers use the principles associated with OMT to reduce the risk of purchasing or investing more money than necessary on the input and operational side of an industry (Meredith, 1998). OMT can be beneficial to utility business managers in exploring the usefulness of managing operations, helping to understand how reduced production inputs might provide savings. Additionally, research guided by the OMT regarding DSM in the electric utility industry may be beneficial to understand the strategies for reducing the demand side of electricity consumption.

Definition of Terms

Demand billing: Demand billing is an arrangement in which a customer of an electric utility pays on a basis of peak electric usage during a specified period (Potter et al., 2018).

Demand-side management (DSM): DSM includes the planning, implementing, and monitoring activities electric utilities use which are designed to encourage consumers to modify their level of electricity consumption (Javaid et al., 2018).

Distribution electric utility: A distribution electric utility owns and operates a distribution system connecting the transmission grid to the retail electric consumer (Corbett et al., 2018).

Integrated demand-side management (IDSM): IDSM is a strategic approach to designing and delivering a portfolio of demand-side management programs to consumers (Potter et al., 2018).

Operations management theory (OMT): OMT includes the set practices companies use to increase production efficiency. Operations management theory is concerned with controlling the production process and business operation in the most efficient manner possible (Voss, 1995).

Power provider: The power provider of a distribution electric utility is the entity responsible for selling wholesale electricity, either by purchasing it from the open market or through generation and transmission capacities (Javaid et al., 2018).

Assumptions, Limitations, and Delimitations

Assumptions

Assumptions represent a variety of aspects of a study a researcher might tactfully accept (Ellis & Levy, 2009). I made three assumptions in this study. The first assumption was that all participants would respond honestly to the interview questions. The second assumption was that some managers in the distribution electric utility industry lack strategies to reduce demand billing charges from their power providers. Finally, I assumed that patterns and themes that would arise from responses provided by managers contributing to this study would help in understanding the research topic.

Limitations

Limitations are investigative biases or risks innate to researchers' study selections (Guyatt et al., 2011). Three limitations were noted in this study. The first limitation was I that used a small sample size, which may not reflect a larger population. Next, the research findings may not include the perceptions of larger organizations, given I limited the study to only distribution electric utility managers. Lastly, my application of a multiple case study to collect data may have limited the depth of input I can achieve in this study.

Delimitations

In investigative studies, researchers note delimitations as potential input not selected for study consideration (Alina et al., 2012). Three delimitations were denoted in this study. First, I delimited my study to only three utility managers possessing at least 5 years of experience. Next, my utilization of interviews and physical documents as data resources may bar contributions I could gain through other qualitative or quantitative designs. Finally, I analyzed my findings exclusively based on DSM. I did not consider other utility management practices that can be utilized.

Significance of the Study

Contribution to Business Practice

The data collected for this study may contribute to the gap in business practice regarding electric utilities' implementation and usage of DSM on the residential level. Electrical utility organizational managers recognized the value of DSM initiatives to improve operation and input management practices (Sheikhi et al., 2014). Lack of implementation of DSM is costly malpractice for electric suppliers (Sheikhi et al., 2014). Proper management of the demand side of the electric grid might aid in the development of a reliable, sustainable, and affordable supply of electricity in the future.

Reducing demand in the electric utility industry can lead to decreased infrastructure costs, which can reduce expenses for both the utility and end-users (Sheikhi et al., 2014). Innovative DSM on the residential level is one step for potentially achieving savings on the input-side of the utility industry (Nguyen et al., 2015). Therefore, business managers may find this study useful to future DSM analysis and implementation. Utility managership tasked with administering DSM might benefit from identifying strategies and practices to implement DSM procedures for managing demand, thereby reducing overall demand costs to the distribution utility from their power providers.

Implications for Social Change

The results of this study may contribute to positive social change by encouraging electric utility managers to update and implement new strategies for improving DSM practices for benefiting residential applications. With the improvement of DSM, total electric consumption by consumers can be decreased, which can increase disposable income for consumers as well as have positive environmental impacts with decreased fossil fuel generation. Reducing electric peak load might result in positive social change by reducing the near-term consumption of natural resources electricity suppliers need for power production for future generations (Corbett et al., 2018). Moreover, reduced infrastructure costs for electric utilities may reduce utility expenses, which can lead to reduced electric rates for the end-consumer.

Literature Review Related to Key Variables

A discussion of the search strategies used to select the literature included in the review is next, followed by a discussion of the framework chosen to support the study. The review of the relevant professional literature is then presented. The material included in the review is not exhaustive due to the substantial global and domestic published literature involved with providing insights and solutions regarding technological advancements, approaches toward sustainable and renewable energy goals, advancing the smart grid, and establishing effective DSM strategies across multiple sectors. The literature review focuses on DSM strategies in the U.S. residential sector and includes themed topics of interest with significant overlap in topics presented. The five themed areas focus on managership, DSM strategies, home energy management strategies, the consumers' role, and barriers and challenges to energy system advancements. A summary concludes the chapter.

Search Strategies

The literature used in this review was obtained through online databases and search engines, including Google Scholar, Educational Resource Information Center (ERIC), EBSCOhost Online Research Databases, DeepDyve, Science Direct, ResearchGate, and ProQuest. Key search terms entered individually or in a Boolean search manner include the following: *demand side management (DSM), demand side, demand-side, DSM, energy, utility provider energy, renewable, renewable energy update, solar, wind, photovoltaic (PV), PV panel, solar panel, electric vehicle (EV), EV, plug-in electric vehicle (PEV), PEV, demand response (DR), DR, IDSM, integrated DSM, home energy management system, smart technology, smart meter, energy markets, day-ahead market, real-time market, time-of-use (TOU), time-of-use tariff, TOU tariff, energy efficiency, utility provider DSM, prosumer, smart home, power grid,* and *smart grid.* Recent literature published between 2016 to 2020 included 56 of the total 68 entries or

82.4%. Twelve citations (17.6%) used were published before 2016 (see Table 1).

Table 1

Source of Data for Literature Review

	References Total	Total Published before 2016	Total Published in or after 2016	% Published in or after 2016
Books	2	2	0	0%
Peer-reviewed journals	53	6	47	85%
Non-peer-reviewed journals	11	2	9	15%
Total	66	10	56	100%

Operations Management Theory

The framework that guided the study is Meredith's (1998) OMT. OMT involves managing the processes of transforming inputs into useful outputs, noting the importance of using quality inputs to improve the value of the outputs generated (Meredith, 1998; Meredith & Shafer, 2015). Raw materials and energy converge through an effective process that involves the least amount of resources necessary to create the desired outcome or the resulting product (Meredith, 1998). Essential components of the theory further supported by labor elements introduced by Voss (1995) indicate the usefulness of the OMT across operational settings.

According to OMT, a production system of operations consists of attention and management to six essential components: (a) the environment, (b) strategies, (c) inputs, (d) the transformation process, (e) outputs, and (f) control mechanisms (Meredith & Schafer, 2015). The first component, the environment, encompasses things external to the production or operations system yet influential to the processes involved in some manner. Examples of environmental influences include customers, technology, or regulatory agencies (Meredith & Shafer, 2015). Strategic goals determined for the system require monitoring and frequent re-evaluation as inputs and transformation processes require updating and evolving to remain relevant regarding goods and services produced (Meredith & Shafer, 2015). Aligned with the strategies needed to maintain the efficacy of operations, maturity policies that prioritize the integration of sustainable production management further support integrating strategies that evaluate the evolving network of operations (Machado et al., 2017).

The third component, inputs, consist of labor, facilities, raw materials, equipment, and financial support and may include functional areas such as marketing and cost-effectiveness (Meredith, 1998; Meredith & Shafer, 2015; Voss, 1995). As the foruth component, the transformation process adds value to the inputs managed in the system processes and might involve altering, transporting, storing, and inspecting inputs resulting in either services or products as the outputs (Meredith, 1998; Meredith & Shafer, 2015). Finally, control mechanisms ensure the efficient operation of the system and may involve observations through measurable data, comparison information, policy updates and integration, and planning and implementation of updates to ensure the ongoing efficiency of the entire operations (Machado et al., 2017; Meredith, 1998; Meredith & Shafer, 2015; Voss, 1995).

Operations Management Theory in Practice

Following the six underlying premises identified in OMT (Meredith, 1998; Meredith & Shafer, 2015), a Fiat Group Automobile plant aimed to identify updates to the manufacturing processes to establish relationships between related processes involving costs and types of waste, with a secondary objective of identifying relationships between the factors of waste and loss with means of reducing those factors (De Felice et al., 2013). The production system area studied involved the elementary technology unit mechanical subgroup, providing circumstances conducive to the essential steps aligned with OMT (De Felice et al., 2013; Meredith, 1998; Meredith & Shafer, 2015). Applying technical specifications, logistic flow analyses, and ergonomic applications, the research team sought a 25% reduction in handling input material losses. The research team implemented the required changes in the production system resulting in effectively managing the operation and developing new strategies that created a leaner production system and effectively minimized waste and loss. The resulting leaner organization aided in accomplishing the goals of reducing waste from input materials, reducing losses through the transformation processes, and maintaining value to the end unit products as indicated in the OMT (De Felice et al., 2013; Machado et al., 2017; Meredith, 1998; Meredith & Shafer, 2015).

Operations Management Theory and Attention to Change

As evidenced by the study by De Felice et al. (2013), the practice of managing operations demands attention to changes required to maintain efficiency (Machado et al., 2017; Meredith & Shafer, 2015). Two examples relevant to the current study include attention to changes in technology and the environment. Technology continues to move forward and offers benefits to individuals who evaluate and implement the technologies needed across the United States to advance the bidirectional flow of energy, furthering the development of the smart power grid (Campbell, 2018; Machado et al., 2017;

Meredith & Shafer, 2015). The technology example merges with concerns for the environment which demand attention to successfully mitigating climate change and transforming the U.S. power grid to a smart and green integrated sustainable system (Campbell, 2018; Machado et al., 2017; Meredith & Shafer, 2015). Within the process of transformation, attention focuses on value, a concept consisting of more than dollar-based constructs (Machado et al., 2017; Meredith & Shafer, 2015), which further provides the impetus toward the societal and environmental benefits of furthering the smart grid (Campbell, 2018).

The Value-Belief-Norm Theory

The value-belief-norm theory is based on a premise of individual perspectives regarding environmental concerns, such as problem awareness, outcome efficacy, and personal normative values, impact decisions regarding energy-use behaviors (Stern, 2000; van der Werff & Steg, 2016). According to Stern (2000), behaviors toward environmentally significant actions encompass individual decisions to participate in smart energy programs. Feelings of moral obligation increase based on the individual's awareness of the environmental issues and behaviors can change as individuals adapt the belief their actions can positively change outcomes (van der Werff & Steg, 2016). Although aspects of the value-belief-norm theory align with the current study, the theory does not provide the broad foundational support needed that extends beyond the decisions and actions of individuals.

Conversely, using OMT, researchers can attend to the rapid changes in technology and make sense of managing the demand-side of industry, such as electricity

(Voss, 1995). Business managers use the principles associated with OMT to reduce the risk of purchasing or investing more on the input and operational side of an industry (Machado et al., 2017; Meredith, 1998). OMT supports the essential need in exploring DSM in the electric industry as both the customer and the utility provider work together to make energy-efficient decisions to avoid rate increases and support the goal of advancing the smart power grid (Campbell, 2018; Corbett et al., 2018). Thus, OMT supports the goals of the current study. The integration of OMT with the variables related to managing power systems' operations informs the following discussion related to issues specific to demand-side players and their role in advancing efficient power across the United States.

Demand-Side Management and Utility Managership

The U.S. power grid consists of all electricity-generating power plants and power providers, the transmission of power by way of utility companies, power lines, and cables, and the distribution of power by utility company managers to end-users including the residential, business, and industrial sectors (Campbell, 2018). Managers in the utility industry face challenges as the energy systems across the United States continue to evolve toward a smart power grid. DSM approaches benefit the utility provider managers by reducing costs and addressing peak energy demands—actions that also benefit utility customers by establishing choices in shifting energy usage to reduce electricity costs (Javor & Janvic, 2016). Commonly used DSM utility manager strategies include valley filling methods, load shifting, load building, peak clipping, energy conservation, and efficiency programs. Providers design strategies to reflect the geographical area and customer base while maintaining focus on the needs of the utility company (Javor & Janvic, 2016).

Advisory Managership

As the energy grid continues to evolve, utility managers who adopt the role of energy advisors may have an advantage as they continue to provide power and services to their existing customer base while serving as an advisor to non-participating customers (Blansfield et al., 2017; Moreno-Munoz et al., 2016; Potter et al., 2018). Utility providers have an interest in providing customer benefits as new services become available and the power grid expands (Blansfield et al., 2017). The legal and social responsibility of utility provider managers to serve all customers has established many providers as trusted advisors (Moreno-Munoz et al., 2016; Potter et al., 2018). Moreover, electric utility providers' participation in the renewable energy markets has had a positive impact on the costs for customers in those markets, such as reducing costs in the solar photovoltaic (PV) and battery storage markets (Blansfield et al., 2017).

At a conceptual design level, IDSM approaches provide an added benefit to a utility provider's current and potential customers by introducing strategies to reduce existing customers' electricity bills and serve as a resource or advisor for non-participating customers. IDSM is the integration of three or more approaches that include (a) energy efficiency programs, (b) demand response (DR) approaches, (c) distributed energy generation, (d) energy storage, (e) the use of electric vehicles (EVs), and (f) time-based rate strategies for end-users including both residential and commercial customers (Potter et al., 2018). Based on a survey of utility program administrators, more than 80%

confirmed the importance of acting as energy advisors in addressing consumer confusion regarding DSM programs, with 75% feeling that IDSM is useful in improving customer satisfaction and engagement in energy programs in addition to being cost-effective. Barriers identified included regulatory reforms, the need for effective and consistently used metrics for measuring the cost-effectiveness of programs, and internal organizational structure in advancing responsibilities for oversight of IDSM strategies adopted (Potter et al., 2018). Other research has shown similar results, indicating that utility company managers benefit by shifting the provider role from the traditional energy resource-based perspective to the role of utility consultants (Blansfield et al., 2017; Moreno-Munoz et al., 2016). Acting as a consultant or energy advisor, utility providers might help improve relationships with existing customers, address consumer attitudes regarding energy system transitions, and alter perceptions to establish the utility provider as a current and future resource for all energy-based consumer needs (Blansfield et al., 2017; Moreno-Munoz et al., 2016; Potter et al., 2018)).

Reliable Managership

Along with researchers in the energy field, utility industry managers share the responsibility for the accuracy and reliability of study methods (Afsar et al., 2016; Frederiks et al., 2016), metrics, fair-balance, and outcomes reported (Niharika, 2018; Schweizer & Morgan, 2016). However, specific to study methods and metrics used in data analysis have resulted in unsuccessful and misleading projections regarding future U.S. energy consumption and electricity demands. For example, a report commissioned by the Intergovernmental Panel on Climate Change included highly plausible and comprehensive scenarios, or storylines, that introduced convincing case examples, but these failed to reach development into actual program models while other possible future outcomes were ignored or overlooked, resulting in overconfident and inaccurate projections. Such approaches are inappropriate for scientific evaluations due to the inability of comparative data methods across studies (Schweizer & Morgan, 2016). Upper and lower bounding limits and analysis can improve the calibration of projections across scientifically-based fields of study such as nuclear engineering and environmental science (Schweizer & Morgan, 2016). Through historical data on electricity demands and estimates of change in the gross domestic product to establish the upper and lower limits, researchers have suggested high bound limits by the year 2040 of 10,000 TWh and low limits of 4800 TWh, noting the prediction more closely aligned with the 2013 U.S. Annual Energy Outlook data (Schweizer & Morgan, 2016).

Other research has suggested a method that provided a robust and straightforward process to optimize operating costs of smart grid DSM applications by advantaging a day-ahead load shifting technique in concert with a symbiosis organism search algorithm (Niharka, 2018). Similar researchers have reviewed the use of day-ahead markets in DSM strategies while considering fair-balance for both the monopolistic and competitive circumstances in the advancing smart grid-focused utility industry (Afsar et al., 2016). The authors of the study showed utility providers could achieve a position of optimal trade-off which minimized energy peaks and attended to three conflicting factors of revenue, end-user costs, and peak load energy demands consistent with DR methods.

Demand Response Strategies

Additional research accomplishments based on the interests of the utility provider have included DR programs, system reliability research, power capacity maintenance, and business models for use by utility companies (Eid et al., 2016; Makros et al., 2018; Muratori & Rizzoni, 2016). DR approaches generally introduce incentives to customers offered by the utility provider to create flexibility in meeting peak energy demands. The goal of a DR approach is to influence energy customers to alter energy demands and meet the provider's needs (Muratori & Rizzoni, 2016). DR programs can improve system reliability and revenues for utility providers, particularly as the intermittent nature and volatility of renewable energy sources continue to penetrate the evolving energy markets (Eid et al., 2016). DR programs serve utility providers further by employing short-term programs to mitigate energy fluctuations and aid in preserving energy reserve margins while maintaining control over market price volatility (Eid et al., 2016).

In addition to DR programs, researchers have developed a business model for utility providers aimed at evolving energy markets by introducing a software package designed to aid in the operation of energy communities (Makros et al., 2018). System capabilities included integrative functioning into smart grid systems for evolving future energy needs, predicted to be in place by 2030. A stepwise method was used to integrate the software system into evolving green social response networks. The software platform further serves other stakeholders by including electrical appliance sales sources, new construction contractors, and construction renovator companies (Makros et al., 2018).

Recognizing the ongoing need for many managers in the utility industry to maintain a substantial amount of power capacity, Muratori and Rizzoni proposed a bottoms-up approach, similar to research methods used by Eid et al. (2016), integrating DR strategies to create a more flexible electricity demand using DR strategies while quantifying energy behaviors among U.S. customers in a given geographical area. Study outcomes indicated a benefit to both consumers and providers as positive views and adoption by residential consumers contributed to smoothing the energy peak and creating a synchronization of energy demand and usage among participating consumers (Muratori & Rizzoni, 2016).

The Complexities of Demand-Side Management

DSM, initially invented in the 1970s, involves strategies introduced by utility providers who use technologies and price modifications to influence electricity usage and purchase patterns by consumers with the intent to provide benefit to both the consumer and the utility provider (Gellings, 2017). A broad definition of DSM includes extensive strategies and programs which include multiple methods to encourage energy efficiency and overall reductions in energy usage while providing plans for longer-term cost savings for the consumer (Aghajani et al., 2017). Corbett et al. (2018) addressed DSM and DR programs as passive and active strategies, respectively, emphasizing the importance of both strategies in load shifting and reducing overall energy demands.

An area of interest in the research literature involves the differences between applications of DSM strategies and DR programs. DR programs introduce short-term adjustments to the energy demands and grid usage, often accomplished by consumer participation in incentive programs which allow utility providers to adjust their energy usage for short periods when needed (Aghajani et al., 2017). Satchwell and Cappers (2018) examined the evolving changes in grid services, available products, and market opportunities impacting electric utility providers, energy consumers, and the overall U.S. energy industries in approaching DSM and DR offerings and noted changes with the evolving energy industry which reached to the very definition of an energy customer.

The evolving energy concerns and strategies have contributed to shifting the definition of an end-user of electricity to include consumers now acting as prosumers and third-party agencies representing groups of consumers or businesses, framing the construct of DSM and DR programs (Sachwell & Capers, 2018). Aligned with the technologies used in the broad scope of DSM strategies are DSM and DR programs that benefit both the utility provider and the consumer (Aghajani et al., 2017; Gellings, 2017). Examples of such programs include load control systems, direct and indirect financial incentives, innovative rate programs, electrification, and keeping pace with updated building code and appliance efficiency standards (Gellings, 2017).

Commonly IDSM strategies included technologies such as (a) peak clipping, (b) valley filling, (c) load shifting, (d) energy efficiency, (e) electrification, and (f) flexible load shaping innovations (Sachwell & Capers, 2018). In the interest of clarity, brief descriptions provided here explain the technologies (Gellings, 2017). Peak clipping technologies reduce coincident demand during system peak times, often implemented by direct load control of appliances by the consumer or by automated control by the utility provider (Gellings, 2017). Valley filling technologies increase electricity demand during off- or low-peak times, including seasonal variations such as EVs, battery storage systems, and smart appliances such as heating and cooling systems selected to be off during peak energy demand times. Load shifting involves moving or shifting existing energy demands to off-peak times using controllable appliances by consumers or utility providers (Afsar et al., 2016). Energy efficiency encompasses technologies to reduce energy needs while improving energy services by using strategies such as high-efficiency appliances, advanced building envelopes, and fenestration (Gellings, 2017). Electrification technologies involve the conversion of non-electric methods to electric options. Examples include electric space heating or water heaters versus natural gas appliances, and EVs versus diesel or gasoline-fueled vehicles. Flexible load shaping enables integrated grid advancements by facilitating dynamic consumer control of energy load and distributed energy generation and storage systems through direct manipulation of energy usage, controllable appliances, and home energy systems (Gellings, 2017).

Warren (2018) used four primary categories to review the impact of possible interventions and examine demand-side policies and strategies (Gellings, 2017) implemented globally (Warren, 2018). The four categories identified by Warren (2018) included market strategies, policies implemented due to regulatory measures, information-based policies, and fiscal policies which primarily involved government or industry grants, subsidies, tax incentives, or loans. Warren (2018) employed a systematic literature review and a mixed-methods study using evidence-based data to review policy interventions, explore the global evidence for reliable reviews of demand-side policies, and further observed the lack of systematic literature reviews published in the energy field (Warren, 2018). Overall, 30 countries had posted data on demand-side policy with the United States leading the number of publications. Standard demand-side policies and policy packages globally included campaigns regarding information specific to tax subsidies, grants, and loan information, followed by policies and packages on performance and efficiency standards, incentives and innovative price schemes, and market transformations, including utility business model changes (Warren, 2018).

Further attention to DSM and DR programs involved load forecasting efforts and pricing schemes. Lusis et al. (2017) described load forecasting in the residential sector as dependent on electricity demands which may vary according to weather patterns, time of day, socio-economic constraints, and characteristics of the end-users. Similarly, Kong et al. (2017) observed the transitions occurring in the evolving energy systems. According to Kong et al. (2017), utility providers' actions in transitioning toward increased penetration of renewable energy sources with intelligent and interactive systems support load forecasting strategies which may involve short-term forecasting for individual consumers according to DR program integration.

Wang et al. (2016) reviewed real-life circumstances and considered the goals of both utility providers and consumers by applying a load shifting mechanism to evaluate changes in energy demand over time. Load shifting methods allowed for peak load demands to be shifted by utility providers to off-peak times to meet target demand levels (Afsar et al., 2016; Gellings, 2017). Wang et al. recognized consumer behaviors vary in real-life versus proposed models, indicating real-life scenarios lead to unexpected results that may differ from predicted research scenarios. Lower-than-anticipated consumer participation in DSM strategies and DR incentives and unpredicted energy loads on the grid based on subjective perceptions of the actions and behaviors of others on the grid supported the suggested perspectives (Wang et al., 2016).

Asadinejad and Tomsovic (2017) discussed two primary pricing strategies involved with DR programs including incentive- and price-based programs. Incentive-based strategies, such as direct load control methods, interruptible service programs, demand bidding and buyback, peak time rebates, and emergency DR programs, offer consumers fixed or time-variant reductions in the costs of energy by allowing load reduction by the utility provider. The price-based strategies provided a significant difference which effectively encouraged consumers to adjust flexible energy loads to realize the savings in the lower price periods (Asadinejad & Tomsovic, 2017). Similarly, Chen and Liu (2017) described two categories for DR programs including either incentive-based or price-based strategies with notable differences in their impact on driving consumers to change behaviors regarding energy consumption patterns. Pricing schemes of the DR strategies encompassed aspects of transactive energy (Chem & Liu, 2017).

Energy Efficiency

As discussed by Gellings (2017), energy efficiency is an essential component of DSM strategies. Improving energy efficiency, thereby reducing energy demand and electricity consumption, is comprehensively integrated into DSM strategies among utility providers across North America (Cai et al., 2018). DSM energy efficiency programs promote efficiency by encouraging consumer use of energy-efficient appliances, often accompanies by rebates, utility provider incentives, tax credits, or low-interest loans.

Outside the utility industry, energy efficiency programs include evolving and restrictive building codes and advancing standards of energy-efficiency applied to household appliances (Cai et al., 2018). Consumers experience new, reliable, and energy-efficient appliances expected to reduce their energy usage cost-effectively. At the same time, utility providers benefit by lowered energy demands contributing to a reduced need for developing higher generation capacities. However, recent studies on the effectiveness of such programs raised questions about the energy load contributions of efficiency incentives and cost savings experienced by the consumer (Cai et al., 2018).

A report prepared for the U.S. Departments of Energy and Environmental Protection Agency included examples highlighting recommendations for efficiency programs to evolve significantly over the next decade (Goldman et al., 2018). Specifically, the report findings showed evidence of the need for utility providers and program administrators to advance programs that accomplish cost-effective savings for the consumer, noting the lack of effectiveness of many existing programs (Goldman et al., 2018). Examples of efficiency standards scheduled for implementation in the next few years included compliance with updated standards for general service fluorescent and incandescent lamps, commercial air conditioners and heat pumps, furnace fans, ceiling fans, pool pumps, and central air conditioners and heat pumps (Goldman et al., 2018). Still, existing evidence raised questions about the accuracy and reliability of some energy-efficient programs (Fowlie et al., 2015).

Fowlie et al. (2015) applied a randomized controlled trial design using experimental and quasi-experimental variants to investigate a federal residential weatherization program involving more than 30,000 U.S. households in Michigan. Study findings showed disappointing results in consumer participation, consistent with concerns identified by Goldman et al. (2018). Other findings showed some advantage in reductions in energy consumption in those who participated; however, the upfront costs were more than twice the cost of the energy savings with the projected savings over time inflated by about 2.5 times the actual savings (Fowlie et al., 2015). Additional findings included no significant improvement in outcome measures with the introduced weatherization offerings. Fowlie et al. (2015) concluded both the internal rate of return at household and societal levels and the cost-effectiveness of energy resources were negative to participants in the Michigan weatherization project. Fowlie et al. observed the need for credible research on energy-efficient programs.

Electrification

Electrification, noted as an essential DSM strategy (Gellings, 2017), involves using electricity where it was not previously used. Many agencies have yet to put forth or accept a clear definition of beneficial electrification (Edwards et al., 2018). A clear example is the advancing growth of electricity to power automobiles where diesel or gasoline fuel was previously the source of powering by vehicle across the United States and other countries. Edwards et al. (2018) put forth a workable definition of beneficial electrification including neutral or reduction in coincident demand for electricity, the costs of energy for the end-user or consumer, a reduction in the source energy used, and a lifetime reduction in carbon emissions.

Tarroja et al. (2018), Edward et al. (2018), and Mai (2018) explored aspects of beneficial electrification involving space heaters and other essential appliances in different climate conditions within the United States. Edwards et al. (2018) investigated study results from a Minnesota statewide research project reviewing economic and carbon emissions implications of EV performance and residential space heating applying different scenarios in the data mix, while Tarroja et al. (2018) investigated electrification in a California population. The research by Mai through the National Renewable Energy Laboratory provided insights for electrification at the national versus state level.

At the time of the study by Edwards et al. (2018), Minnesota held the country's sixth position for wind power production, noting wind resources produced 18% of the state's electricity in 2016. Still, the study results indicated significant challenges in reducing statewide emissions. Edwards et al. noted Minnesota is on track with its energy plan to reduce emissions by 23% over the next few years as renewable resources grow, and coal plants, the most significant cause of unwanted emissions in the state, are retired. Beneficial electrification plans included the conversion of all air source heat pumps to higher efficiency units accompanied by the use of natural gas in replacing existing coal and nuclear energy sources (Edwards et al., 2018). The greatest challenge in electrification for space heating in Minnesota included attention to pricing strategies (Satchwell & Cappers, 2018) and cost factors (Edwards et al., 2018). The price reportedly varied by more than 50%, depending on the changing energy market prices, with current costs of electrification as much as 50% more than older inefficient resources in the residential sector. Edwards et al. concluded the operational performance of the newer space heating technologies is a critical factor in developing cost-effective beneficial electrification in homes across Minnesota (Edwards et al., 2018).

Consistent with the works by Edwards et al. (2018), Tarroja et al. (2018) investigated the electrification of space heating and water heating systems in California using present-day data compared to the projected capacity of the 2050 future electric grid. Other research involving water heating systems and heat pumps aligned with the study by Edwards et al. (2018) and Tarroja et al. (2018) included research efforts by Mai (2018) at the National Renewable Energy Laboratory. Tarroja et al. observed electrification of space heating doubled greenhouse gas emissions, with total emissions reduced by 30 to 40%, as electrification replaced on-site use of natural gas resources. Study findings showed the continued evolving effects of climate change specific to increased electricity demands based on the need for increased cooling capacity due to the gradual rise in climate temperatures. However, this prediction was offset by reductions in the use of natural gas, increased electrification for space heating, less demand for heating resources, and advancing efficiencies in heat pump technology. Similar to the positive findings by Edwards et al. (2018) in Minnesota, developing renewable energy sources across California is further predicted to contribute to reduced greenhouse gas emissions by the 2050 target year (Tarroja et al., 2018).

In a study done by researchers at the National Renewable Energy Laboratory and sponsored by the U.S. Department of Energy's Evolved Energy Research Office of Strategic Programs, Mai (2018) determined the expected increase in electrification across the United States (Mai, 2018). Advancing economic incentives and policies encourage electrification to accomplish reduced emissions, improve the quality of the air, and promote security issues in the energy industries. Utility providers invested in electrification advances noted the potential to increase revenues while advancing electrification processes and technologies to meet future energy demands. Mai (2018) observed current progress in electrification to include technological advancements in procedural costs, operational performance, and demand-side strategy adoptions. Similar to the works by Edwards (2018) and Tarroja et al. (2018), Mai (2018) reported air sourced heat pumps and heat pump water heaters are vital technologies for electrification developments.

Home Energy Management Systems

Many homeowners seek to reduce energy costs by participating in the energy markets using smart technologies and distributed energy generation (Gazafroudi et al., 2019). Evolving research indicated home energy management approaches provide cost-effective results for homeowners by integrating differing aspects within energy systems (Hansen et al., 2018; Martinez-Pabon et al., 2018; Parag & Sovacool, 2016; Rastegar et al., 2017). Consumer participation in the energy markets through viable systems is essential in the effective implementation of smart grid technologies supporting DSM strategies.

Gazafroudi et al. (2019) proposed a residential energy management system using an optimization scheme for homeowners who participated in the bidirectional energy exchange. Based on data collected through the literature review, Gazafroudi et al. proposed a residential management system using a smart meter interface and assumed solar panels and battery storage in the home design. Must-run services, outdoor temperature, and updated information on the price of electricity in the local markets were accounted for as the management system developed offering and bidding strategies using day-ahead and real-time bidding and offering data. Strategies differed as stochastic programming determined the real-time pricing opportunities using mathematical formula adjustments to account for the mismatch between the day-ahead and real-time markets. Noting the robustness of the proposed model across different scenarios noting, Gazafroudi et al. observed the proposed system was limited in managing day-ahead bidding strategies (Gazafroudi et al., 2019). Consistent with information suggested by Gazafroudi et al., Hansen et al. (2018) examined three home energy systems, including one myopic approach and two non-myopic processes with partially observable Markov decision methods. Study findings showed a savings of at least 10% and an overall reduction in peak energy demands experienced by the utility provider for all models evaluated (Hansen et al., 2018).

Consumer participation in the evolving energy systems is vital in implementing DSM strategies and smart grid technologies effectively. Parag and Sovacool (2016) explored potential prosumer markets, noting a prosumer to be someone both consumers and producers electricity, a construct assumed across many research models, including the proposal by Gazafroudi et al. (2019) and research by Hansen et al. (2018). Parag and Sovacool described three types of prosumer models with the first described as peer-to-peer markets. Parag and Sovacool's model involved prosumers interconnected to buy and sell energy services directly to and from one another. The second type required producers interconnected to microgrids or stand-alone grids termed islander grids which allowed for power exchanges through a microgrid connecting either to a larger power grid or exchanged power with other users connected to the independent microgrid. The third type described organized prosumer groups. In this model, prosumers formed virtual power plants by buying and selling services from one another without the need for more extensive grid services or utility providers (Parag & Sovacool, 2016).

The actual operation of such models raised questions and challenges. For example, such models conflict with the traditional power grids currently used by utility providers across the United States. The conflict between models creates concern as prosumer groups must consider national and state laws and ensure the interests of participating prosumers align with the energy goals of the community and the broader society (Campbell, 2018; Parag & Sovacool, 2016). According to Parag and Sovacool (2016), the attitudes and actions of many consumers suggest the financial costs of producing and related energy activities are prohibitive, with those attitudes strengthened by concerns of security and invasions of privacy based on the need to share personal information (Campbell, 2018). Moreover, the adoption and integration of prosumer and smart grids by any design are dependent on future technologies. Predictions indicate conventional energy sources used with traditional power grids and the use of fossil fuels is predicted to remain in use regardless of the progress of smart grids and prosumer group activities (Parag & Sovacool, 2016).

Consistent with the automated decisions made in the research by Gazafroudi et al. (2019) and Hansen et al. (2018), and the prosumer model explored by Parag and Sovacool (2016), Martinez-Pabon et al. (2018) studied a smart home energy management system with a controllable load device connected to the home's smart meter. The load device provided automated control of smart appliances to optimize resident energy management and prevented manual operation by the 247 prosumer households with solar capacities studied. Homes were clustered based on electrical usage patterns. Study findings showed the automated load device effectively collected and evaluated data across multiple smart homes on the same grid. The automated function of the load device, thereby preventing manual changes by the homeowner, allowed the system to make decisions for homes as groups and reduced energy use peaks while maintaining overall reductions in energy usage and reduced homeowners' costs. Results indicated positive outcomes encompassed a significant decrease in energy consumption across the residences and a 33% reduction in the cumulative cost of energy per day (Martinez-Pabon et al., 2018).

In a study evaluating multi-sourced energy supplies such as electricity and natural gas inputs, Rastegar et al. (2017) introduced an energy management strategy by using energy hubs in applicable residences, similar to the grouping of homes employed by Martinez-Pabon et al. (2018). Rastegar et al. defined the capacity for an energy hub as a possible option in any location involving multiple activities involving energy, including the production, storage, conversion, and consumption from more than one energy source. The description outlined by Rastegar et al. encompassed residences as energy hubs when those residences had either multiple energy sources, such as electricity and natural gas or in situations where renewable energy sources, such as solar panels or EVs, actively provided energy sources or storage of energy. Using a series of sophisticated mathematical formulas and probability calculations across multiple case scenarios, both the costs to the home for energy sources and the consumption of energy improved through the introduction of the proposed model when considering the residence as an energy hub. According to the case scenarios presented, the load energy demand became flattened with no peaks, and the costs of energy to the household decreased by as much as 50% (Rastegar et al., 2017). While the research by Rastegar et al. used single homes as energy hubs, applying Rastegar et al.'s proposed approach to the strategy of clustered homes introduced by Martinez-Pabon et al. (2018) warrants consideration. Differences in the costs of energy experienced by the residences within a defined energy hub may result in more significant savings to the consumer.

Hybrid Battery Storage Systems

In a review of the research literature on hybrid solar PV and wind energy storage systems, Badwawi et al. (2016) pointed out the challenges with solar and wind energy sources related to the unpredictable changes imposed by nature. The technology needed to adapt to the variable aspects involved voltage and frequency fluctuations and the need for appropriate filters and switching converters to mitigate the distortions caused by nature's fluctuations in harmonics of the system. Optimization of battery storage (Kabir et al., 2018; Nemet et al., 2017) is essential for stand-alone energy management systems to ensure the desired control for energy usage (Badwawi et al., 2016).

The PV panels, or wind sources, if used, collect the energy through the embedded sensors then transfer the energy to a battery storage system for use in meeting the energy demands of the residence as they occur. Homes connected to a utility provider's power grid also need a battery system to provide for control of the power intended for use by the residence and the stored energy designed for sharing with or selling to the utility provider (Badwawi et al., 2015). Optimization strategies included using the proper battery storage system for both wind and solar (Kabir et al., 2018; Nemet et al., 2017) residential energy sources. However, the costs involved, and the wind and sun exposure based on the geographical location, must be considered in optimization efforts (Badwawi et al., 2016).

Wu et al. (2015) proposed a hybrid battery storage system for solar PV panels to benefit grid-connected residential consumers participating in DSM, noting not every rooftop PV panel array needs a battery system. However, depending on the homeowner's needs and goals for PV panels, a battery system could provide a stable and continuous energy supply (Badwawi et al., 2016). According to Wu et al., battery systems help meet the user's energy needs when PV power is low or unavailable and connects to the home's energy management system to adjust grid access and PV stored energy according to the prosumer goals of the user. Wu et al. presented opportunities and challenges to hybrid battery system technologies with consideration for integration with DSM strategies. Similar to other researchers and published cost data, the average cost of a new PV array and battery system resulted in a payback timeframe between six and seven years (Nemet et al., 2017; Wu et al., 2015).

Sandhu and Mahesh (2018) evaluated the impact of a DSM strategy involving a hybrid battery system for solar and wind sources which also introduced a filter system to reduce peak demands. Single objective designs functioned to reduce system cost while multi-objective foals targeted both costs and system reliability. Consistent with other researchers in considering DSM strategies for presumption (Gazafroudi et al., 2019; Hansen et al., 2018; Parag & Sovacool, 2016), a future scenario smart grid function developed for the study included bidirectional considerations of power flow (Sandhu & Mahesh, 2018). The DSM model introduced the capability for consumers to manage power utilization and costs by making changes according to the peak demands and price of electricity. Outcomes resulted in reduced peak load demands relying on battery operations during peak times, consistent with the findings of Badwawi et al. (2015). Findings further indicated the need for considerable reductions in the energy storage elements leading to reduced cost per unit of electricity (Sandhu & Mahesh, 2018).

Electric Vehicles in the Residential Sector

According to the discussion by Campbell (2018), the renewable energy goals which align with providing more effective electricity sources encompassed an expected increase in electricity consumption in the field of transportation due to the increased production of EVs, also referred to as plug-in electric vehicles (PEVs) and hybrid vehicles. Challenges presented included the need to advance the technologies involved with EVs, such as the limited driving ranges per charge. Moreover, regulatory concerns exist regarding the sale, or resale, of electricity produced by EV charging stations specific to residential users with renewable energy storage systems. Consistent with the predictions introduced by Campbell (2018), Tavakoli et al. (2016) predicted 25% of light-duty commercial vehicles in use across the United States would be EVs by the year 2020, increasing to 66% by the year 2030. The United Nations projected internal combustion engines would no longer be used in U.S. automobiles by 2050, noting the complete conversion to EV production. Recent decisions by major automobile producers support those goals, such as the announcement by the Swedish company Volvo indicating their plan to phase out the use of internal combustion engines beginning in 2019 (Campbell, 2018).

Similarly, the U.S. automobile maker General Motors announced plans to produce 20 all-electric models to be available by 2030. Moreover, many countries, including China, Britain, and France, recently revealed plans to ban gas-powered vehicles in the next two decades. Utility providers across the United States vary in their capacity to manage the EV market's continuing growth and subsequent charging of those vehicles (Campbell, 2018). Many utility providers considered to potentially benefit included those companies prepared for the EV charging to occur at night, thereby decreasing any expected change in peak-load demands (Campbell, 2018). Still, the advancement of EV production and the changes expected at the residential level as a result of increased EV usage, including the adoption of grid-connected battery storage systems, bring challenges to the current level of smart grid technologies and the needed upgrades to the electrical power infrastructure across the country (Badwawi et al., 2016; Campbell, 2018; Sandhu & Mahesh, 2018).

Liu et al. (2018) proposed a DSM program addressing the scheduling of energy in households using bidirectional energy trading from EV-generated energy storage. Moreover, the advancing use of EVs described as a double-edged sword for utility providers and the power grid, brings greater focus on the residential sector as market penetration of PEVs continues to advance (Campbell, 2018). While utility providers expressed concern regarding possible energy grid challenges with charging and discharging of PEVs, which may aggravate the peak to valley load differences in the power grid, efficient scheduling programs of PEVs could impact the grid positively (Liu et al., 2018). Liu et al. applied a Bayesian game model with added privacy features preventing costs and profits experienced by one player to be known by other players. The profit model described scenarios for PEV owners to use their vehicles for profit, such as owners who use their vehicles daily for transportation yet have energy still in the battery when they return home. Surplus energy can be discharged and sold to the grid at a time when the selling price exceeds the price the owner pays for the electricity needed to recharge the battery for the PEV. Discharge of surplus energy by users occurred during peak energy demands and higher pricing times, while battery charging happened during low demand times and lower pricing for energy while maintaining a privacy barrier between consumers (Liu et al., 2018).

The Role of the Consumer

Saad et al. (2016) pointed out the importance of active consumer participation in accomplishing goals aligned with renewable energy projects and DSM strategies. Saad et al. underscored the importance of DSM strategies in moving forward with the implementation of a smart grid requiring the incorporation of consumer-based energy storage units capable of contributing to active energy trading. Similarly, other researchers highlighted the critical importance of consumer participation in DSM (Sandhu & Mahesh, 2018; Sattarpour et al., 2018; Stenner et al., 2017). Sandhu and Mahesh (2018) viewed the role of the consumer in participating in smart grid technology as a critical variable noting the importance of consumer participation without experiencing compromised comfort while maintaining cost-benefit, and Sattarpour et al. (2018) identified consumer participation as key in advancing efforts for the efficient operation of intelligent or smart grids.

Consistent with the perspectives of Saad et al. (2016), Sandhu and Mahesh (2018), and Sattarpour et al. (2018), Stenner et al. (2017) used a mixed-methods study design to evaluate customer trust in the advancing smart grid in Australia. Stenner et al. surveyed 1499 households in Australia using three survey design methods to determine the role of customer trust or distrust regarding participation in a DSM direct load control program presented by a power utility provider. Methods included face-to-face interviews, telephone contact, and online survey administration. Study results found the first of three hypotheses to be supported. The first hypothesis expected distrust of the utility provider would contribute to customer decisions not to participate in the DSM direct load control program. The second hypothesis, expecting an increase in consumer participation based on acknowledgment by the utility provider of consumer distrust accompanied by a statement of interest in improving relationships, was only partly supported. The final hypothesis, based on customer participation in those with higher degrees of utility provider distrust, was not supported as those customers were not willing to participate in programs of DSM offered by the utility provider regardless of the provider's efforts. While the study was carried out in Australia and not within the United States, the sample size and results inform consumer opinion regarding DSM participation (Stenner et al., 2017).

The adoption of DSM technologies, including those involved with smart homes, depends on consumers' perceptions of benefits as outweighing the risks (Wilson et al., 2017). Consistent with the findings of Stenner et al. (2017) in Australia, Wilson et al. (2017) found similar issues with consumer trust in the U.K. Using a survey of 1025 homeowners and an additional survey of 42 smart homeowners in the U.K., Wilson et al. concluded the industry is not effectively building consumer confidence for DSM approach in smart homes particularly in the areas of data security and privacy. Based in the U.K. and guided by directives from the European Union Commission, smart home technologies consisted of sensors, monitoring devices, interfaces, and smart appliances, integrated into a network to allow both automated and manual control of the smart residential environment. While public interest was well-substantiated, actual consumer participation based on perceived benefits and risks was low, contributing negatively to anticipated market growth (Wilson et al., 2017). Barriers to participation included upfront costs, security, privacy, system reliability, and the interchangeable use of devices across manufacturers. Wilson et al. considered the quantitative methodology of the study as a limitation, suggesting a qualitative approach using interviews for data collection may have provided richer insights into consumer perspectives.

The systematic review of the literature by Marikyan et al. (2019) provided further evidence regarding the importance of consumer perceptions concerning the usefulness of the advancing technologies and smart grid transitions. The systematic review examined 143 publications on smart homes including attention to the perspectives of the homeowner or smart technology user. Consistent with the findings by Wilson et al.

(2017) and Stenner et al. (2017), Marikyan et al. observed the adoption rates for smart homes and participation in the advancing smart grid remained low with adoption decisions sometimes aligned with potential threats despite the potential benefits. Services recognized as beneficial for smart homes encompassed energy efficiency capacities associated with smart technologies (Marikyan et al., 2019). The primary barrier to adoption referred to as technology fit including the compatibility, connectedness, and system reliability, is linked strongly to the user's perception of the usefulness of smart technology. Additional barriers included financial, ethical, legal concerns, and knowledge gaps specific to equipment operation (Marikyan et al., 2019). Privacy and security matters also acted as barriers to adoption, noting smart technologies store tremendous amounts of information with privacy intrusion considered a significant issue encouraging users against adoption (Marikyan et al., 2019).

Consistent with the security concerns put forth by Marikyan et al. (2019), Campbell (2018) indicated sensor upgrades to the U.S. power grid intended to improve system reliability involving wireless methods of access were of significant concern specific to cybersecurity and the potential for attacks to the advancing U.S. power grid. In a congressional research report, Campbell (2018) identified the energy sector as one of 16 critical infrastructure elements considered by the Department of Homeland Security as a potential target for cyber intrusions. Similarly, Shaukat et al. (2018) described fundamental challenges involved with smart grid development to include both consumer acceptance and cyber terrorism. Barrios-O'Neill and Schuitema (2016) observed the importance of engaging the public in participating in the energy sector to accomplish energy goals and further recognized the challenges of the energy industry in accomplishing the participation of consumers regarding concerns of privacy and data protection. As advancements on the smart grid continue, concerns for cybersecurity for the electricity sector and related areas consisting of the natural gas industry, water supplies, and transportation systems, remain a point of interest (Campbell, 2018).

Barriers and Challenges to Energy System Advancements

Saad et al. (2016) listed three primary challenges in transitioning from the traditional power system to adopting a smart grid to promote DSM strategies. The first challenge required the active introduction of smart meters and consumer-oriented energy systems serving to manage the overall grid load, otherwise known as load shaping. Meeting this challenge involved increased research into technologies for automation and active consumer participation. The second area identified involved the integration and use of storage devices, such as using EVs to store energy reserves. Such integration may occur through independent system operators or consumer-based storage units and battery systems used to store and sell energy back to the power company. The final challenge included the need to effectively integrate consumer-based power sources, like solar panels, into a smart grid system (Saad et al., 2016). A 2018 congressional report on the status and outlook for advancing DSM by adopting the smart grid in the United States identified similar concerns by Campbell (2018).

Campbell (2018) outlined the government programs required to advance the energy system transition to the smart grid and provided challenges from the same perspective. Financial costs were the first barrier mentioned, although congressional funding and grant strategies were described as possible solutions to aid in the cost barrier. Still, some stakeholders at the government level viewed the progress of the transition to the smart grid as a gradual update of the system by replacing older components with newer ones in the existing grid system. Campbell discussed the status of the grid technologies and noted a primary barrier to smart grid adoption as the incompatibility of technologies. Campbell further described decisions in the chain of command specific to compatible technology.

The role of the National Institute of Standards and Technology (NIST) involved developing standards to ensure the compatibility of smart grid technologies according to recommendations of the Smart Grid Federal Advisory Committee, and presenting those standards to the Federal Energy Regulatory Commission for adoption. In 2010, NIST established standards and presented those to the commission. However, a 2011 Government Accountability Office Report indicated that they did not adopt the standards. Therefore, as of 2018, NIST continued to work with the Smart Grid Federal Advisory Committee to develop standards for technology compatibility (NIST, 2018). The United States is not alone in addressing tech-compatible standards. Jafari et al. (2019) described similar challenges in Australia as residential applications involving standardized safety features for multi-port converter mechanisms resulted in the need for compatible mechanisms for use in residential applications to support hybrid renewable energy systems.

As energy programs and policymakers consider the substantial research published regarding solutions for the energy concerns (Campbell, 2018), one common challenge faced by researchers in this arena involved consistency and reliability of study data and the questions which sometimes exist regarding the accuracy, applicability, and credibility, of the studies as presented (Frederiks et al., 2016; Schweizer & Morgan, 2015). Sovacool et al. (2015) suggested the need for combined research in the technical aspects of solving energy problems accompanied by the social problems contributing to the acceptance and application of the technical solutions. Sovacool et al. reviewed three concerns with research into energy solutions. The first included the lack of study into the social dimensions aligned with energy problems. The second dealt with attitudes associated with technical disciplines that place social science matters as secondary. The third concern addressed an identified pattern of homogenous perspectives, clarified as a predominance of research done by science and engineering specialists, the majority of those specialists being male, the majority of research falling within the quantitative realm, and the high percentage of researchers living in North America (Sovacool et al., 2015).

Frederiks et al. (2016) indicated the importance of using the gold standard approach of randomized controlled studies for studying behavior changes of energy consumers. In contrast to the findings of Sovacool et al. (2015), Frederiks et al. identified a lack of quantitative studies applied to advance understanding of causal effects related to social behaviors. Frederiks et al. conducted a systematic literature review, observed the lack of quantitative studies applying gold standard methods to understanding causal effects related to social behaviors, and summarized the stated goals of many studies. Study aims in the residential sector addressed the shift in the public interest toward energy-efficient practices, acceptance levels for DSM strategies, overall interest in renewable energy sources and related technologies, and acceptance of evolving pricing programs. However, assessing the effectiveness of study data is limited at best, noting the weaknesses in study designs and processes of evaluation and analysis. Emphasizing the role of randomized controlled studies to determine the stated research goals effectively, Frederiks et al. asserted best practice guidelines for policymakers to aid in moving forward with research in this area. Similarly, López et al. (2019) recommended the consistent use of a residential load simulator method, which their group developed, to allow for valid comparison of data to determine reliable comparative outcomes.

While the perspectives presented above reflect the opinions of each group as stated, the underlying arguments regarding the need for attention to study designs and research outcomes are consistent with the goals of the current study in providing useful research with accurate and meaningful outcomes. Addressing technology advancements, security concerns, and the perspectives of utility providers is critical in providing safe and productive transitions to a smart energy grid. The public perspective is also a vital and integral part of adopting and moving forward with the power grid transitions. The role of the consumer in accomplishing energy goals aligns with the social importance of the current study and related research, as discussed in this review.

Observations of the Literature Reviewed

Multiple areas of interest presented by researchers in the content of this review included some common threads. One such thread, emphasized by multiple researchers and research groups, involved the need for the public to accept and participate in the evolving energy system, including DSM programs, DR approaches energy efficiency efforts, electrification options, adoption of new technologies, and multiple changes under consideration and development. For example, the discussion specific to the role of the consumer involved no less than nine research studies which provided evidence of difficulties with consumer participation. Outside of the section and with overlapping content, at least eight more research groups cited the importance of encouraging programs that attract the interest of the public. Examples of those included the consumer distrust of smart meters in California resulting in active protests (Büscher & Sumpf, 2015) and the description of disappointing participation outcomes in Michigan's weatherization project described by Fowlie et al. (2015). Others included Paraq and Sovacool's (2016) discussion in the prosumer market regarding the lack of consumer interest, low participation in managing peak load energy demands identified by Javaid et al. (2018), and the importance of consumer participation in using home energy management systems presented by Gazafroudi et al. (2019). Similarly, some researchers suggested value in using social media strategies to promote consumer interest, including work by Barrios-O'Neill and Schuitema (2016) and Moreno-Munoz et al. (2016).

Another common thread identified involved attention to security factors including personal security and privacy matters identified at the customer level reaching cybersecurity concerns at the national level. Parag and Sovacool (2016) and Wilson et al. (2017) described concerns by the public regarding the potential for invasion of privacy, and Liu et al. (2018) used the Bayesian method in the study procedures to ensure a privacy barrier between consumers. Similarly, Marikyan et al. (2019) noted the public's realization of the tremendous amount of data stored in smart devices, creating concern over using such devices for energy system advancements. Cybersecurity and the concern for cyber terrorism attacks on the U.S. energy system resulted in the observation by Büscher and Sumpf (2015) which consumers may consider reassurances of security at the federal level as useless in some circumstances. Further concerns of cybersecurity by government agencies, including Homeland Security, involved discussions in the works presented by Campbell (2018) and Shaukat et al. (2018).

While some researchers evaluated data collected from actual situations, homeowners, communities, and energy system program administrators, much of the research consisted of futuristic planning concepts. As technology and energy systems are evolving resulting in the lack of real-world data, many researchers used proposed methods or models, addressed aggregated versus disaggregated data in a simulated way, and employed sophisticated and complicated mathematical formulas to evaluate theoretical data collected, further supported by the use of scenarios and sample cases versus real-world data. The theoretical and futuristic study methods used throughout the research literature further identify the importance of the ongoing study. Such research serves as a cornerstone in supporting the critical need for the evolving technologies, the programs under development, and the strategic approaches under consideration, to accomplish the goals of addressing climate change and emissions control in the identified timelines.

While the literature included in this review effectively contributes to the need for advancing the energy systems across the United States and the globe, inconsistencies observed in study methods and goals warrant mention. For example, the study by Edwards et al. (2018) explored energy use in Minnesota which included a review of the state's energy plan to increase the use of natural gas as a primary energy source, as less efficient resources follow the state's plan to be retired from use. However, other researchers, including a study by Gellings (2017) and another by Tarroja et al. (2018), encompassed the goal of reducing the use of natural gas as an energy resource by replacing appliances using natural gas with other resources including electrification methods. The Minnesota research showed the benefit of natural gas over the retiring coal industry, yet clarity behind the state's strategy to introduce an identified inefficient energy source over other options was unclear.

A variety of study designs introduced in this review included observations by some researchers regarding the choice of methodologies used in energy studies. For example, Schweizer and Morgan (2016) provided opinion scenarios, storylines, and sample presentations of data that were inappropriate for use in scientific evaluations, including research in the energy field. Schweizer and Morgan identified significant errors in prediction models that guide many industry and government decisions, further citing similar opinions by other researchers in the literature review section of their study which supported this opinion. The opinion of Schweizer and Morgan, and the researchers in their review, conflict with much of the futuristic technological research lacking real-world evidence to use for data collection and, therefore, must rely on scenarios and storylines to support the proposed research material.

Sovacool et al. (2015) identified concerns across published research into energy system solutions including a lack of study into social dimensions, inappropriate attitudes associated with technical disciplines which placed social sciences as secondary, and an identified pattern of researcher homogeneity, noting the predominance of research in the science and engineering category and the majority of researchers being male and living in North America. Similarly, the issue of qualitative versus quantitative study data was reviewed by Frederiks et al. (2016) as they criticized the qualitative study methodology used to evaluate the social behaviors of consumers in studies exploring the public role regarding participation in the evolving energy system. Frederiks et al. concluded published research regarding the public interest and participation of energy programs, including DSM strategies, was, at best, limited due to poor study design. Frederiks et al. (2016) further indicated the only accurate method to use in understanding causal effects related to social behaviors was randomized controlled studies. Interestingly, Wilson et al. (2017) applied a quantitative approach to research into consumer perspectives regarding energy system integration and strategy adoption. Frederiks et al. (2016) noted the quantitative approach as a limitation of the study, stating the use of a qualitative approach involving an interview method may have yielded richer insights into the study results.

Summary

The purpose of the current research is to explore strategies distribution electric utility managers use to reduce demand-side billing charges from their generation and transmission utilities. The literature review provided evidence of the substantial depth and reach of the published research literature related to the goals of the current study, recognizing the content of the literature used in the review is far from exhaustive for any given section presented. Each section topic encompassed highly complex and detailed research involving sophisticated formulas and processes involved with complicated and detailed technologies, system advancements, and improving the market penetration of DSM, noting the critical role of the consumer. Reaching from a single device, meter, or residence, to data at the utility system level, state-level research, government-based research, national energy projections, then to international data, the information discussed in this review underscored the need to attend to evolving energy systems at every level. The impact of climate change leaves no untouched corner, community, or continent across the globe.

The topics reviewed here included evolving grid transitions, home energy systems, solar energy, EV advancements, the critical need for consumer participation in DSM programs, and understanding DSM approaches from utility providers' perspectives. The review further evidenced the complexities involved with the steps necessary to move forward in advancing energy systems across the United States. The current study can add further significance to the literature through the planned investigation of DSM strategies from an individual provider. The content reviewed here forms a basis of support for the current study design and methodology, as presented in Section 2.

Section 2: The Project

A lack of DSM practices in the electric utility industry can affect utility profitability by compelling higher infrastructure costs and increasing the peak load by up to 37.69% (Javaid et al., 2018). Demand for electricity in the residential sector is projected to increase by 1.4% annually until the year 2040 (Corbett et al., 2018). However, DSM practices for residential applications are underutilized in the electric utility industry, which can adversely affect the potential for the industry to generate revenue. Therefore, the study addressed strategies to reduce demand billing charges used by managers in the distribution electric utility industry.

Purpose Statement

The purpose of this qualitative multiple case study was to explore strategies that distribution electric utility managers use to reduce demand billing charges from their power providers. The targeted population was comprised of three general managers of electric distribution utility companies in the Midwestern United States who have demonstrated success in implementing DSM at their utility. The implications for positive social change include the potential to reduce electric rates for distribution utilities from the electrical providers, resulting in cost savings for consumers. Additionally, expanding DSM practices might reduce the overall electric load for the electric generation system, which might lead to reduced fossil fuel generation during peak load periods as well as the lessened potential for an electric rate increase for the consumers. Burning less fossil fuel can be beneficial to the environment and keep electric rates stable, providing savings and increased disposable income for consumers of electricity.

Role of the Researcher

In case study research, the researcher is heavily involved in data collection and has an intricate role in collecting data (Yin, 2018). I served as the sole source for data collection and analysis and ensured study integrity and participant confidentiality. As the researcher, I recruited participants and generated a representative group of individuals with sufficient experience in the field. I used a semistructured interview with open-ended questions.

I bring 5 years of practitioner experience to this research study, working in the electric utility industry in a variety of capacities. During my experience, my duties included serving as a communications manager, energy efficiency advisor, economic developer, and key accounts manager. My experiences required observational and active listening skills, which were valuable in my role as the researcher in this study. Despite my experience, I had no direct personal or professional relationship with the participants. Researchers who have a direct relationship with the participants can make obtaining genuine voluntary consent problematic (Dush, 2012).

Additionally, the protection of participants' involvement and input is important (Marrone, 2015; Silverman, 2016). I adhered to the Walden University Institutional Review Board (IRB) guidelines as a means of protecting participants' input in this study. IRB's provide safety mechanisms restricting research on populations (Pike, 2012). Researchers should utilize ethical principles throughout the study process (Pollock, 2012) and should also adhere to standards presented in the Belmont Report (1979) concerning the protection of participant rights. Researchers must show beneficence by demonstrating respect for each participant (Silverman, 2016). Furthermore, participants should understand the fundamental aspects of a study in which they are participating, and the researcher is responsible for providing this understanding (Mike, 2012). Through this process, I safeguarded participants' inclusion and input.

In addition to protecting participants, researchers should mitigate potential bias by determining how open they are to findings contradictory to their ideas (Yin, 2018). Diminishing personal bias is one method for a researcher to strengthen research objectivity (Krimsky, 2012). I did not project bias from the data collected and remained open to findings that were contrary to predetermined ideas regarding the research question. Researchers should identify their position on the topic and be truthful about their preconceived perspectives (Yin, 2018). Therefore, I strove to eliminate bias.

I also used an interview protocol for my case study research (see Appendix) to ensure the collection of viable and reliable data (Yin, 2018). Researchers use an interview protocol as a technique to elicit participants' input for specific questions (Pike, 2012). Using an interview protocol can guide the researcher in gathering reliable data (Yin, 2018). Furthermore, using an interview protocol can provide clarity for interview sessions (Silverman, 2016). These steps were necessary for yielding themes related to the phenomenon of interest.

Participants

Participant eligibility should reflect the research topic (Mullins, 2013). The population identified for this study were general managers of distribution electric utility companies located in the Midwestern United States with at least 4 years' experience and who have demonstrated success in implementing DSM at their cooperative. CEOs are likely to have the highest degree of knowledge of practices utilized within the utility as they are the overarching manager of all the organization's operations (Lee et al., 2020). Additionally, when a company embarks on a new strategy or project, the CEO is responsible for presenting this information to the company's stakeholders (Lee et al., 2020). The criterion was being the CEO or general manager of a utility company in the Midwestern United States. The individuals selected were deemed to have substantial knowledge of DSM through the utilization of varying DSM practices at their utility.

I conducted an Internet search of electric cooperatives in the Midwest that are participating in DSM strategies at their utility. Researchers often use public websites to identify potential research participants (McGuire et al., 2012). I randomly selected websites and identified the general manager of each utility. I attempted to select individuals from across the Midwest, including South Dakota, Kansas, Missouri, Iowa, Illinois, Indiana, Michigan, and Wisconsin. Eligible individuals were be contacted via telephone. If the interest was indicated, I emailed the participants an informed consent form. Through phone conversations, I solicited recruitment. Individuals who indicated interest and volunteered were recruited for the study.

I expressed my past involvement in DSM at the onset of each interview to gain rapport. Researchers should communicate with participants to build a relationship as a means of collecting data during the interview process (Lyons et al., 2013). Researchers should share their related history with participants to establish trust and create a relationship of open dialogue (Fletcher, 2014). A discussion of my previous professional experience was important for building a relationship with participants to enable appropriate and in-depth dialogue.

Research Method and Design

This section includes a discussion of the research method and design. A qualitative study method was chosen for this study. Qualitative researchers observe and document the natural environment of the participants whom they are studying. When employing an in-depth analysis of different programs, a qualitative design is most appropriate (Yin, 2018).

Research Method

Qualitative, quantitative, and mixed methods are the most common research methods (Yin, 2018). Based on the research question, a qualitative method was the most appropriate choice. Qualitative research is based on an interpretivist epistemological and ontological position, which is associated with the assumption reality is experienced through the lens of human perception (Silverman, 2016). As a result, research based on such a position incorporates subjective perceptions and experiences to understand phenomena (Yin, 2018). Since I explored a social phenomenon and gained insight into complex business practices, a qualitative study was most appropriate.

In contrast, quantitative research draws from a positivist epistemological and ontological position in which is the assumption is made an independent reality exists free from the lens of human perception (Yin, 2018). A quantitative study involves the use of statistical and measurable data to test a hypothesis (Quinlan et al., 2019; Yin, 2017). Quantitative researchers seek to remove human subjective interpretation from the analytical process as much as possible by using objective, structured, and numerically based instruments of data collection (Quinlan et al., 2019). Because I did not use statistical or measurable data to test a hypothesis, a quantitative method was not appropriate for my study.

With a mixed-methods approach, researchers combine qualitative and quantitative methods to gain insight into a topic (Quinlan et al., 2019; Silverman, 2016). Furthermore, mixed methods practitioners seek to clarify and expound upon results from one research method with findings from another research method (Kim, 2015). Since I did not use a combination of qualitative and quantitative research, a mixed-methods approach was not appropriate for my study. I did not measure the relationship between variables; I only described the perceptions and experiences of participants.

Research Design

I chose a multiple case study design, which can be used to review multiple types of data to explore real-life situations (Yin, 2018). Additionally, case studies are the preferred strategy used by researchers who are asking how or why questions (Silverman, 2016). Because I used multiple resources to explore a variety of perspectives related to the phenomenon under study, a case study design was most appropriate for my study. A case study is also an appropriate design to understand the research problem whether the problem is a person, process, or system (Petty et al., 2012). Therefore, a multiple case study design was most appropriate.

Other designs were considered but not chosen. Ethnographic researchers seek to understand the beliefs, language, and behaviors of a group by immersing in their culture

(Yin, 2018). Scholars use the ethnographic design to describe values, attitudes, and behaviors and to explore social cultures or subcultures (Petty et al., 2012). Furthermore, ethnographic researchers study 100% of the population. Since the purpose of my study was not to immerse myself in a culture or explore 100% of a population, an ethnographic design was not appropriate. Additionally, a phenomenological researcher explores a population's lived experiences (Bell et al., 2018), which was not suitable for my study because I will explore an analysis of the research population's experience and not the express lived experiences of individuals.

Population and Sampling

Qualitative researchers use purposeful sampling to select and enlist participants (Petty et al., 2012). Purposeful sampling is useful for assisting researchers in understanding phenomena by focusing on the unique characteristics of the population (Koch et al., 2013). A purposeful sample was optimal for my study to ensure that participants had prior experience with or knowledge of DSM practices before being deemed eligible.

In case studies, the sample size is dependent on the ability to capture a thorough description of the phenomenon, and a small sample size is often appropriate for investigating the phenomena (Yin, 2018). For my study, three general managers of electric utilities in the Midwestern United States were interviewed. In qualitative case studies, determining an exact sample size is difficult, because researchers typically continue investigating until their results indicate no new information (Marcella & Kelly, 2015). Therefore, a small sample size is justified based on data saturation.

I based my participant selection criteria on the objectives of my study. Potential participants for this study were contacted through the utility companies with which they are employed. I reached out via email, at which point the participants were screened for eligibility. Those who do not meet the eligibility requirements were informed, and those who did were asked to set up a time for the interview. This recruitment process continued until the study has at least three participants. All participation in this study was voluntary.

Ethical Research

Informed consent is a process the researcher uses to obtain permission from an individual to participate in a research study (Schrems, 2014). Before completing the interview, participants were required to complete an informed consent document stating they had been debriefed, they understood their rights and roles as human subjects, and had been allowed to ask questions. The briefing included an overview of the manners in which this study could contribute to the larger field. Participants who were not willing to take part in this informed consent process were not able to continue with their interviews. There were no incentives and participants were given the right to withdraw at any time until member checking is complete (see Drake, 2013).

I assigned unique identifiers to each participant's interview information. Any information about participants that were not contained within an encrypted location had the participant's name removed. To protect participants, each participant was assigned the letter "P"for "participant" and an assigned number/letter combination (e.g., P1., P2., P3., etc.). These letter/number combinations were used to identify different participants throughout the final doctoral study. Protecting the identities of participants in this study is important so participants in this study remain anonymous. I also complied with all requirements for research per the Walden University IRB. Walden University IRB's approval number for this study is 12-23-20-0760208, and it expires on December 22, 2021.

Protecting the confidentiality of the participants is crucial in the research process (Silverman, 2016). Data were password protected and stored in an encrypted file on my computer. No personally revealing information was used to match participants with their data at any point during this study. All data were kept confidential and stored in an encrypted file on my computer during the study and then destroyed following analysis.

Data Collection Instruments

Data collection is a critical element in case study research (Yin, 2018). I was the primary data collection instrument in this study. Quinlan et al. (2019) postulated the researcher as the primary data collection instrument is a widely used practice in qualitative studies. As the key instrument, researchers must serve as the interview facilitator while acquiring participants' perspectives of the study phenomenon (Yin, 2018). Semistructured interviews are utilized by researchers to allow participants the opportunity to share personal experiences regarding a specific set of questions regarding a phenomenon (Njie et al., 2014). For this research, an interview guide was developed based on recent, peer-reviewed literature related to the subject of organizational management in the electrical utility field, as well as experiential knowledge based on the research question.

Researchers utilize pre-established questions with semi structured interviews to reduce interviewer bias (Doody & Noonan, 2013). The interview questions and semi structured interview guide designed for this study assisted when acquiring participants' perceptions of DSM. In case studies, semi structured interviews are a guide to address topics related to the overall study (Redshaw & Frampton, 2014). I collected data using semi-structured interviews with open-ended questions and physical documents.

Dabic and Stojanov (2014) explained within qualitative case studies, researchers should conduct interviews and access various documents (i.e., physical sources) as vital sources of input. In addition to conducting interviews, I collected physical documents for data triangulation. These physical documents consisted of pamphlets and brochures explaining the utility's DSM programs, as well as descriptions of the programs from each of the utilities' webpages. These helped in the process of triangulation.

Interviewers should select a site conversant with the participants (Chenail, 2011). Doody and Noonan (2013) stated the location researchers select to conduct interviews is important to the participants. As a means of member checking, I read their responses again to confirm data authenticity and accuracy. Member checking can be characterized as a practice researchers exert to confirm interviewer findings with actual study participants for authenticity and accuracy (Marshall & Rossman, 2014). I asked participants follow up questions to ensure they understood the questions I was asking them. I emailed a summary of my interpretation of the individual interview responses to each study participant as a means of member checking for authentication, ensuring data reliability, and validity.

Data Collection Technique

Data collection consisted of the implementation of semi structured interviews with participants. All interviews were performed following the interview guide while field notes were being taken by the researcher during interactions with participants. Interviews were recorded using a telephone recording application for later transcription and analysis.

My interviews included asking open-ended questions to collect data and gain insight from business managers of electric cooperatives. Siedman (2012) explained open-ended questions are helpful to allow participants to share constitutive details of experiences related to the phenomenon under review. Through open-ended questioning, CEOs may feel free to provide in-depth study topic responses (Yin, 2018).

The data for this study was recorded using a voice recording application. The recording was then transcribed into a Microsoft Word™ document. I used a journal as an additional source to log participants' responses and fully document any expressive cues during my interviews. Personal field notes can complement interview recordings to ensure a high level of accuracy and consistency (Petty et al., 2012). To ensure accuracy, I used the journal as an additional source of data collection. Each interview lasted approximately one hour. Wahyuni (2012 referenced interviews should not be more than 90 minutes and Yu (2012) stated at least 25 minutes should be used for interviews.

Data Organization Techniques

The data for this study was organized as both mp3 files and Microsoft Word™ documents. All of these files were hosted in an encrypted folder for which only the primary researcher has the password. The files were organized in the order of their assigned letter/number sequence followed by the word “interview” starting with “P1_interview”.

Researchers organize participants’ input based on categorical themes (Bernauer, 2015). Throughout the analysis process, the data was reorganized in groupings to reflect themes. The distillation of themes occurred through listening to the audio multiple times and performing multiple readings of the transcriptions. Separate notes were taken on each interview. I used a reflective journal for capturing and reviewing notes to expand my understanding of the study topic based on participants’ insight. Al-karasneh (2014) explained researchers use reflective journals to experience a heightened level of intellectual knowledge.

Once the interviews had been sufficiently analyzed, all emergent themes were categorized within a Microsoft Excel™ spreadsheet. Relevant information was be included with each theme, including the number of participants who mentioned it, the total number of times it was mentioned, and relevant quotes that help to explain the theme.

Researchers hold a position to ensure confidentiality among their collected research data sets (Beskow et al., 2012). Moreover, participants’ information and data should remain confidential via a secure measure (Laurila et al., 2012). I ensured the safeguarding of participants’ data by saving raw data used in the study in a safe for five years following the study.

Data Analysis

Based on the qualitative case study design and semistructured interviews being conducted, data were analyzed to understand the study's purpose. Instead, Baskarada's (2014) content analytical approach will be used to code and organize data. Data analysis also allows for greater flexibility in comparing multiple sources and types of data, which was appropriate in the case of the current study, which sought to triangulate evidence from semi-structured interviews, observations, and field notes taken by the researcher. Data analysis in the current study draws specifically from Baskarada's (2014) method, which involves the following phases:

1. Planning the data analytical process based on the content emerging from the case study.
2. Designing the coding and thematical analytical process, preparing data by organizing and classifying results based on initial themes.
3. Analyzing data based on sub-themes and verifying these themes.
4. Sharing and disseminating themes through both tabular and/or conceptual models that best depict the data and then annotating this evidence in a narrative format.

An attempt was also made to identify conceptual trends and distinctions to construct classes, series, procedures, or trends emerging from the combination of interview data that has been collected from this sample of general managers of electric utility companies in the Midwestern United States. Several specific techniques were used to analyze this data-dependent on the nature of the sample's responses following the semi-structured interviews. These include the matching of patterns, building explanations, analysis of time series, logic models, and cross-case analysis (Baskarada, 2014). A combination of these techniques was used in the current study based on the nature of the results.

I conducted data triangulation as a process of analyzing data to ensure an accurate portrayal of participants' input. Triangulation is used by researchers as a method for converging multiple sources of information (Yin, 2018). The utilization of multiple sources of data assists in understanding the topic of DSM in the electric utility industry.

Reliability and Validity

Although ensuring reliability and validity within qualitative methods is different than doing the same for quantitative methods, it is just as important (Bell et al., 2018). These concepts are also related to the *trustworthiness* of a qualitative study, which is similarly a measure a measure of the *credibility, dependability, confirmability,* and *transferability* of the data produced by a study (Ghauri et al., 2020). The actual strategies for ensuring reliability and validity within qualitative research act as checks of authenticity and bias throughout the research process (Ghauri et al., 2020). In this way, these strategies can reasonably confirm all results truly reflect the phenomena under investigation.

Reliability

Reliability refers to the consistency of participant answers throughout the study as well as how a researcher works to minimize their impact on the study. The recognition of bias is an important aspect of the phenomenological process which increases reliability

(Yin, 2018; Bell et al., 2018). Researchers are then better able to fully comprehend the experiences of participants, which allows them to produce, comprehend, and analyze data more reliably (Ghauri et al., 2020).

Validity

The process of defining researcher bias is also important for ensuring validity, which refers to how well aligned the results are with the data (Bell et al., 2018). Furthermore, the validity of this study was critiqued through thorough record-keeping, the inclusion of quotes within the final manuscript, and the engagement with other researchers and the participants in terms of their perceptions of the study (Ghauri et al., 2020; Yin, 2017). The final strategy was to utilize bracketing to ensure the researchers' biases are acknowledged and kept in check. The following sub-section contains a transition and a summary of the contents of this section.

Credibility

Credibility in a qualitative study refers to the extent to which the data is an authentic representation of the experiences of the subjects and the phenomenon under consideration. For example, one question to potentially be asked is whether the researcher used rigorous analytical methods to develop the key themes and findings of the study (Ghauri et al., 2020; Vaismoradi et al., 2013; Yin, 2017). Trustworthiness also relies on the researcher minimizing bias by, for example, refraining from asking leading questions that could corrupt the reported qualitative data. Credibility in the present study was achieved with the semi-structured interview method. Bias was minimized by the researcher framing the prompts as neutrally as possible.

The process of member checking will enhance the study's research credibility. Member checking is a process researchers use to assure the credibility of data (Torrence, 2012). Ghauri et al. (2020) suggested member checking is the most formal way of ensuring the credibility of research data. To ensure credibility, I asked participants to review a summary of their interview responses via transcript review.

Transferability

Transferability refers to the extent to which the findings of the study can be applied to other contexts, including professional practice, and future research. Achieving transferability requires a thorough description of data so the parameters of the context of the study are made extremely clear (Ghauri et al., 2020; Vaismoradi et al., 2013; Yin, 2018). Transferability can enable professionals and researchers to discern other contexts in which the findings of the study can be applied, including the elements of translation across contexts that would be required to effectively apply the findings. Transferability in the present study was achieved by specifying the intersectional identity of the subjects and the specific parameters of the population and sample for the study. The qualitative methodology presents inherent limitations to transferability, but the present study describes the selected context and methods used by the researcher as thoroughly as possible, so this limitation was overcome to at least some extent.

Dependability

Dependability refers to following a reliable procedure across the study to generate the data and findings of the study (Ghauri et al., 2020; Vaismoradi et al., 2013; Yin, 2018). The present study achieved dependability by recording the semistructured interviews with the subjects with an audio recorder and then keeping careful coding notes throughout the data analysis process, which were then checked against transcripts of the audio recordings. Dependability helped ensure arbitrariness in the analysis and interpretation of the data was kept to a minimum.

Confirmability

Finally, confirmability refers to the extent to which other researchers would be able to follow one's procedure to produce similar or compatible findings (Ghauri et al., 2020; Vaismoradi et al., 2013; Yin, 2017). The present study achieved confirmability in part by achieving dependability, but the researcher also presented the findings of the study as clearly as possible and ensured competing interpretations or tensions within the responses of the subjects were duly noted. Confirmability helped provide signposts and benchmarks for future research conducted on the selected topic.

Data Saturation

I collected input from identified participants until data saturation was achieved. Data saturation represents the point during the data analytic process at which further analysis no longer yields new codes or themes related to the phenomenon of interest (Yin, 2018). For scholarly research, data saturation occurs at the point of redundancy among interview participants (Dworkin, 2012). Bristowe et al., (2014) suggested researchers should continue seeking participant responses until they achieve data saturation. I interviewed three general managers of distribution electric utilities located in the Midwestern United States. I found this provided sufficient input to understand and postulate study results without the emergence of any new themes. For my study, interviews continued until participants no longer provided any new information. When evaluating data, a thematic analysis took place until no new themes emerged.

Transition and Summary

This section included a description of the project to be employed, including the methods, methodology, and design. The purpose statement was reiterated first, followed by the role of the researcher, and a description of the sample. The research method and design were then discussed in detail, followed by the population, and sampling techniques. Data collection instrumentation and analysis were then outlined and methods for ensuring study validity are presented.

A qualitative, multiple case study design was employed in this study to address the purpose and central research question. A purposeful, non-probabilistic sampling approach was employed to locate three general managers of electric utility companies within the Midwestern United States. All participants were subjected to semistructured interviews led by the research, and field and observational notes will be collected to gain a comprehensive understanding of the research phenomenon. Data were analyzed according to a stepwise and evidence-based process of identifying codes and themes which best depict the nature of the phenomenon. All stages of the research were carried out by the researcher and reliability checks were performed with the assistance of third-party researchers.

Section 3: Application to Professional Practice and Implications for Change

Introduction

The purpose of this qualitative multiple case study was to explore strategies distribution electric utility leaders use to reduce demand billing charges from their power providers, addressing the underutilization of DSM practices, which can affect the potential for the industry to reduce costs and increase profitability. Without strategies to reduce demand billing charges from their power providers, utility profitability can be descreased through higher infrastructure costs and increased the peak load (Javaid et al., 2018).

The convenience sample in this study included three general managers of three electric utility companies located in the Midwestern United States. Three major themes emerged to indicate strategies distribution electric utility leaders use to reduce demand billing charges from their power providers. The major findings were (a) residential demand billing is used to promote peak-shaving, (b) education is used to make demand billing more acceptable to consumers, and (c) incentive structures are tailored to ensure utility company costs are reduced or recouped.

Presentation of the Findings

The central research question used to drive this study was "What strategies do distribution electric utility leaders use to reduce demand billing charges from their power providers?" Interview data and archival documents were collected from three electric utility leaders from three electric utility companies. To maintain the confidentiality of participants' identities, alphanumeric codes have been substituted for their real names.

The participants’ code names were P1, P2, E2, P3, and E3, with P2 and E2 both representing the second case organization, and with P3 and E3 both representing the third case organization.

The classical content analysis approach recommended by Baskarada (2014) was applied to the data to identify categories inductively. In the first step, the analysis approach was planned based on the content that emerged from the case study. Data collected in this multiple case study included interview data and archival documents from the general managers of three electric utility company case organizations. The interview data were transcribed verbatim into Microsoft Word documents. The archival documents were converted to pdf documents. These source documents were imported into NVivo 12 software for analysis.

The second step of the classical content analysis involved initial coding. The data from the first case organization was read and reread. Phrases from the transcripts and archival documents were assigned to an NVivo node when they expressed meanings relevant to addressing the research question. Each NVivo node represented a code. When different phrases or groups of consecutive phrases from the source documents expressed similar meanings, they were assigned to the same code. In this way, initial codes were identified inductively through the recognition of patterns of meaning in the data, per Yin’s (2017) recommendation that data analysis should remain flexible and adaptable to data content. The initial codes were labeled descriptively to indicate the meaning of the data included in them. Table 1 indicates the 15 initial codes identified after this step was conducted with the data from all three case organizations. Findings from the within-case analyses are discussed in the following sections under cross-case theme headings.

Table 2

Initial Codes

Initial code (alphabetical list)	# of case organizations included (*N* = 3)	# of data excerpts included
Cost-savings as an incentive	1	5
Demand rates do not reduce kWh sales	1	2
Demand rates do not typically increase costs to members	2	3
Demand rates promote fairness	2	7
Demand-side water heater controls	3	10
Educating staff so they can educate members	2	6
Enabling members to make informed choices	3	11
Explaining demand to members	3	19
Flexible billing structures	2	3
High cost of solar power	3	9
Need for member awareness	3	13
Noncoincidental demand billing	2	4
Recouping costs	3	9
Residential demand rates defray demand rates for utility company	3	9
Tailoring billing through rebates as incentives for demand-side control	3	7

The third step of the classical content analysis involved the identification of overarching categories or themes by grouping the initial coding categories. Initial codes were grouped when they indicated different aspects of a comprehensive pattern of meaning in the data. In NVivo, related initial codes were assigned as child nodes to a parent node that represented the theme. After themes were identified in the interview and archival data from the first case organization, the analysis proceeded with initial coding and theme identification for the data from the second and third case organizations. The data from those participants were sorted into the initial codes and themes identified in the data from P1 when appropriate. When new initial codes or themes were identified in the data from the later participants, new nodes were created for them in NVivo, allowing the analysis process to remain flexible to any variations between case organizations. After the data from the three case organizations were coded and themed, a cross-case analysis was conducted to identify points of convergence and divergence across the three cases. Table 2 indicates how the 15 initial codes were grouped to form the three major, cross-case themes during this step.

Table 3

Initial Codes Grouped into Cross-Case Themes

Cross-case theme Initial code grouped into theme	# of cases included (*N* = 3)	# of data excerpts included
Theme 1: Residential demand billing is used to promote peak-shaving	3	34
Cost-savings as an incentive		
Demand rates do not reduce kWh sales		
Demand rates promote fairness		
Enabling members to make informed choices		
Residential demand rates defray demand rates for utility company		
Theme 2: Education is used to make demand billing more acceptable to consumers	3	41
Demand rates do not typically increase costs to members		
Educating staff so they can educate members		
Explaining demand to members		
Need for member awareness		
Theme 3: Incentive structures are tailored to ensure utility company costs are reduced or recouped	3	42
Demand-side water heater controls		
Flexible billing structures		
High cost of solar power		
Noncoincidental demand billing		
Recouping costs		
Tailoring billing through rebates as incentives for demand-side control		

The fourth step of the analysis involved creating a presentation of the findings. The findings are presented with tables indicating initial code and theme frequencies, a saturation grid to indicate which participants contributed to each code and theme, and a narrative discussion of each theme. The discussion of each theme includes evidence in the form of direct quotes from the data from each of the three case organizations. Convergences and divergences identified in the cross-case analysis are discussed. The remainder of this presentation of the results is organized by theme.

Theme 1: Residential Demand Billing is Used to Promote Peak-Shaving

Participants from all three case organizations indicated that residential demand billing to promote peak-shaving is an effective strategy that electric utility leaders use to reduce demand billing charges from their power providers. Demand billing is determined by the highest power generation capacity demanded at any time during a given interval, rather than by the total number of kWh consumed during that interval and peak-shaving is a practice used to lower the peak demand and thereby reduce demand billing charges to the electric utility company (Corbett et al., 2018; Javaid et al., 2018). Participants in this study stated that demand billing was the most effective strategy because it allowed consumers to save money by helping to lower the peak load, thereby incentivizing cooperation. This strategy was consistent with the DR practice of incentivizing consumer participation peak reduction to reduce utility company peak load (see Eid et al., 2016; Muratori & Rizzoni, 2016). As a DR practice, incentivizing the reduction of peak load by residential consumers was an example of the IDSM approach (see Potter et al., 2018). Table 3 indicates the findings from the three case organizations about this theme. The following subsections are discussions of the within-case analyses, followed by a summary describing the cross-case analysis.

Table 4

Theme 1 Within-case Analysis Results

Cross-case theme Initial code grouped into theme (alphabetical)	*n* of references to theme or code by case		
	CO1	CO2	CO3
Theme 1. Residential demand billing is used to promote peak-shaving	3	15	6
Cost-savings as an incentive		5	
Demand rates do not reduce kWh sales		2	
Demand rates promote fairness		5	1
Enabling members to make informed choices	3	5	2
Residential demand rates defray demand rates for utility company	3	1	3

Case Organization 1

Demand billing through Case Organization 1 (CO1) was implemented by charging customers a higher rate per kWh during specified peak hours. In interview responses, P1's focus was on residential demand billing as a means of enabling customers to make informed choices. P1's concern with allowing residential consumers to make informed choices was associated with the potential future practice in CO1 of allowing customers to choose whether they wanted to pay for electricity through demand billing or traditional billing. To enable customers to make an informed choice, P1 stated that CO1 was considering providing a sample of customers with both a demand bill and a traditional bill: "They're going to select some members to receive two bills, one with demand billing and one without, and the member gets to decide which one they want to pay for a while."

Archival documents collected from CO1 also emphasized enabling consumers to make informed choices as part of the reason for demand billing, but the materials further indicated that the purpose of demand billing was to reduce or offset the power providers' demand billing charges to CO1. The document entitled *Demand*, in which demand billing was explained to residential consumers, indicated in part that CO1, "Has always billed members for the demand charge, it just wasn't a separate line item on the bill. We have always had to recover the demand charge that our power provider bills us through the kWh charge." The same document indicated that demand billing was being implemented to allow consumers to make informed decisions about their electricity usage as a means of reducing the demand for which they were billed:

> Now, thanks to new meter technology, we can bill each household for the demand that they are using. This way members have control of their demand charge and can take advantage of reducing the demand during critical peak times and save on the electric bill.

P1 stated that the goal of implementing demand billing was to lower CO1's peak load (kW) as opposed to overall power consumption (kWh): "If we can get more members to use more capacity in the times where we got no chance of hitting a peak, that'd be great." The archival document entitled *Understanding Demand* indicated this goal to consumers in describing the relationship between peak demand and infrastructure costs: "Certain appliances—such as HVAC units, electric ovens and clothes dryers—demand significant power from the grid. That's why not running them at the same time is important to minimize the Demand Charge."

Case Organization 2

Data from CO2 included the most references to Theme 1 of the three COs. P2 stated that residential demand billing was used to incentivize load shifting among consumers: "The cheapest and the most effective option for our members is to shift the usage of their larger appliances to outside of the peak hours." P2 stated that switching to demand billing from traditional billing incentivized peak-lowering among residential consumers because "Those seeing the increase [in their bill amount when demand billing is implemented] do have the ability to shave peak and lower their bill." An infographic expressing the relationship between demand and infrastructure costs appeared in an archival document from CO2 entitled *Demand Rates/Rate Increase* in the form of a table, which depicted that using a 100-Watt light bulb for 10 hours required 1 kWh. The bottom row depicted 10 100-Watt light bulbs being activated for one hour, resulting in the same expenditure of 1 kWh, but representing 10 times the demand as the single bulb's use of 1 kWh over 10 hours.

P2 discussed the relationship between residential demand billing and lowering the utility company's peak in stating, "There are two reasons you put in demand rates: One reason is to shave the utility's peak . . . set the demand high enough where they [the utility] got some shaving." P2 added that the second reason for implementing demand rates was, "to charge a fair rate" to consumers whose peak demands contributed disproportionately to the utility's demand costs. P2 contrasted a voluntary DR program with cost savings as an incentive for the residential consumer with a program CO2 had implemented in the past that did not include an incentive:

> We'd asked our members to shave peak for the benefit of their utility. Well, that didn't benefit the members at all personally . . . there was no carrot to offer. Just be nice to us and shave peak for the utility.

In contrast, residential demand billing offered the consumer an incentive to shift as much of their load as possible outside of peak hours: "What I liked about this program is if they shaved peak, they saved money and it's voluntary." P2 stressed the benefit of enabling consumers to make informed choices associated with a higher billing rate during peak hours: "By assigning time-of-day demand rates that match when you peak, you're giving your members the option to shave peak and have more control over their bills."

Case Organization 3

Data from CO3 were focused on the effectiveness of residential demand billing as a means of reducing peak load for electric utility companies. P3 said of demand billing from the power provider to CO3, "That's essentially how [CO3's power provider] gets paid. They get paid 100 percent through our demand usage, so what that means is if we reduce . . . those demand revenues to [power provider], they didn't get them." Of the greater effectiveness of residential demand billing in lower peak load versus other potential strategies, P3 stated that it depended on giving consumers a choice and incentivizing the reduction of peak load through cost savings:

> [Residential demand billing] is a tool that if you use it correctly, which we strive to do, is that you're giving members another choice in how they can control their costs, and it is a choice. I mean they can choose to do nothing about it and use what they're going to use whenever they use it or they can be conscious about it,

shift the usage around, and have a direct impact on their costs.

Concerning the fairness of residential demand billing in distributing the CO3's demand costs equitably among consumers, P3 stated, "It levels the playing field in making sure that the higher demand members are paying for more of their share of the demand portion of our bill." In the archival document entitled *Introducing Demand Charges*, the same infographic provided in CO2's document was reproduced to indicate the relationship between demand and infrastructure costs. The CO3 archival document entitled *Energy Demand FAQs* also included text indicating the relationship between demand and utility company expenditures as part of the rationale for introducing residential demand billing: "CO3's wholesale rates are based on total co-op demand, demand (the rate at which electricity is used) and the total energy consumed." The relationship between the co-op's wholesale rates and consumer behavior was indicated in text from the same document reading, "Some members create more demand by using more appliances at the same time and as a result, a higher electricity demand." The same CO3 archival document indicated fairness for consumers as the second rationale for demand billing, stating, "Unbundled charges for demand more fairly distributes the costs of providing service to those members who use large amounts of electricity at one time."

Cross-Case Analysis

Archival documents and interview data from all three case organizations indicated that the purpose of residential demand billing was to reconcile two competing needs. The first need was to reduce or offset the utility company's wholesale rate, which increased as peak load increased. Data in this study and the findings of previous researchers have indicated that lack of DSM practices results in higher peak loads, with Javaid et al. (2018) finding that lack of effective DSM resulted in peak loads almost 38% higher. Consistent with the findings of researchers such as Muratori and Rizzoni (2016), Corbett et al. (2018), and Eid et al. (2016), and Potter et al. (2018), findings in this study indicated that DR practices are an effective means of reducing demand charges for utility companies by reducing peak load. The findings were also relevant to operational management theory, the conceptual framework in this study, as indicating a strategy for updating the input of financial support to reduce the risk of purchasing or investing more on the input and operational side of an industry (Machado et al., 2017; Meredith, 1998; Meredith & Shafer, 2015; Voss, 1995). The findings in this study extended those of previous researchers by indicating participants' perception that residential demand billing was perceived as the most effective DR strategy for reducing peak load or offsetting demand charges to the utility company. Residential demand billing was perceived as effective because it reconciled the goal of reducing demand billing charges from the power provider with the goal of consumer protection through fairness and choice. Residential demand billing enabled consumers to make informed decisions about whether or not to shift part of their load outside of peak hours. The potential for cost savings incentivized such redistribution. If consumers made the informed decision not to reduce their peak demand, demand billing offset the resulting demand billing charges to the utility company through payments from the customers who were responsible for them, rather than distributing them across all customers.

Theme 2: Education is Used to Make Demand Billing More Acceptable to Consumers

Data from all three case organizations indicated that a significant barrier to implementing the effective strategy of residential demand billing to reduce demand billing charges for the utility company was that many customers were unaware of how demand billing worked. When customers were billed demand rates without understanding how or why demand billing was implemented, participants reported that they received pushback, often in the form of phone calls and other communications from concerned or confused consumers. Javor and Janvic (2016) found that while DSM approaches (e.g., residential demand billing) may address peak energy demands and establish customer choices in shifting energy usage to reduce electricity costs, consumers must have sufficient information to engage in informed decision-making. Findings in this study indicated that participants were aware that meeting consumers' informational demands was necessary for establishing customer choices and reducing pushback against residential demand billing. Table 4 indicates the findings from the three case organizations concerning this theme. The following subsections are discussions of the within-case analyses, followed by a summary describing the cross-case analysis.

Table 5

Theme 2 Within-Case Analysis Results

Cross-case theme Initial code grouped into theme (alphabetical)	*n* of references to theme or code by case		
	CO1	CO2	CO3
Theme 2: Education is used to make demand-rate billing more acceptable to consumers	8	15	12

Demand rates do not typically increase costs to members		1	2
Educating staff so they can educate members		4	2
Explaining demand to members	5	10	4
Need for member awareness	5	3	5

Case Organization 1

Data from CO1 was focused on the need for explaining demand to members to ensure member awareness and acceptance of residential demand billing. P1 stated that awareness-raising among consumers was the most important strategy for promoting DSM to reduce demand billing charges for CO1: “We know that the best way for us to experience demand-side savings is with our members is to turn their attention to it and ability and desire to save their bill.” P1 described a strategy to raise consumer awareness of how demand rates influenced costs: We’re going to start putting the demand reading on the residential bills. Now we’re not going to put a charge to it. It’s never going to be the same box where the billing goes. It’s going to be more in the note section, but we’re going to show them when the peak was and how much they were using at the peak in an education campaign.

Strategies already in use at the time of the study to educate members about demand billing included brochures in which demand and its relationship to utility costs were defined. In the archival document Understanding Demand, an analogy was made to a hypothetical household’s Internet bandwidth demand:

> Think about it like your internet service. When one person streams a movie or television show on a device in your home, the stream works perfectly. But as additional people in your home attempt to stream video at the same time, more

bandwidth is needed.

The document Tips to Reduce Peak Demand included suggestions to educate consumers about why and how they should consider load-shifting to lower peak load: "As more appliances in your home run simultaneously, your demand for power increases. This is why it's important to limit the simultaneous use of appliances during non-peak hours." The same document included the following recommendation for residential consumers: "Shift the use of appliances away from higher-cost on-peak demand hours, to lower-cost off-peak hours. This is the most effective way to reduce your demand cost."

Case Organization 2

Data from CO2 was focused on the need for explaining demand to members to ensure member awareness and acceptance of residential demand billing, and also on the need to educate staff members about demand billing so they could relay the information to customers. P2 indicated the high priority placed on giving clear explanations of demand to consumers in stating: "The first question is: What is demand? Utility employees know what demand is, but how do you explain demand rates to our members?" P2 said of the challenging nature of explaining demand to consumers clearly, "I would say just getting the concept of demand, it's just new to people, so just really getting people to understand the concept of demand was hard even though we're explaining it in easy-to-understand terms."

P2 spoke of receiving a large number of calls from consumers with concerns about demand billing, saying of the strategy for addressing customer inquiries, "Most of the calls, they just didn't understand it. So once you could explain it to them and tell them it was about fairness and making sure all members paid their fair share, that seemed to appease a lot of them." The document entitled Demand Rates / Rate Increase indicated the care taken on CO2 to log consumer concerns in text reading, "We need to keep a record of all phone calls received on-demand rates. Summarize the content and note whether it was positive, negative, or neutral."

To meet the challenge of addressing customer concerns and inquiries about demand billing, P2 reported, it was necessary to begin by educating CO2 employees about demand: "We had to learn what [demand] was here in the office first and we spent several months learning what it was, so we would feel more comfortable just telling the members." P2 described a process of conducting a brainstorming session with employees to predict questions customers were likely to ask about demand billing, writing down the answers, and then giving employees who answered customer phone calls time to memorize those responses to ensure clear and consistent messaging.

Case Organization 3

Data from CO3 was also focused on the dependence of effective residential demand billing on consumer education and awareness. P3 said of implementing residential demand billing, "I would say the main challenge there was just educating members on the topic and one of the best ways we did that is we talked about it for a year before it ever went into effect." E3 emphasized the importance of educating members about demand, stating that in CO3 the process involved,

> Education and talking about [demand billing] and explaining the whys and the reasons behind it to get buy-in at every level, from the board to the employees to

> the members. That consistency helps people to understand and not just be upset if the bill goes up, but they understand why and they understand that they're paying what they're costing the co-op.

P3 and E3 both indicated that when determining how much education to provide to members, they preferred to err on the side of excess. P3 described how educational efforts that seemed more than exhaustive to utility company employees might be inadequate for gaining consumer buy-in for demand billing: "When we were educating our members on demand, I thought we were overeducating them and they were sick of it. I was certainly sick of it at the time. And you know what? We probably could've communicated even more." E3 agreed with P3, stating, "When we've done 10 different efforts to talk about it and we feel like it's overkill, [consumers have] probably noticed one of those." P3 added that exhaustive education efforts were also needed to prepare employees to address customer questions and concerns about demand billing: "Our member service reps had no idea what demand was other than what our engineers told them it was on the bill, so it was a big learning curve for our employees." To address employees' informational deficits, P3 stated, "We had to do a lot of training with the employees first [before educating consumers]."

In the archival educational document entitled Energy Demand FAQs, demand was defined as follows: "Demand is the amount of power needed to supply every electrical device running in your home or business at a specific point in time. It is the maximum rate at which your household has consumed electricity." An additional explanation that related demand to infrastructure costs stated, "Equipment to meet members' electrical demand must be on standby and ready to meet any increased need for electricity immediately. This may ultimately include installing additional transformers, wires, substations and even additional power plants.” The same document including text advising consumers, “Managing demand is as simple as being aware and spacing out activities and not running all of the large appliances or equipment at the same time.” A link to an online energy demand calculator application was provided in the online version of the document, and sample bills in the form of infographics were provided to illustrate how demand billing affected charges to consumers.

Cross-Case Analysis

Findings related to Theme 2 were consistent with those of Shaukat et al. (2018) and Barrios-O’Neill and Schuitema (2016) indicating that consumer acceptance and engagement were necessary to the success of implementing demand-side measures to accomplish energy goals. The findings in this study extended those of Shaukat et al. (2018) and Barrios-O’Neill and Schuitema (2016) by indicating the specific strategies implemented in the case organizations to engage residential customers in informed decision-making regarding demand, load shifting, and peak load reduction. Data from all three case organizations indicated that educating consumers about what demand was, how it was assessed, and how it could be reduced was essential to effectively implement the strategy of residential demand billing to reduce demand billing charges for utility companies. Data from all three case organizations further indicated that clearly explaining demand billing to consumers was a significant challenge. Participants described demand billing as counterintuitive to consumers because it was based on generation and distribution capacity requirements rather than the amount of electricity used over an interval of time. Participants suggested that the most effective way to educate consumers about demand billing was to train employees to communicate clear and consistent messages. This finding was consistent with those of Voss (1995) in the OMT theoretical framework in this study indicating that principles of labor included educating employees and intimate cooperation between employees and management. The messages communicated to consumers in archival documents included abstract definitions of demand and analogies to more familiar contexts, such as a household's Internet bandwidth requirements as a function of peak demand rather than the amount of data transmitted over time.

Theme 3: Incentive Structures Are Tailored to Ensure Utility Company Costs Are Reduced or Recouped

Findings from all three case organizations indicated that residential demand billing alone was not an optimal strategy for reducing demand billing charges for electric utility companies. Variations in residential consumers' load patterns associated with existing factors such as water heaters and solar panels, and with anticipated factors such as widespread use of EVs, required further tailoring of billing structures to meet the dual goal of reducing demand rates while maintaining customer awareness, engagement, and participation. Rebates were the primary strategy used in the three case organizations to reduce peak load and ensure equitable distribution of costs among consumers. Table 5 indicates the findings from the three case organizations concerning this theme. The following subsections are discussions of the within-case analyses, followed by a summary describing the cross-case analysis.

Table 6

Theme 3 Within-Case Analysis Results

Cross-case theme Initial code grouped into theme (alphabetical)	*n* of references to theme or code by case		
	CO1	CO2	CO3
Theme 3: Incentive structures are tailored to ensure utility company costs are reduced or recouped	12	8	19
Demand-side water heater controls	6	1	3
Flexible billing structures	1		2
High cost of solar power	2	2	5
Noncoincidental demand billing	3		1
Recouping costs	2	2	5
Tailoring billing through rebates as incentives for demand-side control	1	3	3

Case Organization 1

Data from CO1 was focused on tailoring billing structures through the strategies of offering rebates, particularly for the installation of demand-side water-heater controls, as well as noncoincidental billing and ensuring equitable billing for consumers who derived part of their power supply from solar panels. P1 described demand-side water-heater controls as a system that enabled the utility company to stop power transmission on an as-needed basis to water heaters in the households in which they were installed to lower peak load. P1 stated, “It’s like a rolling blackout for water heaters” in which a utility company employee would, “Control for a certain period and try to not make that too many hours.” Specifically, P1 stated, the system, “Controls a certain percentage of water heaters. It doesn’t shut them all off at the same time. It only shuts them off for 15 minutes, 30 minutes, and those water heaters can hold hot water for a long time.” P1 indicated that the incentive for consumers to participate in the program was a rebate that allowed them to purchase a new, high-quality water heater at a reduced rate. The archival document entitled "Water Heaters" specified the following rebate rates for electric water heaters that met the program requirements: "Electric Replacement $100.00; New Construction $150.00; Gas Replacement $200.00." Program requirements listed in the same document included, "All-electric water heaters must be 40 gallons or larger to receive a rebate," "Appliances must be Energy Star©," and, "Water Heaters must be .90 efficiency or higher."

Concerning solar power, P1 described a program that allowed residential customers who could not afford or did not want to invest in an expensive, home-based solar array to invest as part of their power bill in a community solar array. P1 said of this program, "That's demand savings that we can achieve through the year based on the fact that whatever we generate ourselves, we don't have to buy from [power provider], it's going to be a winner for us over time." CO1 also offered a rebate for EV chargers, P1 stated: "We've got a new electric vehicle charger rebate, which honestly the early adopters are about to buy these car chargers anyway, but we need to know what they're going to charge them." P1's response was notable for the emphasis is placed on the information-gathering purpose of the EV-charger rebate program, which P1 described as a means of learning when consumers charged EVs to predict loads.

Case Organization 2

P2 discussed the implementation of residential demand billing as a means of ensuring that a fair share of demand billing charges was recouped from consumers who had solar panels installed on their homes: I just ran the numbers just last week on what our members are paying for solar and the average cost is $27,500 and our poorer members can't afford that, so this potential cost shift to our poorer members is something we wanted to address. If we can limit this cost shift now before solar becomes prevalent, we'll be sending the right cost signals to those who want to invest in solar. Once we limit this cost shift, and the solar users are paying more of their fair share.

P2 explained that solar users consumed fewer kWh than other customers who did not use solar power, but that solar users contributed significantly to demand billing charges for the utility company when weather conditions limited solar power production. Without residential demand billing, the cost of solar users' occasional but significant demand was shifted to consumers who did not use solar power. In describing how demand billing ensured that solar users paid their fair share, P2 offered the example of a specific solar user, stating,

They're paying $112 in kilowatt-hour charges for a year, and you'll see that there are eight months that they paid zero for kWh because their solar panels generated more than their house needed. So, if we did not have demand rates, this would have been our revenue for that member. But because we have demand rates, we collected an additional $364 for their peak demands.

P2 described demand versus kWh billing rates as carefully calculated at CO2 to ensure equity for consumers while at the same time covering expenses for the utility company. P2 stated, "Our cost-of-service study showed that we only needed to charge a kW demand of $5 to recover our wholesale demand charge. This is because of the diversity of when our members peak." The careful and continual calibration of billing rates maintained revenue neutrality for CO2 during the changeover to demand billing, a factor P2 described as important for consumer acceptability: “We didn’t want our members to think that we were gouging them . . . We wanted to make sure that we could lower the kilowatt-hour at the same time we raised the kW, so it’s revenue-neutral.” P2 also described the use of rebates for EV chargers in stating, “We basically have an incentive for people to not charge their electric cars during demand hours. They can charge their car overnight. They can put it on a timer.” The rebate program contributed to reducing demand billing charges for CO2, P2 stated, “Making sure our members that do put in electric car charges in their home, making sure that they are aware of the demand hours and how they can charge off-peak.”

Case Organization 3

Data from CO3 indicated a comprehensive approach to structuring incentives, involving rebates, demand-side water-heater controls, and accounting for consumers who installed solar arrays. Of the water-heater control program, E3 stated that it involved selling residential consumers who opted to participate a high-quality water heater at a deeply discounted price: “Initially we’ve sold them the water heater at a very steep discount and then they signed a service agreement where they’re enrolled and they’re just billed every month $2.50, and it’s an initial three-year contract.” E3 explained the monthly service fee program: “If [consumers] have any issues with their water heater, we have a contractor who will come out and fix it or replace it if it can’t be fixed.” The water-heater program at CO3 had been ongoing for more than 20 years, P3 stated, adding of the benefit of offering the discounted appliance and affordable service subscription for

CO3: “We put switches on all of our electric water heaters . . . at [peak] time, we were able to go in and shut those water heaters off to reduce [CO3’s] peaks.”

P3 reported that CO3, like CO1, had a community solar array: “We set up a program with our membership to where they could buy the energy out of that solar array, or they can own the production from those panels for the next 25 years.” P3 stated of solar users generally, “They’re trying to reduce their kilowatt-hours [kWh] by adding solar to their home, but there are times that that solar member, the sun’s not going to shine. It’s going to be cloudy for several days at a time.” When the weather was overcast, P3 explained, solar users, “Are relying on the utility to provide their demand. So what happens is that member will set a demand . . . and we’ll capture that demand, and essentially they’ll have to pay on that fixed cost.” Thus, the utility company recouped demand billing charges from the power provider in part by implementing demand billing for solar-using residential customers whose contributions to demand were unlikely to be reflected in their consumption of kWh.

P3 also indicated that all-electric utility companies needed to be fixed costs associated with demand and that in traditional billing by kWh, the fixed costs were built into kWh rate. The traditional billing structure was problematic for utility companies, P3 stated because reductions in kWh consumption reduced their ability to recoup the built-in fixed costs:

> When you look at a traditional rate, you’ve got a lot of your fixed cost built into the variable rate structure, so what happens when you get a mild winter or you get a mild summer? You don’t sell as many kilowatt-hours [kWh] and it’s very

difficult to recoup your fixed costs.

P3 said of implementing a demand rate structure that addressed this challenge and allowed CO3's fixed costs to be more reliably recouped: "With the demand rate structure, we've built-in, based upon the member's usage specifically in their demand, to give us some of that fixed cost back every single month regardless of what the weather does."

P3 reported that the incentives offered through CO3 included rebates for EV chargers. P3 stated that an agreement was bundled with the rebate to ensure the reduction of peak load: "Part of that rebate is the member agrees to use that programmable charger between 10 PM and 6 AM to shift that usage to a time that doesn't impact our peak demand members." E3 said of the importance of the rebate incentive program in ensuring that CO3's demand billing charges were reduced or recouped, "One EV can very easily double a household's demand. We set ourselves to be ready for that in terms of the cost recovery when it happens, so I feel like we've done a really good job positioning ourselves."

Cross-Case Analysis

Data from all three case organizations indicated that tailoring incentive structures to reduce or recoup utility company costs was a strategy that electric utility leaders used to reduce their demand billing costs. Incentive programs were set up to engage residential users' participation in addressing specific challenges. One such challenge was the large increase that water heaters made in peak load when they operated during peak hours. This challenge was addressed in all three case organizations by offering residential customers rebates on water heaters with built-in controls that allowed the utility company to deactivate them during peak hours as needed. A second challenge was that solar users' contributions to demand were not being recouped from traditional billing by kWh. Implementing demand billing for residential solar users addressed this challenge and ensured that solar users paid their fair share of demand billing charges. A third challenge was the increasing prevalence of EVs, which all participants expected to become increasingly common. When EVs were charged during peak hours, their addition to peak load could be significant. All three case organizations, therefore, used rebate programs for EV chargers to incentivize consumers' charging their EVs outside of peak hours, by making the rebate conditional on an agreement that the user would charge the vehicle only at night. Like the findings under Theme 2, findings related to Theme 3 were consistent with those of Shaukat et al. (2018) and Barrios-O'Neill and Schuitema (2016) indicating that consumer acceptance and engagement were necessary to the success of demand-side measures to accomplish energy goals. The findings in Theme 3 extended those of Shaukat et al. (2018) and Barrios-O'Neill and Schuitema (2016) by indicating the incentive structures implemented in the case organizations as strategies to engage residential customers in informed decision-making regarding demand, load shifting, and peak load reduction.

Applications to Professional Practice

The application of the findings in this study to professional practice is that they indicate specific, feasible strategies that electric utility company leaders have implemented to reduce or recoup demand billing charges from power providers. The specific business problem in this study was that some leaders in the distribution electric utility industry lack or underutilize DSM strategies to reduce demand billing charges from their power providers, a situation that can cause a decrease in utility profitability by compelling higher infrastructure costs and increasing the peak load (Javaid et al., 2018). The lack of DSM strategies adversely impacts the industry's potential to reduce demand billing charges, generate revenue, address the need for renewable energy sources, and secure consumer participation in the generation and transmission of utilities in a cost-effective manner. The findings in this study indicated that a residential demand billing strategy can be used to promote peak-shaving, education strategies can be used to make demand billing more acceptable to consumers, and incentive structures can be tailored as a strategy to ensure utility company costs are reduced or recouped. The findings in this study may apply to addressing the specific business problem and its consequences by indicating strategies that leaders in the distribution electric utility industry may be able to implement to reduce demand billing charges from their power providers.

The general business problem was that DSM practices for residential applications are underutilized in the electric utility industry, which can adversely affect the potential for the industry to reduce costs and increase profitability. The strategies associated with the findings in this study may be used to decrease demand in the electric utility industry, leading to decreased infrastructure costs, which can reduce expenses for both the utility and end-users (Sheikhi et al., 2014). Innovative DSM on the residential level is one step for potentially achieving savings on the input-side of the utility industry (Nguyen et al., 2015). Electric utility company leaders may therefore find this study useful to future DSM analysis and implementation. Utility leadership tasked with administering DSM might also benefit from the strategies identified in this study to implement DSM procedures for managing demand and thereby reducing overall demand costs to the distribution utility from their power providers.

The gap in the literature related to effective DSM strategies to reduce demand billing charges for electric utility companies has left electric utility leaders without guidance in meeting the significant challenges they have encountered when trying to implement DSM (Javaid et al., 2018). For example, consumer participation in DSM strategies is necessary to manage peak load energy demands effectively; yet many consumers do not actively participate (Javaid et al., 2018). To address this challenge, Corbett et al. (2018) recommended exploring the role and impact of consumers regarding different DSM strategies implemented in various utility provider jurisdictions to reduce peak load demands.

Findings in this study have indicated that the role and impact of the consumer are to contribute to load shifting and peak shaving, but that incentives are needed to engage the consumer in voluntary, day-to-day practices to shift loads to off-peak hours. Potter et al. (2018) reported a need for consumer-centric engagement strategies that also benefit the utility company in controlling base and peak load energy demands. Findings in this study have indicated that effective, consumer-centric strategies for engaging customer participation in reducing demand charges include education about demand, as well as residential demand-billing and incentive structures with built-in financial incentives for voluntary consumer participation in load shifting. The application of the findings to business practice is that they may contribute to addressing the professional practice need, reported by researchers such as Javaid et al. (2018), Nguyen et al. (2015), Potter et al. (2018), and Sheikhi et al. (2014), for consumer-centric DSM strategies to engage residential customers in reducing demand billing charges for electric utility companies. The recommended strategies are presented in more detail in the Recommendations for Action section of this chapter.

Implications for Social Change

Projections have indicated a substantial climb in energy use over the next several decades (Chu et al., 2016). In 2012, the global consumption of energy totaled 549 Quad BTUs, with that number expected to increase to 813 Quad BTUs by the year 2040. CO_2 emissions across the globe doubled between 1975 and 2015, and projections have indicated 2015 CO_2 emissions levels may triple by the year 2040 (Chu et al. 2016), although those projections are disputed based on changes in the industrial sector and advancements in electric power systems (U.S. Department of Energy, 2019). Whether or not current CO_2 emissions levels continue to rise, strategies to optimize energy usage are needed to mitigate climate change and provide for future energy needs (Owusu & Asumadu-Sarkodie, 2016). DSM strategies are a highly effective means of reducing electricity demand, with researchers have found that lack of such strategies in the electric utility industry was associated with peak load demands almost 38% higher than when effective DSM strategies are implemented (Javaid et al., 2018).

The implication for social change of the findings in this study is that utility company leaders' implementation of the identified strategies may contribute to a reduction in residential electricity demand, as well as to curbing the expansion of infrastructure needed to meet rising demand. The results of this study may contribute to positive social change by encouraging electric utility leaders to update and implement new strategies for improving DSM practices for benefiting residential applications. With the improvement of DSM, total electric consumption by consumers can be decreased, which can increase disposable income for consumers, as well as have positive environmental impacts with decreased fossil fuel generation. Reducing electric peak load might result in positive social change by reducing the near-term consumption of natural resources electricity suppliers need for power production for future generations (Corbett et al., 2018). Moreover, reduced infrastructure costs for electric utilities may reduce utility expenses, which can lead to reduced electric rates for the end-consumer.

Recommendations for Action

The first recommendation is that utility company leaders implement residential demand billing. Residential demand billing as described in the findings in this study as an effective strategy for incentivizing consumer participation in load shifting to lower peak load, meeting the need described by Potter et al. (2018) for consumer-centric strategies to increase customer participation in meeting energy goals. Residential demand billing involves installing meters that measure consumer demand at regular intervals (participants in this study described meters that measure and log demand at quarter-hour or hourly intervals), averaging those measurements across a given time interval (participants in this study reported averaging across one month or one year), and billing the consumer a fair price to recoup demand billing charges from the power provider to the utility company. Demand billing thereby creates a financial incentive for consumers to lower their peak demand. Demand billing can also be implemented by charging higher kWh rates for electricity used during peak hours, a practice implemented successfully in the first case organization in this study. When a utility company has customers who are solar users, demand billing is effective in ensuring that they pay their fair share of demand costs, findings in this study indicated.

The second recommendation is that utility company leaders consider implementing demand billing through phased, revenue-neutral increases in demand billing that are offset by reductions in traditional billing rates. Findings in this study indicated that this strategy is effective in reducing consumer resistance to demand billing by introducing it gradually and demonstrating that it has not been implemented for the utility company's profit. The revenue neutrality of demand-billing implementation can be demonstrated to consumers through a bill that indicates the amount due under the demand billing structure and the amount that would have been due under traditional rates so the consumer can easily compare the two figures.

The third recommendation is those utility company leaders interested in implementing residential demand billing begin by educating their employees about demand. With employee input, one participant in this study indicated, a list of likely consumer questions about demand can be brainstormed, allowing for the formulation in advance of answers to address customer concerns and inquiries. Customer service representatives can then be given time to learn and understand the pre-scripted answers to ensure clear and consistent messaging about demand in communications with consumers. If feasible, one participant indicated, requiring customer service representatives to log the consumer concerns and questions they address can be an effective strategy for adding to answer scripts if and when new areas of customer concern emerge.

The fourth recommendation is those utility company leaders interested in implementing residential demand billing undertake an extensive campaign to educate residential consumers about demand billing. Educational strategies described as effective by participants in this study included publishing information about demand and tips for reducing it prominently on the utility company website, having the same information printed in brochures, buying advertisement space in local periodicals to disseminate information about why and how demand billing will be implemented, and training customer service representatives to address consumer questions and concerns as they arise. Participants in this study stressed that efforts to educate the community that seem exhaustive or excessive to company personnel may still not be adequate to raise awareness and gain buy-in from customers. Thus, education efforts should be intensive, prolonged, and directed to the consumer through a variety of channels, participants indicated. One participant recommended that educational efforts to build consumer awareness and gain consumer buy-in for residential demand billing were effective when they began one year in advance of demand billing implementation and sustained at an intensive level.

The fifth recommendation is that utility company leaders implement incentive programs to gain passive customer compliance in shifting appliance loads outside of peak hours to the greatest extent possible. All three case organizations in this study achieved this goal in part by offering rebates to customers willing to purchase a water heater that had integrated controls allowing utility company personnel to remotely deactivate the water heater for limited time intervals during peak hours. Participants further suggested the incentivization of timer installation on other appliances, such as dishwashers and washing machines, to cause them to run outside of peak hours. However, none of the case organizations had successfully implemented this strategy for most appliances yet.

The sixth recommendation is that rebates be offered to incentivize active consumer participation in load shifting to reduce peak demand. This recommendation differs from the previous one in that it incentivizes active consumer participation, rather than the customer's consent to passively allow the utility company to remotely deactivate water heaters during peak hours. In all three case organizations in this study, rebates were used as incentives for consumers to agree to charge EVs overnight rather than during peak hours. Participants consistently stated that EV chargers could as much as double a household's demand when in use, so shifting charger use outside of peak hours is an increasingly high priority for utility companies as EVs become more prevalent. By offering rebates on chargers, leaders from all three case organizations in this study were able to establish agreements with rebate recipients to charge their EVs during off-peak nighttime hours.

Recommendations for Further Research

Limitations of this study were associated with its methodology and its delimitations. Qualitative research entails methodological limitations, including the inability of qualitative findings to be generalized from a sample to a population and the inability of qualitative approaches to yield objective findings (Yin, 2017). To address these methodological limitations, it is recommended that quantitative research be undertaken to confirm or disconfirm the findings in this study. By using a validated survey instrument with a sufficiently large, random sample of electric utility company leaders, future quantitative researchers would be able to determine and measure whether and to what extent the findings in this study are generalizable to the population of U.S. electric utility company leaders. Quantitative research of the recommended kind is also recommended for confirming or disconfirming the objectivity and measuring the strength of the correlations and causal relationships suggested by the perceptions of participants in this study, such as the suggested causal relationship between consumer education and consumer buy-in, and between tailored incentive structures and recouping or reducing demand billing charges for the utility company.

The delimitation of this study to a small sample of utility companies in two U.S. states may limit the transferability of the findings to other populations and samples. Transferability must be assessed by readers of the study on a case-by-case basis, by comparing the sample and setting from which the findings in this study were derived to other populations and settings. It is recommended that future researchers replicate this research with utility companies in other geographic settings to assess transferability.

Reflections

I work in the electric utility industry and have experience with energy efficiency and DSM. I selected this research topic based on an interest in learning more about the topic. Since I was close to the topic, I had assumptions and preconceived thoughts regarding DSM for residential applications. Therefore, mitigating personal bias was crucial for my study. I made a list of my potential bias and included them during data analysis. The results show that my biases and assumptions were practical realities.

The doctoral study process was exciting to me. I enjoy learning and this opportunity to learn about something I thoroughly enjoy was a great experience. I did not face any challenges with the selection of participants and interviewing them. The participants I selected were excited someone wanted to learn more about this unique concept.

In my DBA Qualitative Research process course, I was able to practice conducting my study and I learned a lot from that assignment. I then decided to use DSM and demand billing as a part of the study data analysis process. I used an application on my phone to record the interviews. I then transcribed the interviews myself. I reviewed the entire output, ensuring no identifying information for the participants or their companies was included. I then completed the member checking process to confirm accuracy.

Conclusion

The purpose of this qualitative multiple case study was to explore strategies distribution electric utility leaders use to reduce demand billing charges from their power providers. The general business problem was that DSM practices for residential applications are underutilized in the electric utility industry, which can adversely affect the potential for the industry to reduce costs and increase profitability. The specific business problem was that some leaders in the distribution electric utility industry lack strategies to reduce demand billing charges from their power providers, a situation that may cause a decrease in utility profitability by compelling higher infrastructure costs and increasing the peak load. The major findings indicated that that effective, consumer-centric strategies for engaging customer participation in reducing demand charges include education about demand, residential demand-billing, and incentive structures with built-in financial incentives for voluntary consumer participation in load shifting.

Based on these findings, six specific strategies were recommended to electric utility company leaders for engaging residential consumers in decreasing demand, including implementing residential demand billing; conducting demand-billing implementation through a phased, multiyear, revenue-neutral approach; training utility company personnel to provide clear, consistent messaging in addressing consumer questions and concerns about demand and demand billing; educating consumers about demand through an intensive, prolonged, multichannel information campaign; implementing incentive programs to gain passive consumer cooperation in shifting appliance loads outside of peak hours, and; implementing rebate programs to gain active consumer participation in shifting appliance loads outside of peak hours. Utility company leaders' implementation of these strategies may contribute to a reduction in residential electricity demand, as well as to curbing the expansion of infrastructure needed to meet rising demand. The identification of these effective strategies is intended to contribute to meeting utility companies' urgent need to gain residential users' cooperation in optimizing energy usage to mitigate climate change and provide for future energy needs.

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Appendix: Interview Protocol

Interview: Residential Demand Side Management: Strategies for Increasing Electric Utility Profitability	
What you will do	**What you will say – script**
Introduce the interview	My name is Allie Bennett and I appreciate you taking the time to participate in my research study project. As you may know, demand side management (DSM), is used to refer to actions designed to efficiently manage a site's energy consumption with the aim of reducing the costs incurred for the supply of electrical energy. I am researching DSM to better understand ways electric companies can reduce incurred costs for peak demand and reduce any need for increased general system charges, such as generation upgrades. My central research question is: "What strategies do distribution electric utility managers use to reduce demand billing charges from their power providers?" I will ask you eight questions. I have been a student at Walden University for three years. I have worked at Northeast Missouri Electric Power Cooperative for one year and, prior to that, worked at Macon Electric Cooperative for four years. Remember, your participation in this project is voluntary, and you may withdraw from the study at any time prior to the data analysis stage. Do you have any questions about the informed consent form that I previously sent to you or the informed consent process?
Give the participant the opportunity to introduce themselves	Would you mind telling me a little about yourself and your electric utility experience?
Continue to set the stage for the interview	I will audio record this interview along with taking notes. Your participation along with this interview is a private matter, and I will keep these proceedings confidential. Do you have any questions or concerns about the confidentiality of your participation? Do you have any questions or concerns about anything that I have discussed with you thus far? Let's begin with the questions.
Interview - Watch for non-verbal queues - Paraphrase as needed - Ask follow-up questions to get more in-depth	1. What are your organization's specific strategies used for sustaining residential demand side management?
	2. What key challenges did the company face in strategizing implementing residential demand side management practices?
	3. How did your organization address the key challenges to implementing residential demand side management practices?

	4. How does your organization assess the success of its strategies for implementing residential demand side management practices?
	5. Based on your organization's experience, how successful are the DSM strategies you are using concerning reducing your peak electrical load?
	6. Based upon your organization's experience, what strategies do you have for enhancing your current DSM strategies in the future?
	7. What, if anything, would you change in your company's approach to residential DSM utilization?
	8. What additional information would you add regarding your organization's residential DSM strategies and practices?
Wrap up interview - Thank participant	This concludes our interview session. Thank you for taking the time to participate in this interview today.
Schedule follow-up member checking interview	I will transcribe this interview and provide a summary of your responses to each of the questions to you via email within three business days from today, so you can make certain I have captured the essence of your responses to the questions. If there are inconsistencies in my transcription and the intended meaning of your responses, we will schedule a follow-up interview so you can provide clarification. Thank you again for your time and I hope that you have a great day/afternoon/evening.