This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and
content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

IEEE Access
Multidisciplinary | Rapid Review | Open Access Journal

Date of publication xxxx 00, 0000, date of current version xxxx 00, 0000.

Digital Object Identifier 10.1109/ACCESS.2022.Doi Number

A Survey on Direct Load Control Technologies in the Smart Grid

Emre Ozkop, Senior, IEEE
Department of Electrical and Electronics Engineering, Karadeniz Technical University, Trabzon, 61080 Türkiye

Corresponding author: Emre Ozkop (e-mail: eozkop@ktu.edu.tr).

ABSTRACT The purpose of this paper is to review the scientific literature on direct load control (DLC) technology in the context of a smart grid (SG). This study synthesized and compared various articles from the literature with the aim of conducting a comprehensive analysis. This study aims to provide a detailed understanding of the landscape, recent advancements, and the relationships among various aspects within this field. The evaluation is conducted through a systematic literature review, examining recent advancements in the field. A survey of over 200 papers published between 1983 and 2022 is classified based on appliance information, aim/objective, constraint, management method and tool, implementation, and publication status. In the DLC application, the study identifies the type and population of appliances used in and the aim/objective and constraint considered. It also determines whether forecast, prediction, and estimation structures, optimization and control algorithms, and specific structures are employed. The practical aspect of the study examines various perspectives, including the modeling and presentation of the research. This involves identifying the validation methods, time period for implementation, solver, program, software, toolbox, and platform structures used during validation. Additionally, the characteristics of the database used for implementation and the location of the implementation are detailed. The publication year and the countries of the authors are also provided. Comparative relationships between these elements are presented based on the aforementioned information.

INDEX TERMS Demand response, direct load control, estimation, forecast, optimization, smart grid.

I. INTRODUCTION

In the 21st century, there has been a significant increase in electricity consumption. This increase has outpaced the growth rate observed in the past. Consequently, the increased demand for electricity has resulted in a significant reliance on fossil fuels. [1, 2]. It is crucial to acknowledge that these energy sources are finite, and their consumption without considering their limited availability has raised concerns.

While consumers have been demanding more electricity, electric utilities have expressed doubts and concerns regarding the quality, reliability, safety, and uncertainties associated with electric power. These concerns have prompted the exploration of new options for the future. The aim is to address the doubts and concerns and find sustainable solutions [3].

Maintaining an equilibrium between the availability and requirement of electricity is essential. However, it is not an easy task to invest in new power generation plants and transmission lines to meet the desires of both consumers and electric utilities [4]. This challenge requires careful planning and considering various factors, including environmental impact, cost-effectiveness, and long-term sustainability. It is essential to find innovative and efficient ways to meet the increasing electricity demands while ensuring a reliable and secure power supply for the future.

The smart grid (SG) can be considered a third type of energy source to maintain a balance, in addition to conventional and renewable energy sources [5]. According to the IEEE, the smart grid is "A next-gen power system is defined by the greater utilization of communication and information technology in generating, transmitting, and consuming electrical energy". The SG offers numerous benefits, including enhanced resilience to disruptions, consumer flexibility, grid security, improved capacity and efficiency of existing electric power networks, reliable and high-quality power supply, enabling predictive maintenance, and self-healing responses to system disturbances [6]. It also facilitates the transition to plug-in electric vehicles, new energy storage options, and the development of new products, services, and markets. Additionally, it reduces greenhouse gas emissions by promoting the use of electric vehicles and new

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and
content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

power sources and reducing oil consumption by minimizing the requirement for ineffective production during high-demand periods.

A utility can be controlled using various methods, such as home energy management or the demand-side management (DSM) method, which is an indispensable element of the SG. The DSM strategy, which was initially introduced in Central Europe in the 1940s, has proven to be a practical approach in optimizing the use of existing energy resources, reducing peak demand, ensuring affordable electricity, decreasing overall electricity consumption, improving electric grid reliability, minimizing the need for network investments, and reducing environmental emissions [3, 7].

The DSM method plays a crucial role in managing utility load characteristics. By employing DSM strategies, utility providers can implement measures such as time-of-use pricing, energy efficiency incentives, and demand response programs to motivate customers to transition their energy consumption towards non-peak hours, thereby reducing strain on the grid during times of high demand. Integrating DSM into the SG improves the overall efficiency and reliability of the electrical system. With advanced monitoring and control capabilities, the SG enables real-time communication between consumers and utility providers, facilitating a more dynamic and responsive energy management approach.

In conclusion, using DSM methods within the SG framework offers numerous benefits. These include optimizing energy resources, reducing peak demand, ensuring affordable electricity, decreasing overall electricity consumption, improving grid reliability, minimizing network investments, and reducing environmental emissions. We can achieve a future of energy that is more sustainable and resilient by actively engaging consumers in energy management and employing innovative strategies.

Consumers are motivated to change their energy usage habits for several reasons. These include achieving better economy and reliability in the grid and providing benefits to the power system, consumers, and society. This can be done through various schemes and programs, such as energy efficiency and savings, load management, smart pricing, exploring and advertising of new uses, strategic conservation, electrification, retention of users, acquiring new customers, and making changes to the percentage of market control.

The literature contains several techniques and algorithms related to DSM technologies. While most of these are suitable for specific strategies, some do not apply to practical systems. Various DSM programs are proposed to achieve an efficient, reliable, secure, resilient, and sustainable system. One such program is direct load control (DLC), an incentive-based program in DSM [8].

The DLC program is available to residential and small commercial customers, offering them incentive payments or rate discounts. Customers whose loads are not affected by short-term interruptions are preferred for participation in the DLC program. There are various examples of DLC applications, and ongoing research is focused on developing optimal DLC scheduling models and implementation mechanisms. The objective is to minimize system peak load, operational costs, and load control differences while maximizing utilities' profits and customer satisfaction [9].

The count of publications (frequency data), assessed by their chronological frequency, is a crucial metric in systematic literature reviews. This approach allows for a detailed analysis of how publications have been released over time in a specific field of study. By quantitatively examining the volume and patterns of publications, researchers gain valuable insights into the evolving trends, thematic shifts, and areas of scholarly interest. It helps identify periods of increased or decreased research activity in a particular domain, highlighting essential moments of heightened or declining attention to a topic. This quantitative perspective provides a nuanced understanding of development and trends, helping to identify knowledge gaps and potential future research directions. Additionally, the consistency of findings across multiple publications reinforces the validity and reliability of established concepts or theories, strengthening the scholarly discourse. This quantitative foundation supports evidence-based arguments and facilitates the synthesis and critical evaluation of diverse perspectives, enabling a comprehensive understanding of the existing body of knowledge.

The primary aim of this extensive study is to thoroughly discuss the concept of DLC within the context of the SG. By conducting a meticulous systematic literature review and implementing content analysis techniques, we aim to explore DLC approaches from multiple perspectives, ensuring a comprehensive understanding of this critical topic. The systematic literature review will not only shed light on the recent advancements in the scientific field related to DLC but also provide valuable insights into different viewpoints, emerging research areas, and the current application trends of DLC in the SG. By delving deep into the existing body of scientific papers, we can provide a holistic and detailed analysis of this fascinating subject matter.

II. DIRECT LOAD CONTROL

The DLC technologies in the SG field have numerous features, making it challenging to evaluate and discuss each comprehensively. Therefore, this study focuses on a specific framework for review and identifies sub-elements that constitute the entire framework. These sub-elements group the terms into six categories: appliance information (types and population), aim/objective, constraint, management methods and tools (forecast, prediction, estimation, optimization, and control), implementation (simulation, experiment, simulation & experiment, duration, implemented database/place, solver, program, software, toolbox, platform, framework), and publication status (year and author country) as shown in Figure 1.

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and
content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

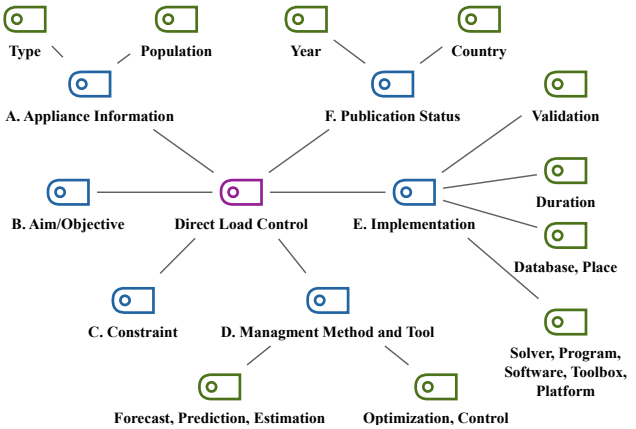

FIGURE 1. The analysis model of DLC applications in smart grids.

Appliance information is determined based on the quantity and type of appliances. For the DLC application in the SG area, the primary appliance types can be assumed to be buildings and electric vehicles. Appliances in the building category can be classified as thermostatically controlled appliances (TCAs) and thermostatically uncontrolled appliances (TUCAs) [10]. Examples of TCAs include electrical water heaters (EWHs), air conditioners (ACs), and heating, ventilation, and air conditioning (HVAC) systems. Examples of TUCAs include washing machines, clothes dryers, and dishwashers. Additionally, plug-in electric vehicles (PEVs) and plug-in hybrid electric vehicles (PHEVs) can be considered as sub-types of electric vehicles (EVs) in the context of this study. The number of appliances with various populations to be controlled by the DLC is determined accordingly.

The aim or objective evaluates whether the results are sufficient to achieve success. The aims or objectives related to DLC in the SG field are defined and emphasized in the literature using various words and phrases. Examples include cost minimization, peak load reduction, cost optimization, load shifting, flexibility, reliability, and peak shaving.

This study's management methods and tools can be categorized into forecast/prediction/estimation and optimization/control. Various types of forecast/ prediction/estimation methods are employed in DLC studies, including time series models (such as Stochastic, ARIMA, ARMA, ARMAX), regression models (autoregressive, multiple linear, nonparametric, support vector), and artificial intelligence (AI) based approaches (such as ANN, FLC, SVM, GA, AI, ES). In terms of optimization and control, algorithms are designed to consider the objectives and constraints of appliances in DLC programs. A variety of traditional and heuristic optimization algorithms and control methods are used in the DLC field.

The implementation of the DLC in the SG field is achieved through two methods: simulation and experimentation. This study focuses on determining the implementation type and identifying the validation method's operation times. The implemented database demonstrates a more realistic implementation of the DLC.

The literature review shows that actual appliance characteristic outputs, such as power consumption, voltage, energy, etc., are measured and recorded to compose the database. This database is then utilized for the realization of the DLC. In the DLC studies conducted in the SG field, it has been noted that various solvers, programs, software, toolboxes, platforms, and framework structures are utilized, particularly during the implementation and verification stages.

The publication status is categorized based on the study's publication year and the author's country. Therefore, the literature reveals the variation in the number of publications over the years, the popularity of DLC technologies in the SG field, and the tendencies of researchers based on their country.

In the literature, numerous investigations are conducted on the DLC in the SG field, and each has a similar or different point of view, contribution, aim, objective, angle, way of handling the subject, writing style, etc. It is necessary to define terms, keywords, synonyms, and related terms to investigate the scientific papers on the common ground platform. Firstly, a meaningful set of terms is identified. This set comprises six terms: appliance information, aim/objective, management methods and tools, validation methods, publication status, and implemented database. Secondly, sub-terms related to the terms are determined to evaluate the papers from different angles. Thirdly, keywords, synonyms, and related terms are specified by investigation of the scientific papers. A hierarchical structure is based on a set of terms, terms, sub-terms, and keywords, respectively. Also, each keyword has a related set of synonyms and terms. Keywords and synonyms ultimately connote the same subject. The main keyword is designated as a term that is more frequently referred to in the literature, and less frequent expressions have been included as synonyms for the main keyword. The related terms serve to pinpoint a range of related subjects that are relevant to the selected keyword. All of these terms can be found in the entire list of abbreviations.

Firstly, scientific papers containing complete "Direct load control" expressions have been searched on the Web of Science for years. Secondly, the search results are examined thoroughly by checking the abstract to determine which papers are related to the DLC in the SG scheme since the DLC technologies are used for various study fields, not only the SG area. By analyzing the literature, this study seeks to investigate the elements and factors that have influenced the advancement of this area of research, including the appliance information, aim/objective, constraint, management method and tool, implementation type, publication status, and implemented database put forth. Utilizing the selected review methodology makes it possible to monitor the current state and progression of research in this field. Consequently, it becomes easier to pinpoint the areas that warrant further investigation. The study examines various DLC programs proposed in the literature and provides a summary in Table 1.

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and
content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

A. APPLIANCE INFORMATION

When examining the studies available in the literature, the following observation can be made that a wide variety of devices, appliances, and tools are used in DLC applications in smart grids. These devices, appliances, and tools have different tasks, features, structures, and purposes compared to each other, which leads to both differences and similarities. Therefore, classifying them can be done in multiple ways.

In this study, a classification/categorization method has been preferred to categorize the names of devices/tools/appliances expressed in the literature. Thus, the devices/tools/appliances have been categorized under the subheadings "Cooling and Heating", "Energy Storage and Management", and "Others", as given in Table 2. The distribution of publications related to these subheadings is presented in Figure 2 in the literature.

In the field of smart grid, we observe that the device/tool/appliance chosen as the focal point in DLC applications predominantly focuses on the "Cooling and Heating" category. Furthermore, it has been noted that in only one of the examined publications, the device/tool/ appliance category is not clearly stated, and the classification/ category related to this publication has been addressed as "NM (Nonmention)" in this study.

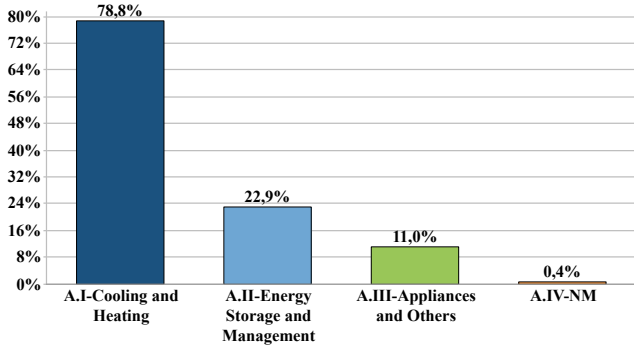

FIGURE 2. The distribution of categorized devices/tools/appliances in the literature.

Firstly, the "Cooling and Heating" category emerges as the dominant category, exhibiting a substantial frequency of 186 paper occurrences. This category alone accounts for an impressive 78.8% of the total instances. Such a significant presence suggests a strong emphasis on "Cooling and Heating" within the literature. In contrast, "Energy Storage and Management", though not as prevalent as "Cooling and Heating," still demonstrates a noteworthy frequency of 54 paper instances, representing 22.9% of the total. This indicates that considerable attention is paid to the "Energy Storage and Management" field, reflecting its relevance and significance in the literature data. Lastly, we find "Appliances and Others" to have the lowest frequency among the three categories, with 26 paper occurrences. However, these instances still comprise 11% of the overall data. This implies that "Appliances and Others", while not as prominent as the other categories, still hold a significant presence and should not be underestimated.

In the literature, the distributions of devices/tools/ appliances identified in studies examining DLC applications in smart grids are given in Tables 7-9.

Table 7 provides data on different appliance types, paper frequencies, and the percentage distribution. The most frequently mentioned appliance type in the data is "Air conditioner", with a paper frequency of 89, accounting for 39.04% of the total. This is followed by "Electric water heater" with a frequency of 48 papers, representing 21.05% of the total. Notably, the top two appliance types, "Air conditioner" and "Electric water heater," make up more than 60% of the total papers. This indicates that these two categories are particularly relevant and widely discussed in the data context. Other significant appliance types include "Heating, ventilation and air conditioning" with a frequency of 28 papers (12.28%) and "Heat pump" with a frequency of 13 papers (5.70%).

On the other hand, some appliance types have relatively low frequencies, such as "Floor heating system," "Combined cooling heating and power," and "Polysilicon reduction furnace," each with a frequency of 1 paper, accounting for 0.44% of the total papers. This data suggests a strong focus on air conditioning-related appliances and heating systems in the research papers analyzed. Further investigation into these categories' specific topics and trends could provide valuable insights for researchers and industry professionals.

Table VII shows that in direct load control (DLC) applications, air conditioners, electric water heaters, and heating ventilation and air conditioning devices are mainly interrupted during working periods. Additionally, the literature has found that dishwashers and washing machines, which cannot be interrupted during working periods, can shift their operating periods in DLC applications (Table IX).

TABLE 7. The number of publications per appliance type (cooling and heating).

Appliance type	Frequency	%
a12.Air conditioner	89	39,04
a11.Electric water heater	48	21,05
a13.Heating, ventilation and air conditioning	28	12,28
a8.Heat pump	13	5,70
a9.Centralized air-conditioning	8	3,51
a20.Refrigerator	8	3,51
a43.Chiller	6	2,63
a24.Heating unit	5	2,19
a21.Freezer	5	2,19
a17.Central chiller plant	3	1,32
a6.Inverter air conditioner	2	0,88
a44.Cooling fan	2	0,88
a34.Electric storage space heating	2	0,88
a38.Floor heating system	1	0,44
a7.Combined cooling, heating and power	1	0,44
a23.Heat pump water heater	1	0,44
a45.Calorifier	1	0,44
a48.Fridge compressor	1	0,44
a18.Electric heating	1	0,44
a25.Ground source heat pump	1	0,44
a27.Ice storage central air conditioning	1	0,44
a5.Polysilicon reduction furnace	1	0,44
Total	228	100,00

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and
content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

First, the most frequent appliance type in the dataset given in Table 8 is "Building/Household/Plant", with a paper frequency of 12, accounting for 17.14% of the total. It suggests that buildings, households, and plants play a significant role in the data context. Second, "Electrical vehicle" and "Controllable load/device/appliance" are the second and third most common appliance types, with paper frequencies of 11 and 8, respectively. These two categories make up a substantial portion of the dataset, with percentages of 15.71% and 11.43%, respectively. It indicates the importance of electric vehicles and controllable loads/devices/appliances in the data context.

Moreover, it is essential to mention that the "Plug-in electric vehicle" and "Battery" categories have relatively high representation in the dataset, with paper frequencies of 6 and 5, accounting for 8.57% and 7.14%, respectively. This suggests a significant focus on these types of appliances in the research. Furthermore, the "Energy storage system" and "Plug-in hybrid electric vehicle" categories also have a notable presence in the dataset, with paper frequencies of 3 and 5, making up 4.29% and 7.14%, respectively. Overall, this data offers valuable perspectives on the frequencies and distribution of different appliance types within the dataset, highlighting the prominence of building/household/plant, electric vehicles, and controllable loads/devices/appliances. These findings can be further analyzed and utilized to understand the research area better.

TABLE 8. The number of publications per appliance type (energy storage and management).

Appliance type	Frequency	%
a1.Building/Household/Plant	12	17,14
a2.Electric vehicle	11	15,71
a29.Controllable load/device/appliance	8	11,43
a15.Plug-in electric vehicle	6	8,57
a22.Battery	5	7,14
a16.Plug-in hybrid electric vehicle	5	7,14
a26.Energy storage system	3	4,29
a10.Thermostatically controlled appliance	2	2,86
a39.Dispatchable load	2	2,86
a61.Shiftable appliance	2	2,86
a62.Interruptible appliance	2	2,86
a64.Battery energy storage system	2	2,86
a14.Thermal energy storage	1	1,43
a40.Interruptible load	1	1,43
a4.Deferrable electrolyzer	1	1,43
a3.Pumped water storage	1	1,43
a63.Battery devices	1	1,43
a37.Flexible appliance	1	1,43
a65.Fuel cell	1	1,43
a66.Electrolysis plant	1	1,43
a70.Dimmable appliance	1	1,43
a71.Programmable appliance	1	1,43
Total	70	100,00

The dishwasher is the most frequently mentioned appliance type in the data provided in Table 9, representing 20% of the total. This is closely followed by washing machines, which account for 18.57%. The dryer, washer, and pool pump also have significant paper frequencies, with 12.86%, 7.14%, and 4.29%, respectively.

The data shows various appliance types, including cooking ovens, lamps, water pumps, and even static appliances. While these may not have as high of a paper frequency as the more common household appliances, they still contribute to the overall energy consumption.

Overall, it is evident that the data provides insights into the usage patterns of different appliance types, allowing for a better understanding of energy consumption and efficiency in households.

Based on the analysis and observations conducted, it has been concluded that in smart grid DLC applications, devices/ tools/appliances of different types and structures are addressed, many of which are directly used and interacted with in people's homes/buildings in their everyday existence. On the contrary, considering the dispersion of these devices/tools/ appliances addressed in DLC programs in the literature, the results in Table 10 emerge.

TABLE 9. The number of publications per appliance type (others).

Appliance type	Frequency	%
a35.Dishwasher	14	20,00
a41.Washing machine	13	18,57
a31.Dryer	9	12,86
a30.Washer	5	7,14
a36.Pool pump	3	4,29
a42.Cooking oven	3	4,29
a47.Lamp	2	2,86
a57.Water pump	2	2,86
a33.Plug load	1	1,43
a69.Static appliance	1	1,43
a19.Lighting	1	1,43
a28.Backup load	1	1,43
a67.Stove	1	1,43
a46.Motor	1	1,43
a68.Dwelling unit	1	1,43
a49.Iron	1	1,43
a50.Vacuum cleaner	1	1,43
a51.Kettle	1	1,43
a52.Toaster	1	1,43
a53.Rise-cooker	1	1,43
a54.Blender	1	1,43
a55.Frying pan	1	1,43
a56.Coffee maker	1	1,43
a32.Optional lighting	1	1,43
a58.Flourmill	1	1,43
a59.Water lifting pump	1	1,43
a60.Crop threshing machine	1	1,43
Total	70	100,00

The categorization structure specified in Table 10 can be done differently, first by emphasizing that. When considering the grouping here, it has been determined that the number of devices/tools/appliances addressed in DLC applications varies, and multiple devices/tools/appliances are examined in terms of weight in the literature.

In Table 10, a majority of the population lies within the range of 2-25, with a paper frequency of 59, representing 25% of the total. The second-largest category is the population

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and
content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

range of 101-1000, accounting for 53 papers and 22.46% of the total. Surprisingly, the population category "Above 1000" has a lower paper frequency than the categories mentioned above, with only 46 papers, representing 19.49%.

TABLE 10. System population in DLC programs.

Population	Frequency	%
1	28	11,86
2-25	59	25,00
26-50	17	7,20
51-100	23	9,75
101-1000	53	22,46
Above 1000	46	19,49
NM	18	7,63
Total	236	100,00

The population ranges of 1, 51-100, and NM (Not Mentioned) have relatively lower paper frequencies, with 28, 23, and 18 papers, respectively. Interestingly, the paper frequency correlates with the population size, as the highest frequencies are found in the population ranges with the most people. Overall, this data suggests that a substantial quantity of research is being conducted in the population categories of 2-25 and 101-1000, indicating a focus on smaller to medium-sized populations. These insights highlight the distribution of paper frequency across various population categories and provide a glimpse into the research landscape.

When we examine the dispersion of the population in the DLC application of devices/tools/ appliances, it is observed that after 1 unit, 1000 units and 10000 units are taken into account, as given in Table 11.

TABLE 11. System population in DLC programs (Detailed: the first three populations with the highest frequency).

Group	Population	Frequency
1	1	28
2-25	2	8
	20	7
	15	6
26-50	40	6
	30	4
	50	3
51-100	100	10
	60	2
	54	1
101-1000	1000	17
	200	4
	500	3
Above 1000	10000	11
	5000	3
	20000	3

In Table 11, group 1 has the smallest population of 1, with the highest paper frequency of 28. This indicates a high level of research activity and productivity within this group. Groups 2-25 have a population of 2, which is relatively small compared to other groups. However, they still have a considerable paper frequency of 8. It suggests that even smaller groups can contribute significantly to research output. The population sizes in the range of 26-50 vary, but the paper frequency remains relatively consistent at 6. This indicates a consistent level of research activity within this range.

Group 51-100 has a population of 100 and a paper frequency of 10. This suggests that larger groups tend to produce a greater number of research papers, which aligns with the notion that increased resources and collaboration can lead to higher research output. The population size in the range of 101-1000 varies significantly, yet the paper frequency remains relatively high at 17. It indicates that research productivity can remain consistent even within a wide range of population sizes. The group labeled "Above 1000" has a population of 10,000, significantly more significant than any other group. Surprisingly, the paper frequency is only 11. This suggests that the research output is comparatively lower while the group has a large population.

B. AIM/OBJECTIVE

The literature on DLC applications in smart grids shows that the objectives and goals are expressed in multiple ways. It has been discovered that many of the expressed objectives and goals in the studies have the same underlying focal points but are stated differently with words.

In this study, the aims and objectives sentences/expressions stated by the authors in the literature have been analyzed in their original form as much as possible without any changes. Considering the aims and objectives in the analyzed studies, the aims and objectives have been classified/categorized under the subheadings of "Cost Minimization", "Load Management", "Environmental Impact", "Efficiency and Optimization", "Comfort and Satisfaction", "Flexibility and Reliability", and "Renewable Energy" as presented in Table 3. The distribution of publications related to these subheadings is shown in Figure 3 in the literature.

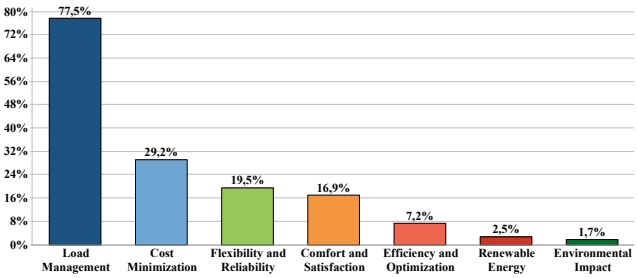

FIGURE 3. Categorization of the objectives and goals and their distribution in the literature publications.

Among the objective groups, "Load Management" has the highest paper frequency, with 183 papers accounting for 77.5% of the total. This indicates a significant focus on load management strategies in energy research. "Cost Minimization" is the second most researched objective group, with 69 papers (29.2%). This suggests that cost reduction is a crucial concern in energy management studies. The objective group "Flexibility and Reliability" has 46 papers (19.5%) highlighting the importance of exploring ways to enhance flexibility and reliability in energy systems. " Comfort and

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and
content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

Satisfaction" is another notable objective group, with 40 papers (16.9%). This indicates a growing interest in understanding and improving user comfort and satisfaction in energy management.

On the other hand, the objective group "Efficiency and Optimization" has a lower paper frequency of 17 (7.2%). This implies that there might be less emphasis on efficiency and optimization in current energy research. Additionally, "Renewable Energy" and "Environmental Impact" have relatively lower paper frequencies, with 6 (2.5%) and 4 (1.7%) papers, respectively. This suggests a possible field for additional investigation and development in renewable energy and environmental impact assessment.

Overall, this analysis highlights the dominant focus on load management and cost minimization in energy-related research while also indicating the need for more exploration in areas such as flexibility, user comfort, efficiency, and renewable energy.

The literature shows that the objectives and goals in the application studies of smart grids are predominantly categorized under Load Management, one of the subheadings classified in this study. When these subheadings are examined in detail, it is determined that the highlighted objectives and goals are as given in Table 12.

TABLE 12. Aim/objective in DLC programs (Detailed: The first two aims/objectives with the highest frequency).

Group	Aim/Objective	Frequency
Cost Minimization	Cost minimization	28
	Saving in cost	7
Load Management	Peak load reduction	125
	Peak shaving	14
Environmental Impact	Reduce CO_2 emissions	3
	Energy content of conventional power generation and battery	1
Efficiency and Optimization	Ancillary services	5
	Energy saving	4
Comfort and Satisfaction	User comfort	10
	Minimization of the end-users discomfort	10
Flexibility and Reliability	Flexibility	14
	Reliability	8
Renewable Energy	Maximize renewable energy penetration	1
	Balancing reserve (Balancing wind generation)	1

The aim of cost minimization is evident in the high paper frequency of 28. It shows that organizations are actively researching ways to reduce costs in various aspects. Peak load reduction has the highest paper frequency of 125, indicating its significance in managing energy demand efficiently. Peak shaving also has a notable frequency of 14, further emphasizing the importance of load management strategies. The low paper frequency of 3 for reducing CO_2 emissions suggests that further research is required in this area. Nevertheless, it is intriguing to observe that the energy capacity of traditional power production and battery technology has a frequency of 1, indicating some focus on understanding the environmental impact of different energy sources. Ancillary services and energy saving have moderate frequencies of 5 and 4, respectively. This suggests that organizations are exploring improving energy efficiency and optimizing energy consumption. User comfort and minimizing end-users' discomfort both have a frequency of 10. This indicates a focus on enhancing user experience and ensuring satisfaction in energy-related systems. Flexibility and reliability have frequencies of 14 and 8, respectively. This suggests that researchers are interested in developing energy systems that are both adaptable and dependable. Maximize renewable energy penetration and balancing reserve (balancing wind generation) have low frequencies of 1 each. This indicates the need for further research and innovation in the field of renewable energy integration. Overall, the data highlights the emphasis on cost minimization, load management, and user satisfaction in energy-related research. While renewable energy and environmental impact topics have lower frequencies, they still demonstrate areas of interest and potential for further exploration.

The dominant aims/objectives identified in the literature are "Peak load reduction" and "Cost minimization". Considering the studies mentioned in detail in Table 1, it can be observed that multiple aims/objectives are addressed in many of these studies.

C. CONSTRAINT

In the literature on DLC applications in smart grids, it has been observed that constraints are expressed in various ways. It has been observed that although many of the constraints mentioned in the studies indicate the same points and have similar meanings, they are expressed using different words or word groups.

In this study, the constraint words and/or word groups specified by the authors in the literature are examined as they are, without any changes. Considering the constraint expressions in the examined studies, the constraints are classified/categorized under the subheadings of "Comfort," "Temperature," "Time," "Energy Storage System," "Load," "Power, Voltage and Frequency," "Flexibility and Reliability," and "Cost, Price and Others" as given in Table 6. Figure 4 provides information on different constraint groups' frequency and percentage distribution.

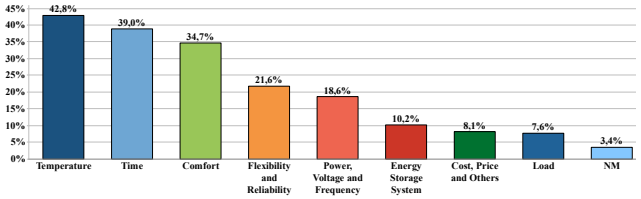

FIGURE 4. Categorization of published constraints in the literature.

The constraint group with the highest paper frequency is “Temperature”, with 101 papers accounting for 42.8% of the total. This suggests that temperature is a significant factor in the context being studied. Following closely is the constraint group “Time”, with 92 papers, representing 39% of the total.

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and
content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

This indicates that time is another essential aspect to consider. The constraint group "Comfort" has 82 papers, accounting for 34.7%. This suggests that ensuring comfort is a significant consideration in the analyzed context.

Regarding flexibility and reliability, the constraint group "Flexibility and Reliability" has 51 papers, representing 21.6% of the total. This highlights the importance of these factors in the context. Power, voltage, and frequency, represented by the constraint group "Power, Voltage and Frequency", have 44 papers, accounting for 18.6% of the total. This implies that these aspects play a crucial role in the analysis. The constraint group "Energy Storage System (ESS)" has 24 papers, representing 10.2% of the total. This indicates that energy storage systems are a relatively less studied constraint in the given context. Cost, price, and others, represented by the constraint group "Cost, Price and Others", have 19 papers, accounting for 8.1% of the total. This suggests that these factors are also considered, although to a lesser extent. The constraint group "Load" has 18 papers, representing 7.6% of the total. This implies that understanding and managing load is a relevant consideration in the context being analyzed. Lastly, the constraint group "NM" has the lowest frequency, with only eight papers accounting for 3.4% of the total. This suggests that non-measurable constraints are relatively less explored in the given context.

Comparatively, the constraint groups with the highest paper frequencies are "Temperature", "Time", and "Comfort". These three constraints seem to have been the subject of extensive research and significant in the analyzed context. On the other hand, constraint groups such as "Energy Storage System (ESS)", "Cost, Price and Others", and "Load" have comparatively lower frequencies and may require further exploration and understanding. Overall, these insights highlight the importance of temperature, time, and comfort as significant factors in the context while also emphasizing the need for continued research and exploration of other constraints such as energy storage systems, cost, and load. When these subheadings are examined in more detail, it is observed that the prominent constraints are shown in Table 13.

Table 13 provides an overview of various constraints grouped into different categories. The "Comfort" category includes user comfort, thermal comfort, and the effect of customer discomfort, with user comfort being the most frequently mentioned constraint. The "Temperature" category focuses on upper and lower temperature limits, the reference setpoint temperature, and temperature in general. The constraint most frequently discussed in this category is the operation time, followed by start-up and shut-down time. Moving on to the "Energy Storage System" category, the state of charge (SOC) is the most mentioned constraint, while battery charging/discharging power and battery capacity are also considered. In the "Load" category, the number of units and maximum dispatchable loads are essential constraints. The "Power, Voltage and Frequency" category highlights power flow variation, capacity, and consumption. Among these constraints, power flow variation is mentioned more frequently.

TABLE 13. Constraint types in DLC programs (Detailed: The first three constraints with the highest frequency).

Group	Constraint	Frequency
Comfort	User comfort	46
	Thermal comfort	22
	Customer discomfort effect	22
Temperature	Upper and lower temperature limits	46
	The reference setpoint temperature	41
	Temperature	30
Time	Operation time	63
	Start-up and shut-down time	43
	Minimum run- and down-times	11
Energy Storage System	State of charge (SOC)	12
	Battery charging/discharging power	9
	Battery capacity	4
Load	Number of units	4
	Maximum dispatchable loads	4
	TCA group state constraint	3
Power, Voltage and Frequency	Power flow variation	7
	Power capacity	7
	Power consumption	6
Flexibility and Reliability	Payback	26
	Power balance	14
	Rebound effect	3
Cost, Price and Others	Others (power, loss, luminescence, etc.)	9
	Fictitious reference value of the water/air flow rate	2
	Uncertainty in price	2

Regarding "Flexibility and Reliability," payback is the most discussed constraint, followed by power balance. Finally, the "Cost, Price and Others" category includes constraints such as power, loss, luminescence, and uncertainty in price, but these constraints are not as frequently mentioned as the others. Comparing the different categories, we can see that the most common constraints are related to comfort, temperature, and energy storage. This suggests that ensuring user comfort, maintaining appropriate temperature levels, and managing energy storage are critical considerations in the analyzed research papers.

The analyzed literature on DLC implementation in smart grids shows that comfort, temperature, time, and payback-based constraints are more prominent than. Moreover, as can be seen from Table 1, many studies include multiple constraints.

D. MANAGEMENT METHOD AND TOOL

The management aspect of DLC in the smart grid is discussed from two different perspectives and is categorized under titles such as forecast, prediction, estimation, optimization and control methods, as shown in Figure 1.

1) FORECAST, PREDICTION AND ESTIMATION

The analyzed studies show that the characteristics and structures of the forecast, prediction, and estimation methods/algorithms/techniques used vary. A classification/ categorization is provided in Table 4 to facilitate the analysis of these forecast, prediction, and estimation structures.

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and
content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

Figure 5 displays the dispersion of forecast, prediction, and estimation methods/algorithms/techniques discussed in the studies. Some of the papers do not clearly mention the forecast/prediction/estimation subject to manage the DLC program, so this situation is expressed as "NM (Unmentioned)" within the context of this paper. "Statistical Methods" has been predominant in the reviewed literature.

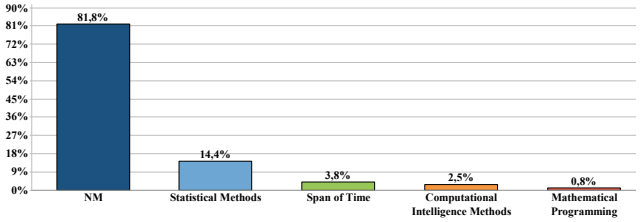

FIGURE 5. Categorization of the distribution of forecast, prediction, and estimation methods/algorithms/techniques in the literature.

Comparing the groups shown in Figure 5, it is clear that "NM" has a significantly higher paper frequency than the other groups. However, from a different perspective, "Mathematical Programming" has the lowest paper frequency, indicating that it may be a less explored area in the research dataset. Additionally, the percentages provide insights into the distribution of papers across the groups. "Statistical Methods" accounts for the majority, followed by "Span of Time". The remaining groups have relatively smaller percentages, indicating their lesser contribution to the dataset. In addition, the prominent techniques among these are provided in Table 14.

TABLE 14. Forecast, prediction and estimation methods/algorithms/ techniques models in DLC programs in the literature (Detailed: The first three with the highest frequency).

Group	Subgroup	Forecast & Prediction & Estimation Type	Frequency
Statistical Methods	Regression Analysis	Regression model	5
		Nonlinear regression model	1
		Multiple linear regression	1
	Time Series Methods	Time series models	5
		Autoregressive moving average	3
		Autoregressive integrated moving average time series	2
	Other/Tools/ Soothing/ Classification Methods	Monte Carlo simulation	4
		Least enthalpy estimation	3
		General exponential smoothing	1
Computational Intelligence Methods		Artificial neural network	3
		Artificial Intelligence based Approach	2
		Moth flame optimization	1
Mathematical Programming		Wavelet Transform	1
		Bottom up models – MARKAL/TIMES/LEAP	1
Span of Time		Short term load forecasting	7
		Very short term load forecast	1
		Long term load forecasting	1

In terms of statistical methods, regression analysis is the most frequently mentioned technique, with a paper frequency of 5. This indicates its widespread usage in research. Nonlinear and multiple linear regression also appear in the statistical methods subgroup but with lower frequencies of 1. Moving on to time series methods, time series models have a paper frequency of 5, suggesting their significance in forecasting and prediction. Autoregressive moving average is the most commonly discussed technique within this subgroup, mentioned three times. Autoregressive integrated moving average time series is also mentioned, albeit with a lower frequency of 2. In the category of other/tools/soothing/ classification methods, Monte Carlo simulation is the most prevalent technique, appearing four times. Least enthalpy estimation and general exponential smoothing are also mentioned but with lower frequencies of 3 and 1, respectively. On moving to computational intelligence methods, artificial neural network is the most frequently discussed technique, with a frequency of 3. Artificial intelligence-based approaches are also mentioned but with a slightly lower frequency of 2. Moth flame optimization is liked only once, indicating its relatively less common usage. Within mathematical programming, wavelet transforms and bottom-up models such as MARKAL/TIMES/LEAP are taken, each with a frequency of 1. This indicates their limited representation in the papers.

Finally, under the category of span of time, short-term load forecasting is the most discussed topic, with a significant frequency of 7. This suggests that short-term load forecasting is a widely researched area. Very short-term and long-term load forecasting are reviewed with frequencies of 1.

Regression analysis and time series models, particularly autoregressive moving averages, are the most prevalent forecasting and prediction techniques. Monte Carlo simulation is the most frequently employed technique in the other/tools/soothing/classification methods category. The artificial neural network stands out as the predominant computational intelligence method. Short-term load forecasting receives the most attention in terms of span of time. By comparing the frequencies of different forecasting and estimation methods, we can see that regression analysis and time series models are more popular and widely researched compared to other techniques.

2) OPTIMIZATION AND CONTROL

The analyzed studies have observed the use of various optimization algorithms, and the classification/categorization of these algorithms is provided in Table 5. The optimization algorithms in the analyzed studies are classified/categorized under the subheadings "Traditional Optimization Algorithm," "Heuristic Optimization Algorithm," and "Method/Technique/Tool used with Optimization Algorithm." The algorithms mentioned under the respective subheadings, along with the more prominent ones in the literature related to "Method/Technique/Tool", are given in Table 15.

In terms of traditional optimization algorithms, mixed-integer linear programming has the highest paper frequency with 17 papers, followed by linear programming with 14 papers, and dynamic programming with 13 papers. This suggests that mixed-integer linear programming is a widely

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and
content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

studied and utilized method in optimization research. On the other hand, heuristic optimization algorithms have relatively lower paper frequencies. The genetic algorithm has eight papers, particle swarm optimization has three papers, and the multi-objective evolutionary algorithm has two. This indicates that heuristic optimization algorithms are less commonly explored or less prevalent in the literature than traditional ones.

TABLE 15. Optimization types in DLC programs in the literature (Detailed: The first three with the highest frequency).

Group	Type	Frequency
Traditional Optimization Algorithm	Mixed-integer linear programming	17
	Linear programming	14
	Dynamic programming	13
Heuristic Optimization Algorithm	Genetic algorithm	8
	Particle swarm optimization	3
	Multi-objective evolutionary algorithm	2
Method/Technique/ Tool used with Optimization Algorithm	Deep reinforcement learning	1
	STEM interactive method	1
	Lyapunov optimization	1

Interestingly, there are a few instances where specific methods or techniques are mentioned alongside optimization algorithms. Deep reinforcement learning, STEM interactive method, and Lyapunov optimization each have one paper associated with them. This implies that these methods or techniques are being integrated or experimented with in the context of optimization research, potentially indicating emerging trends or novel approaches. The data suggests that traditional optimization algorithms, particularly mixed-integer linear programming, receive more attention and research focus than heuristic optimization algorithms. However, the presence of specific methods or techniques alongside optimization algorithms highlights the exploration of alternative approaches in optimization research.

When examining the studies in the literature that focus on the DLC application in terms of control methods, it is observed that there are various control techniques with different features and structures. These diverse control methods have been classified/categorized as shown in Table 5. The prominent control methods in DLC applications are provided in Table 16.

TABLE 16. Control types in DLC programs in the literature (Detailed: The first three with the highest frequency).

Group	Type	Frequency
Power/Load Control	Central load control	5
	Duty cycling control	4
	Ripple control	3
Logic Control	Fuzzy logic control	8
	Cognitive agent based-fuzzy logic controller	1
	Priority-stack-based control framework	1
Optimization Control	State-queuing control	2
	Optimal control	2
	Representative control	1
Feedback Control	On-off control	27
	PID control	4
	Temperature control	4
Predictive Control	Model predictive control	10
	Hierarchical centralized control	2
	Hierarchical control	2
Adaptive Control	Adaptive control	3
	Model-free dynamic control	1
	Model reference adaptive control	1
Others (Control)	Two-stage control approach	2
	Step control method	2
	Switching control	1

Regarding power/load control, the most common technique mentioned in the papers is central load control with a frequency of 5. This is followed by duty cycling control with a frequency of 4 and ripple control with a frequency of 3. The fuzzy logic control stands out as the most prevalent technique, with a frequency of 8 in the logic control group. It is worth noting that a cognitive agent-based-fuzzy logic controller and a priority-stack-based control framework are mentioned in the papers, each with a frequency of 1. Regarding optimization control, state-queuing control, and optimal control have the highest frequencies, with a frequency of 2. Representative control is mentioned once in the papers. Feedback control is the most frequently discussed technique in the papers, with on-off control having a striking frequency of 27. PID and temperature control are also mentioned, with frequencies of 4 each. In predictive control, model predictive control stands out with a frequency of 10. Hierarchical centralized control and hierarchical control are mentioned twice each. Adaptive control has a frequency of 3, while model-free dynamic control and model reference adaptive control are mentioned once each. Lastly, in the "Others (Control)" category, the two-stage control approach and step control method are mentioned twice each, while switching control is mentioned once.

We can observe that feedback control techniques, particularly on-off control, have received the most attention in the papers. Fuzzy logic control is also notable, showing a significant frequency. On the other hand, representative control and switching control techniques have relatively low frequencies compared to others mentioned in Table 16.

In the analysis of the studies, it is observed that various aspects of the method used in DLC applications, such as its name, content, features, and structure, are discussed. In some studies, the method is described in depth and from different perspectives, while in others, the control method is examined superficially, and the expression "On-off control" is used or implied in many of them.

E. IMPLEMENTATION

The designed program can be realized with only simulation works, only experimental works or simulation and experimental works for specific operation times. In this study's scope, validation and duration are the main points constituting the realization section. The DLC program performances are validated by experimentation, simulation, or both, as given in Figure 6.

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

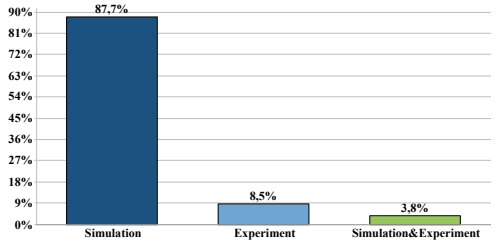

FIGURE 6. Categorization of distribution of validation types in the literature.

The category with the highest paper frequency is "Simulation", accounting for 207 papers, or 87.7% of the total. The "Experiment" category has a significantly lower paper frequency, with only 20 papers representing 8.5% of the total. The "Simulation & Experiment" category has the lowest paper frequency, with just nine papers making up 3.8% of the total. These figures show that "Simulation" is the most prominent category, with a significantly higher number of papers than the other categories. This suggests that simulation-based research is more prevalent in the given dataset. On the other hand, "Experiment" has a relatively lower frequency, indicating a lesser emphasis on experimental research. The Simulation & Experiment" category, representing papers that combine both simulation and experiment, has the lowest frequency, suggesting that such combined research approaches are less common.

Overall, the data highlights the dominance of simulation-based research and the relatively limited presence of experimental or combined approaches. Further investigation and analysis could provide deeper insights into the reasons behind these patterns and their implications in the field.

Developing a commercially available direct load control program is challenging, slow, and expensive. First, theoretical and numerical system modeling is developed, and prototypes are then tested under actual operational conditions after a time-consuming and expensive task. The difficulty of establishing an experimental process affects studies on DLC programs. Therefore, most of the papers refer only to the simulation validation methods.

Experimentation, simulation, or both validate the DLC program performances for specific operational time intervals/durations. The status of the examined/focused time interval/slice in the analyzed studies is shown in Figure 7.

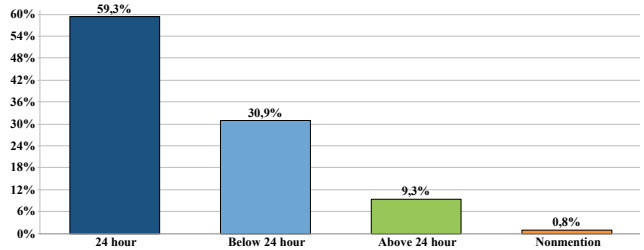

FIGURE 7. Categorizing the distribution of duration types in the literature publications.

The category "24-hour" has the highest paper frequency, with 140 papers accounting for 59.3% of the total. The category "Below 24-hour" has a paper frequency of 73, representing 30.9% of the total. The category "Above 24-hour "has the lowest paper frequency, with 22 papers making up 9.3% of the total. Lastly, the category "Nonmention" has the lowest paper frequency, with only two papers accounting for 0.8% of the total. From these numbers, we can observe that the majority of the papers fall into the "24-hour" category, indicating a higher frequency of papers within a 24-hour timeframe.

On the other hand, the "Nonmention" category has the lowest paper frequency, suggesting a significantly lower occurrence of papers in this category. Overall, this analysis reveals the distribution of paper frequency across different categories, emphasizing the dominance of the "24-hour" category and the relatively lower occurrence in the "Nonmention" category. In addition, trends in other time intervals are presented in Table 17 to reveal their patterns.

A "24-hour" time interval/slice was used in the study to observe and analyze the results of the DLC application alongside different time zones/intervals. A more detailed explanation of its usage can be found in Table 1.

TABLE 17. Duration types in DLC programs in the literature (Detailed: The first three with the highest frequency).

Group	Type	Frequency
	8	9
Below 24 hour	5	8
	2	7
24 hour	24	139
	48	6
Above 24 hour	72	3
	120	2

One of the essential factors in conducting a study is modeling and using the system structure to be implemented real or realistically. In smart grids, the features of appliances where DLC application will be implemented, grid structure, energy/power consumption profile/characteristics, consumer characteristics/habits, etc., are essential elements.

In the analyzed studies, it has been observed that different data sources/structures are used during simulation and implementation. Some studies indicate that data from different web pages are utilized for DLC applications, while in others, data stored for different regions of an electric company are utilized. Some publications mention using information about the region/city/town where this DLC study is conducted. Detailed information about the applied databases/locations is provided in Table 1. The prominent databases/locations in the DLC application are listed in Table 18.

Comparatively, it can be observed that the USA has the highest overall frequency in both group and paper categories. This suggests a significant presence and activity in the data. Taiwan follows closely behind, indicating a noteworthy group and paper frequency level. Although lower in frequency

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

compared to the USA and Taiwan, China still exhibits a considerable presence in the data given in Table 18.

TABLE 18. Duration types in DLC programs in the literature (Detailed: The first three with the highest frequency). Implemented database/place types in DLC programs in the literature (Detailed: on the agenda).

Group Frequency	Group	Implemented Database/Place	Frequency
26	USA	Chicago, Illinois	2
		Virgin Islands	1
13	Taiwan	Taiwan Power Company	8
		National Taiwan University of Science and Technology	1
12	China	Guangzhou	4
		Shanghai	1
10	Web	www.cedi.uqcloud.net	1
		www.city-data.com	1

In studies addressing DLC programs in smart grids, various structures such as Solver, Program, Software, Toolbox, Platform, and Framework are examined for modeling the system, testing under different operating conditions, applying and testing forecast, prediction, and estimation methods/algorithms/techniques related to the system, as well as optimization and control algorithms. The details of this examination are provided in Table 1. The prominent types in terms of usage in the examined studies are presented in Table 19.

TABLE 19. Solver/program/software/toolbox/platform/ framework types in DLC programs in the literature (Detailed: on the agenda).

Group	Subgroup	Frequency
Matlab	Matlab	49
	Matlab/AMPL	2
	Matlab/YALMIP/Gurobi	2
GAMS	GAMS/Cplex	10
	GAMS	4
	GAMS/LINDO	1
C	C++	3
	Turbo C	3
	Visual C++	2
TRNSYS	TRNSYS	5
Python	Python	4
EnergyPlus	EnergyPlus	4

Matlab and GAMS are the most prominent tools in the research papers analyzed. Each tool has its specific subgroups, and the presence of certain subgroups may indicate their popularity or specialization within the broader group. Meanwhile, the C group and other tools like TRNSYS, Python, and EnergyPlus also have a notable presence, although to a lesser extent. In addition, dozens of different structures are utilized in DLC applications, and more detailed information about them is provided in Table 1.

F. PUBLICATION STATUS

The literature studies are addressed regarding publication years and authors' countries. Table 20 gives information regarding papers related to DLC programs in the smart grid with the year of publication. The number of publications regarding DLC programs has increased in the last decade.

TABLE 20. Publication year in DLC programs in the literature.

Year	Frequency	%		Year	Frequency	%
2022	12	5,08		2005	3	1,27
2021	12	5,08		2004	5	2,12
2020	16	6,78		2003	2	0,85
2019	23	9,75		2002	3	1,27
2018	13	5,51		2001	2	0,85
2016	11	4,66		2000	3	1,27
2015	12	5,08		1999	2	0,85
2014	16	6,78		1998	4	1,69
2013	16	6,78		1997	1	0,42
2012	16	6,78		1996	3	1,27
2011	9	3,81		1995	4	1,69
2010	5	2,12		1993	3	1,27
2009	6	2,54		1992	1	0,42
2008	6	2,54		1991	2	0,85
2007	5	2,12		1989	1	0,42
2006	3	1,27		1983	1	0,42

From 1983 to 1991, the number of papers published per year remained relatively low, ranging from 1 to 2. However, starting from 1992, there was a significant increase in paper frequency, with the numbers reaching as high as 23 in 2019. This indicates a growing interest in research and publication within the given field.

When considering the distribution of paper frequency percentages, we can see that the highest percentages are concentrated in the years 2019 (9.75%), 2020 (6.78%), 2014 (6.78%), 2013 (6.78%), and 2012 (6.78%). This suggests that these particular years had a higher concentration of research activity than others.

Regarding comparative inference, we can observe that the publication frequency in recent years (2019-2022) has remained consistently high, with values ranging from 5.08% to 9.75%. On the other hand, the years prior to 2011 had relatively lower publication frequencies, with percentages ranging from 0.42% to 3.81%. This indicates a potential shift in the level of research activity over time, with more focus and interest in recent years.

Overall, the data analysis highlights a notable increase in research activity in recent years and suggests a growing interest and engagement trend within the given field. Researchers from different countries show interest in DLC applications in smart grids and conduct various studies. The distribution of researchers in the reviewed studies according to countries is given in Table 21.

evident that the United States of America has a significantly higher number of papers compared to other countries. This suggests a strong research output and activity in the United States. China also commands attention due to a comparatively elevated quantity of papers, indicating its growing research contributions. Taiwan, Canada, and Australia also show notable paper frequencies, highlighting their active research environments.

Interestingly, some smaller countries, such as the Islamic Republic of Iran, Portugal, and Spain, have relatively high paper frequencies, indicating their active participation in research. On the other hand, larger countries like Japan and

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

India have moderate paper frequencies compared to their population size and research capacities.

TABLE 21. Author's country used in DLC programs in the literature.

Country	Frequency	Country	Frequency
United States of America	59	Republic of Korea	3
China	33	Arab Republic of Egypt	2
Taiwan	24	Belgium	2
Canada	18	Malaysia	2
Australia	16	Oman	2
Islamic Republic of Iran	12	Sweden	2
Portugal	12	United Kingdom	2
Spain	11	Vietnam	2
Japan	9	Brazil	1
India	8	Chile	1
Netherlands	7	Colombia	1
Turkey	7	Croatia	1
Italy	6	Czech Republic	1
Singapore	6	Israel	1
Denmark	5	Jordan	1
Hong Kong, SAR	5	New Zealand	1
Saudi Arabia	5	North Macedonia	1
Switzerland	5	Norway	1
France	4	Philippines	1
Pakistan	4	Romania	1
South Africa	4	Russian Federation	1
Finland	3	Tunisia	1
Germany	3	United Arab Emirates	1
Ireland	3	Palestine	1

Comparing the paper frequencies of different countries, it is Overall, this data analysis reveals the variation in research output among different countries, with the United States leading the pack and several other countries making significant contributions.

III. RELATIONSHIP AND COMPARISON

Figure 8 provides data on the number of papers produced in different validation time periods for simulations, experiments, and a combination of both.

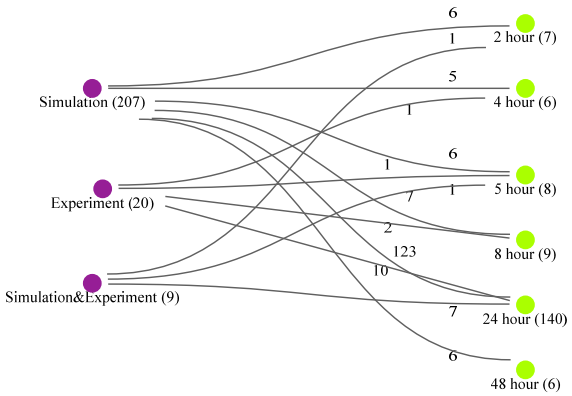

FIGURE 8. Relatives of validation and duration types.
[Left side: validation type (total paper frequency), Right side: duration type: hour (paper frequency)]

In the 24-hour time period, simulations had the greatest quantity of papers with 123, followed by experiments with ten papers. However, the combination of simulations and experiments had only seven papers. It suggests that simulations alone were more productive than a combination of simulations and experiments in this time frame. In the 48-hour time period, simulations again had the highest number of papers with 6, while experiments and the combination of simulations and experiments had 0 papers each. This indicates that simulations were the most productive method in this extended time frame.

These findings highlight the potential of simulations as a research method for generating a higher volume of papers within 24-hour time frames. Researchers may consider prioritizing simulations over experiments or exploring the combination of both methods more effectively to enhance research productivity.

Based on the data in Figure 9, it can be observed that the simulation method has the highest number of papers published across different population sizes. The simulation method has 23 papers for the one population size, while the experiment method has only four papers. As the population size increases, this trend continues with the simulation method consistently outperforming the experiment method regarding the quantity of published papers.

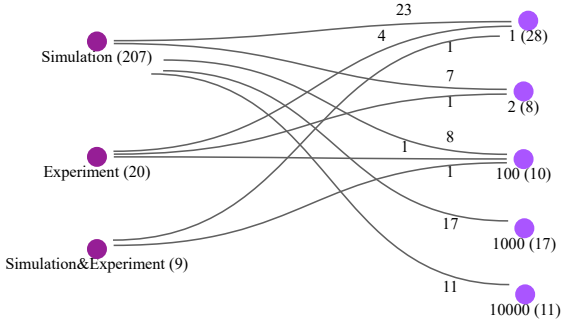

FIGURE 9. Relatives of validation and population types.
[Left side: validation type (total paper frequency), Right side: population type: population (paper frequency)]

Interestingly, as the population size increases from 1 to 100, the quantity of documents published utilizing the simulation method remains relatively stable, ranging from 23 to 17 papers. On the other hand, the number of papers published using the experiment method decreased significantly, from 4 papers to 1 paper. This suggests that the simulation method may be more suitable for studying larger population sizes, while the experiment method may have limitations in scalability.

Furthermore, the table shows that only one paper was published using both simulation and experiment methods, which occurs for the 1 and 100 population sizes. This suggests that the combination of simulation and experiment methods is less commonly employed in research compared to using either method alone.

In summary, the data analysis reveals that the simulation method is the most prevalent approach in the published papers across different population sizes. The experiment method shows a decline in usage as the population size increases. The combination of simulation and experiment methods is

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

relatively rare in the published literature. These insights highlight the dominance of simulation in population-based research and raise questions about the scalability and potential benefits of combining simulation and experiment methods.

Figure 10 shows the relatives of publication year and duration intervals in specific conditions.

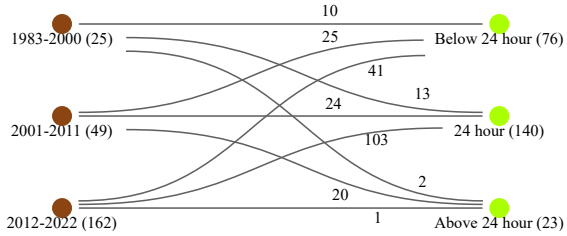

FIGURE 10. Relatives of publication year and duration intervals.
[Left side: publication year interval (total paper frequency), Right side: duration interval (paper frequency)]

In the below 24-hour interval, the number of papers gradually increased from 10 in the 1983-2000-year interval to 41 in the 2012-2022-year interval. However, in the above 24-hour interval, the number of papers remained relatively low, with only two papers in the 1983-2000-year interval, 20 papers in the 2001-2011-year interval, and one paper in the 2012-2022-year interval.

The 24-hour interval consistently achieved the greatest quantity of papers, reaching a peak of 103 in 2012-2022. This suggests a shift in research focus towards this timeframe. The number of papers in 2012-2022 significantly increased compared to previous intervals, indicating growing interest in this area. However, the above 24-hour interval showed a declining trend, with fewer papers published each year.

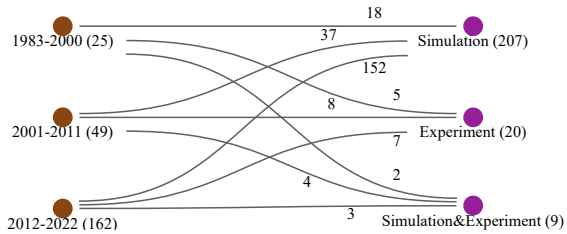

FIGURE 11. Relatives of publication year interval and validation types.
[Left side: publication year interval (total paper frequency), Right side: validation type (paper frequency)]

Figure 11 provides an overview of the number of papers published in different time intervals categorized by simulation, experiment, and simulation & experiment. Comparing the intervals, it is evident that the use of simulation as a research method has been consistently on the rise as time has passed. In the first interval, simulation papers were the least common, but by the last interval, they dominated with a significant number of publications. On the other hand, the number of experiment papers remained relatively stable throughout the years, without showing a significant increase. The combination of simulation and experiment had a small presence in all intervals, but the numbers did not show a clear trend.

These findings highlight the growing popularity and importance of simulation as a research method in the field. The consistent growth in the quantity of simulation papers suggests that researchers are recognizing its value and incorporating it into their studies. Nevertheless, it's important to observe that experiments still play a significant role, as evidenced by the consistent number of experiment papers over the years. The combination of simulation and experiment remains a relatively niche area of research with a limited number of publications. This suggests that additional exploration and investigation are necessary to fully comprehend the potential advantages and disadvantages of integrating these two methods.

Upon analyzing the data in Figure 12, firstly, clearly, the quantity of papers published increased over time, with the highest number of papers being observed in the 2012-2022-year interval. This suggests a growing interest in population data and its associated research.

Second, when comparing the different population sizes, it is notable that the 1000 population group consistently had the highest number of papers published across all year intervals. This could imply that this particular population size is of significant interest to researchers. Additionally, it is interesting to observe that the two population and 10000 population groups had the lowest number of papers published in most year intervals, indicating that these population sizes may not have been as extensively studied as the others.

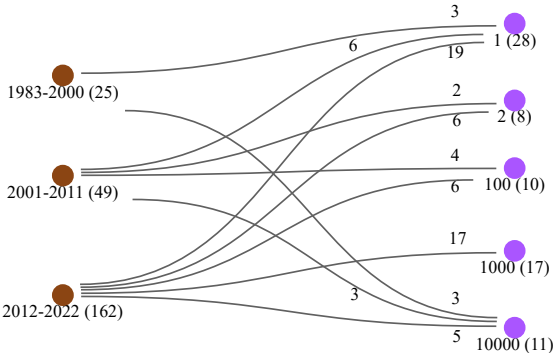

FIGURE 12. Relatives of publication year interval and population types.
[Left side: publication year interval (total paper frequency), Right side: population type: population (paper frequency)]

In summary, the data analysis reveals an increasing trend in research publications over time, with the 1000 population group consistently attracting the most attention. The variations in paper counts across different population sizes suggest differing levels of research focus and interest.

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

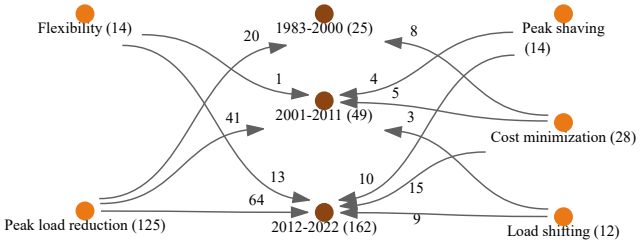

FIGURE 13. Relatives of aim/objective types and publication year interval. [Left-Right sides: aim/objective type (total paper frequency), Center side: publication year interval (total paper frequency)]

Figure 13 provides data on different parameters for three year intervals: 1983-2000, 2001-2011, and 2012-2022. In terms of peak load reduction, there is a clear upward trend over the years. The number of papers discussing peak load reduction increased from 20 in the first interval to 41 in the second interval and further to 64 in the third interval. When it comes to cost minimization, there is a decrease in the number of papers from the first interval to the second interval. However, in the third interval, the number of papers discussing cost minimization increased to 15, higher than the first and second intervals.

Regarding flexibility, the data shows a gradual uptrend over the years. From 0 papers in the first interval, the number of papers discussing flexibility increased to 1 in the second interval and further to 13 in the third interval. For peak shaving, load shifting, and load leveling, there is an increase in the number of papers from the second interval to the third interval. The third interval held the top position in terms of paper quantity discussing these topics, with ten papers on peak shaving, nine papers on load shifting, and 13 papers on load leveling.

From the data, it can be inferred that there is a growing interest in peak load reduction, flexibility, and cost minimization in the field of study. The increase in the number of papers over the years indicates a rising importance and focus on these areas. Additionally, the higher number of papers on peak shaving, load shifting, and load leveling in the third interval compared to the second interval suggests increasing attention to these strategies for managing electricity demand. Overall, the data highlights the evolving research landscape and the shifting priorities in the field, with a clear emphasis on peak load reduction, flexibility, and cost minimization in recent years.

As shown in Figure 14, the air conditioner has the highest peak load reduction score of 50 paper frequency, indicating its effectiveness in reducing the overall power demand during peak periods. This suggests that using energy-efficient air conditioning systems can significantly contribute to managing peak loads. In terms of cost minimization, the electric water heater performs well with a score of 6 paper, indicating its potential to reduce energy costs. This suggests that investing in energy-efficient water heating systems can lead to significant cost savings.

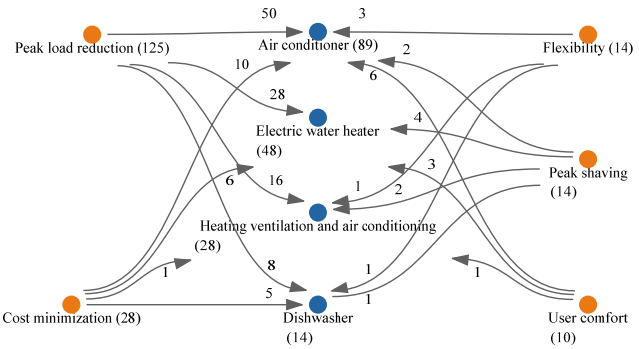

FIGURE 14. Relatives of aim/objective and appliance types. [Left-Right sides: aim/objective types (total paper frequency), Center side: appliance type (total paper frequency)]

Regarding flexibility, the air conditioner and HVAC systems score relatively high, indicating their ability to adapt to varying conditions and provide customizable settings. This suggests that these appliances offer users a higher degree of control over their comfort levels. The air conditioner and electric water heater score the highest for peak shaving, indicating their effectiveness in reducing power consumption during peak demand periods. This suggests that these appliances can help reduce the strain on the electrical grid during peak usage times.

Interestingly, user comfort scores across the appliances vary. The air conditioner and dishwasher score relatively high, suggesting that they provide a comfortable user experience. On the other hand, the HVAC system and electric water heater score lower in user comfort. This suggests that there could be potential for enhancement in these areas to enhance user satisfaction.

In comparative inference, we can observe that the air conditioner performs consistently well across multiple categories, indicating its overall effectiveness and versatility. However, the electric water heater also stands out for its strong performance in cost minimization and peak shaving. This suggests that investing in energy-efficient air conditioning and water heating systems can exert a notable influence on both managing energy costs and reducing peak loads.

These insights highlight the importance of considering various factors, such as peak load reduction, cost minimization, flexibility, peak shaving, and user comfort, when evaluating the performance of different appliances. By understanding these aspects, individuals and organizations can make informed decisions to optimize energy efficiency and effectively manage energy consumption.

If the data in Table 1 and Figure 15 is taken into account, firstly, in terms of the regression models, the most commonly used one across all three-time intervals is the AR model, with at least one paper dedicated to it in each interval. On the other hand, the MLR model is only mentioned in the 1983-2000-year interval. Secondly, when it comes to time series models, the ARIMA model is the most widely explored, with two papers discussing it in the 2012-2022-year interval. The ARIMAX, ARMAX, and ARMA models also have some

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and
content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

presence, but the MA model is only mentioned in the 2001-2011-year interval.

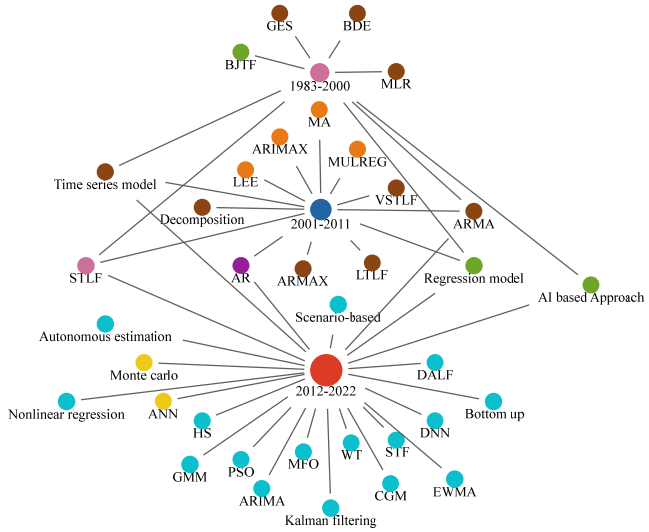

FIGURE 15. Relatives of forecast, prediction, and estimation methods/ algorithms/techniques and publication year interval.

Thirdly, in terms of alternative approaches, the Monte Carlo method stands out with four papers in the 2012-2022-year interval. Other notable methods include the AI-based approach, ANN, and DNN, each with multiple papers in different intervals.

Comparing the different time intervals, it is worth highlighting that the STLF model has gained more attention over time, with an increase in the number of papers from 2 papers in the 2001-2011-year interval to 3 papers in the 1983-2000-year interval. Additionally, the LEE model is more prominent in the 2001-2011-year interval compared to the other intervals.

These insights reveal the changing trends and preferences in research on regression models, time series models, and alternative approaches for data analysis in specific time periods. These findings highlight the evolving trends and interests in the realm of data interpretation and forecasting over time. The increased emphasis on advanced techniques like regression models, ARIMA, ANN, and Monte Carlo simulations in recent years suggests a shift towards more sophisticated methods. Meanwhile, the continued focus on time series models and STLF underscores their ongoing significance in the realm of data analysis and forecasting.

Table 22 provides data on the frequency of different constraint topics discussed in papers within three different year intervals: 1983-2000, 2001-2011, and 2012-2022. Comparing the three year intervals, it is evident that the frequency of papers discussing operation time has increased over time. In the 2012-2022 interval, 30% of the papers focused on operation time, while in the 2001-2011 and 1983-2000 intervals, the percentages were 22% and 16%, respectively. This indicates an increasing trend in the emphasis on operation time in recent years.

TABLE 22. Relation between constraints and publication year.

	Paper frequency			%		
Constraints	**2012-2022**	**2001-2011**	**1983-2000**	**2012-2022**	**2001-2011**	**1983-2000**
Operation time	48	11	4	30	22	16
Upper and lower temperature limits	40	3	3	25	6	12
The reference setpoint temperature	39	2	0	24	4	0
User comfort	34	7	5	21	14	20
Temperature deadband	25	4	0	15	8	0
Temperature	22	5	3	14	10	12
Start-up and shut-down time	22	12	9	14	24	36
Thermal comfort	17	5	0	10	10	0
Customer discomfort effect	8	9	5	5	18	20
Payback	6	12	8	4	24	32

Another discernible pattern is the escalation in the frequency of papers discussing upper and lower temperature limits. In the 2012-2022 interval, 25% of the papers focused on this topic, compared to only 6% and 12% in the 2001-2011 and 1983-2000 intervals, respectively. This suggests a growing interest in understanding and setting temperature limits in recent years.

Furthermore, the topic of user comfort has consistently been a significant area of focus across all three intervals. In the 2012-2022 interval, 21% of the papers discussed user comfort, while in the 2001-2011 and 1983-2000 intervals, the percentages were 14% and 20%, respectively. This indicates the ongoing importance of addressing user comfort in research and design.

In terms of comparative inference, it is worth pointing out that customer discomfort effect and payback are topics that have gained more attention in the earlier intervals. In the 2012-2022 interval, 5% of the papers discussed the customer discomfort effect, compared to 18% in the 2001-2011 interval and 20% in the 1983-2000 interval. Similarly, payback was a topic in 4% of the papers in the 2012-2022 interval, while the percentages were 24% and 32% in the 2001-2011 and 1983-2000 intervals, respectively. This suggests a decreasing recognition of the importance of addressing customer discomfort and considering financial implications in recent years.

Overall, the analysis of this data highlights the consistent interest in operation time and the increasing focus on user comfort in the research community. It also indicates a potential shift in priorities away from the economic aspect of payback in recent years.

In the given Table 23, the occurrences where "forecast, prediction, and estimation methods" and "aim/objective types" appeared together are recorded. There are varying numbers of occurrences for each combination of forecast, prediction, and

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and
content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

estimation methods and aim/objective types. The highest number of occurrences is found in the combination of forecast, prediction, and estimation type c1 and aim/objective type b2, with four papers. This suggests a strong correlation between c1 and b2.

On the other hand, some combinations have no occurrences, indicating a lack of relationship between specific forecast, prediction and estimation type and objective type. For example, c8 and 119 have no papers associated with them, suggesting that these two aspects may not be closely related in the paper.

By comparing the numbers of occurrences across different forecast, prediction and estimation and objective types, we can identify patterns and make comparative inferences. For instance, c21 and c30 both have a single occurrence, but they are associated with different aims/objectives. This implies that these constraints have different impacts or requirements on the project, leading to distinct objectives.

c22 appears in conjunction with b2, b63, b71, b48, b94, b35, b56, b103, b64, b49, b115, and b104, indicating a precise alignment between this forecast, prediction, and estimation type and multiple objectives. This suggests that addressing c22 would directly contribute to achieving these aims/objectives. Comparatively, c27 is associated with only one aim/objective - b54. This indicates a specific focus on addressing this objective, potentially indicating its high importance or complexity compared to others.

Furthermore, c20, c32, c35, c37, c40, c36, and c38 each have a unique association with one or two objectives, highlighting the specific objectives they are intended to address. This targeted approach suggests a strategic alignment between these forecast, prediction and estimation types and aims/objectives.

TABLE 23. Relation between forecast & prediction & estimation and aims/objectives types.

FORECAST & PREDICTION & ESTIMATION TYPES	AIMS/OBJECTIVES																						
	b2	b1	b82	b21	b119	b51	b52	b54	b3	b9	b63	b71	b48	b94	b35	b56	b103	b64	b49	b115	b104	b50
c22	1	-	-	-	-	-	-	-	-	1	-	1	1	-	-	1	1	1	1	-	1	1
c1	4	1	-	3	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
c27	7	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
c20	2	-	1	-	1	1	1	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-
c2	5	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
c32	-	1	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	1	-	-
c35	2	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-
c37	2	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
c40	3	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
c36	1	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
c38	1	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
c21	1	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
c30	1	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
c8	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
c16	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
c42	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
c3	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
c26	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
c4	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
c17	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
c18	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Overall, this analysis highlights the importance of considering the relationships between forecast, prediction, and estimation methods and aims/objectives in project planning. Some forecast, prediction, and estimation methods show strong associations with multiple aims/objectives, while others exhibit more focused alignments. It reveals which forecast, prediction, and estimation methods are closely aligned with specific aims/objectives and identifies potential areas that require further attention or investigation.

The literature's studies can be classified according to their similarity. To determine similarity, factors such as variable values/codes (including appliance information, aim/objective, management methods and tools, implementation types, publication status, and implemented database) can be considered. Figure 16 shows the similarity map of these studies. The frequency with which a code/value has been assigned in a document is taken into account when creating the similarity map. Closely located circle symbols represent papers with similar codes/values assigned to them, while less similar papers are located further apart. Papers that share similar code assignments and variables can be marked with matching colours. Table 24 presents the paper clusters related to the similarities.

Typology related to the prominent similarities in paper clusters is given in Table 25. The most frequently mentioned software in the papers is Matlab, with a high frequency of 63.6% in Cluster-3. The top countries mentioned in the papers are the USA, China, and the Netherlands, with varying frequencies across different clusters. The majority of papers (100%) in Cluster-3 were published between 2012 and 2022,

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and
content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

indicating a recent focus on research in this area. This implies that research in Cluster-3 may be more focused on current advancements and developments in the field.

In contrast, Cluster-2 has a high frequency of papers published between 2001 and 2011. The population size of 1 has a relatively high frequency across multiple clusters, indicating that research often considers smaller-scale scenarios. Population sizes of 6, 8, and 15 also appear in some clusters, suggesting a range of scenarios being studied. Papers with a duration of 24 hours have a high frequency in Cluster-3, while papers with a duration below 24 hours have a high frequency in Cluster-5 and Cluster-6. This indicates a focus on both short-term and longer-term studies in different clusters.

The validation method based on simulation is the most prevalent validation method across multiple clusters, with high frequencies in Cluster-5, Cluster-7, and Cluster-9. Experimentation as a validation method is more prominent in Cluster-1 and Cluster-4. Various constraints are explored in the papers. Notable constraints with high frequencies include e1.Start-up and shut-down time, e2.Operation time, and e5.Payback across different clusters. Different optimization and control methods are mentioned in the papers. Noteworthy methods include d4.Dynamic programming, d39.Fuzzy logic control, and d42.On-off control, each with varying frequencies in different clusters.

The objective of peak load reduction (b2.Peak load reduction) has a high frequency in Cluster-1, Cluster-2, and Cluster-6, indicating its importance across different research areas. Other objectives, such as b1.Cost minimization, b3.Load shedding, and b21.Load shifting, also appears in multiple clusters. The most frequently studied appliances are air conditioners (a12.Air conditioner) and electric water heaters (a11.Electric water heater), with high frequencies in multiple clusters. Lamp (a47.Lamp) is also mentioned in Cluster-4.

The data shows research clusters focused on direct load control in smart grid environments. Cluster-3 prominently features Matlab, indicating its prevalent use in simulation and analysis. Other clusters show diverse software usage patterns, suggesting varied methodologies. The USA, China, and the Netherlands are primary contributors geographically, demonstrating global interest in smart grid technologies. Recent publications (2012-2022) concentrate on Clusters 3 and 5, indicating increased research activity in recent years. The papers cover a wide range of load control methods, considering varied population sizes and durations. Simulation-based validation is predominantly used, with studies focusing on constraints like start-up/shut-down time, operation time, and temperature. These studies showcase the challenges in direct load control. Constraints like 'Customer Discomfort Effect' (e4) and 'Payback' (e5) emphasize the significance of economic and user-related factors. Future research could explore comprehensive models that integrate multiple constraints while optimizing energy systems. Diverse optimization and control methodologies, including traditional programming, fuzzy logic, and model predictive control, are used. While peak load reduction remains a primary objective, emerging concerns like 'User Comfort' (b64) and 'Minimization of End-Users Discomfort' (b82) indicate a shift towards user-centric objectives. Future research could focus on human-centric solutions in energy management and comfort optimization. The prominence of air conditioners and HVAC systems across multiple clusters suggests continued interest in optimizing energy usage in these appliances. Future directions could involve exploring smart technologies, IoT integration, or the incorporation of renewable energy.

These insights demonstrate the diverse research topics and methods explored in the field of user research, emphasizing the significance of taking into account different factors, such as software, country, publication year, population, duration, validation methods, constraints, optimization and control methods, objectives, and appliances. The comparative analysis offers a more profound insight into the different focuses within each cluster and the commonalities across clusters.

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

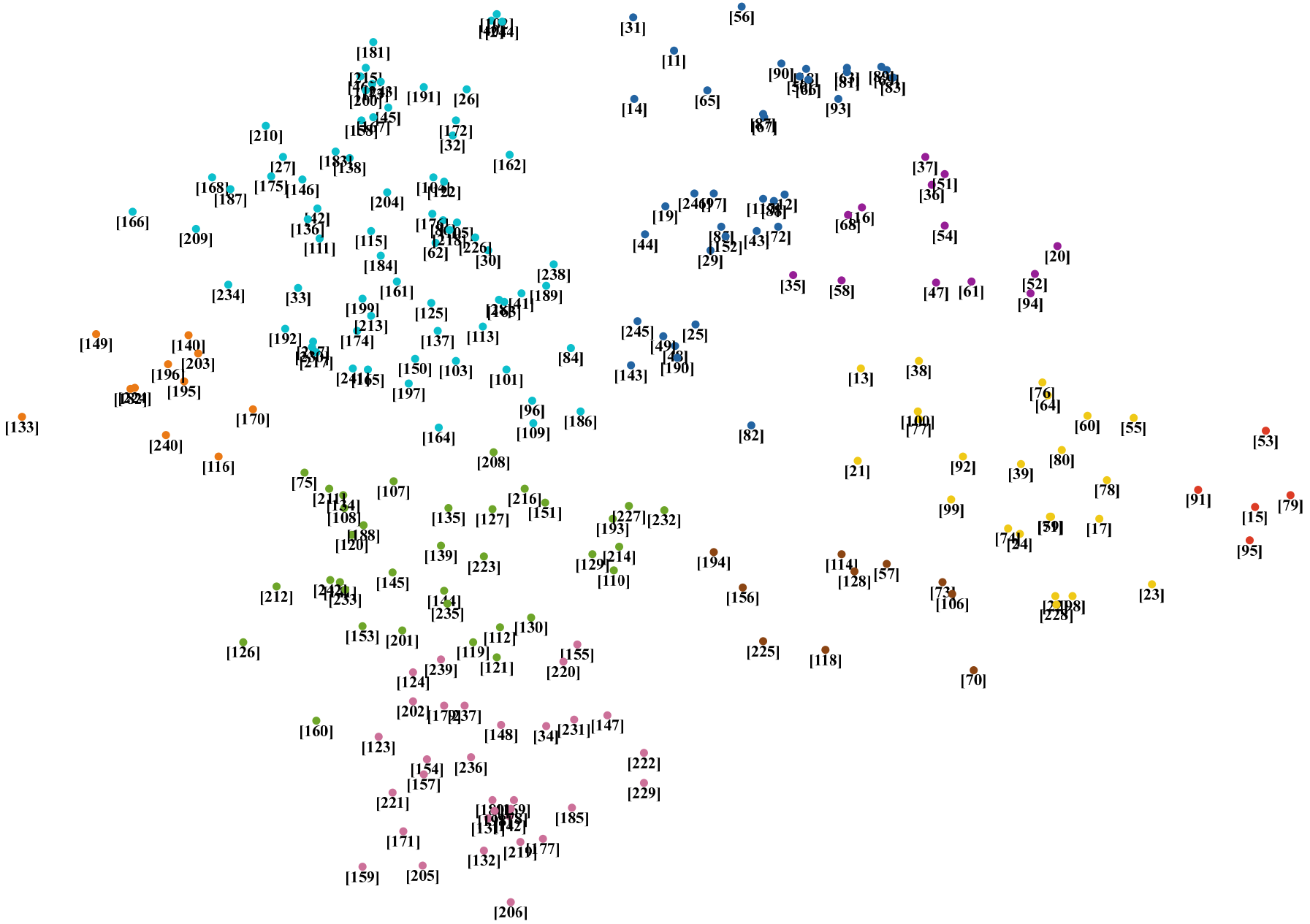

FIGURE 16. **Similarity map of the studies examining in the literature.**

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

TABLE 24. Paper clusters related to the similarities.

Cluster-1 (N=5)	Cluster-2 (N=13)	Cluster-3 (N=11)	Cluster-4 (N=10)	Cluster-5 (N=32)	Cluster-6 (N=23)	Cluster-7 (N=35)	Cluster-8 (N=36)	Cluster-9 (N=71)	
[15]	[16]	[116]	[57]	[34]	[13]	[75]	[11]	[26]	[165]
[53]	[20]	[133]	[70]	[123]	[17]	[107]	[12]	[27]	[166]
[79]	[35]	[140]	[73]	[124]	[21]	[108]	[14]	[28]	[167]
[91]	[36]	[149]	[106]	[131]	[22]	[110]	[18]	[30]	[168]
[95]	[37]	[170]	[114]	[132]	[23]	[112]	[19]	[32]	[172]
	[47]	[182]	[118]	[142]	[24]	[119]	[25]	[33]	[173]
	[51]	[195]	[128]	[147]	[38]	[120]	[29]	[40]	[174]
	[52]	[196]	[156]	[148]	[39]	[121]	[31]	[41]	[175]
	[54]	[203]	[194]	[154]	[55]	[126]	[43]	[42]	[176]
	[58]	[224]	[225]	[155]	[59]	[127]	[44]	[45]	[181]
	[61]	[240]		[157]	[60]	[129]	[48]	[46]	[183]
	[68]			[159]	[64]	[130]	[49]	[62]	[184]
	[94]			[169]	[71]	[134]	[50]	[84]	[186]
				[171]	[74]	[135]	[56]	[86]	[187]
				[177]	[76]	[139]	[63]	[96]	[189]
				[178]	[77]	[141]	[65]	[101]	[191]
				[179]	[78]	[144]	[66]	[102]	[192]
				[180]	[80]	[145]	[67]	[103]	[197]
				[185]	[92]	[151]	[69]	[104]	[199]
				[198]	[98]	[153]	[72]	[105]	[200]
				[202]	[99]	[160]	[81]	[109]	[204]
				[205]	[100]	[188]	[82]	[111]	[207]
				[206]	[228]	[193]	[83]	[113]	[209]
				[219]		[201]	[85]	[115]	[210]
				[220]		[208]	[87]	[122]	[213]
				[221]		[211]	[88]	[125]	[215]
				[222]		[212]	[89]	[136]	[217]
				[229]		[214]	[90]	[137]	[218]
				[231]		[216]	[93]	[138]	[226]
				[236]		[223]	[97]	[146]	[230]
				[237]		[227]	[117]	[150]	[234]
				[239]		[232]	[143]	[158]	[238]
						[233]	[152]	[161]	[241]
						[235]	[190]	[162]	[243]
						[242]	[245]	[163]	[244]
							[246]	[164]	

Note: N: number of total paper

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

TABLE 25. Typology table related to the similarities in paper clusters.

		Paper frequency (%)								
	Code/Value	**Cluster-1**	**Cluster-2**	**Cluster-3**	**Cluster-4**	**Cluster-5**	**Cluster-6**	**Cluster-7**	**Cluster-8**	**Cluster-9**
Software	Matlab			63.6	20.0	43.8		28.6	5.6	19.7
Country	Netherlands			18.2						
	USA		15.4	9.1	20.0	18.8	34.8	25.7	47.2	19.7
	China			36.4	20.0	18.8	4.3	17.1		19.7
	Canada			18.2		9.4	4.3	11.4	2.8	9.9
	Australia			18.2	10.0	15.6		11.4	2.8	4.2
	Spain		15.4	9.1	20.0		8.7	5.7		2.8
	Netherlands			18.2		12.5				1.4
Publication year interval	2012-2022			100.0	70.0	100.0		100.0	27.8	94.4
	2001-2011	100.0	76.9		10.0		69.6		38.9	4.2
	1983-2000		23.1		20.0		30.4		33.3	1.4
Population	1	20.0	15.4	18.2	10.0	12.5	8.7	11.4	8.3	12.7
	6	20.0	7.7			6.3		2.9		
	8	20.0			10.0			5.7	2.8	
	15	20.0					17.4			1.4
	20		7.7	18.2	10.0	3.1		2.9		1.4
	58	20.0								
Duration	Above 24 hour		7.7			28.1	4.3	20.0	8.3	1.4
	24 hour		61.5	100.0		3.1		57.1	83.3	98.6
	Below 24 hour	100.0	30.8		100.0	71.9	91.3	22.9	5.6	
Validation	Simulation & Experiment	20.0	23.1	9.1			4.3	2.9	2.8	1.4
	Simulation	40.0	53.8	90.9	60.0	96.9	82.6	97.1	80.6	97.2
	Experiment	40.0	23.1		40.0	3.1	13.0		16.7	1.4
Constraint	e1.Start-up and shut-down time	60.0	38.5		20.0		30.4	8.6	30.6	16.9
	e2.Operation time	60.0	30.8		50.0	28.1	21.7	22.9	19.4	31.0
	e3.Temperature	20.0	15.4		40.0	25.0	17.4	14.3	5.6	5.6
	e4.Customer discomfort effect	80.0	15.4		10.0		17.4	8.6	11.1	5.6
	e6.Others	20.0					4.3	5.7	11.1	1.4
	e5.Payback	80.0	46.2	9.1	30.0		17.4	2.9	16.7	1.4
	e12.Thermal comfort	40.0		18.2		12.5	8.7	14.3	5.6	7.0
	e13.The reference setpoint temperature			18.2	10.0	43.8	4.3	25.7	2.8	18.3
	e15.Upper and lower temperature limits		7.7	36.4	20.0	50.0	8.7	14.3	8.3	18.3
	e17.User comfort			27.3	30.0	15.6	21.7	17.1	19.4	23.9
	e22.Power balance					6.3		17.1	2.8	7.0
	e38.Outdoor and indoor temperature	20.0				9.4				
	e44.Temperature deadband			18.2		21.9	8.7	20.0	5.6	12.7
Optimization & Control	d1.Traditional programming	20.0					4.3		2.8	2.8
	d4.Dynamic programming	20.0	7.7			3.1	8.7	5.7	16.7	
	d6.Fuzzy dynamic programing		7.7		10.0		17.4		2.8	
	d13.Mixed-integer linear programming			27.3		12.5		11.4		8.5
	d36.Genetic k-means algorithm	20.0								
	d39.Fuzzy logic control	40.0				3.1	4.3	2.9	5.6	1.4
	d41.Model predictive control		7.7	18.2		12.5			2.8	2.8
	d42.On-off control		23.1		40.0	15.6	8.7	11.4	8.3	8.5
	d60.Step control method			18.2						
	d118.Iterative dynamic programming	20.0								
	d140.Quadratic programming problem			18.2						
Forecast & Prediction & Estimation	c35.Autoregressive moving average	20.0	7.7			3.1				
	c40.Least enthalpy estimation	60.0								
Objective	b1.Cost minimization		15.4	18.2			17.4	2.9	13.9	19.7
	b2.Peak load reduction	100.0	92.3	9.1	80.0	18.8	87.0	31.4	83.3	45.1
	b3.Load shedding	20.0			20.0	6.3	13.0	2.9	2.8	1.4
	b18.Flexibility			27.3		6.3	4.3	17.1		2.8
	b21.Load shifting		7.7			6.3	8.7	2.9	2.8	7.0
	b54.Peak shaving			18.2	10.0	9.4	8.7	2.9	2.8	5.6
	b64.User comfort			18.2		6.3				8.5
	b82.Minimization of the end-users discomfort				20.0	6.3	4.3		8.3	2.8
Appliance	a2.Electric vehicle			18.2				11.4	2.8	5.6
	a8.Heat pump			27.3	10.0	9.4	4.3	2.9	2.8	4.2
	a11.Electric water heater		7.7	9.1		15.6	17.4	20.0	33.3	25.4
	a12.Air conditioner	80.0	53.8	27.3	30.0	31.3	56.5	40.0	41.7	28.2
	a13.Heating ventilation and air conditioning				30.0	21.9	8.7	14.3		15.5
	a47.Lamp				20.0					

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and
content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

IV. CONCLUSION

This paper presents a different viewpoint regarding the status of DLC technology in the smart grid domain. It includes a literature review of DLC programs and classifies systems based on various criteria. The evaluation process is carried out by conducting a comprehensive and rigorous systematic literature review, carefully examining and analyzing recent advancements, developments, and breakthroughs in the specific field of study. This thorough examination aims to provide a comprehensive understanding and insight into the current state of the field and to identify any gaps or areas for further research and exploration.

An analysis was conducted based on publications released between 1983 and 2022, focusing on the type of appliance addressed in the analyzed publications, the number of controlled appliances, the structure of the DLC application's aim/objective, and the constraints considered. Studies were examined from the perspectives of forecast, optimization, and control structures, and the solver, program, software, toolbox, and platform infrastructure used in these studies were highlighted. The preferred types of validation and the validation time period examined in the studies were presented. If a database structure was utilized, it was specified, and if the study was implemented in a real place, that place was clarified. The numerical distribution of the studies over time and the global distribution of the authors who conducted these publications were revealed.

In this study, the relationships between DLC studies in the literature were examined from different perspectives. The relationship between the validation types (simulation, experiment, and simulation & experiment) of the studies in the literature, the appliance population structure in which DLC is applied, and the duration type of the examination were revealed. The distribution of studies over the years and the relationship between the duration type in which the results are observed in studies depending on the status of the year range and the trends of studies over time in this regard were revealed. Trends in validation and population structure in studies were determined according to the years. Whether the focus of aim/objectives observed in DLC studies changes over the years and the extent to which these aim/objectives are preferred in which types of appliances were presented.

In addition, the variety, intensity, and trend of the preferred forecast, prediction, and estimation approaches, along with the categories of constraints, have been indicated depending on the time intervals in DLC studies. Furthermore, the relationship between forecast, prediction, and estimation methodologies and aim/objective types in the studies has been presented.

The similarities of over 200 studies discussed here, which are focused on the application-oriented studies in the literature about DLC in SG, were determined by considering the categories, sub-classification structures, and related codes addressed in these studies. These studies were grouped, a similarity map was created, and the prominent similarities related to these groups were highlighted using a typology table.

Looking ahead, integrating advanced AI and machine learning techniques for load forecasting and adaptive control algorithms, particularly in direct load control within smart grid systems, could redefine research approaches. Critical future research directions in the realm of energy systems and management, including direct load control, encompass cybersecurity resilience, understanding consumer behavior, renewable energy integration, edge computing, and decentralized control strategies.

Collaborative interdisciplinary efforts, incorporating direct load control methodologies, open datasets, standardization, and sustainability-oriented objectives, will drive further progress in developing efficient, adaptive load control systems for smart grid environments. This infusion of direct load control techniques contributes to the broader perspective of enhancing energy management while considering technological, social, economic, and environmental aspects, ultimately leading to holistic solutions.

Future trends in the field may increasingly focus on integrating renewable energy sources into existing systems, with an emphasis on sustainable and eco-friendly solutions, including those supported by direct load control mechanisms. This underscores the growing significance of holistic, sustainable, and human-centric approaches, including personalized energy management, considering individual preferences, behaviors, and comfort to optimize energy usage within the context of direct load control frameworks.

In conclusion, future research is expected to prioritize holistic, sustainable, and human-centric solutions in energy systems and optimization, integrating and leveraging direct load control methodologies within smart grid systems. This comprehensive approach represents a crucial step towards effective and comprehensive energy management in evolving energy landscapes.

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

TABLE 1. Summary of DLC programs proposed in previous studies.

Ref.	Conclusions	A	H	B	E	C	D	F	K	L	M	G	N
[11]	A dynamic programming approach has been developed for DLC dispatch, integrating it into the unit commitment problem to maximize fuel cost savings. Applied to the Taiwan power system, the approach yielded variable DLC dispatching strategies that reduced total fuel costs more effectively than fixed strategies.	a12	25	b1	e1, e83	NM	d4	f1	1991	Taiwan	Taiwan Power System	24	NM
[12]	This paper introduces a novel approach for dispatching demand response load control groups, which identifies candidate control patterns and determines the optimal dispatch strategy using a binary flow network model. The method is compared to a DP-based approach and also considers the impact of DLC on unit commitment decisions and capital costs.	a10	NM	b1	e1, e2, e5, e6	NM	d4	f1	1995	USA	NM	168	NM
[13]	A new load model is proposed for DLC dispatch that incorporates customer preferences using fuzzy logic. The model also considers device range and thermal differences within cycling groups to compute cycling time, and net restored energy. These values are used in an optimization procedure to schedule groups for minimum production cost.	a12	5000	b1	e3, e5	NM	d6	f1	1996	USA	NM	8	NM
[14]	This paper proposes a new approach to minimize real power losses and associated costs in a distribution system using DLC of residential water heaters. The method is applied to a three-phase 23 kV distribution feeder, resulting in a net annual savings of $20,350.55. Future work will extend the method to include laterals and sub-laterals of the distribution system and investigate its impact on transmission and sub-transmission systems.	a11	13250	b1	e5	NM	d1	f1	2001	USA	NM	24	MAPLE V
[15]	A DLC plan can reshape a system's peak load profile, but it must consider customer TCL, weather, and load payback constraints. To weaken DLC constraints, a novel algorithm utilizes the least ON time constraint of air-conditioning units with a LEE-based thermal comfort control. The group-DLC concept simplifies the load management program by producing an optimal schedule for all units with a LEE-based thermal comfort control, treating the g-DLC controller as an aggregate load.	a12	6	b2	e3, e4, e5	c40	d1	f1&f2	2008	Taiwan	NM	5	NM
[16]	DLC of households' water heaters effectively reduces peak-load consumption with average reductions of 0.35-0.58 kWh/h in the morning and 0.18-0.59 kWh/h in the evening. However, disconnection leads to a payback effect that causes additional consumption upon reconnection, averaging an extra 0.28 kWh/h per household in the first hour. This payback demand may cause a new peak, so load diversity should be reestablished in a controlled manner.	a11	475	b2, b63	e5	c2	NM	f1	2009	Norway	Norwegian large-scale project (Norway)	24	Stata
[17]	Direct control of EWHs can increase acceptable the generation of wind energy, as per research conducted on the Hokkaido power grid. The proposed control methodology can balance the power system while maintaining user comfort with a control interval shorter than the system's inertia constant. Implementing direct control on 70% of EWHs in Hokkaido can increase acceptable wind power generation almost threefold during light-load periods at night.	a11	170000	b2, b21, b121	e17	c1	d90	f1	2011	Japan	Hokkaido Island (Japan)	8	NM
[18]	This paper proposes a process for utilities to project the impacts of controlling water heaters on the total system load. The process uses data on water heater usage to accurately determine load profiles and capacity, DSM forecasts, control strategies, and impacts on transmission and distribution systems. Data should be gathered for hourly demand, temperatures at the point of entry and exit, as well as the surrounding air temperature. The analysis will compare actual usage to projected usage and provide a utilization factor, which can determine if direct water heater load control is cost-effective for DSM programs.	a11	30000	b2	e6	c1	NM	f1	1993	USA	Western USA	24	NM
[19]	Proposing a customer-interactive DSM strategy for electric water-heaters that uses fuzzy logic and multiple-blocks to level power demand. Simulation results show that this strategy can shift peak demand to off-peak hours, improving the utility load factor. Financial incentives like real-time electricity pricing can make this strategy attractive to customers.	a11	1	b2, b72	e15	NM	d39	f1	2000	USA	NM	24	NM
[20]	The controller demonstrated promising results in reducing energy consumption during peak hours by 20.33% and overall energy consumption in a month by 24.41%. The subsequent phase involves examining the equipment in realistic conditions in a residential building.	a12, a20 a21, a41	1(each)	b2	e1, e2	NM	d42	f2	2002	Brazil	NM	24	NM
[21]	This paper models how the price of TCAs changes in response to electricity price changes in a competitive market. Results show that TCAs become synchronized in their dynamic behaviour when responding to price changes. To create a successful program for aggregated TCAs, it's important to consider load-shifting characteristics and ensure shifted loads peak after peak-price time. This methodology can be used to create DSM simulation tools that consider load-shifting behaviour.	a13	100	b1, b21	e15	c1	d1	f1	2004	USA	NM	8	NM
[22]	A controller was used to reduce energy consumption by comparing experimental data with power and energy targets and switching corresponding loads. The load curve with the controller showed a reduction in energy consumption, indicating successful fulfilment of the power target by turning off specific loads according to a priority list.	a12	1	b2, b80	e3	NM	d42	f2	2006	Malaysia	NM	8	Visual C++

A: System Types, B: Objectives, C: Forecast & Prediction & Estimation, D: Optimization & Control, E: Constraint, F: Validation, G: Duration (h), H: System Population, K: Publication Year, L: Publication Country, M: Implemented Database/Place, N: Solver/Program/Software/Toolbox/Platform/Framework

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

TABLE 1. Summary of DLC programs proposed in previous studies (Continue).

Ref.	Conclusions	A	H	B	E	C	D	F	K	L	M	G	N
[23]	This paper suggests a new load management paradigm that balances customer comfort with traditional load management goals. It provides a method for optimizing load control with minimal disruption. Two load cycling algorithms were presented, and their effectiveness was evaluated. The conclusions from the simulations can be applied to improve DSM programs.	a12	10000	b2, b82	e3, e84, e85	c26	d7, d8	f1	2008	USA	NM	2.5	NM
[24]	The Colored Power algorithm manages small-customer energy demand by maintaining a global summary model of the system state. Managed devices take independent probabilistic actions. Improvements could be made to feedback control, fairness models, and aggregation protocols. Prototype devices should be used to validate the algorithm's behaviour before test deployments with actual consumers.	a29	100	b2	e86, e87	NM	d47, d91	f1&f2	2010	USA	NM	2	Proto
[25]	A program that directly controls air-conditioners can reduce energy usage by 10-35% or 0.2-0.9 kW per household. Results vary based on the chosen analytical approach and the time of day. Policy makers should use multiple analysis methods and time-series methods to improve the accuracy of future estimates. Identifying the households that contribute most to reducing energy usage can help target programs more effectively.	a12	195	b2	NM	c25, c33, c37, c41	NM	f1	2011	Canada	Peaksaver program (Ontario, Canada)	24	SPSSv.18
[26]	This paper presents a model for investing in storage and DSM facilities in a medium-voltage grid, accounting for demand and wind output uncertainty. The study shows that there is no need for grid reinforcements at the 10 kV level. Storage devices are profitable up to a capacity cost of 850 EUR/kWh. DSM investments are not advantageous and are only beneficial up to a cost of about 200 EUR per consumer. The study concludes that storage may replace DSM investments, depending on the cost of investing in storage and load management devices, wind intermittency, and EV penetration.	a15	NM	b1	e88, e89	NM	d125	f1	2011	Germany	Mannheim (Germany)	24	GAMS/Cplex 9.0
[27]	An algorithm was created to optimize the DSM of electric storage water heaters, which can reduce grid losses, increase generator efficiency, and lower energy storage needs. The algorithm creates a constant load profile and can be used by an aggregator to reduce load variation during any optimization period. Additionally, the algorithm can be applied to schedule other residential loads with energy storage capacity.	a11	30000	b2, b126	e2	NM	d2, d93	f1	2012	Netherlands, Switzerland	Switzerland and Germany	24	Matlab
[28]	This paper examines using direct control of refrigerators for DSM to reduce energy costs. Results show up to 11.4% cost reduction and 37.9% demand shifting. Controlling defrost is crucial for DSM of refrigerators. The study suggests future work on designing a control algorithm for optimum schedules and integrating renewables in electric power systems.	a20	1	b1	e1, e2	NM	d94	f1	2012	Turkey	NM	24	NM
[29]	This paper proposes a new DSM model for load scheduling that enables the control center to delay turning on loads. The proposed architecture integrates Digital direct load scheduling programs into the grid and manages energy demand from deferrable loads. Simulations demonstrate the program can balance demand and generation with little inconvenience to customers. Future work will focus on adding storable demand to the electricity market, analyzing statistics, and integrating thermostatically controlled appliances into a neighbourhood DSM program.	a2	15000	b2, b82, b105	e1, e2	c27	d41	f1	2012	USA	NM	55	NM
[30]	The proposed DSM system can save 43 MW of peak demand for 1 million residential customers. Allowing customers to designate appliances for DSM would be beneficial, as UC aggregators could automatically disconnect them instead of load shedding. To make the system work, SMs with programmable HAN and AM devices connected to appliances are needed, with the potential for factory-installed DSM load control friendly appliances in the future.	a11, a30, a31, a35, a36	5000	b2	e1, e2	NM	d42	f1	2013	USA	NM	24	Matlab, Excel
[31]	This paper introduces a tool to evaluate domestic hot water load management programs. The tool uses hot water usage profiles and a hot water cylinder model to estimate peak reduction potential with different switching programs. Results indicate that starting time is critical, equal assignment of switching groups is better than targeted assignment, and hot water consumption profiles must be considered for each family type to ensure user comfort.	a11	1000	b2, 127	e1, e2, e4, e5, e90	NM	d7	f1	2013	Australia	NM	24	NM
[32]	This analysis investigated the use of heat pumps with TES units for home heating. It found that turning off the heat pump during peak hours had minimal impact on energy consumption but could lead to cost savings on electricity bills with "time of use" tariffs and incentives for renewable heat generation. Underfloor heating can maintain room comfort without additional heat storage but may impact temperature control when the heat pump is inactive. These findings highlight the need for further research on heating DSM strategies.	a8	1	b1, b2	e1, e2	NM	d42	f1	2013	Italy, UK	Belfast (Ireland)	24	TRNSYS
[33]	Proposes a DSM system for LV distribution networks that optimizes EWH dispatch based on RES generation and household load predictions. Uses LP and MILP optimization to reduce energy imports/exports, improve voltage quality, and require minimal modification of household wiring. It has the capability to function autonomously and can be seamlessly integrated into a more intricate distribution management system when required.	a11	40	b2, b128	e91, e92	NM	d12, d13, d93	f1	2014	Czech Republic	Germany	24	Matlab using YALMIP toolbox
[34]	This work shows that adding timers to endpoint temperature controllers can generate pulses to offset fast fluctuations without synchronization of individual states of TCLs. The minimally invasive and inexpensive protocols require only a few aggregate parameters for feedback control strategies. Such strategies based on timer-based safe protocols can become commercially attractive for utility companies to develop DSM programs, reducing cost and maintaining grid reliability.	a12	10000, 15000, 25000	b2	e13, e15	c27	d42	f1	2014	USA	Arizona (USA)	72	Matlab

A: System Types, B: Objectives, C: Forecast & Prediction & Estimation, D: Optimization & Control, E: Constraint, F: Validation, G: Duration (h), H: System Population, K: Publication Year, L: Publication Country, M: Implemented Database/Place, N: Solver/Program/Software/Toolbox/Platform/Framework

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

TABLE 1. Summary of DLC programs proposed in previous studies (Continue).

Ref.	Conclusions	A	H	B	E	C	D	F	K	L	M	G	N
[35]	Real-time information on peak demand and sheddable equipment can optimize the trade-off between savings and convenience. Accurate simulation of thermal behaviour is necessary for proper optimization, but simplified equipment models can still work well. Predicting future demand can help maintain optimal peak levels, and setting optimal control limits for sheddable equipment is critical.	a43, a44, a45	2(each)	b2	e3, e15	c11, c35	NM	f1&f2	1998	South Africa	Parliament complex in Cape Town (South Africa)	24	NM
[36]	A control method was created using a model of the building developed using real-world measurements. It forecasted load repositioning and the decrease in peak load for a strategy tested on a small commercial building. Using this approach led to a 30% decrease in the highest cooling load during a 5-hour demand-limiting period. Thermal storage can be used in small commercial buildings, but larger ones have even more significant potential due to having a lower proportion of external surface area compared to thermal mass and incorporating denser materials.	a1	1	b2, b21	e4	c27	d41	f1&f2	2008	Korea, USA	Energy Resource Station at the Iowa Energy Center (USA)	24	NM
[37]	This document presents papers on DSM systems for load control and peak demand reduction. Topics include DSM with smart meters, evaluation tools for DSM of domestic hot water systems, heat pumps for load management, and protocols for controlling thermostatically controlled loads. Other papers discuss peak demand control in commercial buildings, a DSM system for areas with high renewable energy sources, and a model-based approach for minimizing peak cooling demand with energy storage. A proposed management system for households with a smart circuit breaker box is introduced, enabling integrated control and prediction of demand power.	a1	1	b2	e80	c27, c29	d42	f2	2010	Japan	NM	24	NM
[38]	This work proposes an online scheduling approach for managing domestic power during peak periods. The architecture is scalable, flexible, and can be integrated with other control algorithms to achieve optimal performance from higher levels. The authors are exploring ways to extend the architecture to adapt to changing energy prices and line capacity and suggest incorporating usage statistics and tenant habits for a more intelligent energy management system.	a11	100	b2, b54	e17, e70	NM	d16	f1	2011	Canada	NM	0.50	NM
[39]	The paper proposes a DSM technique for reducing electricity bills and participating in utility DLC programs by aggregating package air conditioner loads in large apartment complexes. This is done using a queuing system model and Markov birth and death process while maintaining thermal comfort levels. The method can also serve as a useful measure for power system operators to assess DLC. Further research can explore multiple queues with different priorities for better flexibility in token allocations.	a12	449	b2, b54	e12	c1	d63	f1	2011	Korea	Seoul (Korea)	0.25	NM
[40]	This paper presents a DSM strategy based on load shifting, formulated as a problem of minimizing and solved using a heuristic-based evolutionary algorithm. Simulations on a smart grid with three different customer areas indicate that the algorithm proposed can handle many controllable devices and achieve substantial savings while reducing peak load demand.	a29	2600, 800, 100	b2, b21	e82	c1	d105	f1	2012	Singapore	NM	24	NM
[41]	This paper suggests a genetic algorithm to minimize energy costs and determine the best configuration of generational facilities in a multi-facility microgrid. The algorithm works daily and considers energy consumption, user-defined limits, and supplier day-ahead pricing information. It effectively minimizes total costs for both suppliers and consumers. Possible improvements include integrating constraint-capturing mechanisms with negotiation algorithms and implementing a tiered-pricing schema for fairness to individual consumers.	a11, a12, a20, a31, a35, a36, a41	10(each)	b1	e1, e2, e82	NM	d17	f1	2014	Pakistan	NM	24	Pakistan
[42]	This paper explores how DR can improve power system efficiency and integrate variable wind power in Ireland's wholesale electricity market. DR can improve energy utilization by changing electricity consumption patterns and shedding load during peak periods. The study also confirms that DR can help integrate wind power, especially in wholesale electricity markets, and examines how electricity market structures impact DR.	a11	100000	b1, b46, b129	e15, e17	NM	d1	f1	2012	Ireland	Building Research Establishment (Ireland)	24	NM
[43]	A model using stochastic difference equations found that DLC actions and load parameter dispersion affect aggregated load. Thermal resistance, air-conditioner rating, and thermostat setting have a more substantial impact on steady-state load than standard deviation and house thermal capacity. To successfully manage load, it is crucial to estimate load reduction and temperature distribution as DCL can increase house temperatures and affect customer comfort in distribution systems.	a12	10000	b2	e15, e17	NM	d7, d42	f1	1998	Turkey	NM	24	NM
[44]	This article suggests an innovative approach for commercial and industrial users to engage in the energy market.The incentive-based DLC model allows consumers to bid on reducing their energy demand during peak hours. This helps the grid handle high-demand periods. The paper uses a mathematical approach called dynamic programming to select the best consumers for the DLC program. The findings indicate that the algorithm performs effectively and produces different solutions based on the bids.	a1	5	b2, b105, b114	e17	NM	d4	f1	2013	Saudi Arabia, Pakistan	NM	NM	NM
[45]	This paper presents a way to incorporate DLC capability into the LC problem, which controls the on/off status of appliances and offers tariff reductions as incentives for DLC contracts. The study finds that customer convenience is an essential element in determining one's choice to engage in DLC programs and proposes an automatic program to help customers respond to price and control signals.	a31, a35, a41	1	b1	e2, e17	NM	d1	f1	2013	Iran	NM	24	NM

A: System Types, B. Objectives, C. Forecast & Prediction & Estimation, D. Optimization & Control, E. Constraint, F. Validation, G. Duration (h), H. System Population, K. Publication Year, L. Publication Country, M. Implemented Database/Place, N. Solver/Program/Software/Toolbox/Platform/Framework

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

TABLE 1. Summary of DLC programs proposed in previous studies (Continue).

Ref.	Conclusions	A	H	B	E	C	D	F	K	L	M	G	N
[46]	Implementing a DLC decision model to manage EVB charging at parking garages with interconnected charging points can improve service quality and reduce global energy costs. The model shifts G2V charges, sets V2G discharges to the grid, and schedules V2V energy exchanges among batteries. Cost savings are achieved by shifting G2V charges from peak to valley price periods. V2G and V2V processes may become more impactful in the future with advances in battery technology. Numerical results have been analyzed for household mobility patterns.	a2, a16	a16(40), a2(10)	b1	e1, e2, e42	NM	d2	f1	2012	Spain	German System (German)	24	NM
[47]	The BDGP is proposed as a solution to the scheduling problem. BDGP improves optimization results compared to iterative deepening and is especially efficient and effective in solving scheduling problems, including DLC. BDGP consists of a master GP and a slave GP and can be applied to similar scheduling problems with slight modifications.	a12	60	b2	e34, e84	NM	d17	f1	2011	Taiwan	NM	4	NM
[48]	This paper introduces a scheme based on fuzzy logic for demand load curtailment in power systems, which integrates transmission network reliability for cost reduction and improved reliability. FDP handles uncertainties and multi-objective optimization, and case studies show that the scheme effectively shaves peak loads and improves system reliability. GAMS is used to implement unit commitment under different DLC schemes enhancing the effectiveness of the technique and makes it practical for system operators in power systems.	a12	10	b2, b19, b54, b130	e2, e16, e93, e94	NM	d6	f1	2010	Singapore	NM	24	Matlab, Matpower
[49]	A DLC scheme for ACL in restructured power systems is proposed to encourage customer participation and compensate them based on their contribution to system reliability. The NIEAR is used to determine compensation rates, and DP is employed to establish the most suitable DLC scheme. Simulation results demonstrate that the scheme proposed enhances reliability, reduces operating costs, and compensates customers fairly.	a12	10	b1, b19, b31	e16, e22, e93, e94	NM	d4	f1	2010	Denmark, Singapore	NM	24	Matpower
[50]	The use of guiding mechanisms through aspiration and reservation levels for each objective function improves the behaviour of the EA in identifying and selecting good compromise load control actions. The DM's preferences and external conditions, such as changes in aggregate load demand or profit forecasts, can be accommodated through the progressive articulation of preferences and relevant information feeding the evolutionary search. This reduces computer effort and produces results more in line with the DM's preferences.	a1	1860	b2, b82	e4, e6	NM	d18	f1	2007	Portugal	NM	24	NM
[51]	This article describes and assesses an application of Controller Area Networks to DLC programs for residential customers, offering a flexible and economical instrument accessed via a graphical user interface environment to activate their participation in deregulated electricity markets. The suggested system has effectively been employed in various actual household settings, primarily focusing on heating and cooling demands, which constitute approximately 50% of residential power consumption.	a12, a20	1(each)	b2	e3, e4	NM	d42	f2	2007	Spain	NM	24	NM
[52]	The IDGA has been successfully used to optimize scheduling for TPC's DLC and Radio Paging-Based Load Management System in Taiwan. It can be applied to similar scheduling and decision-making problems with some modifications, but the structure of IDGA and iterative deepening strategy remain effective.	a12	60	b2	e1, e2, e5	NM	d17	f1	2005	Taiwan	NM	4	NM
[53]	This paper proposes an efficient load management algorithm for Taipower's air-conditioning systems during summer. The algorithm uses pre-stored chilled-water heat transfer capacity and a LEE-based fuzzy thermal comfort controller to maintain thermal comfort, avoid transient payback load, and prolong load shedding time. This reduces the need for additional generation with expensive fuels and less efficient plants and improves transmission capacity.	a12	1	b2	e1, e2, e4, e5, e12	c40	d39	f2	2005	Taiwan	Taiwan	4	NM
[54]	This stud presents an adaptive control approach that combines ILM with DLC. The algorithm adjusts the DLC's pre-scheduling by interrupting the ILM in real time and removes energy payback in the DLC by using forecasted load as a reference model. This strategy maintains system security with fewer customer disturbances and can be easily applied to the competitive power market to provide ancillary services.	a12	20	b2, b60	e1, e2, e5, e84, e95	NM	d6	f1&/f2	2004	Taiwan	Taiwan Power Company (Taiwan	24	Turbo C
[55]	This paper suggests using NLPCA and periodic analysis with SOM networks to cluster DLC curves, followed by DB indexes and k-means for final clustering. The approach was tested on practical DLC load data, showing positive results. The program evaluates decreases in power and energy attributed to DLC programs using compliant load curves. Reduction values are used as performance indexes to improve programs. The proposed approach screens daily load patterns that do not adhere to DLC control patterns in performance evaluation.	a9	1	b2	e1, e2	NM	d24, d151, d152	f1	2004	Taiwan	Taiwan Power Company (Taiwan)	8	NM
[56]	This paper introduces a new method to reduce power losses and expenses in a distribution network by controlling the load of residential electric water heaters. The technique is tested on a three-phase primary feeder, resulting in an annual cost reduction of $23,863.29. Future studies will expand this approach to single-phase systems, address unbalanced conditions, and analyze non-radial primary feeders' impact on transmission system losses and expenses.	a11	927	b2, b131, b132	NM	NM	d122	f1	2002	USA	NM	24	NM
[57]	A new HVAC program has been developed that uses a control algorithm to modify the load curve to meet a target curve while considering customer comfort and system constraints. The algorithm underwent evaluation on a real load curve, and improvements are being made to increase calculation speed and expand its use. Load modelling is being developed to assess control effects and payback periods, with load demand data being collected to test the models.	a13	5	b2	e4, e5, e17	NM	d95, d120	f1	2000	Spain	Polytechnic University of Cartagena (Spain)	14	Matlab

A: System Types, B: Objectives, C: Forecast & Prediction & Estimation, D: Optimization & Control, E: Constraint, F: Validation, G: Duration (h), H: System Population, K: Publication Year, L: Publication Country, M: Implemented Database/Place, N: Solver/Program/Software/Toolbox/Platform/Framework

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

TABLE 1. Summary of DLC programs proposed in previous studies (Continue).

Ref.	Conclusions	A	H	B	E	C	D	F	K	L	M	G	N
[58]	A profit-based load management scheduling program using linear programming is presented, which achieves better solutions than the conventional cost-based approach when the rate structure varies. The algorithm schedules each control device of DLC, and the integer solutions achieved are a practical representation of the control system.	a29	NM	b1	e5	NM	d2, d11	f1	1998	USA	NM	12	NM
[59]	This paper presents an approach using fuzzy sets to cut operation costs and enhance customer satisfaction. The algorithm combines UC with the scheduling of ACLs, considering uncertainties due to forecasting errors and DLC-UC interaction. Constraints on ACLs' on/off duration are fuzzified to reflect different temperature control preferences. The algorithm is tested on Taipower systems, showing the ability to reduce peak-loads and the robustness of the proposed DLC schemes using Monte-Carlo simulation.	a12	15	b1, b2	e1, e4, e5, e6	NM	d6	f1	1998	Taiwan	Taiwan Power Company (Taiwan)	6	Turbo C
[60]	The study proposes an optimization method for scheduling the DCL of air conditioners in commercial buildings to reduce customer discomfort and maintain total incomes for the TPC during the summer peak season. The method considers constraints such as compressor operation limitations and room temperature and can dynamically specify target load levels. This makes it useful for other utilities looking to control peak load growth rates and maximize benefits.	a12	15	b2	e1, e3, e4, e11	NM	d4	f1	1993	Taiwan	Taiwan Power Company (Taiwan)	5	NM
[61]	A new MPDP approach was developed for DLC dispatch, resulting in significant cost savings and peak load reduction. The approach was tested on the Taiwan Power Company system and showed that peak load reduction and cost savings are related to energy payback patterns. The MPDP approach can quickly calculate load control values for each time stage during the study period and requires minimal memory, making it suitable for other types of load control operations.	a12	27	b1, b2	e5, e60	NM	d5	f1	1995	Taiwan	Taiwan Power Company (Taiwan)	192	NM
[62]	This paper shows how a demand response program can reduce power demand by controlling room air conditioners in residential complexes. ACL+HAC hardware makes it easy to implement such programs, and large-scale demonstrations suggest that it can be implemented in many internet-connected smart homes. The future of demand response could solve challenges for the electric power industry. One improvement is to use Zigbee-enabled ACLs or smart homes and explore ways of computing electricity demand reduction for each ACL.	a12	100	b2	e13, e15	NM	d56	f2	2014	Philippines	NM	24	Visual Studio
[63]	This paper proposes a control method for EWHs to regulate their electricity usage in accordance with regulation signals. A computer-generated model for a twin-component EWH to estimate hot water demand. Results suggest that a smart grid can control appliances and collect revenue from the regulation market, while consumers benefit by offering their appliances to help integrate renewable resources into the electrical grid.	a11	10000	b2	e1, e5, e17, e44	NM	d44	f1	2011	USA, Japan	NM	24	NM
[64]	This project implements DLC using ripple signals, with a 40 kVA rating for a 60 MVA power transformer. Three strategies were used for load control simulation, and a surge absorber was installed to avoid transducer damage resulting from electrical surges. A remote measurement system was also installed to enhance the ripple control system to provide bidirectional functionality.	a11, a12	a11(13), a12(76)	b2	e2, e4, e16	NM	d93	f1	1997	Taiwan	National Taiwan University of Science and Technology (Taiwan)	10	NM
[65]	This paper analyzes how demand response programs, specifically DLC, affect the reliability of a deregulated power system. By using economic load models, DC power-flow-based optimal load curtailment objectives, and reliability evaluation techniques, the study finds that DLC improves the overall system and nodal reliability of a deregulated power system.	a11	NM	b2, b19	e6	NM	d2	f1	2008	Iran	NM	24	NM
[66]	Direct control of air conditioners can be projected based on hourly demand, ambient temperature, humidity, instantaneous demand, and actual rating. A load research program should gather data for hourly demand and environmental factors. The analysis will compare actual usage to projected usage based on design specifications to provide a utilization factor and determine control strategies for all hours of the day. The data can also serve for evaluating the effects of capacity reduction and reduced losses for transmission and distribution systems.	a12	10000	b2	e1, e17	c27	NM	f1	1993	USA	NM	24	NM
[67]	A method to reduce peak energy consumption while maintaining thermal comfort has been proven effective in simulations. The method can be adjusted to different loads and contexts, considering economic and technical signals from managers and DNO. This method can contribute to ancillary services, like voltage control in distribution networks, and avoid abrupt load shedding by adaptively modifying the set temperature for each air conditioner to achieve a desired power level designated by DNO.	a12	12	b2	e12, e13, e44	NM	d75	f1	2009	France, Vietnam	NM	24	NM
[68]	This paper suggests a DLC algorithm that uses LP to control a VPP of controllable customers, enabling aggregators to submit load reduction bids to electricity markets. The algorithm optimizes control strategies for groups of customers by modelling controllable loads with EnergyPlus. The model is tested in northern Spain and found to be effective for generating load reduction bids and allowing controllable customers to participate in transmission system operation markets.	a12	6503	b2	e1, e5, e8	NM	d2	f1	2009	Spain	Northern Spain	24	EnergyPlus

A: System Types, B: Objectives, C: Forecast & Prediction & Estimation, D: Optimization & Control, E: Constraint, F: Validation, G: Duration (h), H: System Population, K: Publication Year, L: Publication Country, M: Implemented Database/Place, N: Solver/Program/Software/Toolbox/Platform/Framework

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

TABLE 1. Summary of DLC programs proposed in previous studies (Continue).

Ref.	Conclusions	A	H	B	E	C	D	F	K	L	M	G	N
[69]	This paper introduces a low-cost load control system that uses an 8-bit microprocessor. It provides detailed instructions for small- and medium-sized utility engineers to design and develop load control methods. The system is powerful enough to control several thousand devices and has been successfully tested. For utilities with existing distribution automation equipment, the system can be integrated with software modifications.	a11	1	b2	NM	c27	d42	f2	1995	USA	NM	24	NM
[70]	A DLC system has been successfully designed, implemented, and evaluated. It is flexible, reliable, and efficient, with adjustable warning periods and load restoration that does not generate additional peaks. The hardware can be integrated with a digital energy meter for complete energy management. Future work will address scaling issues related to cost, customer acceptance, and comfort.	a46, a47	A46(2), A47(6)	b2, b3	e2	NM	d42	f2	1999	Saudi Arabia	NM	2.5	C++, Visual Basic
[71]	This paper proposes a fuzzy set-based DLC method to decrease operational expenses and enhance customer satisfaction. The algorithm schedules the ACLs by incorporating the UC to minimize system operation costs while taking into account load uncertainties. The algorithm was tested on Taipower systems using 15 ACL groups and validated the effectiveness of peak-load reduction. The proposed DLC scheme's robustness in handling load uncertainties was confirmed using the Monte-Carlo simulation technique.	a12	15	b1, b2, b133	e1, e4, e53,	NM	d6	f2	1999	Taiwan	Taiwan Power Company (Taiwan)	5	Turbo C
[72]	The duty cycle model is a helpful tool for analyzing appliance load data and characterizing customer usage patterns. The beta function can be utilized to estimate the load effects of alternative cycling strategies. The model can help evaluate load reductions from control programs and improve utility demand-side planning. The analysis also demonstrates the feasibility of integrated desktop load data analysis for DSM managers.	a8, a9, a11, a34	a8(35), a9(20), a11(45), a34(10)	b2	NM	c39	d96	f2	1989	USA	Athens (Greece), Tennessee (USA)	24	NM
[73]	Physical load models have been developed for accurate DLC program assessment. These models have been widely tested and found to provide accurate results when implemented using Simulink-Matlab. They can be utilized to conduct a more precise evaluation of various LM actions and to select the best option before implementation by the utility. An aggregate model for individual HVAC load models is being developed to study their advantages.	a13	1	b2	e3, e5, e17	NM	d42	f1	2003	Spain	Elnur-Gaharron S.A. (Spain)	3.50	Matlab
[74]	MLR load analysis is helpful for studying feeders in the NCEMC LM system. We hope to develop a general model for load deferred per switch. Improvements to the diversified load model include dropping the index and including variables indicating system conditions for the previous two to three days. However, most of the energy deferred by load control is lost in the NCEMC LM system, so minimizing control length is crucial to maximize energy sales.	a11, a12	NM	b2, b134	e1, e2	c24	NM	f1	1991	USA	North Carolina Electric Membership Corporation (USA)	10	SAS
[75]	This paper suggests a semi-automated HEMS programmed by an aggregator to reduce peak demand and initial costs. The HEMS uses data from residential units and a GC function or GMM to generate new data. The proposed DADLCS improves distribution transformer and feeder utilization and prevents overloading. A case study with 200 residential units confirms that the proposed method can control aggregate domestic flexible loads with minimal impact on customers' lifestyles and lower peak demand effectively.	a2, a35, a41	200(each)	b1, b2	e60, e68	c42	d116	f1	2014	Iran	NM	24	GAMS, Matlab
[76]	This paper proposes an efficient on-line optimization approach for TWDLC based on linear programming. It calculates shedding ratios at fixed intervals to reduce computational complexity and proposes a coordination scheme with gateways placed at customer premises for the main computer. This two-way control scheme can be implemented in different systems, provided that the communication speed meets the required threshold to complete optimization and communication within the sampling interval.	a9	30	b2, b3	e1, e2	NM	d6	f1	2008	Taiwan	NM	120	LINGO
[77]	This paper presents a control approach for Cyber-Physical Power Systems that limits peak power consumption and ensures specific behaviour of the environment. Real-time scheduling algorithms are used for loads with constant dynamics and stochastic disturbance on state variable evolution. Future work will focus on releasing assumptions made, alternative system models, integrating renewable sources, and modelling real-time parameters as multiples of a finite time quantum.	a43	3	b2, b17	e15	NM	d42, d113	f1	2011	Italy	NM	20	NM
[78]	This study presents a system that utilizes wireless sensor networks for the supervision and regulation of electric consumption in residential regions. The system allows customers to manage their electricity usage through compelled switching actions. It is flexible, powerful, and low-cost, eliminating the need for additional wiring by using wireless communications, and can be applied to commercial or industrial customers. The system has been evaluated within an academic setting as an initial trial initiative and can also be integrated into domestic appliances, supporting other uses like home automation and security monitoring.	a13	15	b2, b18	e5, e17	NM	d120	f2	2007	Spain	NM	18	NM
[79]	This paper suggests using ARMA modelling to cluster DLC curves using the GKA approach. This will lead to better classification rates and fewer input variables. Compliant DLC curves can be used to evaluate power and energy reductions from DLC programs. The reduction values can be used as performance indexes for individual programs. This approach can help TPC improve DLC programs by removing those not complying with control patterns.	a12	58	b2	e1, e5	c35	d36	f2	2005	Taiwan	Taiwan Power Company (Taiwan)	6, 8, 10.5	NM

A: System Types, B: Objectives, C: Forecast & Prediction & Estimation, D: Optimization & Control, E: Constraint, F: Validation, G: Duration (h), H: System Population, K: Publication Year, L: Publication Country, M: Implemented Database/Place, N: Solver/Program/Software/Toolbox/Platform/Framework

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

TABLE 1. Summary of DLC programs proposed in previous studies (Continue).

Ref.	Conclusions	A	H	B	E	C	D	F	K	L	M	G	N
[80]	Proposing a new load model for DLC that uses fuzzy logic to incorporate customer preferences and accounts for device and thermal differences within cycling groups. The load model helps compute cycling time, and net restored energy for each group, which is then utilized in an optimization procedure to schedule groups and reduce production costs.	a12	25000	b2, b44	e1, e5, e17, e31	NM	d39	f1	1995	USA	NM	8	NM
[81]	DLC can generate production cost savings, but DLC strategies must be coordinated with system dispatch on a daily or weekly schedule. Computer tools like end-use load models and unit commitment programs can be used to synthesize, coordinate, and evaluate DLC strategies' impacts on the system load curves, unit commitment schedule, production cost, and spinning reserve policy.	a11	NM	b1, b2	e5, e60	NM	d4	f1&f2	1983	USA	City of Lakeland, Florida (USA)	24	NM
[82]	This research proposes a tool for controlling peak demand in commercial zones. It uses DLC programs applied to CenAC equipment in office buildings, including a load prediction model, thermal behaviour modelling of buildings, and an algorithm. The tool reduces practical application by 13% of the total manageable load, which represents about 1.3% of the substation considered. In countries like the USA, where air conditioning load represents 50-60% of the peak during summertime, values of about 8% of the system's peak demand are obtained through DLC plans. The proposed model is validated and could yield similar results in the American market.	a9	18	b2	e1, e5, e15, e17	NM	d40	f1	2012	Chile	Santiago (Chile)	8	NM
[83]	This paper examines a DLC program and suggests improvements. The current on-off cycle in DLC controllers is not suited to many residences, which limits effectiveness. Two alternatives are proposed: pre-screening and advanced DLC controllers. An advanced DLC controller with the ability to set cycle-off time based on monitoring of normal house operation would yield kW load savings and cost 29% less than current controllers.	a12	555	b2	e1, e17	NM	d45	f2	1992	USA	New Jersey by the Atlantic Electric Company (USA)	24	NM
[84]	This paper addresses the LCom problem, which controls appliance usage and battery charging/discharging cycles. It also incorporates DLC capability. Results show that LCom can lower customer payments but may not decrease peak value and PAR of load profile. A maximum transfer limit is needed to prevent simultaneous switching of high-consumption appliances, storage facilities, and PHEVs. This could create a new peak. Tariff reduction is considered an incentive for DLC contracts, and uncertainty about problem parameters is still being researched.	a16, a22, a31, a35, a41	NM	b1, b2, b72	e1, e2, e17, e41, e96	NM	d117	f1	2012	Iran	Baltimore (BGE) (USA), Texas SECO (USA)	24	NM
[85]	A censored regression model is introduced to predict AC loads in a utility territory, which is simpler and requires less data than non-parametric methods. This model is more accurate than moving averages and straightforward to put into practice, which makes it a valuable gradual modification for utilities and ISOs. Further refinement is planned for the future.	a12	467	b2	NM	c2	NM	f1	2014	USA	Pepco (USA)	24	NM
[86]	This paper introduces a real-time scheduling technique for electric load management to reduce peak loads and meet service constraints. The approach achieves an 8% average and 41% worst-case reduction in peak loads for a single apartment. The technique can manage multiple apartments as a Virtual Electricity Consumer, achieving up to a 46% peak load reduction.	a13, a35, a41, a42	NM	b2, b54	e13, e55	NM	d16, d113	f1	2014	Italy	NM	24	NM
[87]	This paper presents an OTM method for short-term load forecasting, which includes techniques for detecting uneven temperature match patterns and reducing forecast errors. Case studies show that the OTM method is on par in terms of precision with the BJTF and neural network methods and outperforms the BJ and multilinear regression methods. However, the OTM method requires a larger database than other methods.	a1	1	b2	NM	c2, c3, c15, c27	d126	f1	1996	USA	NM	24	NM
[88]	This study presents a technique to study peak load probabilities for a group of air conditioners. The study compares natural diversity peak loads to those from controlled diversity. Results show that natural diversity results in a higher peak load than controlled diversity. However, peak load reduction from DLC is insignificant with many air conditioners, a control frequency of 4, and an on-time ratio not exceeding 0.75. DLC achieves maximum peak load reduction only when the on-time ratio is 1.0, but this leads to energy deficits and may cause customers to drop out of the DSM program.	a12	10000	b2	NM	NM	d7	f1	1996	USA	NM	24	NM
[89]	This study presents the design and execution of a dual microprocessor-based demand controller for industrial and commercial customers to monitor and reduce peak load and energy consumption. A load management software was also developed to provide data loading, database management, and load analysis. Field tests were conducted on air conditioners, demonstrating the efficacy of the model in reducing peak load and energy consumption.	a12	8	b2	e20	NM	d2	f2	2001	Taiwan	NM	24	NM
[90]	This paper emphasizes the significance of OCLD in air conditioning systems, given the heightened cooling load from the semiconductor industry. It provides a mathematical model for the OCLD issue and suggests a Lagrangian approach to solve it. The proposed method outperforms traditional methods in energy savings, as demonstrated by tests on two sample systems.	a43	12	b2	e20	NM	d127	f1	2002	Taiwan	Hsinchu Science Industrial District and Taipei (Taiwan)	24	NM
[91]	This paper presents a DSS for a substation with a capacity shortage. It uses IDP to schedule the ILG and an enumerative search algorithm to achieve the best or nearly best timetable. The HIR adjusts the interruptible load schedule online, and the suggested algorithms prove to be efficient in addressing the issue of insufficient capacity. This methodology has the potential for expansion to different systems in future studies.	a40	15 groups	b2	e1, e2, e4, e6	NM	d4, d118	f1	2003	Taiwan	NM	9	NM

A: System Types, B: Objectives, C: Forecast & Prediction & Estimation, D: Optimization & Control, E: Constraint, F: Validation, G: Duration (h), H: System Population, K: Publication Year, L: Publication Country, M: Implemented Database/Place, N: Solver/Program/Software/Toolbox/Platform/Framework

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

TABLE 1. Summary of DLC programs proposed in previous studies (Continue).

Ref.	Conclusions	A	H	B	E	C	D	F	K	L	M	G	N
[92]	A tool that assesses the flexibility of residential load demand by controlling space conditioning is introduced. The tool selects the best load control strategy using a non-intrusive load decomposition technique and multivariable constraint predictive control methodology. Advantages include shaping global demand to a target profile, aggregating load models without mathematical expressions, and not requiring individual load monitoring. The tool can be applied from both the utility's and customer's perspectives and has been tested in a real environment.	a8, a12	75 (each)	b2, b104	e17	c8	d95	f1	2004	Spain	Universidad Politécnica de Cartagena (Spain)	14	NM
[93]	This study introduces a mathematical model and optimization method for the OCO problem in air-conditioning systems. Using the DP method to optimize chiller operation based on characteristic curves, the proposed method reduces energy consumption and increases equipment lifetime compared to the conventional method. It is readily deployable for use in modern chillers with control panels that provide the necessary data.	a43	9	b2	e1, e11, e20	NM	d4, d127	f1	2006	Taiwan	NM	24	Visual C++
[94]	This paper explores the utilization of a two-way DLC system with a real-time TWDLC algorithm load-shedding mechanism in power companies, demand bidding, load service entities, aggregators, and energy service companies. The system can also be used for automatic monitoring of air conditioning by manufacturers or maintenance companies.	a17	100	b2	e1, e2	NM	d4,d119	f1	2006	Taiwan	NM	2.5	NM
[95]	This paper proposes using an algorithm for DLC with thermal comfort control based on LEE to manage air-conditioning loads and maintain thermal comfort levels. The g-DLC controller is used to manage the shedding load and constraints of all air conditioning system as an aggregate load, simplifying the load management program.	a12	8	b2, b3	e2, e4, e5, e12, e38	c40	d39	f1	2007	Taiwan	NM	5	NM
[96]	The current fixed electricity rate for households does not reflect the actual cost of electricity during consumption. This means that customers do not have an incentive to save energy during power shortages if they are not affected by variable pricing. We are researching how to control major appliances like ACs, heaters, and water heaters, which consume significant amounts of electricity. We will use Matlab simulations with ERCOT's pseudo real-time pricing and actual outdoor temperature data to demonstrate our strategy. Our customer-focused control approach balances user comfort and price preferences effectively and is simple for residential consumers to use in real life.	a11, a12	NM	b1, b64	e4, e15, e27	NM	d42, d136	f1	2007	USA	www.findlocalweather.com (Dallas/Forth Worth) (USA), The Electric Reliability Council of Texas (USA)	24	Matlab
[97]	The proposed thermal regulator can efficiently reduce peak consumption while maintaining thermal comfort and can adapt to new contexts by taking into account dynamic tariffs and network signals. This regulator is an intelligent solution for load management and can be put into practice for a cluster of loads or buildings to reduce peak consumption and avoid network congestion.	a12	50	b2	e4	NM	d39, d47, d75	f1	2008	France	NM	24	Matlab
[98]	This paper suggests an online optimization method for TWDLC using linear programming. It aims to improve computational efficiency by calculating shedding ratios for fixed time periods. In addition, a coordination scheme for the main computer and gateways at customer sites is proposed, which can be used for other systems as long as the data transfer rate is sufficiently high to complete optimization and communication within the sampling interval.	a17	30	b2, b3	e2, e11, e12, e34	NM	d2	f1	2009	Taiwan	Northern Taiwan	7	NM
[99]	This paper presents a load-shedding algorithm that maximizes multi-chiller efficiency while meeting TPC requirements by optimizing the total cooling load. The algorithm, using the Penalty Function Method and Simplex Method in C++, outperforms previous methods. Further studies should investigate the impact of load-shedding on customer comfort and explore the potential benefits of fan and ice water flow rate control.	a43	5	b2, b3	e60	NM	d14	f1	2009	China, Taiwan	Taiwan Power Company (Taiwan)	NM	C++
[100]	This paper presents an innovative structure for managing and regulating thermostatic AC loads using a universal set point temperature command. The resulting model is a bilinear system that is conditionally controllable, stable in an open-loop configuration, and a state-space feedback controller is designed using Lyapunov stability criteria. Numerical simulations validate the model and the controller's performance for load following during DSM of the AC systems.	a12	NM	b2	e13, e31, e44	NM	d17	f1	2011	USA	NM	5	NM
[101]	This paper proposes a control method for HVAC units that can provide 24-hour load-balancing services. The authors suggest extending the control to TCAs to generate extra income from the ancillary service marketplace while consumers have the opportunity to earn extra income by making their appliances available for valuable load-balancing services and contributing to the integration of renewable resources into the power grid. Subsequent efforts will concentrate on developing direct control algorithms for different TCA loads and enhancing control and enhancing predictive precision through the utilization of smart meter data.	a13	1000	b2	e13, e17, e44	NM	d38	f1	2012	USA	NM	24	NM
[102]	This paper presents a multiagent system for managing a residential microgrid in real-time. The system was developed using an open-source IEEE FIPA-compliant platform and implements a two-stage operational strategy. Simulation research showcases the efficacy of the method put forth and the possibility of autonomous operation. The two-stage scheduling outlined in the paper is a valuable tool for efficient management, addressing both the economic and technical objectives of the operation.	a29 (a31, a35, a 41, a42, a44, a49, a50, a51, a52, a53, a54, a55, a56)	2600	b2, b21, b59	e8, e41, e45,	NM	NM	f1	2012	Singapore	NM	24	JADE (FIPA)

A: System Types, B: Objectives, C: Forecast & Prediction & Estimation, D: Optimization & Control, E: Constraint, F: Validation, G: Duration (h), H: System Population, K: Publication Year, L: Publication Country, M: Implemented Database/Place, N: Solver/Program/Software/Toolbox/Platform/Framework

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

TABLE 1. Summary of DLC programs proposed in previous studies (Continue).

Ref.	Conclusions	A	H	B	E	C	D	F	K	L	M	G	N
[103]	This paper presents a centralized controller design for TCA units to provide CRR services. The method for regulating HVAC systems to achieve load balancing within the hour was suggested and simulations showed that 1000 HVAC units could provide 24 hours of balancing services by the suggested control plan. Subsequent efforts will be directed towards optimal control parameter selection and improving accuracy using smart meter measurements.	a13	1000	b2, b21	e13, e15, e44	NM	d38	f1	2013	USA	NM	24	NM
[104]	This paper introduces a dynamic model of an EWH that captures thermal stratification and a statistical model for populations of EWHs. Four rule-based control approaches for aggregate power set point tracking have been introduced and evaluated for tracking quality, customer comfort, and device operation. The introduction of the SOC concept improves control performance by considering the whole temperature distribution inside the tank.	a11	4	b2	e13, e17, e44	NM	d70, d97	f1	2012	Switzerland	Lawrence Berkeley National Laboratory (USA)	24	NM
[105]	The article looks at DLC methods for energy management, emphasizing comfort's qualitative and subjective evaluation. Results show that direct load action, especially on air conditioning, saved 21% of energy. Scheduled programming had average savings of 45% but had poor customer interaction and limited management actions. The proposed criteria resulted in better energy efficiency with 25.2% energy savings and computer use as a significant variable. Intelligent integration of criteria can improve energy efficiency.	a13	11	b2, b46	e15, e17, e97,	NM	d37	f1	2012	Colombia	NM	24	NM
[106]	PG&E tested using residential AC loads for ancillary service operations. They found that programs for controlling air conditioning loads can promptly initiate resources , with 80% of demand reduction in under 3 minutes. Control centers can receive near real-time aggregate AC loads, and demand reductions change with the time of day and temperature fluctuation. Short-term AC curtailments did not significantly affect customer satisfaction or comfort.	a12	403	b2, b60, b135	e2, e17	c2	NM	f2	2013	USA	(Fresno) and Bay Area suburbs (Antioch and Fairfield) [Pacific Gas and Electric] (USA)	7	NM
[107]	This paper proposes a centralized controller for HVAC in a cooling model, studies factors affecting performance such as imperfect forecast, lock-off time, delay response, and outdoor temperature impact, and evaluates the performance of HVAC cooling load for providing CRR services. The results indicate that the suggested control scheme can provide 24 hours of intra-hour continuous balancing services with approximately 1000 HVAC units, and load service providers can collect additional revenue from the ancillary service market while consumers can receive additional revenue by offering their appliances for load balancing services.	a13	1000	b2	e13, e44	NM	d38	f1	2013	USA	NM	24	Matlab
[108]	This paper proposes a new multi-level Quality of Power Usage (QoPU) concept and corresponding scheduling policy for balancing power distribution in smart grids. The proposed policy effectively levels power distribution during peak hours, as demonstrated by computer simulations. QoPU grades can also be used by other control policies for priority-based scheduling of electrical appliances.	a12, a16, a24, a31, a35, a41	3	b2	e2, e22	NM	d21	f1	2012	Japan, Egypt	NM	24	Matlab
[109]	This paper discusses the parameter selection process for a centralized DLC controller to provide LBSs, evaluating its performance based on device switch cycles, customer discomfort durations, and energy and power errors. Computing scenarios in parallel enables real-time updates of performance metrics and index lookup tables to adapt to changing conditions. Future research will concentrate on creating performance lookup tables for various TCA loads to assist grid operators in selecting the appropriate load resources.	a13	1000	b2	e2, e13, e44,	NM	d38	f1	2013	USA	NM	24	NM
[110]	A model was created to predict air conditioning loads under different demand response scenarios accurately. A control strategy was also developed to track the demand curve while maintaining good performance. This structure has the potential for expansion to encompass additional loads and is useful for studying stability issues related to demand-side control.	a12	5000	b2	e13, e44	NM	d4	f1	2013	USA	NM	4	GridLAB-D
[111]	This paper examines how TCL aggregations can use DLC to engage in intra-hour electricity market price arbitrage. The findings show that ACs participating in energy arbitrage in CAISO's market for energy with 5-minute intervals in Merced could achieve savings of around $13 per demand response TCL device annually, amounting to approximately 14% of wholesale energy expenses. However, the potential for energy cost savings is reduced by stochasticity, making actual savings more modest. A load aggregator must determine if expected revenues will cover the costs of TCL control and provide sufficient profit.	a12	1000	b1	e13, e20, e44	NM	d2, d7, d41	f1	2013	Switzerland, USA	Merced, California (USA)	24	NM
[112]	A new system has been proposed to reduce peak loads in low-voltage distribution networks. The system uses low-cost controllers featuring bidirectional communication to monitor and control loads and a multi-objective decision-making process to select which loads to delay or reduce. It also improves network voltage drop problems and reduces power imbalance using the MODM method. Results from a simulation in Matlab show the system's ability to control overloads while meeting objectives.	a1, a15, a22	A1(60), A15(15), A22 (NM)	b2, b128, b133, b135	e4, e6, e98, e99	NM	d110	f1	2013	Australia	NM	48	Matlab
[113]	This paper presents a tool for evaluating domestic hot water loads and suggesting DSM switching programs. The tool estimates peak load reductions while ensuring customer comfort. It works with various switching programs and optimizes programs that meet peak reduction targets. Control period length is important for peak reduction but must be limited for customer comfort. The tool helps DSOs design DSM programs by predicting potential peak load reductions and customer comfort levels. It has been used by a DSO in Tasmania since June 2013.	a11	1000, 279 (actual)	b2, b64, b71	e2, e5, e15	c22	d128, d130, d131	f1	2013	Australia	NM	24	NM

A: System Types, B: Objectives, C: Forecast & Prediction & Estimation, D: Optimization & Control, E: Constraint, F: Validation, G: Duration (h), H: System Population, K: Publication Year, L: Publication Country, M: Implemented Database/Place, N: Solver/Program/Software/Toolbox/Platform/Framework

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

TABLE 1. Summary of DLC programs proposed in previous studies (Continue).

Ref.	Conclusions	A	H	B	E	C	D	F	K	L	M	G	N
[114]	This research suggests using socioeconomic clustering to enhance DR programs. It improves predicting DR availability during events and benefits customers, aggregators, and system operators. The cost-effectiveness of demand response incentives in handling peak load incidents should surpass that of maintaining operating reserve generation capacity. Collective demand response has the capacity to function as a virtual energy storage. This paper analyzes zip code 67212 residents' socioeconomic conditions to implement DLC during DR events. An optimization model was developed to find the maximum aggregator revenue and virtual storage capacity of corresponding clusters.	a13	11106	b2	e3, e5, e13	NM	d17	f1	2019	USA	www.city-data.com www.zillow.com https://www.import.io/post/what-is-data-and-why-is-it-important/	2	NM
[115]	This study proposes a MINLP model to improve multi-carrier energy systems' resilience. It considers generation and consumption uncertainties and examines factors that enhance resilience, such as automatic switching, DR and DLC programs, heat exchange, storage systems, and P2G technology. The study demonstrates that these factors can reduce load shedding and increase available electrical power during emergencies.	a1	3	b1, b3	e3, e6	c16	d12	f1	2022	Iran	NM	24	GAMS/ DECOPT
[116]	This manuscript outlines a methodology for sizing a microgrid with ROD plant components that allows for flexible operation. It uses DLC-DSM to optimize ROD plant operation while determining component sizes. We tested different evolutionary algorithms for solving the sizing method and found that PSO had faster convergence while GA offered the most optimal solution with a slight advantage. Our results indicate that the suggested combined dimensioning of a microgrid with an ROD system and adaptable functioning of RO units is more cost-effective than traditional methods.	a1	1	b1	e8, e63	c4, c3, c17, c18	d13, d23	f1	2020	India	Ashkelon (Israel), Chennai (India)	24	Matlab, GAMS/ GUROBI
[117]	Deregulation of the US electricity industry has led to more DR programs to reduce peak load and save energy. While studies have shown that DR programs have benefits, little research has been done on the impact on participants' behaviour. This paper analyzes the response of participants in one DR program and finds that they increase energy consumption before and after event hours compared to the counterfactual. This has significant implications for understanding net benefits and forecasting demand.	a12	294	b2	e2, e3	c2	NM	f2	2015	USA	Environment Northeast (USA)	24	NM
[118]	This document contains papers on DSM and load control. Topics include evaluating programs for hot water systems, predicting residential participation in DR programs, and proposing an optimal power control method for distribution systems with SNOP and DLC AC loads. The papers also address the impact of behavioural responses on DR program effectiveness and using decision-making to select loads for delay or control.	a12	NM	b2, b3	e1, e2, e3, e9, e15	NM	d42, d43	f1	2018	China, Singapore	Chengdu (China)	1	NM
[119]	This document contains research papers on demand response, load control, and energy management systems for microgrids. The papers cover topics such as optimizing hot water load reduction, predicting residential participation in DR programs, using socioeconomic clustering to target customers for DR, enhancing energy system resilience, sizing microgrids with desalination plants, evaluating behavioural responses to DR programs, and improving power control methods for DLC air-conditioning loads. The papers also present EMS models for microgrids that incorporate DR programs, energy storage systems, and electric vehicles.	a2, a12	NM	b17	e3, e4, e12, e13, e17	NM	d13, d42	f1	2022	Turkey, Ireland, Portugal	Renewable Energy Laboratory (https://midcdmz.nrel.gov/), http://www.liotech.ru/ensmallford	24	GAMS v.24.1.3 with Cplex v.12 solver
[120]	This paper presents an innovative method for optimizing a smart grid's economic, reliability, and flexibility goals using a multi-objective GMS technique. The technique was tested on the 24-bus IEEE-RTS and includes a flexible analysis procedure that uses FMOGM scheduling associated with demand response programs optimization and deep learning to forecast RER uncertainty. The findings suggested notable enhancements in the system's flexibility and reliability without increasing overall costs. Price-based and incentive-based DR programs were both found to have notable benefits for improving techno-economic indices. Future research should address real-world constraints such as load and price uncertainties.	a1	NM	b9, b18, b19	e6	NM	d137	f1	2022	Iran	NM	8760	GAMS, Python
[121]	This study proposes an optimal sizing method for a micro-grid on Hengam Island, Iran, using wind and solar energy resources. The approach is applicable to other islanded micro-grid projects. Implementing DLC-DR programs reduces overall cost, and sensitivity analysis evaluates the DR program. Energy providers can use these findings to create load flexibility and enable peak load shaving in the planning phase of isolated micro-grids.	a2, a39	a2(60), a39(NM)	b2, b19	e48, e100	NM	d25, d9	f1	2019	New Zealand	Hengam Island (Iran)	288	Matlab
[122]	A new method is proposed to control the charging of deferrable electrolyzer (DE) units for intra-hour load balancing. The suggested approach is being compared to the original hysteresis control, investigating different energy constraints, dead bands, and charging errors. The ECSPL model is demonstrated by investigating DE units, and additional problems related to optimizing dispatch based on SPL models for other energy storage in smart grid environments are recommended.	a4	a4(300)	b29	e10, e11	NM	d50	f1	2016	China, USA	NM	24	NM
[123]	This paper models load shifting for heat pumps to reduce the operational expenses of the power generation system and building owners using model predictive controllers. Load shaping outperforms price-based incentives, reducing operational costs by 0.9% to 5.5% and CO_2 emissions by 0.4% to 6.6%. A practical implementation could optimize the functioning of the power generation system and communicate the load profile to buildings.	a8	500 bin buildings	b21, b30, b31	e3, e7, e11	NM	d13, d41	f1	2016	Belgium, USA	Belgium	48	GAMS 24.4, Matlab 2011b, CPLEX 12.6

A: System Types, B: Objectives, C: Forecast & Prediction & Estimation, D: Optimization & Control, E: Constraint, F: Validation, G: Duration (h), H: System Population, K: Publication Year, L: Publication Country, M: Implemented Database/Place, N: Solver/Program/Software/Toolbox/Platform/Framework

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

TABLE 1. Summary of DLC programs proposed in previous studies (Continue).

Ref.	Conclusions	A	H	B	E	C	D	F	K	L	M	G	N
[124]	A new feedback control strategy for cooling supply is proposed to reduce power during demand response events. The strategy uses an adaptive utility function to distribute chilled water/air flow among different zones/spaces, maintaining uniform thermal comfort. The strategy effectively solves disordered cooling distribution problems and avoids issues with conventional demand-based feedback control. Test results show a 24% reduction in power consumption with acceptable thermal comfort and reduced power rebound after DR events.	a43	a43(6)	b48	e12, e13, e14	NM	d46, d47	f1	2017	Hong Kong	NM	6	TRNSYS
[125]	A novel algorithm for DLC in HVAC systems was found to reduce peak power by up to 60% while maintaining indoor temperatures, compared to 26% reduction with typical set-point control. The algorithm also limits DR restrike and only requires IoT-based smart thermostats, making it a potential service for demand aggregators to sell to the grid.	a13	200	b2	e1, e2, e15, e17,	NM	d27, d28, d49	f1	2018	USA	Chicago, Illinois (USA)	24	SimPy
[126]	This paper suggests a two-stage optimization model for managing multiple thermostatically controlled load groups in a distribution network. The goal is to minimize load regulation costs and use renewable energy efficiently. The model uses proportion aggregation and local optimal task decomposition. Tests on the IEEE 33 node system with eight random load groups show that the proposed method reduces net exchange power fluctuation and regulation costs effectively. Future research will focus on practical testing and multiple time control strategies.	a13	8	b32, b33	e13, e15, e16, e44	NM	d12, d142	f1	2018	China	Guangzhou (China)	24	TOMLAB/SNOPT
[127]	This paper compares centralized and decentralized energy scheduling with and without a game-theoretic approach. Results show that using RESs and CSF helps reduce the burden on the grid and individual costs. However, the proposed algorithms do not consider deviations from predicted solar profiles or consumer behavioural patterns. Future research may include adding penalty functions to discourage schedule shifting, studying the effect of grid stability, and investigating communication failure scenarios.	a13	30	b4, b22, b34	e1, e12, e17	NM	d28, d143	f1&f2	2018	Australia	Sydney (Australia)	24	EnergyPlus, SolarPro
[128]	This study showed that over 300 residential buildings equipped with heat pumps could reduce their electricity usage by 40-65% through a demand response scheme that estimates electric flexibility using data from energy meters and external temperature readings. The study also found that low-cost equipment can efficiently exploit residential building flexibility for anticipated load reduction solutions. Subsequent research will concentrate on enhancing communication and control and exploring ways to increase flexibility without sacrificing user comfort.	a8	322	b2, b34	e15	c19	NM	f2	2019	Switzerland	NM	12	NM
[129]	This paper establishes a model of polysilicon load for DLC, analyzing the connection involving active power usage and the radius of polysilicon rods. The control strategy is effective in eliminating power disruption resulting from variations in wind power or generator shutdown, improving frequency regulation of isolated power systems and enabling utilization of wind energy at the local level. The method is applicable to industrial isolated power systems powered by both coal and wind energy and can be generalized to other loads such as copper and zinc.	a5	2	b36, b37	e18, e19	NM	d51	f1	2019	China	Chifeng, Inner Mongolia (China)	1/60	NM
[130]	This paper proposes an HCM for improving the control process of FLs in power systems. The HCM compensates for CML and FDE and includes a modification method to improve the estimation accuracy of system frequency deviations. Numerical studies show that the HCM can avoid CML and reduce FDE, making it useful for future smart grid DR projects.	a6, a13	10000	b38	e15	NM	d51	f1	2019	China, USA	Hangzhou (China)	250/ 3600	NM
[131]	This paper suggests a control method using residential controllable loads to reduce demand while accounting for uncertain factors. A two-stage approach is used: priority clusters are established during the first stage, and optimal control of devices in chosen clusters is determined in the second stage. The suggested control method is expected to perform better than existing commercial implementations in terms of accuracy and control effort.	a6, a11	100 &1000	b39, b40	e3, e15, e20	NM	d15, d59	f1	2022	Australia	The University of Queensland, Centre for Energy Data Innovation, https: //cedi.uqcloud.net	1	MATLAB 2019a together with YALMIP toolbox and solved using Gurobi 9.0.2
[132]	This paper explores how residential heat pump pools with thermal storage tanks can participate in a smart grid. The study developed a model, tested in Germany, that showed flexibility parameters are affected by temperature. Using electric back-up increases flexibility but reduces system efficiency. Signals like SG-Ready improve flexibility compared to an "Off" signal.	a8	284	b18, b21	e3, e11, e13, e15	c5	d42	f1	2017	Germany, Sweden	Germany (WP-Monitor project)	8760	NM
[133]	This paper investigates the use of HEMSs for grid support. A rule-based approach is proposed to manage congestion by curtailing power injection/consumption via HEMS. The findings suggest that the recommended approach is efficient at managing congestion, but a more advanced algorithm is needed for local voltage control. A laboratory prototype of the proposed HEMS has been developed and tested, showing promising potential for local under-voltage control and congestion management. Future research will explore optimal incentives for consumers and grid operators.	a2, a8, a21, a35, a41,	42 (each)	b1, b22, b41, b42, b43	e9, e12, e15, e21	NM	d17, d60	f1&f2	2019	Australia, Netherlands	Netherlands	24	Matlab
[134]	This paper presents a scheduling framework for an AEDS that considers distributed generation units, renewable energy sources, electric vehicles, and energy storage systems. The framework includes demand response programs and models uncertainty from five sources. An optimization algorithm is proposed to minimize AEDS operational costs and maximize energy hub benefits. The ODAS algorithm reduces AEDS costs and increases EH benefits. The authors recommend investigating alternative demand response methods for ODAS in the future.	a7, a14, a16, a26	NM	b5	e22, e23, e24, e25	NM	d13	f1	2020	Iran, Finland, Portugal	NM	24	GAMS/ Cplex

A: System Types, B: Objectives, C: Forecast & Prediction & Estimation, D: Optimization & Control, E: Constraint, F: Validation, G: Duration (h), H: System Population, K: Publication Year, L: Publication Country, M: Implemented Database/Place, N: Solver/Program/Software/Toolbox/Platform/Framework

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

TABLE 1. Summary of DLC programs proposed in previous studies (Continue).

Ref.	Conclusions	A	H	B	E	C	D	F	K	L	M	G	N
[135]	This paper suggests using direct control of electric water heaters to increase renewable energy usage and lower costs through a demand response program. The model underwent testing using the typical IEEE 30-bus and 118-bus systems and was influential in achieving system reliability, cost savings, and increased renewable energy penetration. The model was tested with different pricing structures, and a comparative study showed that DLC is effective. Future research will consider the impact of trading markets for renewable obligation certificates.	a11	6, 54	b5, b9, b21, b39, b44, b45	e4	NM	d15	f1	2021	South Africa, USA, United Arab Emirates	South Africa	24	IBM ILOG Cplex
[136]	A new AC DLC control can reduce peak loads and control demand expansion. It can improve grid flexibility, reduce blackouts and load shedding, and lead to significant energy savings and environmental impacts. The mechanism is simple and easy to apply any region, making it a promising solution for cooling demand in developing regions.	a12	579950	b2, b46	e4, e26, e27	NM	d38	f1	2022	Sweden	Karnataka (India)	24	Matlab
[137]	This study explores how DLC affects the temperature and humidity of a university lecture hall. The study finds that during DLC events, mean radiant temperature, air temperature, and relative humidity all fluctuate. Using variable-speed fans or dedicated outdoor air systems can help maintain lower indoor humidity during DLC events. The five parameters tested have significant impacts on thermal environments during DLC events, with off-cycle fractions, cycling durations, and cooling temperature targets having the most influence. DLC scenarios often go beyond the acceptable thermal comfort range in ASHRAE55-2013. Customized DLC algorithms are needed to ensure occupants' thermal comfort.	a12	1	b47	e3, e12	NM	d42, d45	f1	2015	Australia	Sydney (Australia)	24	NM
[138]	This paper analyzed how people adjust their thermostats before, during, and after DREs, especially those who are less willing to participate. The study found that some users manually set a hold action before a DR event, showing anticipatory behaviour. Different patterns were observed in how people adjust their thermostats after the DREs, and the paper suggests that customized DREs based on user behaviour can increase the effectiveness of direct control strategies. A data-driven approach towards personalized DREs can significantly improve people's acceptance. The paper's findings will help design more effective DR programs.	a13	990	b47	e13	NM	d144, d145	f1	2022	Spain, France	Canadian homes, US homes [DYD program]	24	NM
[139]	The study created a way to measure the benefits of DLC in reducing distribution network reinforcement costs. It assessed the change in electricity demand due to flexible loads, accounting for energy shift and power rebound. It also proposed a method to estimate DSO's reinforcement costs and found that using flexibility to handle peak demand was the best way to optimize load control. The results indicated that consumer flexibility could benefit the DSO, but further optimization from the electric system stakeholders' perspective was necessary.	a11, a13	1040 (each)	b2, b22	e2, e28, e29	NM	d2, d10	f1	2015	France	Grenoble and Lyon (France)	125	GAMS
[140]	A unified control approach is proposed to manage network congestion and voltage limit violations in LV radial distribution networks. The approach uses active power curtailment mechanisms with a MAS-based system architecture, allowing for both centralized congestion management and decentralized voltage control. Simulation results show that the approach effectively addresses overvoltage, under voltage, and transformer congestion in a Dutch LV network with solar PV and heat pumps. The MAS-based system architecture also allows for the integration of different market-based control mechanisms to identify challenges with integrating other DERs and market entities.	a8	20	b2, b18	e12	NM	d13, d52, d60	f1	2017	Netherlands	Netherlands	24	Matlab
[141]	This study proposes three schemes for DLC in commercial buildings to respond to smart grid requests: building power optimization, control system reinitialization and real-time control/management. The study focuses on determining the power limiting threshold, the number of chillers and pumps to shut down, and how to systematically regulate equipment loads during a DR event. The proposed DLC strategy could achieve almost 23% of immediate power reduction at the onset of the DR event and reduce 3300 kW power demand, or approximately one-third of the overall electricity consumption, by limiting the system power consumption during the power rebound period.	a9	1 (6 units a43)	b48, b49, b50	e2, e15, e30	NM	d47	f1	2018	Hong Kong	Hong Kong	24	TRNSYS, FORTRAN
[142]	The proposed online scheme optimizes air flow to control the indoor environment and air-side systems during load control or demand response events. Two strategies, optimal and near-optimal, adjust air flow set-points of individual AHUs to achieve ideal indoor conditions under limited cooling supply and pre-determined power limits. Test results prove the strategies improve thermal comfort and ensure successful DR controls while reducing AC power demand.	a9	1 (6 units a43)	B48	e2, e15, e30, e31, e32	NM	d17, d41, d79, d123	f1	2018	Hong Kong	Hong Kong	6	MATLAB, TRNSYS
[143]	This paper introduces a new DLC architecture that uses IoT and MQTT technologies and open-source software to optimize energy consumption and reduce costs for consumers and retailers. The architecture combines four algorithms and was tested on a community of 114 modern single-family houses. Results show significant benefits, including lower electricity bills and fewer interruptions. Future research directions include integrating flexibility auction-oriented markets with DLC and D-1 optimization.	a61, a62 (a12, a18) a63	A61(31), A62(22), A63(30)	b2, b51, b52,	e1, e2, e4, e12, e30, e33, e34	c20, c21, c30	d29	f1	2021	Romania	North America (USA)	24	ElasticSearch, MySQL, Python, Node Red
[144]	A proposed DLC method employing a multi-objective optimization algorithm has demonstrated a notable influence on the demand-offer management of power grids. The method controls refrigerators, freezers, and lighting to reduce demand by up to 20% and can be scaled according to power grid size. Future research could analyze different optimization algorithms and include other types of appliances while integrating user preferences as restrictions to address the quality of service.	a19, a20, a21	1350 households	b2, b18, b53	e33, e34, e35	NM	d30	f1	2015	Spain	Germany	24	Opt4J

A: System Types, B: Objectives, C: Forecast & Prediction & Estimation, D: Optimization & Control, E: Constraint, F: Validation, G: Duration (h), H: System Population, K: Publication Year, L: Publication Country, M: Implemented Database/Place, N: Solver/Program/Software/Toolbox/Platform/Framework

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

TABLE 1. Summary of DLC programs proposed in previous studies (Continue).

Ref.	Conclusions	A	H	B	E	C	D	F	K	L	M	G	N
[145]	This paper suggests a novel algorithm for peak-shaving that reduces energy costs and improves reliability while maintaining building thermal comfort. It guarantees thermal comfort, eliminates the need for smart thermostats or complex controllers, and continuously monitors prices. This algorithm fixes existing DSM algorithm problems and enhances smart grid operation. Future plans include testing the algorithm in residential pilots and scaling it to multiple buildings.	a29	50 buildings	b19, b54, b55	e2, e12, e13, e22, e36	NM	d54	f1	2016	Italy, Singapore	Steinkjer (Norwegian)	24	GLPK
[146]	This paper puts forward an approach for achieving self-sustainability in energy communities through a demand response program that manages consumption and PV production. The program groups devices by consumption patterns and distributes excess renewable energy produced by PV panels among contributors, who receive reductions in their electricity bills based on their performance.	a11, a12, a24, a35, a41	A11(29), A12(72), A24(28), A35(14), A41(17)	b5	e22, e37	NM	d31	f1	2020	Portugal	Portugal	24	NM
[147]	This paper suggests an aggregate RAC model for analyzing the DR characteristics of RAC loads and offers DR control strategies for large-scale RAC loads. The model and strategies reduce costs and privacy issues. Although the impact of dynamic pricing on users is not taken into account, future research will investigate DR control strategies that consider real-time prices and uncertainties of users' behaviours and outdoor environment on RACs' participation in DR.	a12	120000	b48, b49, b50, b56	e17, e38, e39	c22	d7	f1	2022	China	China	2	NM
[148]	The lack of power infrastructure in rural areas is a challenge for providing electricity to developing countries. Bangladesh's energy crisis is impeding its economic growth, with 4% of the population still without electricity. Solar power can help meet the demand for energy sustainably. This paper proposes an off-grid power system for St. Martin's Island, Bangladesh, that uses 100% renewable energy and consists of PV, BESS, FC, and EP. The system in case 4, which utilizes rooftop PV for increased reliability, proved to be the most profitable and stable option.	a64, a65, a66	NM	b22, b57, b58	e2, e22, e40	NM	d13	f1	2022	Japan	St. Martin's Island (Bangladesh)	216	Matlab
[149]	This study proposes using a VBPS to represent DEWHs in power systems. The VBPS helps maintain system frequency without using reserve capacity. Benefits of using VBPS include large capacity, easy expansion, direct use of stored energy, and quick response. The study concludes that using DEWHs for frequency control is feasible and has potential for further exploration.	a11	20000	b54, b60	e13, e17	NM	d51	f1	2022	China, Canada	UK households model	24	CYME
[150]	This paper suggests an efficient way to operate a controllable load in a smart home using advanced DLC to reduce daily costs. Results show that advanced DLC can lower operating costs and carbon emissions while promoting the use of renewable energy. Self-consumption in smart homes can lead to more efficient generator operation and decreased electricity bills for consumers.	a22	1	b2, b5, b30, b31	e1, e2, e16, e41, e42	NM	d32	f1	2021	Japan, Saudi Arabia, Russia, Egypt, India	NM	24	Matlab
[151]	This paper proposes an optimization model to size PV, WG, BESS, and DG for a HES on Aguni Island in Japan. The model aims to minimize cost and carbon emissions using advanced DLC, residential PV, and BESS programs. The e-constraint method solves the proposed model, and the best solution is selected using FSM. Three case studies are showcased to illustrate the efficacy of the DR program with residential PV and BESS. The results show that using advanced DLC, home PV, and home BESS can significantly reduce IL while only slightly increasing the total cost compared to case 1.	a64	1	b30, b31	e1, e2, e22, e41	NM	d13, d31	f1	2021	Japan, USA	Aguni Island (Japan)	48	NM
[152]	Targeted strategies for load shifting in high hot water usage homes can yield more energy savings than non-targeted approaches. Utilities can achieve these benefits by sending shed commands to these homes without installing CTA-2045 controllers on all HPWHs. Two-way communication strategies have the most potential to maximize load-shifting benefits while minimizing negative impact on consumers but require careful coordination. The data collected from this field study could be used to develop behavior models for larger-scale studies on HPWH load-shifting potential.	a23	150	b2, b21, b59	e1, e2	NM	d42, d55	f2	2021	USA	Pacific Northwest (USA)	24	NM
[153]	This article presents an alternative method to evaluating the performance of smart grid functions in residential settings. The method is based on ENS at each distribution transformer supplying residential loads. The ENS is calculated by taking into account the reduction in power demands during peak-demand times, which depends on the energy stored in thermal energy storage devices. The ENS-based assessment method has been tested for 200 households, showing its ability to evaluate smart grid functions regardless of the number or type of loads.	a11, a12, a24	200	b2, b39	e3, e13, e15, e43	NM	d42	f1	2022	Canada, Jordan, Oman	New Brunswick (Canada)	24	Matlab
[154]	This paper introduces a data-driven thermal dynamic model for building energy system control. The model uses a linear function to project detailed states into an aggregate state and a nonlinear regression model to estimate parameters and occupant behavior. An efficient algorithm is developed based on the block coordinate descent method. Real-world data simulations confirm the effectiveness of the methods.	a13	20 homes	b61	e3, e13, e15, e43	c23	NM	f1	2022	China	UK	720	NM

A: System Types, B: Objectives, C: Forecast & Prediction & Estimation, D: Optimization & Control, E: Constraint, F: Validation, G: Duration (h), H: System Population, K: Publication Year, L: Publication Country, M: Implemented Database/Place, N: Solver/Program/Software/Toolbox/Platform/Framework

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

TABLE 1. Summary of DLC programs proposed in previous studies (Continue).

Ref.	Conclusions	A	H	B	E	C	D	F	K	L	M	G	N
[155]	This paper suggests a way to reduce load pickup during cold-load pickup by directly controlling air conditioning loads. The approach estimates post-outage load pickup and calculates the maximum restorable load. Simulation results demonstrate dependable load restoration for systems with TCLs.	a12	2	b62	e15, e44	NM	d56, d57, d111, d112	f1	2021	China	NM	~3	NM
[156]	This paper explores using central air conditioning as a controllable load for peak load regulation in the Shandong power grid. The study shows that central air conditioning has excellent regulation performance and can encourage the adoption of alternative energy sources.	a9	20	b54	e3	NM	d42	f2	2021	China	Shandong (China)	22/60	NM
[157]	This paper presents a structure for a controller that adjusts to load changes that adjusts thermostat set points of TCLs to maintain customer comfort while mitigating the payback effects of control actions. The proposed system uses a model-based forecasting module and a model-free controller based on fuzzy logic for DLC.	a12	10000	b63, b64	e3, e15	NM	d58	f1	2021	Canada	Barbados Island	8	Matlab
[158]	This paper presents a scheduling model that uses air conditioning load and electric vehicles to reduce peak-to-valley load difference. The model is guided by TOU pricing and DLC with the aim of minimizing load differences and maximizing total user revenue. The strategy successfully reduces peak load and eliminates secondary peak load caused by the unorganized charging of electric vehicles.	a2, a12	a2 (50), a12(180)	b65, b68	e1, e41, e42, E45	NM	d17	f1	2021	China	NM	24	NM
[159]	This paper suggests a hierarchical control method for TCL aggregators to accomplish precise power tracing and alleviate control recovery. The method uses a two-layer architecture, a PSA optimizer, and a PTEM-based controller. Two case studies validate the potential of TCL aggregators to help VPPs attain complete controllability across various electricity markets . The method enables robust ON/OFF switching control and might lead to a decrease in both the expense and intricacy of the communication network.	a11, a12	10000 (each)	b63, b64, b67	e3, e13, e15, e44	NM	d42, d54, d146	f1	2021	Canada	NM	18, 24	Matlab
[160]	Thermo-electrical frameworks of EWHs, ACs, and GSHPs have been proposed for use in DR dynamic studies, along with a novel DR strategy for frequency control validated using a real microgrid. The findings illustrate the capability for TCL-based DR to provide primary frequency control and compensate for customer participation in frequency control in isolated microgrids.	a11, a12, a25	22 households	b68	e13, e15, e17, e44, e46	NM	d42, d61	f1	2021	Ireland, Canada	Nemiah Valley (Canada)	24	Matlab
[161]	DLC and CVR reduce energy losses and consumption, with the best results when used together. The 24-hour algorithm is most effective for DSM technique selection. PV integration improves voltage profile and helps with CVR despite minor adverse effects on DSM techniques.	NM	NM	b2, b59, b69, b70	e47	NM	d42	f1	2020	Palestine, Italy	NM	24	OpenDSS, Matlab
[162]	This paper analyzes 2314 demand response programs in residential, commercial, and industrial categories and uses an optimization algorithm to achieve program goals. Results show the algorithm's applicability in achieving desired levels of demand reduction in specific loads and can be integrated into systems for managing energy in buildings for DLC and interruptible/curtailable programs.	a11, a12	1392, 13692, 4899 customers	b2	e17	NM	d2	f1	2020	Portugal	Federal Energy Regulatory Commission (Portugal)	24	NM
[163]	This paper suggests a DEWH control algorithm that divides DEWHs into groups based on their hot-water usage and parameters. It uses a time-dependent heating time to maintain user comfort without needing real-time temperature measurements. The algorithm uses a QIEA to choose operational measures for every cluster and effectively provides peak shaving services for DLC that use DEWHs.	a11	1000	b2, b54	e17	NM	d33	f1	2020	Canada, China	NM	24	NM
[164]	This study introduces a deep reinforcement learning technique for load control in a distribution network by solving a sequence of SDPs for updating neural network parameters. The suggested algorithm can attain an optimum solution within a few days. Simulations demonstrate a 16.7% reduction in total electricity consumption in high-demand periods and a 26.6% reduction in expected cost for customers. Subsequent efforts will center on the creation of a distributed algorithm for scheduling household appliances.	a2, a11, a12, a35, a41, a67	59 (each)	b2, b9	e17, e48	NM	d34, d147	f1	2020	Canada	NM	24	MATLAB/CVX with MOSEK solver and PYTORCH library in PYTHON 3.7
[165]	This paper presents a new DEWH control method that uses a time-varying weight matrix to represent end-user comfort with the CSPI index. Control actions are based on the CSPI, and worst-case considerations are presented to ensure the comfort of end-users. The proposed method effectively addresses the DLC challenge with DEWHs and performs well in case studies. Future work includes improving hot-water consumption identification and providing ancillary services for more benefits from DLC.	a11	20000	b2, b71, b72	e17, e49, e50	NM	d39, d62, d98	f1	2020	Canada, China	NM	24	CREST Demand Model V 2.2
[166]	This study presents a new demand response strategy that coordinates different DR programs at three-time levels. The strategy reduces system frequency variations by involving loads dependent on frequency, and two methods are implemented to evaluate its performance. The program successfully flattens the load curve, reduces customer costs, and considers the effect of load uncertainty. The proposed DR program outperforms other DR programs, and future work should investigate the price effects on the day-ahead market.	a26	7	b18	e51, e52, e53	NM	d2	f1	2020	Iran	NM	24	Matlab, GAMS

A: System Types, B: Objectives, C: Forecast & Prediction & Estimation, D: Optimization & Control, E: Constraint, F: Validation, G: Duration (h), H: System Population, K: Publication Year, L: Publication Country, M: Implemented Database/Place, N: Solver/Program/Software/Toolbox/Platform/Framework

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

TABLE 1. Summary of DLC programs proposed in previous studies (Continue).

Ref.	Conclusions	A	H	B	E	C	D	F	K	L	M	G	N
[167]	This research presents an efficient and scalable demand response scheme for multiple customers. The optimization only needs one computer for every twenty customers in a neighbourhood. It minimizes power usage while maintaining consumer comfort. Moving forward, the optimization can be expanded to handle millions of homes and seasonal changes.	a13, a61, a62	A13(120), A62(2560), A61(2560)	b48, b64	e2, e55	NM	d139	f1	2020	USA, South Africa	NM	24	NM
[168]	This paper studies using smart parking lots as energy resources for microgrids and how demand response programs can reduce costs. The model manages the charging/discharging of electric vehicles and provides a spinning reserve for microgrids. The results show that demand response programs significantly cut operating costs, with using TOU and DLC together being the most effective.	a2	230	b30	e11, e41	NM	d13	f1	2021	Iran	NM	24	GAMS by the Cplex tool
[169]	This study introduces an fuzzy logic controller for air conditioning that reduces thermal loads while maintaining comfort and achieving energy savings. By augmenting the quantity of membership functions, the controller achieves temperature with less than 1% error, humidity ratio with 6% error, and reduces energy consumption by 25% annually. The fuzzy controller produces better results and maintains human comfort compared to other techniques.	a12	1	b46, b61	e38, e55, e56	NM	d39	f1	2020	Pakistan, Saudi Arabia	NM	6	Matlab
[170]	This study suggests a compensation scheme for multi-user participation in TCL based on air-conditioning load peak-shaving, with additional compensation for load reduction. The scheme prioritizes users with high responsiveness and considers cross-group dispatching and load fluctuation. The compensation mechanism is more reasonable than others in the literature and could smooth load reduction fluctuations. Further discussion is needed to allocate compensation among groups of users based on an additional mechanism to encourage user participation in DR at different temperatures.	a12	199 consumers	b32, b73	e15, e17, e44	NM	d2, d63, d140	f1	2020	China	NM	24	GAMS/ Cplex
[171]	A new DR method for smart grids was developed using a centralized air-conditioning system that coordinates supply and demand. The method was tested virtually and reduced power consumption by an 18.3% reduction compared to the initial profile in the absence of DR measures. The proposed performance indexes can evaluate different DR methods' thermal comfort sacrifice performance effectively. The proposed DR method is a broader and practical DR approach based on HVAC for existing buildings, but nevertheless, there are constraints and opportunities for enhancement when applied in real situations.	a17	1 (6 units a43)	b48	e2, e3, e12, e13, e15	NM	d62	f1	2019	China, Hong Kong	NM	4-5	TRNSYS
[172]	This study suggests a strategy to optimize load management in distribution networks by using time-of-use electricity pricing. The strategy divides peak and valley periods and uses DLC to adjust for flexible load transfers. A modified multi-objective PSO algorithm is employed to optimize electricity and compensation prices. Restrictions are used to change user habits, and flexible load transfer is utilized to reduce costs. Future work will focus on real-time flexible load management and advanced optimization algorithm adaptation.	a11, a12	NM	b1, b22, b72, b74	e1, e11, e34	NM	d19	f1	2019	China	NM	24	NM
[173]	This paper explores how to improve the operation of distributed DLC programs in power systems. Results show that performance can be affected by the variance of desired consumption and network topology of energy management centers (EMCs). Improvements can be made through better contracts with customers and network design of EMCs. Simulations were done with actual consumer data, showing the potential of distributed DLCs for practical use.	a1	45 residences	b75	e57	NM	d64	f1	2019	Japan, Republic of Korea	Pal Town Josai-no-Mori (Japan)	24	NM
[174]	This article suggests a demand control strategy for a smart residential building using a Stackelberg game approach. A virtual energy trading facility is created between the building load controller and dwelling units, with load-dependent virtual energy prices based on the criticality level of each residence's load profile. Simulation results show that users with higher load criticality levels will have higher virtual electricity costs, encouraging them to reduce their demand. Future studies can include appliance constraints and the impact of solar panels and battery storage on load management.	a68	4	b2, b76	e20	NM	d148	f1	2019	India	NM	24	Matlab
[175]	This paper suggests a way to manage waste water and wind employind an ice-storage air-conditioning system. The method reduces water and wind waste, balances power usage, and improves efficiency, all while keeping users comfortable. The number of ACs and ice storage capacity are essential for control, and additional research is necessary to address uncertainty in ice storage and changes in ice melting rate and compressor power.	a27	20	b22, b66, b77	e15, e17	NM	d65	f1	2019	China	NM	24	NM
[176]	This work proposes a voltage control strategy using building loads to regulate bus voltages. An optimal demand response strategy is used to minimize voltage deviations. Results from testing the strategy on an adapted 4-bus test feeder following the IEEE standards show that voltage deviations are reduced by using battery dispatch and optimal demand response. Future work includes developing a technique to handle uncertainty and providing reactive power support from building loads.	a13, a26	1	b9	e41, e58	c22	d66	f1	2019	India	NM	24	NM
[177]	This paper suggests a 3-stage scheduling framework for TCLs that uses an advanced thermal inertia model and a simplified thermal comfort model to maintain occupants' comfort. Load aggregators estimate their TCL capacities, and then the system operator determines load-shedding instructions. Finally, the aggregators schedule control plans while accounting for occupants' thermal comfort. Simulation results validate the framework. Future work will explore effects of adaptive models on TCL control and DSM.	a13	5558	b2, b3, b78	e12, e34, e59	NM	d35, d42	f1	2019	Australia	Guangzhou Central Meteorological Observatory (China)	2	MATLAB and AMPL/IPOPT solver

A: System Types, B: Objectives, C: Forecast & Prediction & Estimation, D: Optimization & Control, E: Constraint, F: Validation, G: Duration (h), H: System Population, K: Publication Year, L: Publication Country, M: Implemented Database/Place, N: Solver/Program/Software/Toolbox/Platform/Framework

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

TABLE 1. Summary of DLC programs proposed in previous studies (Continue).

Ref.	Conclusions	A	H	B	E	C	D	F	K	L	M	G	N
[178]	A new approach to DR programs was proposed. Residential end-users receive free energy credits in exchange for allowing intervention in their HVAC units during DR events when energy prices are high. The approach reduced operational costs by around 10% in a day-ahead planning context. It increased end-user participation in DR programs, making it potentially decisive.	a13	40 and 250 households	b2, B79, B80,	e2, e13, e17, e38, e44	NM	d67	f1	2019	Turkey, Netherlands, Portugal	NM	3	GAMS 24.0.2 with the solver CPLEX 12
[179]	This paper suggests a modified 0-1 Knapsack problem for DSM using the DLC technique. Consumers assign priority to loads, and those with high priority and power consumption are cut off during peak times. A backup load system is also proposed to prevent power outages. The system is flexible in load selection and scalable for adding/removing households. The simulation outcomes demonstrate the system's efficiency and possess the potential for further improvements.	a28	3	b72	e33, e34, e35	NM	d4	f1	2019	India	NM	15/(60x60)	Matlab
[180]	A bi-level optimization problem was used to reduce energy demand while maintaining end-user comfort. Shared ESS units reduced energy supplied from the grid, resulting in a 22% decrease in energy demand compared to end-user HVAC control and an 8% decrease compared to DR programs focused only on energy reduction. ESS deployment improved end-user comfort compared to conventional DR programs. Future studies will investigate the approach's effectiveness with rooftop PV systems and different control techniques.	a13	240	b62, b81, b82,	e16, e22, e42, e61,	NM	d141	f1	2019	Turkey, Netherlands, Portugal	NM	4	GAMS version 24.1.3, MOSEK solver
[181]	This paper introduces a distributed DR control strategy for building groups, utilizing a DR system model to diminish the peak-to-average consumption ratio and minimize dissatisfaction caused by load shedding. The proposed algorithm, based on ADMM and building consumption pattern grouping, decomposes the centralized DR optimization problem into optimization challenges that are both decentralized and run in parallel on each building. Simulation results using real data from UConn campus utility demonstrate that the suggested approach has the potential to level out the load duration curve, reduce electrical bills, and decrease end-user dissatisfaction caused by load shedding.	a1	10 buildings	b34, b54, b64, b83,	e4	NM	d149	f1	2018	USA	UConn campus (USA)	24	NM
[182]	This paper suggests a way to reduce demand charges by more than 80% by combining water filling and active DRLC. The proposed method was tested with actual EV charging information from practical scenarios at non-residential sites. It can save a large retail venue with 30% EV usage up to C$6000 in demand charge annually and reduce the impact of DRLC on EV charging demand by over 70%.	a2	164	b54, b71, b84	e43, e62	NM	d102	f1	2018	Canada,	www.fleetcarma.com/evcloud	24	Matlab
[183]	This study presents a model for determining the capacity of a HEGS in an MG that uses DLC and considers physical, technical, and operational constraints. An enhanced PSO algorithm combined with QS-PSO is used to reduce the overall expense associated with designing the MG system. The proposed methodology efficiently identifies the optimal HEGS capacity, reduces peak power, and decreases the complete expenditure for the MG system planning.	a29	1	b85, b86	e22, e42, e58, e63	NM	d150	f1	2017	China, Taiwan	NM	24	NM
[184]	A distributed residential scheme was proposed to maximize welfare for LSE and households while considering three-phase unbalanced distribution network constraints. The scheme can shave peaks effectively and scale to large networks, with appliance details protected locally in each household's HEMS. Incorporating three-phase network models ensures physical and security constraints are met, but more investigation is needed for external network interaction.	a12, a30, a31, a32, a33	64 and 70 households	b75, b87, b88	e43, e64, e65, e66	NM	d149	f1	2018	China	NM	24	Matlab/YALMIP/Gurobi
[185]	This paper suggests a planning framework for TCL dispatch that uses a sophisticated thermal comfort model to estimate residents' comfort levels. The framework comprises a self-adaptive TCL grouping method, a hierarchical day-ahead scheduling model, and an MPC-based real-time dispatch model. Future work could include integrating more advanced building and HVAC system models and applying the load allocation based on modeling for use in other grid-related contexts.	a13	24000	b54	e2, e11, e12, E67	NM	d12, d41, d103	f1	2017	Australia, China	Australian Energy Market Operator (Australia), Guangzhou Central Meteorological Observatory (China)	2	MATLAB programs invoke the AMPL/IPORT solver
[186]	This paper suggests a way to optimize demand response in real-time by controlling the air-conditioning load of central chillers across a wide area. The approach uses fuzzy linear programming to achieve precise load scheduling and match target load. Simulation studies show that the approach is computationally effective and appropriate for optimizing in real-time with varying precision tolerance. Overall, this approach is a great way to optimize demand response with a broadband network and a customer-controlled gateway at every site.	a9	30	b59	e2, e17	NM	d121	f1	2016	Taiwan	NM	120	NM
[187]	A simulation was done for an energy retailer that manages multiple consumers with energy storage by buying energy from the spot market and offering flexibility to the intra-day market. The simulation found that optimizing DLC can improve flexibility and offer performance and monetary benefits through intra-day demand response.	a34	20	b1, b18	e68, e69	NM	d2	f1	2016	Finland	NM	24	Matlab
[188]	This paper introduces a new DLC model that considers thermal comfort to minimize the impact on customers' satisfaction. It also presents a new algorithm called FAICA, which uses fuzzy logic to adjust mutation parameters and has better searching capability than other algorithms. FAICA effectively solves the proposed DLC model.	a12	4000	b2, b89, b90,	e2, e11, e59, e67,	NM	d104	f1	2016	China, Australia	Southern China	24	Matlab

A: System Types, B: Objectives, C: Forecast & Prediction & Estimation, D: Optimization & Control, E: Constraint, F: Validation, G: Duration (h), H: System Population, K: Publication Year, L: Publication Country, M: Implemented Database/Place, N: Solver/Program/Software/Toolbox/Platform/Framework

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

TABLE 1. Summary of DLC programs proposed in previous studies (Continue).

Ref.	Conclusions	A	H	B	E	C	D	F	K	L	M	G	N
[189]	This paper suggests a new approach to DSM that cuts load peak and costs for both consumers and utilities. The algorithm works with all equipment that can shift, and simulation outcomes indicate that the approach rooted in the utility and consumer's target curve is more effective in reducing load peak and saving costs.	a29	260	b2, b91	e63	NM	d106	f1	2015	Iran	NM	24	NM
[190]	This paper suggests a load control method for frequency stabilization in micro-grids that prioritizes strategy proofness and individual rationality. The method uses a frequency control system with controllable loads and an electricity charge that satisfies these priorities. Simulations showed that the method is effective, and future work will address the limitations of controllable loads.	a29	NM	b68, b92, b93,	NM	NM	d70	f1	2015	Japan	NM	5	NM
[191]	This paper suggests DLC measures to improve the IRP model in microgrids by shifting loads and reducing peak demand, ultimately reducing societal expenses. DLC measures offer benefits in contrast to typical power sources within microgrid systems, and a more controllable load leads to an economical solution. Different control strategies of DLC yield varying outcomes , and modifications in the coefficients influencing return on investment and the duration of control have little impact on configuration results and cost.	a12	NM	b2, b19, b20, b21	e2, e3, e4, e8, e22, e41, e42, e63, e89	NM	d14, d45	f1	2015	China	Shanghai (China)	24	LINGO, HOMER
[192]	This paper presents a cooperative game model to enhance market activity and efficiency between residential users and a retailer. The retailer adjusts power scheduling and bidding strategies based on market information while balancing quantities bought and actual consumption. The method reduces risk and improves retailer profits. However, DLC actions are not sufficient for scheduling end-use loads and require integration with other control actions. Subsequent studies will encompass the assessment of risks and their management in DLC within collaborative gaming scenarios, along with the optimization of individual gains within the consortium.	a10, a16, a30	5 (each)	b1	e2	c32, c43	d157	f1	2016	China	NM	24	Matlab/Cplex
[193]	This paper shows that TCLs can regulate the grid and that a priority-stack-based control strategy works well. More research is needed on model uncertainty, low-cost infrastructure for direct-load control, regulation service quality, availability estimation using historical data, and fair compensation schemes for participating loads.	a12	1000	b18	e13, e44	NM	d71	f1	2015	USA	Pennsylvania-New Jersey-Maryland Interconnection (PJM) (USA)	1, 6	NM
[194]	This study proposes a hybrid algorithm that employes two meta-heuristics (GRASP and SA) and the ELECTRE TRI method to support decision-making in electricity distribution. The algorithm combines a construction phase and solution exploration to obtain solutions that align with the decision-maker's preferences. Preference information is used in the SA phase to decide whether to explore new solutions and in the acceptance probability function. Although the construction phase requires significant computational time, the algorithm achieves solutions that match the preferences expressed.	a12	500	b16, b82, b94, b95,	e1, e2	NM	d132, d134	f1	2014	Portugal	NM	11	NM
[195]	It proposed a data-driven control method that uses the SSID approach for implementing DR services in large refrigeration systems. The method balances between system COP and DLC performance while including a signal design method for SSID. Simulation results show a 22% reduction in energy consumption and superior load following performance compared to other control methods. Future work includes investigating the use of an adaptive algorithm for online updating of subspace matrices and applying the design to a whole supermarket system.	a20	1	b80	e15	NM	d41, d69, d140	f1	2014	Denmark	Denmark	24	SRSim
[196]	This paper suggests a DLC model that uses the ISO standard thermal comfort model to reduce TCL load without affecting customer comfort levels. The model uses PMV and PPD indexes to estimate thermal comfort. The PSO algorithm is used for solving the optimization problem. The authors are developing a hierarchical dispatch framework to handle large numbers of TCL groups.	a12	200	b96	e17, e59, e67	NM	d19	f1	2015	China, Australia	NM	24	Matlab
[197]	This paper presents a method for enhancing the efficiency of the use of air conditioning systems in residential areas. By installing smart meters, the technique schedules loads and optimizes temperature control of indoor and cooling systems. The system uses a PSO controller on DLC to improve control structure and effectively manage energy, minimizing cost and maintaining power quality. Matlab results show that the proposed technique is effective even under varying temperature conditions.	a12	1	b2, b64	e15, e70	NM	d19	f1	2016	India	NM	24	Matlab
[198]	This paper proposes a Home Automation strategy that balances inhabitant comfort, low electric bills, and technological constraints. Using the AG-FLC method, energy consumption can be reduced by up to 58% during high-demand periods. This outperforms other methods like Net-Service, PLC-FLC, FMBMPC, and appliance elasticity. The SM uses a Multi-Agent paradigm for self-control of residential energy.	a11, a12, a20, a21, a30, a35	1	b97, b98	e15, e17	NM	d68	f1	2017	Tunisia	NM	5	Matlab, Labview
[199]	This paper proposes an IRES that uses multiple energy sources (MHP, biogas, biomass, solar, wind, and battery storage) to meet energy needs. The system has a scheduling model based on the DR strategy, which reduces peak hourly energy consumption in both summer and winter. The DHS algorithm results in significant savings in system sizes and costs. The proposed IRES offers the lowest TAC of INR 3.4108 million and an estimated LCOE of INR 4.86 per kWh, with a total land use of 21472 m2. This IRES could be helpful for developing IRES in other rural areas without electricity.	a11, a24, a57, a58, a59, a60	a11(2), a24(3), a57(40), a58(4), a59(8), a60(4)	b2, b22, b23	e2, e45, e100	NM	d115, d138	f1	2017	India	Chamoli (India)	24	Matlab

A: System Types, B: Objectives, C: Forecast & Prediction & Estimation, D: Optimization & Control, E: Constraint, F: Validation, G: Duration (h), H: System Population, K: Publication Year, L: Publication Country, M: Implemented Database/Place, N: Solver/Program/Software/Toolbox/Platform/Framework

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

TABLE 1. Summary of DLC programs proposed in previous studies (Continue).

Ref.	Conclusions	A	H	B	E	C	D	F	K	L	M	G	N
[200]	This paper explores how DR programming can optimize micro-grid components that use non-dispatchable renewable energy resources. The study modelled and optimized the micro-grid components using integer linear programming and GAMS software. Results showed that applying DR decreased the number of required batteries, inverter capacity, PV panels, and net present costs by 35.6%, 35%, 1.8%, and 17.1%, respectively. DR also decreased peak consumption and DF index by 36.8% and 26.3%, respectively, while increasing consumption and correlation factors by 57.9% and 368%, respectively.	a31, a35, a41, a57	NM	b2, b24, b25, b26	e1, e2, e22, e58, e63	NM	d13	f1	2017	Iran	Iran	24	HOMER, GAMS/Cplex
[201]	This manuscript outlines a methodology for sizing microgrids that includes DSM and considers BESS capacity degradation and generator lifetime. A bi-level algorithm is used to balance power and optimize sizing. The results show the importance of considering DSM in the optimization process, managing dynamic loads, and selecting CCPs carefully to maximize benefits. The degradation in BSS capacity should also be taken into consideration in the dimensioning issue.	a2, a3	NM	b27, b28	e1, e41, e42	NM	d12	f1	2019	India	Hyderabad (India)	72	Matlab, GAMS/ LINDO
[202]	A novel TCA control scheme for MGs is presented, utilizing local interactions between devices and a modified control message distribution scheme utilizing the GSA. The scheme is robust, scalable, and resilient to node failure and can be easily accepted by customers as it considers their comfort and does not require their ongoing participation in the management procedure.	a11	100	b3	e13, e15, e17	NM	d107	f1	2018	Macedonia	NM	5	Matlab
[203]	This paper proposes a new flexibility service for domestic heat pumps that involves activating them at specific times for a certain number of periods, followed by deviations from typical consumption over a fixed number of periods. An optimization plan is employed to establish the modulation potential. The method is tested on a cluster of Belgian houses to provide a secondary reserve to solve a winter imbalance. Results show that a load aggregator using 100 heat pumps could expect to harvest up to 138 kW for upward modulation and up to 51 kW for downward activations.	a8	100	b18, b63, b76	e5, e71	NM	d13	f1	2017	Belgium	Belgium	24	MATLAB compatible toolbox YALMIP coupled to CPLEX solver
[204]	This paper suggests a DR control algorithm for HVAC units that uses Lyapunov optimization to decrease nonrenewable power demand and maintain customer comfort. The algorithm uses a distributed strategy that is less expensive and more secure. Future research could expand the DR problem to include Type-I elastic load, apply the algorithm to HVAC units with different power sources, and improve the distributed DR strategy's resilience by increasing the frequency of customer reports.	a13	2000	b99, b100	e17	NM	d133	f1	2014	Canada	http://climate.weather.gc.ca	24	NM
[205]	This paper proposes two algorithms for controlling HVACs for DR with MPC: A centralized approach and a distributed approach. Both effectively reduce load fluctuations while maintaining room temperature within a set range. However, open issues include extending the algorithms to control other types of elastic load, adjusting the water level change rate, managing computational complexity, and investigating communication impairments on control performance.	a13	1000	b41, b101	e13, e33	c31	d72	f1	2015	Canada	The wind energy (Eirgrid)	85/60	Matlab
[206]	This paper looks at how infrastructure for sensing and communication affects the power tracking of TCLs. The study finds that it is possible to control loads with little information, but performance decreases with less information. Basic communication infrastructure is needed, including a broadcast receiver at each load, a low-power transmitter, and a conventional SCADA system at each distribution substation. This can be added to existing distribution companies' network modernization efforts with minimal additional infrastructure investment. Future work includes exploring other estimation methods and advanced controllers and studying scenarios with communication delays or bandwidth constraints	a12, a20	10000	b68, b77	e13, e15, e44	c10	d99	f1	2013	USA, Switzerland	California	1	Matlab
[207]	They have developed a framework for DSM of thermostatically-controlled air conditioning loads using a universal set point temperature control strategy. PDEs of the system were derived and validated against a Monte Carlo model. A sliding mode controller was designed for robust output tracking control of the system, which mitigates power supply and demand imbalance in the existence of wind energy production. The controller only requires the measurement of power supply and demand error, making it practical for implementation. Future research will focus on interactions between demand-side energy management of TCLs and other load groups with generation resources in multi-area power systems.	a12	1000	b77	e13, e15, e44	NM	d73	f1	2013	USA	the city of Pittsburg, PA by National Weather Services and Forecast Office (USA), the National Renewable Energy Laboratory (USA)	24	NM
[208]	This paper suggests a flexible product approach for controlling large-scale groups of water heaters. An optimization approach is used to find a trajectory for the water heaters to follow as a mean field control strategy. A linear program is used to evaluate the flexibility that can be provided during a fixed interval. An algorithm is introduced to iterate through potential temperature timetables and identify qualifying schedules that meet additional constraints, limiting rebound at the end of the control period.	a11	500	b102, b103, b104	e2, e3, e71	c22	d2, d22, d74	f1	2020	Canada	SMARTDesc project, Independent Electricity System Operator of Ontario (Canada)	24	NM
[209]	A simulation study found that using smart control on a typical air-to-water heat pump system based on a residual-load-based DSM signal can achieve almost half of the load-shifting potential without additional investments or hardware changes. However, active load shifting may increase electricity consumption and investment costs. Future research should explore alternative control strategies and heat pump system configurations for smart DSM.	a8	1	b21, b105	e13, e55	NM	d48, d100	f1	2014	Germany	NM	24	Dymola/Modelica

A: System Types, B: Objectives, C: Forecast & Prediction & Estimation, D: Optimization & Control, E: Constraint, F: Validation, G: Duration (h), H: System Population, K: Publication Year, L: Publication Country, M: Implemented Database/Place, N: Solver/Program/Software/Toolbox/Platform/Framework

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

TABLE 1. Summary of DLC programs proposed in previous studies (Continue).

Ref.	Conclusions	A	H	B	E	C	D	F	K	L	M	G	N
[210]	The proposed is a two-level control system for managing high heat pump penetration. It consists of local primary control and central coordinative control. The central controller generates an adaptive economic schedule and assigns operating states to individual heat pumps (HP), while the local controller manages consumer comfort and network conditions. The system provides adaptive updates to schedules to compensate for scheduling uncertainties and ensures consumer comfort as well as network support.	a8	2	b104, b106	e42	NM	d75, d76	f1	2014	Danmark, Canada	NM	24	NM
[211]	A study introduced a control model for a residential energy system. The model included photovoltaics, a ground-source heat pump, thermal energy storage, a battery, and shiftable appliances. By optimizing costs and maximizing self-consumption, the model achieved significant savings in electricity costs (13-25%) and reduced electricity fed to the grid (8-88%) with cost-optimal control. The heat pump with thermal storage and a battery was more effective than shiftable appliances. Future research will explore the impact of these elements on cost savings, grid interaction, and energy system requirements.	a8, a11	1	b105, b107	e3, e33, e54	NM	d4, d77	f1	2016	Finland	Porvoo (Finland)	24	ALLSOL
[212]	This paper proposes a fuzzy system model for peak load curtailment. It can handle multiple outputs and different parameters of interest, making it applicable to different scenarios in a city with many regions and load profiles.	a11, a12, a24, a36	5 (each)	b108	e3, e33	NM	d39, d45, d56	f1	2014	Canada	NM	24	C, Matlab
[213]	This paper proposes a MILP-based RHO control scheme to enhance the utilization of wind energy and reduce operational expenses, interruptible air conditioning loads are scheduled without compromising on thermal comfort. The RHO strategy is used to mitigate uncertainties. The control strategy is validated on a radial distribution network comprising five nodes, and simulation results show guaranteed wind power penetration and minimized operation costs. The RHO strategy can update real-time information and re-schedule resources based on day-ahead decisions.	a12	419	b2, b30	e12, e15, e22, e42	NM	d13, d129	f1	2017	Australia, China	The suburb of Randwick in Sydney (Australia)	24	NM
[214]	This paper presents a wireless network that can monitor and control thermostatically controlled electrical loads. The solution allows customers to collect electrical and environmental data and adjust their power usage through local nodes. The algorithm is based on predictive control theory, providing a decentralized and low-cost solution. The system is flexible, powerful, and adaptable, using wireless communications to avoid extra wiring. The system has been tested in a university environment and can be integrated into other appliances.	a12	40	b18, b71	e5, e73	NM	d120	f1	2012	Spain	NM	18	C
[215]	This proposes a new approach for large-scale residential demand response. The approach allocates control tasks to each building's EMC in a distributed way, using average consensus algorithms in the network to set target consumption levels. The protocol integrates the two layers seamlessly and enables non-intrusive operation of appliances, with results showing significant improvement in the system's ability to match a target consumption profile.	a37	40	b109	e12	NM	d13, d84, d108	f1	2014	USA	New York City from NYISO (USA)	24	NM
[216]	A new way to model TCLs has been introduced using neuroscience-inspired oscillator modelling and phase model reduction. This simplified approach leads to control policies that can handle differences in system parameters and accurately assess demand response capabilities over different time periods. These tools have a significant impact but require further exploration. By using an open-loop control architecture, the need to measure the states of the TCLs is eliminated, ensuring customer privacy and avoiding investment costs and technical complications.	a12	1000	b2, b110	e13, e17, e44	NM	d78	f1	2018	USA	NM	30	XPPAUT
[217]	This paper suggests a way for ACs to provide operating reserve by using a sequential dispatch strategy. The strategy and recovery algorithm allows ACs to provide reserve with multiple duration times, considering variables including the quantity of ACs and power volatility limit. Capacity-time co-optimization among AC groups helps relieve congestion or reduce peak load without burdening the power system.	a12	25000, 60000	b111	e12, e13, e44	NM	d12, d153	f1	2018	China	Electric Reliability Council of Texas (USA)	24	NM
[218]	This study proposes a tool to reduce peak energy usage in commercial buildings by optimizing the cooling set points of each thermal zone. The tool uses the PMV index to balance energy savings and occupant comfort. It can estimate the effectiveness and benefits of reducing peak energy usage, making it useful for building owners and utilities. The study provides insight into the relationship between thermal comfort, peak energy usage, and energy consumption and shows how the tool can be integrated with EnergyPlus for building energy analysis.	a1, a13	1	b2, b112	e2, e12, e17	NM	d80	f1	2016	USA	Virginia (USA)	24	EnergyPlus
[219]	This paper suggests an algorithm to evaluate energy supply reliability in distribution systems. The algorithm treats commercial air conditioning loads as adjustable, and a two-stage demand response strategy is developed. Case studies prove its effectiveness. The paper concludes that defining "Loss of Load" for commercial air conditioning loads is crucial, and quantifying load reliability with customer-oriented and energy-oriented indices can guide distribution system planning and operation.	a12	1	b19, b113	e13, e17, e44, e63, e74	NM	d59	f1	2019	USA	Chicago (USA)	12	EnergyPlus
[220]	This study showed a strategy to remotely control heating systems in individual rooms during morning peak hours, resulting in an 85% reduction in energy consumption. However, the ideal goal of 100% reduction was not achieved due to user constraints and mechanical issues. The results confirmed that automated buildings can reduce energy consumption and emphasized the importance of real-world trials. Future studies can explore advanced control methods and apply the strategy to other heating systems.	a38	90	b2, b18	e2, e3	NM	d81, d82	f2	2020	Denmark	Copenhagen (Denmark)	72	Python
[221]	This study examines the possibility of 100% DER penetration, including EVs and HPs, in a Danish urban residential LV distribution network. It finds that 100% penetration is possible with simple congestion management algorithms, even with high charging power. Two congestion management methods were suggested with similar economic performance and no inconvenience to users. Future research will evaluate market-based integration strategies by considering users' willingness to participate and their impact on system operation.	a8, a15	42	b114	e15, e31, e42	NM	d42	f1	2014	Denmark	Denmark	48	Matlab, DIgSILENT

A: System Types, B: Objectives, C: Forecast & Prediction & Estimation, D: Optimization & Control, E: Constraint, F: Validation, G: Duration (h), H: System Population, K: Publication Year, L: Publication Country, M: Implemented Database/Place, N: Solver/Program/Software/Toolbox/Platform/Framework

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

TABLE 1. Summary of DLC programs proposed in previous studies (Continue).

Ref.	Conclusions	A	H	B	E	C	D	F	K	L	M	G	N
[222]	This paper outlines a framework for a smart distribution network that lets consumers submit a CDRB during peak demand hours. The CDRB includes power reduction levels and control strings. The study presents three scenarios that demonstrate how the service provider's choice affects the availability of dispatchable loads and CDRB. The findings from simulations reveal that the algorithm efficiently schedules devices and is beneficial for both the consumer and service provider.	a39	5	b71	e2, e75, e76	NM	d83, d254	f1	2015	Netherlands, Sultanate of Oman, Kingdom of Saudi Arabia, Pakistan	NM	1	NM
[223]	The DR is essential for optimizing smart grids, reducing costs, and preventing power outages. A novel DR algorithm was introduced to manage loads, implemented across various load categories through load reduction techniques and smart DLC to manage supply and demand. The algorithm is based on appliance types (static, programmable, and dimmable) and can control load in real-time. Simulations indicate that the power network can promptly react to demand during emergency situations and oversee the grid by means of distributed load reduction through the intelligent-interruptible DLC system.	a69, a70, a71	500, 1500	b3, b35, b115	e12, e17	c32	d20	f1	2017	Malaysia, Iran	NM	24	Hadoop
[224]	This paper proposes a flexible contract scheme for consumers enrolled in a DR program with a utility company, incentivizing enrollment and offering advantages for energy efficiency. This strategy has the potential for expansion to encompass different energy systems and requires periodic analysis, which could benefit from parallel computing techniques to reduce computational time.	a28	10 (serial) + 10 (parallel)	b18, b64, b88, b116	e42, e45, e101, e102	NM	d106	f1	2019	Viet Nam, Spain, Portugal, Israel	Virgin Islands (USA)	24	Matlab
[225]	The BPSO algorithm effectively schedules distributed energy resources, even with curtailment duration constraints. It also handles multiobjective optimization problems with constraints, but complex objective functions may hinder optimal solution location. Using multiple independent swarms increases the chances of finding a valid schedule. BPSO's simplicity and versatility are ideal for more complex interruptible load behaviours and scheduling needs in centralized dispatch or day-ahead markets.	a47	19	b2, b5, b82	e2, e11, e34, e59	NM	d6, d135	f1	2019	Australia	NM	16	NM
[226]	BPSO helps manage electric water heaters for DSM. It balances load management and customer satisfaction goals, considering water temperature. Testing on 200 households proves its effectiveness for cost savings and power system stability.	a11	200	b54, b82, b117	e17	NM	d135	f1	2010	Canada	Saint John Energy (Canada)	24	Matlab
[227]	This paper examines how to control thermal inertial loads to make a smarter microgrid. The authors have found optimal set-points for each load and designed a decentralized control for many loads. Numerical results suggest this method could lead to simple control logic for load aggregators. Future work could consider economic incentives for loads to participate and test in a realistic microgrid.	a12	3	b9, b18	e17	NM	d85	f1	2013	USA	NM	3	NM
[228]	This paper proposes using TCLs as virtual storage devices to manage changes in renewable electricity generation or demand. Populations with more variety and faster response times are best suited, and thermostat sensor resolution need not be more accurate than 14 bits. TCLs can provide regulation and load following services, with each load contributing 0.5 kWh of energy capacity and 0.75 kW of power capacity. This approach could eliminate the need for load-following or regulation-generating capacity. Future research will investigate the impact of ambient conditions on the control method's accuracy and the benefits/challenges of spatially distributing load following/regulation capacity in the distribution grid.	a12	10000	b62, b118	e44	c34	d4, d86	f1	2009	USA	NM	10	NM
[229]	This study proposes a strategy to reduce end-user discomfort during demand response events while still achieving load reduction targets. The approach uses a method to aggregate HVAC loads and adjust temperature settings while also considering fairness and load factor reduction. Instead of using ambient temperature, the approach uses HI and simulations show it decreases discomfort while still meeting requirements. Future studies could expand the approach to other appliances and consider decentralized solutions, stochastic approaches, and economic incentives.	a13	40	b2, b82, b119	e2, e13, e15, e44	c20, c36, c37, c38	d13	f1	2017	Turkey, Netherlands, Portugal	NM	18	GAMS 24.1.2, CPLEX 12
[230]	This paper presents a 2-D model for describing the behaviour of second-order TCLs and explores a centralized MPC design based on this model. Simulation results indicate that the model can track the desired power output trajectory with minor deviations. Future research will investigate the use of robust and distributed MPC for improved performance.	a12	1000	b60	e13, e15, e44	NM	d41	f1	2016	Canada	Victoria, B.C. (Canada)	24	NM
[231]	This paper proposes a new way to control AC demand based on a linear model for temperature setpoints. The strategy uses practical distributed and centralized MPC schemes to modulate clusters of ACs. Numerical simulations demonstrate that solar fluctuations can be decreased by as much as 94.2%. Accurate forecasting can lead to substantial improvements in performance, as shown in a comparison of different PV forecasting methods.	a12	10000	b106	e13, e15, e44	NM	d41	f1	2017	Australia	the CSIRO Black Mountain site, ACT, (Australia)	2	NM
[232]	This paper suggests a hieratical centralized control strategy for coordinating multiple TCL aggregators in DSM. The algorithm can regulate continuously and is not limited to load shifting. Simulation results show that the strategy effectively drives the TCL population to the desired power level without affecting customer comfort.	a12	26532	b60, b118	e44	NM	d53	f1	2017	China, Hong Kong	NM	2	NM
[233]	This paper suggests a DLC model that minimizes operation costs with network constraints, using a thermal inertia model and a distributed ICA algorithm based on the ICA algorithm and process communication model. The technique is evaluated using the IEEE 39-bus standard test system and a distributed computing test bed.	a12	8	b120	e12, e22, e44, e59, e77	NM	d109	f1	2014	Australia, China	NM	24	MPICH2, C++, Visual Studio 2010

A: System Types, B: Objectives, C: Forecast & Prediction & Estimation, D: Optimization & Control, E: Constraint, F: Validation, G: Duration (h), H: System Population, K: Publication Year, L: Publication Country, M: Implemented Database/Place, N: Solver/Program/Software/Toolbox/Platform/Framework

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

TABLE 1. Summary of DLC programs proposed in previous studies (Continue).

Ref.	Conclusions	A	H	B	E	C	D	F	K	L	M	G	N
[234]	Proposed an optimization mechanism for home DSM in smart grid using integer linear programming. The mechanism schedules power and operation time for appliances based on user preference and power consumption patterns. Simulation results show effectiveness and a more balanced hourly load when multiple households participate.	a11, a21, a41, a48	43	b28, b122	e1, e2,	NM	d13	f1	2012	UK	NM	24	Matlab
[235]	This paper studies how load management affects a distribution network with a PV power plant using a computer model. The algorithm reduces peak loads by controlling air conditioning units in different PV plant expansion scenarios. Simulations show that PV plants decrease demand levels but can cause an imbalance. Load management and electric power storage eliminate peak loads in the system.	a12	1	b71	e16, e22	NM	d87	f1	2015	Crotia	Osijek (Croatia)	12	PowerWorld
[236]	A new V2G control scheme reduces peak loads at the distribution substation level. The algorithm adjusts the discharging rates of PEVs based on the electricity grid's load pattern and the characteristics of PEVs. The algorithm achieves good peak-shaving even at low PEV penetration rates. 8% PEV V2G penetration achieves a 99% peak shaving rate on a 1MVA transformer. The outcomes are comparable to the best possible solution, and the algorithm is low-cost, making it applicable for field implementation.	a15	1000	b54, b71	e2, e78	NM	d53, d85, d146	f1	2018	USA, Turkey	Baskent DisCo (Turkey)	9	Matlab/CVX
[237]	The P-P energy transaction system was created to predict power demand and identify prosumers, reducing peak load demand in homes. It was tested on an Australian power network, showing a reduction of up to 14.63% in peak load demand and 12.85% in peak-to-average ratio. The study provides insights into P-P energy transactions, prosumers, and virtual power plants. Future research could focus on prediction errors, power flow behaviour, and distribution transformer implications.	a15, a22	4	b54, b94	e42	c20, c35	d13	f1	2020	Australia, Italy	NM	48	GAMS/ Cplex
[238]	This paper examines using remote load control for central air conditioning systems with high power usage. The study built a power model for a cold water chiller and water pump to analyze how the load ratio affects COP and power consumption. The results show that operation scheme 3 with curtailment control strategy is the best option for reducing daily power consumption and increasing energy savings, while pre-cooling control strategy leads to the highest COP for each operation scheme.	a12	2	b2, b80	e2, e3	NM	d42, d56	f1	2020	China	Guangzhou (China)	24	NM
[239]	The article explores the use of Q-learning and other ADP methods to control DEWH and lower energy costs. Simulation results demonstrate that Q-learning outperforms other approaches in reducing costs, increasing customer satisfaction, and eliminating or shifting load peaks. The authors propose that Q-learning is a simple and reliable ADP method that can deliver significant financial and environmental advantages.	a11	100	b2, b9, b80, b122	e13, e15	NM	d114, d155	f1	2017	USA, China	NM	2400, 720	Matlab
[240]	This paper suggests a new algorithm for load control and aggregation. The algorithm combines the 2D state bin concept and the rolling optimization model based on MPC. It has improved accuracy and a strategy for selecting loads with priorities at different scales. This strategy improves response accuracy, satisfies customer thermal comfort, and ensures fairness in DR programs.	a12	1000	b64, b123	e13, e15, e44	NM	d41	f1	2019	China, USA	NM	24	Matlab
[241]	This research introduces a dynamic control plan for RACs to engage in demand response initiatives. The strategy considers external uncertainties, user behaviour, and online RACs. RACs provide temperature set points and online state information, and the load aggregator's control center sends signals to each RAC. Simulation verifies the accuracy of the dynamic DR control strategy. Subsequent research will focus on improving power distribution and effectively handling network congestion by combining distribution network topology with RAC distribution.	a12	3700	b64	e2, e13, e15, e17, e44	NM	d92	f1	2019	China	Changzho (China)	24	NM
[242]	This paper puts forth an energy optimization approach that relies on incentives for scheduling electric appliances in a community. Customers are compensated based on the level of inconvenience, and the system maintains privacy. The proposed approach saves costs by 11.3% on average and 6.2% more than the TOU-based case. Future work includes incorporating rooftop PV.	a30, a31, a35, a42	25 houses	b18, b39, b124	e2, e71, e79	NM	d13	f1	2019	USA	NM	24	CPLEX
[243]	This paper introduces a framework for tracking renewable power using PEVs. The framework uses a state-space model and sliding mode control to track desired power trajectories. The controller can accurately track real wind power trajectory despite fluctuations. The paper also explores the utilization of alternative controllable loads, like thermostatic systems, to overcome the loss of control authority during high renewable generation and low PEV demand.	a15	1000	b67, b125	e80, e81	NM	d88	f1	2012	USA	National Household Travel Survey (USA)	24	NM
[244]	This paper proposes a model for load management programs that considers reducing peak power requirements, optimizing utility revenue, and minimizing inconvenience to customers. The model uses binary variables for flexible load control and is independent of load type. The STEM interactive method helps decision-makers select solutions, and a physically-based load model generates control strategies. Using multi-objective models in decision support environments is a promising research area for selecting remote load control strategies.	a11	4000	b16, b71, b82	e82	NM	d124, d3	f1	2000	Portugal	NM	24	NM
[245]	The CAC model modifies the schedule of individual EWHs to move the load to periods with lower demand, balancing user needs and utility. Simulations for 77 EWHs show that a low grid power limit of 0.4 kW/EWH can prevent cold events, with energy savings of 4.68% for TM and 11.82% for EML. Predicting water usage did not affect energy savings, but setting a power limit increased cold events.	a11	77	b2	e3, e17	NM	d80, d89	f1	2022	South Africa	South Africa	48	NM

A: System Types, B: Objectives, C: Forecast & Prediction & Estimation, D: Optimization & Control, E: Constraint, F: Validation, G: Duration (h), H: System Population, K: Publication Year, L: Publication Country, M: Implemented Database/Place, N: Solver/Program/Software/Toolbox/Platform/Framework

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

TABLE 1. Summary of DLC programs proposed in previous studies (Continue).

Ref.	Conclusions	A	H	B	E	C	D	F	K	L	M	G	N
[246]	Choosing load control strategies for LM programs poses a challenge because of conflicting goals and diverse power systems. This paper presents a model that compares non-dominated solutions based on minimizing peak power demand, consumer discomfort, loss factor, and maximizing utility profits. An evolutionary algorithm and PBLM are used to quickly identify and select control strategies without pre-specifying LM actions, leading to faster, satisfactory solutions.	a11, a12	a11(1415), a12(445)	b3, b16, b82, b94	e63	NM	d18	f1	2004	Portugal	NM	24	NM

A: System Types, B: Objectives, C: Forecast & Prediction & Estimation, D: Optimization & Control, E: Constraint, F: Validation, G: Duration (h), H: System Population, K: Publication Year, L: Publication Country, M: Implemented Database/Place, N: Solver/Program/Software/Toolbox/Platform/Framework

TABLE 2. Appliance types classification (A).

A.I-Cooling and Heating	A.II-Energy Storage and Management	A.III-Others	
a5 Polysilicon reduction furnace	**a1** Building/Household/Plant	**a19** Lighting	**a59** Water lifting pump
a6 Inverter air conditioner	**a2** Electric vehicle	**a28** Backup load	**a60** Crop threshing machine
a7 Combined cooling, heating and power	**a3** Pumped water storage	**a30** Washer	**a67** Stove
a8 Heat pump	**a4** Deferrable electrolyzer	**a31** Dryer	**a68** Dwelling unit
a9 Centralized air-conditioning	**a10** Thermostatically controlled appliance	**a32** Optional lighting	**a69** Static appliance
a11 Electric water heater	**a14** Thermal Energy Storage	**a35** Dishwasher	
a12 Air conditioner	**a15** PEV: Plug-in electric vehicle	**a36** Pool pump	
a13 Heating ventilation and air conditioning	**a16** PHEV: Plug-in hybrid electric vehicle	**a33** Plug load	
a17 Central chiller plant	**a22** Battery	**a41** Washing machine	
a18 Electric heating	**a26** Energy storage systems	**a42** Cooking oven	
a20 Refrigerator	**a29** Controllable load/device/appliance	**a46** Motor	
a21 Freezer	**a37** Flexible appliance	**a47** Lamp	
a23 Heat pump water heater	**a39** Dispatchable load	**a49** Iron	
a24 Heating unit	**a40** Interruptible load	**a50** Vacuum cleaner	
a25 Ground source heat pump	**a61** Shiftable appliance	**a51** Kettle	
a27 Ice storage central air conditioning	**a62** Interruptible appliance	**a52** Toaster	
a34 Electric storage space heating	**a63** Battery device	**a53** Rise-cooker	
a38 Floor heating system	**a64** Battery energy storage system	**a54** Blender	
a43 Chiller	**a65** Fuel cells	**a55** Frying pan	
a44 Cooling fan	**a66** Electrolysis plant	**a56** Coffee maker	
a45 Calorifier	**a70** Dimmable appliance	**a58** Flourmill	
a48 Fridge compressor	**a71** Programmable appliance	**a57** Water pump	

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

TABLE 3. Objective types classification (B).

B.I-Cost Minimization		B.II-Load Management			
b1	Cost minimization	**b2**	Peak load reduction	**b99**	Reduce the variation of nonrenewable power demand
b4	Cost optimization	**b3**	Load shedding	**b102**	Mean load reduction
b5	Minimizing operating cost	**b17**	Minimizing distribution grid losses	**b108**	Peak load curtailment
b7	Minimizing capital investment	**b21**	Load shifting	**b111**	Mitigate the lead–lag rebound
b8	Minimizing fuel costs	**b28**	Minimizing peak hourly energy consumption	**b112**	Mitigate network overloading conditions
b9	Minimizing total cost	**b29**	Maintain a charging trajectory	**b113**	Rebound suppression
b20	Minimize total social cost	**b34**	Peak average ratio reduction	**b117**	Minimize the peak load demand
b22	Saving in cost	**b35**	Peak rebound power damping	**b118**	Delivering services such as regulation and load following
b23	Minimization of total annualized cost	**b39**	Demand reduction	**b119**	Reduce the load rebound effect
b27	Minimization of microgrid lifetime cost	**b43**	Active power curtailment	**b126**	Reduce load variation
b30	Reduce operational costs	**b48**	Power reduction	**b127**	Minimization of peak demands
b33	Reduce load regulation costs	**b54**	Peak shaving	**b134**	Load deferred
b37	Reduce high cost of the electricity consumption	**b56**	Minimize load and target power		
b44	Minimizes generation costs	**b59**	Load curtailment		
b51	Electricity bill reduction is up	**b62**	Load reduction		
b52	Minimize the electricity cost	**b65**	Reduce the peak to valley load difference		
b55	Reduce the energy cost	**b66**	Minimize the load peak valley difference in the regulation period		
b57	Minimizing the difference between energy generation costs and revenue of surplus power utilization	**b67**	Accurate power tracking		
b58	Minimize the entire life cycle cost (LCC)	**b70**	Reduction in consumed energy		
b63	Low payback effect	**b71**	Peak demand reduction		
b76	Energy cost minimization	**b72**	Peak load shifting		
b78	Minimize the load shedding cost	**b74**	Peak clipping		
b79	Reduce their energy procurement cost	**b80**	Reduction energy consumption		
b84	Demand charge reduction	**b81**	Minimize the energy demand		
b86	Decrease the total planning cost of the MG system	**b83**	Reduce the peak-to-average consumption ratio		
b91	Reduce the peak cost	**b85**	Reduce peak power		
b100	Reduce the communication cost and complexity	**b87**	Satisfaction of power flow constraints		
b109	Decrease the real-time deviation cost	**b94**	Minimize the maximum peak power demand		
b110	Reduce equipment cost	**b95**	Minimize the total time in which loads are in curtailment		
b130	Cost reduction	**b96**	Maximize the power consumption		
b131	Minimize power losses	**b97**	Reduce end-users electric consumption		
b132	Minimize costs	**b98**	Alternate the shape of the utility load curve		

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

TABLE 3. Objective types classification (B). (Continue)

B.III-Environmental Impact	
b6	Minimizing fossil fuel consumption
b11	Minimizing pollutant emissions
b12	Minimizing environmental impact
b15	Emission minimization
b31	Reduce CO_2 emissions
b116	Energy content of conventional power generation and battery discharging energy are minimized

B.IV-Efficiency and Optimization	
b13	Minimizing electricity grid losses
b14	Optimization of cost
b16	Maximizing the profit
b24	Reduce the number of batteries, inverters, photovoltaic cells
b25	Reduce total net present costs
b26	Reduce or eliminate the mismatch between the consumption and generation profiles
b46	Energy saving
b60	Ancillary services
b69	Reduction in energy losses
b73	Retailer profit
b120	Minimize the total operational cost
b103	Provides guarantees on the size of post-load-control rebound dynamics

B.V-Comfort and Satisfaction	
b10	Minimizing discomfort
b41	Comfort maximization
b42	Preferences reservation for the consumer
b47	Less adverse thermal comfort impacts
b49	Acceptable zone temperature
b61	Thermal comfort
b64	User comfort
b75	Maximizing customer welfare
b82	Minimization of the end-users' discomfort
b88	Satisfaction of appliance operational constraints
b89	Minimize the disturbance of the residents' thermal comfort
b92	Social welfare
b114	Congestion alleviation
b115	Minimize power outage
b122	Satisfy the user preference
b123	Fairness of the response
b124	Minimize privacy concerns
b133	Customer satisfaction

B.VI-Flexibility and Reliability	
b18	Flexibility
b19	Reliability
b32	Reduce net exchange power fluctuation
b38	Compensation of communication latency and detection error
b40	Uncertainty mitigation
b50	Fast demand response
b53	Grid stability
b68	Frequency regulation
b77	Alleviate power imbalance
b90	Minimize the total deviations between the total scheduled and instructed shed air conditioner loads (ACLs) over the entire dispatch horizon
b93	Frequency stabilization
b101	Minimize the fluctuation of non-renewable power generation
b104	Load/demand flexibility
b105	Balance supply and demand
b106	Compensate fluctuating generation
b128	Reduction in voltage fluctuations
b135	Power balancing among three phases

B.VII-Renewable Energy	
b36	Alleviate the wind power curtailment problem
b45	Maximise renewable energy penetration
b107	Maximizing PV self-consumption
b121	Balancing reserve (Balancing wind generation)
b125	Tracking of real wind power trajectory
b129	Wind power integration

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

TABLE 4. Forecast & prediction & estimation types classification (C)

C.I-Statistical Methods

C.I.a.Regression Analysis

c2	Regression models
c14	Iterative reweighted least-squares
c23	Nonlinear regression
c24	Multiple linear regression
c25	Multiple regression

C.I.b.Time Series Methods

c1	Time series models
c32	Autoregressive integrated moving average
c33	Autoregressive integrated moving average with external (oreXogenous) input
c34	Autoregressive moving average with exogenous variables
c35	Autoregressive moving average
c37	Autoregressive
c41	Moving average

C.I.c.Other/Tools/Soothing/Classification Methods

c7	Econometric
c8	Decomposition
c9	Cointegration
c10	Kalman filtering
c11	General exponential smoothing
c12	State space
c15	Box-Jenkins transfer function
c16	Scenario-based method
c19	Autonomous estimation
c22	Monte Carlo simulation
c31	Exponentially weighted moving average
c36	Spatio-temporal forecasting
c39	Beta distribution estimation
c40	Least enthalpy estimation
c42	Gaussian mixture model

C.II-Computational Intelligence (CI) Methods (ANN, FLC, SVM, GA, AI, ES, etc.)

c3	Artificial Intelligence based Approach
c4	Particle swarm optimization
c6	Grey prediction
c13	Knowledge based method
c17	Moth flame optimization
c18	Harmony search
c20	Artificial neural network
c21	Deep neural network
c43	Cooperative game method

C.III-Mathematical Programming (MP)

c5	Bottom up models – MARKAL/TIMES/LEAP
c38	Wavelet Transform

C.IV-Span of Time

c26	Very short-term load forecast
c27	Short-term load forecasting
c28	Medium-term load forecast
c29	Long-term load forecasting
c30	Day ahead load forecasting

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

TABLE 5. Optimization & control types classification (D)

D.I-Traditional Optimization Algorithm

d1	Traditional programming	**d107**	Gossip algorithm
d2	Linear programming	**d108**	Average consensus algorithm
d3	Multi-objective linear programming	**d110**	Multi-objective decision making
d4	Dynamic programming	**d113**	Real-time scheduling algorithm
d5	Multi-pass dynamic programming	**d115**	Integer Linear Programming
d6	Fuzzy dynamic programing	**d117**	Mixed-integer programming
d7	Monte Carlo based dynamic programming	**d118**	Iterative dynamic programming
d8	Stochastic programming	**d119**	Integer programming
d9	Robust programming	**d120**	Sequential quadratic programming
d10	Convex programming	**d122**	Lagrange multiplier method
d11	Successive approximation gradient technique	**d123**	Empirical method
d12	Mixed-integer non-linear programming	**d125**	Benders Decomposition Method
d13	Mixed-integer linear programming	**d127**	Lagrangian method
d14	Nonlinear programming	**d140**	Quadratic programming problem
d15	Multi-objective mixed integer quadratic programming problem	**d141**	Bi-level optimization problem
d28	Binary search algorithm	**d145**	Unweighted pair group method with arithmetic mean
d29	Day ahead load optimization	**d146**	Convex optimization technique
d102	Real-time water-filling algorithm	**d149**	Alternating direction method of multipliers

D.II-Heuristic Optimization Algorithm

d16	Heuristic programming	**d112**	Bisection algorithm
d17	Genetic algorithm	**d114**	Action dependent heuristic dynamic programming
d18	Multi-objective evolutionary algorithm	**d116**	Stochastic non-linear programming
d19	Particle swarm optimization	**d121**	Fuzzy linear programming
d20	Machine learning	**d126**	Optimal template temperature match method
d21	Game theory	**d128**	Iterative optimization process
d22	Auction	**d129**	Rolling horizon optimization
d23	Cat swarm optimization	**d130**	User-defined control period optimizer
d24	K-mean clustering machine learning technique	**d131**	Optimized control period optimizer
d25	Moth-flame optimization algorithm	**d132**	Greedy randomized adaptive search procedure
d26	Hybrid GA-PSO	**d134**	Simulated Annealing
d27	Greedy algorithm (Juggling Algorithm type)	**d135**	Binary particle swarm optimization
d30	Multi-objective particle swarm optimisation	**d136**	Multi-objective optimization
d31	K-mean clustering method	**d137**	Flexibility-based multi-objective generation maintenance
d32	Tabu Search	**d138**	Discrete harmony sear
d33	Quantum-inspired evolutionary algorithm	**d139**	Success-history based differential evolution
d36	Genetic k-means algorithm	**d142**	A hierarchical and iterative algorithm: two-stage optimization model
d35	History driven differential evolution	**d143**	Nash game theory
d37	Artificial neural networks	**d147**	Markov decision process
d101	Knapsack problem based optimization algorithm	**d148**	Stackelberg game approach
d103	Differential evolutionary algorithm	**d150**	Enhanced particle swarm optimization algorithm combined with quorum sensing
d104	Fuzzy adaptive imperialist competitive algorithm	**d151**	Self-organizing maps
d105	Evolutionary algorithm	**d152**	Nonlinear principal component analysis
d106	Integer genetic algorithm	**d153**	Optimal sequential dispatch strategy
d109	Imperialist competitive algorithm	**d154**	Consolidated demand reduction bid
d111	Linear search algorithm		

D.III-Method/Technique/Tool used with Optimization Algorithm

d34	Deep reinforcement learning	**d155**	Q-learning
d124	STEM interactive method	**d156**	Fitted Q-iteration
d133	Lyapunov optimization	**d157**	Cooperative game method
d144	Agglomerative hierarchical clustering		

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

TABLE 5. Optimization & control types classification (D). (Continue)

D.IV-Power/Load Control

d38	Central load control	**d70**	Load frequency control
d43	Reactive power control	**d93**	Ripple control
d44	Active power control	**d64**	Distributed and uniform control
d45	Duty cycling control	**d83**	Load scheduling controllers
d61	Primary frequency control	**d85**	Fully decentralized control
d66	Coordinated voltage control	**d90**	Tertiary control
d67	Dead-band control		

D.V-Logic Control

d39	Fuzzy logic control	**d77**	Rule-based control
d68	Cognitive agent based-fuzzy logic controller	**d84**	Two-layer communication-based control architecture
d71	Priority-stack-based control framework	**d100**	Smart controller

D.VI-Optimization Control

d40	Genetic algorithm	**d80**	Optimal control
d49	Set-point change based control	**d81**	Local automatic controller
d55	Representative control	**d91**	Distributed probabilistic control
d63	State-queuing control	**d92**	Dynamic rolling optimization control
d65	System level optimization control	**d94**	Time shift control
d76	Central coordinative control	**d97**	Stochastic blocking control
d79	Optimal and near-optimal control		

D.VII-Feedback Control

d42	On-off control	**d52**	Linear droop control
d46	Supply-based feedback control	**d56**	Temperature control
d47	PID control	**d62**	Direct temperature feedback control
d48	PI control	**d73**	Lyapunov stable sliding mode controller
d50	Hysteresis control	**d96**	Average duty cycle model control
d51	Frequency feedback control	**d99**	Look-ahead proportional controller

D.VIII-Predictive Control

d41	Model predictive control	**d69**	Subspace predictive control
d53	Hierarchical centralized control	**d72**	Dynamic water-filling method based on model predictive control
d54	Hierarchical control	**d95**	Multivariable predictive control

D.IX-Adaptive Control

d58	Model-free dynamic control	**d86**	Model reference adaptive control
d75	Adaptive control	**d89**	Centrally adapted control

D.X-Others (Control)

d57	Switching control	**d82**	Supervisory control
d59	Two-stage control approach	**d87**	Coordinated control
d60	Step control method	**d88**	Sliding mode control
d74	Mean field games	**d98**	Customer satisfaction prediction index selection based controller
d78	Open loop control		

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

TABLE 6. Constraint types classification (E).

E.I-Comfort

e4	Customer discomfort effect	**e27**	Upper and lower limit of the comfort band
e12	Thermal comfort	**e73**	Maintaining minimum comfort levels
e17	User comfort		

E.II-Temperature

e3	Temperature	**e38**	Outdoor and indoor temperature
e13	The reference setpoint temperature	**e44**	Temperature deadband
e15	Upper and lower temperature limits	**e50**	Tolerance temperature
e19	Temperature of polysilicon rod	**e49**	The internal temperature of a DEWH
e24	Heat output limit	**e55**	Room temperature
e26	Maximum temperature difference (between outdoor-indoor)	**e56**	Room humidity ratio
e30	Maximum acceptable indoor air temperature increase	**e74**	Satisfying the thermal demand of zones
e31	Indoor air temperature	**e85**	Temperature excursion
e32	Relative humidity	**e97**	Indoor temperature range

E.III-Time

e1	Start-up and shut-down time
e2	Operation time
e11	Minimum run- and down-times
e34	Maximum time under control
e35	Minimum time between controls
e39	Adjustment time
e59	Minimum online time
e66	The non-working hour constraints
e75	Minimum duration for ON
e76	Maximum duration for OFF
e84	Maximum off-time and minimum on-time

E.IV-Energy Storage System (ESS)

e41	Battery charging/discharging power
e42	State of charge
e45	Battery capacity
e58	Rated capacity of the ESS
e62	Lower and upper bounds for maximum energy for charging
e68	Charging schedule
e78	Minimum SOC
e88	Storage capacity limits
e89	Storage power limits
e96	Sufficient charge
e101	Minimum voltage of the battery
e102	Maximum voltage of the battery

E.V-Load

e8	Number of units	**e81**	Maximum number of grid-connected PEVs
e53	Uncertainty of load	**e82**	Maximum number of loads
e60	Maximum dispatchable loads	**e90**	Load diversity
e67	TCA group state		

E.VI-Power, Voltage and Frequency

e9	Voltage level	**e54**	Power usage
e10	End-user's desired energy level	**e57**	Power imbalance
e16	Power flow variation	**e61**	Lower and upper limits of voltage at each bus
e20	Upper and lower power limits	**e63**	Power capacity
e21	Voltage drops	**e64**	Power factor
e33	Power consumption	**e70**	Minimum and maximum energy consumption
e36	Time-varying renewable generation	**e80**	Maximum power consumption
e37	Total amount of power	**e91**	EWH energy
e40	Maximum energy consumption	**e92**	EWH power input
e43	Power demand	**e93**	Power generation
e46	Upper and lower frequency limits	**e94**	Voltage variation
e47	Pre-declared threshold power		

E.VII-Flexibility and Reliability

e5	Payback	**e72**	Rebound size
e22	Power balance	**e83**	Spinning reserve margin
e23	Nonlinear feasible operating region	**e86**	Scalability
e28	Consumer flexibility	**e87**	Fairness
e29	Control reliability	**e95**	Balance supply and demand
e51	Flexibility index of aggregate demand	**e98**	Flexibility
e52	Percentage flexibility level	**e99**	Satisfaction
e65	Operational limits	**e100**	Reliability
e71	Rebound effect		

E.VIII-Cost, Price and Others

e6	Others (power, loss, luminescence, flexibility, priority, etc.)	**e48**	Uncertainty in price
e7	Cost	**e69**	Electricity purchased from spot market
e14	Fictitious reference value of the water/air flow rate	**e77**	Transmission network
e18	Cooling water flow rate	**e79**	Running order
e25	Energy cost		

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

LIST OF ABBREVIATIONS

AC	Air Conditioner
AI	Artificial Intelligence
ACA	Average Consensus Algorithm
ACL	Air Conditioner Load
AdapC	Adaptive Control
ADCMC	Average Duty Cycle Model Control
ADHDP	Action Dependent Heuristic Dynamic Programming
ADMM	Alternating Direction Method of Multipliers
ADP	Approximate Dynamic Programming
ADS	Advanced Distribution System
AEDS	Active electric Distribution System
AG-FLC	Cognitive Agent Based-Fuzzy Logic Controller
AHO	Agglomerative Hierarchical Clustering
AHU	Air Handling Unit
ANN	Artificial Neural Network
APC	Active Power Control
AR	Autoregressive
ARIMA	Autoregressive Integrated Moving Average
ARIMAX	Autoregressive Integrated Moving Average with External (Orexogenous) Input
ARMA	Autoregressive Moving Average
ARMAX	Autoregressive Moving Average with Exogenous Variables
BDE	Beta Distribution Estimation
BDM	Benders Decomposition Method
BDGP	Genetic Programming with Block Deepening
BESS	Battery Energy Storage System
BISECA	Bisection Algorithm
BJ	Box-Jenkins
BJTF	Box-Jenkins Transfer Function
BLOP	Bi-Level Optimization Problem
BPSO	Binary Particle Swarm Optimization
BSA	Binary Search Algorithm
CAC	Centrally Adapted Control
CAISO	California Independent System Operator
CC	Coordinated Control
CCC	Central Coordinative Control
CCHP	Combined Cooling Heating And Power
CCP	CC Programming
CDRB	Consolidated Demand Reduction Bid
CenAC	central air conditioning
CGM	Cooperative Game Method
CLC	Central Load Control
CML	Communication Latency
COP	Coefficient of Performance
COT	Convex Optimization Technique
CPISBC	CSPI Selection Based Controller
CRR	Continuous Regulation Reserves
CSF	Common Storage Facility
CSPI	Customer Satisfaction Prediction Index
CVC	Coordinated Voltage Control
CVR	Conservation Voltage Reduction
DADLCS	Day Ahead Direct Load Control Strategy
DALF	Day Ahead Load Forecasting
DALO	Day Ahead Load Optimization
DBC	Dead-Band Control
DCC	Duty Cycling Control
DE	Differential Evolutionary
DEA	DE Algorithm
DEWH	Domestic Electric Water Heater
DG	Diesel Generator
DHS	Discrete Harmony Search
DLC	Direct Load Control
DM	Decision Maker
DNN	Deep Neural Network
DNO	Distribution Network Operators
DP	Dynamic Programming
DPC	Distributed Probabilistic Control
DR	Demand Response
DRE	Demand Response Event
DRLC	Demand Response and Load Control
DROC	Dynamic Rolling Optimization Control
DSM	Demand-Side Management
DSO	Distribution System Operator
DSS	demand subscription services
DTFC	Direct Temperature Feedback Control
DWFM-MPC	Dynamic Water-Filling Method Based on Model Predictive Control
EA	Evolutionary Algorithm
ECSPL	Energy-Constrained State Priority List
ELECTRE	Elimination and Choice Translating Reality
EM	Empirical Method
EMC	Energy Management Controller
EML	Energy–Matched Optimal Control with Legionella Prevention
EMS	Energy Management System
ENS	Energy Not Supplied
EP	Electrolysis Plant
ERCOT	Electric Reliability Council of Texas
ESS	Energy Storage System
EV	Electrical Vehicle
EVB	Electric Vehicle Battery
EWH	Electrical Water Heater
EWMA	Exponentially Weighted Moving Average
FAICA	Fuzzy Adaptive Imperialist Competitive Algorithm
FC	Fuel Cell
FDC	Fully Decentralized Control
FDE	Frequency Detection Error
FDP	Fuzzy Dynamic Programming
FFC	Frequency Feedback Control
FIPA	Foundation for Intelligent Physical Agents
FL	Flexible Load
FLC	Fuzzy Logic Control
FLP	Fuzzy Linear Programming
FMBMPC	Fuzzy Model Based Multivariable Predictive Control
FMOGM	Flexibility-Based Multi-Objective Generation Maintenance
FPE	Forecast, Prediction and Estimation
FQI	Fitted Q-Iteration
FSM	Fuzzy Satisfying Method
GA	Genetic Algorithm
GAMS	General Algebraic Modeling System
GC	Gaussian Copula
GES	General Exponential Smoothing
GKA	Genetic K-Means Algorithm
GMM	Gaussian Mixture Model
GMS	Generation Maintenance Scheduling
GP	Grey Prediction
GrA	Greedy Algorithm
GRASP	Greedy Randomized Adaptive Search Procedure
GSA	Gossip Algorithm
GSHP	Ground Source Heat Pump
G2V	Grid-to-Vehicle
HAC	Home Area Controller
HC	Hierarchical Control
HCC	Hierarchical Centralized Control
HCM	Hybrid Control Method
HDDE	History Driven Differential Evolution
HEGS	Hybrid Energy Generation System
HEMS	Home Energy Management System
HIA	Hierarchical and Iterative Algorithm
HIR	Heuristic Inference Rules
HOA	Heuristic Optimization Algorithm
HP	Heat Pump
HPWH	Heat Pump Water Heater
HS	Harmony Search
HVAC	Heating Ventilation and Air Conditioning
HysC	Hysteresis Control
ICA	Imperialist Competitive Algorithm
IDGA	Iterative Deepening GA
IDP	Iterative Dynamic Programming
IGA	Integer Genetic Algorithm
ILM	Interruptible Load Management
ILP	Integer Linear Programming
INTERP	Integer Programming
IOP	Iterative Optimization Process
IQP	Integer Quadratic Programming
IRES	Integrated Renewable Energy System
IRP	Integrated Resources Planning
ISO	Independent System Operator
JA	Juggling Algorithm
KBM	Knowledge Based Method
KPBOA	Knapsack Problem Based Optimization Algorithm
LAC	Local Automatic Controller
LAGM	Lagrangian Method
LAPC	Look-Ahead Proportional Controller
LBS	Load Balancing Service
LC	Load Control
LCC	Life Cycle Cost
LCOE	Levelized Cost of Energy
LCom	Load Commitment
LDC	Linear Droop Control
LEE	Least Enthalpy Estimation
LFC	Load Frequency Control

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

LIST OF ABBREVIATIONS (CONTINUE)

LM	Load Management
LMM	Lagrange Multiplier Method
LP	Linear Programming
LSA	Linear Search Algorithm
LSC	Load Scheduling Controllers
LSE	Load Service Entity
LSSMC	Lyapunov Stable Sliding Mode Controller
LTLF	Long-Term Load Forecasting
LV	Low Voltage
LYAOP	Lyapunov Optimization
MA	Moving Average
MAS	Multi-Agent Systems
MDP	Markov Decision Process
MFDC	Model-Free Dynamic Control
MFGs	Mean Field Games
MFO	Moth Flame Optimization
MFOA	Moth-Flame Optimization Algorithm
MG	Micro Grid
MHP	Micro Hydro Power
MILP	Mixed-Integer Linear Programming
MINLP	Mixed-Integer Non-Linear Programming
MIP	Mixed-Integer Programming
MIQP	Multi-Objective Mixed IQP Problem
MLC	Microgrid Lifetime Cost
MLR	Multiple Linear Regression
MODM	Multi-Objective Decision Making
MOOP	Multi-Objective Optimization
MOPSO	Multi-Objective Particle Swarm Optimization
MPC	Model Predictive Control
MPDP	Multi-Pass Dynamic Programming
MRAC	Model Reference Adaptive Control
MTLF	Medium-Term Load Forecast
MULREG	Multiple Regression
MulvaPC	Multivariable Predictive Control
NCEMC	North Carolina Electric Membership Corporation
NGT	Nash Game Theory
NIEAR	Nodal Interrupted Energy Assessment Rate
NLP	Nonlinear Programming
NLPCA	Nonlinear Principal Component Analysis
NLR	Nonlinear Regression
NM	Unmentioned
OCLD	Optimal Chiller Loading Distribution
OCO	Optimal Chiller Operation
OCP	Optimized Control Period
OCPO	OCP Optimizer
ODAS	Optimal Day Ahead Scheduling
OLC	Open Loop Control
ONOC	Optimal and Near-Optimal Control
OOC	On-Off Control
OPTC	Optimal Control
OSDS	Optimal Sequential Dispatch Strategy
OTM	Optimal Template Temperature Match
PAR	Peak Average Ratio
PDE	Partial Differential Equation
PEV	Plug-In Electric Vehicle
PFC	Primary Frequency Control
PG&E	Pacific Gas and Electric
PHEV	Plug-In Hybrid Electric Vehicle
PIC	PI Control
PIDC	PID Control
PLC	Programmable Logic Controller
PMV	Predicted Mean Vote
P-P	Peer-to-Peer
PPD	Predicted Percentage of Dissatisfied
PSA	Principal Sub-Aggregator
PSBCF	Priority-Stack-Based Control Framework
PSO	Particle Swarm Optimization
PTEM	Power Tracking Error Model
PV	Photovoltaic
P2G	Power to Gas
QIEA	Quantum-Inspired Evolutionary Algorithm
QL	Q-Learning
QoPU	Quality of Power Usage
QPP	Quadratic Programming Problem
QS-PSO	PSO Algorithm Combined with Quorum Sensing
RAC	Residential Air Conditioning
RC	Representative Control
RER	Renewable Energy Resource
RHO	Rolling Horizon Optimization
RIPC	Ripple Control
RO	Reverse Osmosis
ROD	Desalination
RPC	Reactive Power Control
RTSA	Real-Time Scheduling Algorithm
RTWFA	Real-Time Water-Filling Algorithm
SA	Simulated Annealing
SBFC	Supply-Based Feedback Control
SC	Switching Control
SCM	Step Control Method
SDP	Semidefinite Program
SG	Smart Grid
SGA	Stackelberg Game Approach
SHADE	Success-History Based Differential Evolution
SLOC	System Level Optimization Control
SLR	Systematic Literature Review
SM	Smart Meter
SMARTC	Smart Controller
SMC	Sliding Mode Control
SNLP	Stochastic Non-Linear Programming
SNOP	Soft Normally-Open Points
SOC	State of Charge
SOM	Self-Organizing Maps
SPC	Subspace Predictive Control
SPCBC	Set-Point Change Based Control
SQ	State-Queuing
SQC	SQ Control
SQP	Sequential Quadratic Programming
SSID	Subspace Identification
STEM	Science, Technology, Engineering and Mathematics
STEMIM	STEM Interactive Method
STF	Spatio-Temporal Forecasting
STLF	Short-Term Load Forecasting
StoBC	Stochastic Blocking Control
SUC	Distributed and Uniform Control
SUPC	Supervisory Control
TAC	Total Annualized Cost
TC	Temperature Control
TCA	Thermostatically Controlled Appliance
TCL	Thermostatically Controlled Load
TerC	Tertiary Control
TES	Thermal Energy Storage
TLC	Thermal Comfort Level
TLCBCA	Two-Layer Communication-Based Control Architecture
TM	Temperature–Matched Optimal Control
TOA	Traditional Optimization Algorithms
TOU	Time-of-Use
TPC	Taiwan Power Company
TS	Tabu Search
TSC	Two-Stage Control Approach
TShiC	Time Shift Control
TUCA	Thermostatically Uncontrolled Appliance
TWDLC	Two-Way Direct Load Control
UC	Unit Commitment
UDCP	User-Defined Control Period
UDCPO	UDCP Optimizer
UPGMA	Unweighted Pair Group Method with Arithmetic Mean
VBPS	Virtual Battery Power System
VPP	Virtual Power Plant
VSTLF	Very Short-Term Load Forecast
V2G	Vehicle-to-Grid
V2V	Vehicle-to-Vehicle
WG	Wind Generator
WT	Wavelet Transform

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and
content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

REFERENCES

[1] A. F. Güven, N. Yörükeren, E. Tag-Eldin, and M. M. Samy, "Multi-objective optimization of an islanded green energy system utilizing sophisticated hybrid metaheuristic approach," *IEEE Access*, vol. 11, pp. 103044-103068, 2023, doi: 10.1109/ACCESS.2023.3296589.

[2] V. Boglou, C. Karavas, A. Karlis, K. G. Arvanitis, and I. Palaiologou, "An optimal distributed RES sizing strategy in hybrid low voltage networks focused on EVs' integration," *IEEE Access*, vol. 11, pp. 16250-16270, 2023, doi: 10.1109/ACCESS.2023.3245152.

[3] A. N. F. Ali, M. F. Sulaima, I. A. W. A. Razak, A. F. A. Kadir, and H. Mokhlis, "Artificial intelligence application in demand response: Advantages, issues, status, and challenges," *IEEE Access*, vol. 11, pp. 16907-16922, 2023, doi: 10.1109/ACCESS.2023.3237737.

[4] A. M. Alshamrani, M. A. El-Meligy, M. A. F. Sharaf, W. A. Mohammed Saif, and E. M. Awwad, "Transmission expansion planning considering a high share of wind power to maximize available transfer capability," *IEEE Access*, vol. 11, pp. 23136-23145, 2023, doi: 10.1109/ACCESS.2023.3253201.

[5] N. Ahmad, Y. G. Ghadi, M. Adnan, and M. Ali, "From smart grids to super smart grids: a roadmap for strategic demand management for next generation SAARC and European power infrastructure," *IEEE Access*, vol. 11, pp. 12303-12341, 2023, doi: 10.1109/ACCESS.2023.3241686.

[6] M. A. Ismeil, H. S. Hussein, M. Farrag, and M. Nasrallah, "Transmission and distribution smart grid system based on self-hailing controllable crowbar," *IEEE Access*, vol. 11, pp. 10149-10157, 2023, doi: 10.1109/ACCESS.2023.3240600.

[7] Z. Asghar, K. Hafeez, D. Sabir, B. Ijaz, S. S. H. Bukhari, and J. -S. Ro, "RECLAIM: Renewable energy based demand-side management using machine learning models," *IEEE Access*, vol. 11, pp. 3846-3857, 2023, doi: 10.1109/ACCESS.2023.3235209.

[8] R. K. Yadav, P. N. Hrisheekesha, and V. S. Bhadoria, "Grey wolf optimization based demand side management in solar PV integrated smart grid environment," *IEEE Access*, vol. 11, pp. 11827-11839, 2023, doi: 10.1109/ACCESS.2023.3241856.

[9] A. Sridhar, S. Honkapuro, F. Ruiz, J. Stoklasa, S. Annala, A. Wolff, A. Rautiainen, "Residential consumer preferences to demand response: Analysis of different motivators to enroll in direct load control demand response," *Energy Policy*, vol. 173, 113420, 2023, doi: 10.1016/j.enpol.2023.113420.

[10] F. Najafi and M. Fripp, "Market-based coordination of price-responsive demand using Dantzig-Wolfe decomposition method," *Energy and AI*, vol. 14, 100277, 2023, doi: 10.1016/j.egyai.2023.100277.

[11] Y.-Y. Hsu and C.-C. Su, "Dispatch of direct load control using dynamic programming," *IEEE Trans Power Syst*, vol. 6, no. 3, pp. 1056–1061, 1991, doi: 10.1109/59.119246.

[12] J. Chen, F. N. Lee, A. M. Breipohl, and R. Adapa, "Scheduling direct load control to minimize system operational cost," *IEEE Trans Power Syst*, vol. 10, no. 4, pp. 1994–2001, 1995, doi: 10.1109/59.476068.

[13] K. Bhattacharyya and M. L. Crow, "A fuzzy logic based approach to direct load control," *IEEE Trans Power Syst*, vol. 11, no. 2, pp. 708–714, 1996, doi: 10.1109/59.496143.

[14] H. Salehfar and A. Wehbe, "Direct control of residential water heater loads to reduce power system distribution losses," *in Proc IEEE Power Eng Soc Trans Distrib Conf*, vol. 3, no. Winter Meeting, pp. 1455–1460, 2001, doi: 10.1109/PESW.2001.917319.

[15] C.-M. Chu and T.-L. Jong, "A novel direct air-conditioning load control method," *IEEE Trans Power Syst*, vol. 23, no. 3, pp. 1356–1363, 2008, doi: 10.1109/TPWRS.2008.926432.

[16] T. Ericson, "Direct load control of residential water heaters," *Energy Policy*, vol. 37, no. 9, pp. 3502–3512, 2009, doi: 10.1016/j.enpol.2009.03.063.

[17] J. Kondoh, "Direct load control for wind power integration," *in IEEE Power Energy Soc. Gen. Meet.*, Detroit, MI, 2011. doi: 10.1109/PES.2011.6039480.

[18] M. W. Gustafson, J. S. Baylor, and G. Epstein, "Direct water heater load control - estimating program effectiveness using an engineering model," *IEEE Trans Power Syst*, vol. 8, no. 1, pp. 137–143, 1993, doi: 10.1109/59.221259.

[19] M. H. Nehrir and B. J. Lameres, "A Multiple-block fuzzy logic-based electric water heater demand-side management strategy for leveling distribution feeder demand profile," *Electr Power Syst Res*, vol. 56, no. 3, pp. 225–230, 2000, doi: 10.1016/S0378-7796(00)00124-3.

[20] R. C. G. Teive and S. H. Vilvert, "Demand side management for residential consumers by using direct control on the loads," *in 2002 Fifth International Conference on Power System Management and Control Conf. Publ. No. 488)*, 2002, pp. 233–237. doi: 10.1049/cp:20020040.

[21] N. Lu and D. P. Chassin, "A state-queueing model of thermostatically controlled appliances," *IEEE Trans Power Syst*, vol. 19, no. 3, pp. 1666–1673, 2004, doi: 10.1109/TPWRS.2004.831700.

[22] M. S. Majid, H. A. Rahman, M. Y. Hassan, and C. A. Ooi, "Demand side management using direct load control for residential," *in 2006 4th Student Conference on Research and Development,* Shah Alam, Malaysia, 2006, pp. 241–245. doi: 10.1109/SCORED.2006.4339346.

[23] B. Ramanathan and V. Vittal, "A framework for evaluation of advanced direct load control with minimum disruption," *IEEE Trans Power Syst*, vol. 23, no. 4, pp. 1681–1688, 2008, doi: 10.1109/TPWRS.2008.2004732.

[24] V. V. Ranade and J. Beal, "Distributed control for small customer energy demand management," *in Proc. - IEEE Int. Conf. Self-Adapt. Self-Organ. Syst.*, SASO, Budapest, 2010, pp. 11–20. doi: 10.1109/SASO.2010.21.

[25] G. R. Newsham, B. J. Birt, and I. H. Rowlands, "A comparison of four methods to evaluate the effect of a utility residential air-conditioner load control program on peak electricity use," *Energy Policy*, vol. 39, no. 10, pp. 6376–6389, 2011, doi: 10.1016/j.enpol.2011.07.038.

[26] A. Schroeder, "Modeling storage and demand management in power distribution grids," *Appl. Energy*, vol. 88, no. 12, pp. 4700–4712, 2011, doi: 10.1016/j.apenergy.2011.06.008.

[27] E. Klaassen, Y. Zhang, I. Lampropoulos, and H. Slootweg, "Demand side management of electric boilers," *in 2012 3rd IEEE PES Innovative Smart Grid Technologies Europe (ISGT Europe)*, Berlin, Germany, 2012. doi: 10.1109/ISGTEurope.2012.6465681.

[28] M. A. Zehir and M. Bagriyanik, "Demand side management by controlling refrigerators and its effects on consumers," *Energy Convers. Manage.*, vol. 64, pp. 238–244, 2012, doi: 10.1016/j.enconman.2012.05.012.

[29] M. Alizadeh, A. Scaglione, and R. J. Thomas, "From packet to power switching: Digital direct load scheduling," *IEEE J Sel Areas Commun*, vol. 30, no. 6, pp. 1027–1036, 2012, doi: 10.1109/JSAC.2012.120702.

[30] F. D. Silva and O. Mohammed, "Demand side load control with smart meters," in *2013 IEEE Power & Energy Society General Meeting,* Vancouver, BC, Canada, 2013. doi: 10.1109/PESMG.2013.6673014.

[31] K. Wong and M. Negnevitsky, "Development of an evaluation tool for demand side management of domestic hot water load," *in 2013 IEEE Power & Energy Society General Meeting,* Vancouver, BC, Canada, 2013. doi: 10.1109/PESMG.2013.6672465.

[32] A. Arteconi, N. J. Hewitt, and F. Polonara, "Domestic demand-side management (DSM): Role of heat pumps and thermal energy storage (TES) systems," Appl Therm Eng, vol. 51, no. 1–2, pp. 155–165, 2013, doi: 10.1016/j.applthermaleng.2012.09.023.

[33] O. Malik and P. Havel, "Active demand-side management system to facilitate integration of res in low-voltage distribution networks," IEEE Trans. Sustainable Energy, vol. 5, no. 2, pp. 673–681, 2014, doi: 10.1109/TSTE.2013.2288805.

[34] N. Mehta, N. A. Sinitsyn, S. Backhaus, and B. C. Lesieutre, "Safe control of thermostatically controlled loads with installed timers for demand side management," *Energy Convers. Manage.*, vol. 86, pp. 784–791, 2014, doi: 10.1016/j.enconman.2014.06.049.

[35] A. J. Hoffman, "Peak demand control in commercial buildings with target peak adjustment based on load forecasting," *in IEEE Conf Control Appl Proc, Anon, Ed.*, Piscataway, NJ, United States: IEEE, 1998, pp. 1292–1296. Accessed: Sep. 01, 1998. [Online]. Available: https://www.scopus.com/inward/record.uri?eid=2-s2.0-0032294586&partnerID=40&md5=f18d39af06ddd480757caf87cd5636a9

[36] K. -h. Lee and J. E. Braun, "Model-based demand-limiting control of building thermal mass," *Build. Environ.*, vol. 43, no. 10, pp. 1633–1646, 2008, doi: 10.1016/j.buildenv.2007.10.009.

[37] Y. Suhara, T. Nakabe, G. Mine, and H. Nishi, "Distributed demand side management system for home energy management," *in IECON Proc*, Glendale, AZ, 2010, pp. 2430–2435. doi: 10.1109/IECON.2010.5675426.

[38] G. T. Costanzo, J. Kheir, and G. Zhu, "Peak-load shaving in smart homes via online scheduling," *in Proc. - ISIE: IEEE Int. Symp. Ind. Electron.*, Gdansk, 2011, pp. 1347–1352. doi: 10.1109/ISIE.2011.5984354.

[39] S. C. Lee, S. J. Kim, and S. H. Kim, "Demand side management with air conditioner loads based on the queuing system model," *IEEE Trans Power Syst*, vol. 26, no. 2, pp. 661–668, 2011, doi: 10.1109/TPWRS.2010.2066583.

[40] T. Logenthiran, D. Srinivasan, and T. Z. Shun, "Demand side management in smart grid using heuristic optimization," *IEEE Trans. Smart Grid*, vol. 3, no. 3, pp. 1244–1252, 2012, doi: 10.1109/TSG.2012.2195686.

[41] A. Arif, F. Javed, and N. Arshad, "Integrating renewables economic dispatch with demand side management in micro-grids: A genetic algorithm-based approach," *Energy Effic.*, vol. 7, no. 2, pp. 271–284, 2014, doi: 10.1007/s12053-013-9223-9.

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and
content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

[42] N. Fitzgerald, A. M. Foley, and E. McKeogh, "Integrating wind power using intelligent electric water heating," *Energy*, vol. 48, no. 1, pp. 135–143, 2012, doi: 10.1016/j.energy.2012.03.014.
[43] C. Ucak and R. Caglar, "The effects of load parameter dispersion and direct load control actions on aggregated load," *in POWERCON - Int. Conf. Power Syst. Technol., Proc., Institute of Electrical and Electronics Engineers Inc.*, 1998, pp. 280–284. doi: 10.1109/ICPST.1998.728970.
[44] M. Babar, T. P. I. Ahamed, E. A. Al-Ammar, and A. Shah, "A novel algorithm for demand reduction bid based incentive program in direct load control," *in Energy Procedia, Fes: Elsevier Ltd*, 2013, pp. 607–613. doi: 10.1016/j.egypro.2013.11.062.
[45] M. Rastegar, M. Fotuhi-Firuzabad, and M. Moeini-Aghtaie, "Improving direct load control implementation by an inititative load control method," *in EPDC - Electr. Power Distrib. Netw. Conf., Kermanshah: IEEE Computer Society*, 2013. doi: 10.1109/epdc.2013.6565975.
[46] P. Sánchez-Martín, G. Sánchez, and G. Morales-España, "Direct load control decision model for aggregated EV charging points," *IEEE Trans Power Syst*, vol. 27, no. 3, pp. 1577–1584, 2012, doi: 10.1109/TPWRS.2011.2180546.
[47] L. Yao, Y.-C. Chou, and C.-C. Lin, "Scheduling of direct load control using genetic programming," *Int. J. Innov. Comput. Inf. Control*, vol. 7, no. 5 A, pp. 2515–2528, 2011.
[48] L. Goel, Q. Wu, and P. Wang, "Fuzzy logic-based direct load control of air conditioning loads considering nodal reliability characteristics in restructured power systems," *Electr Power Syst Res*, vol. 80, no. 1, pp. 98–107, 2010, doi: 10.1016/j.epsr.2009.08.009.
[49] Q. Wu, P. Wang, and L. Goel, "Direct load control (DLC) considering nodal interrupted energy assessment rate (NIEAR) in restructured power systems," *IEEE Trans Power Syst*, vol. 25, no. 3, pp. 1449–1456, 2010, doi: 10.1109/TPWRS.2009.2038920.
[50] A. Gomes, C. H. Antunes, and A. G. Martins, "A multiple objective approach to direct load control using an interactive evolutionary algorithm," IEEE Trans Power Syst, vol. 22, no. 3, pp. 1004–1011, 2007, doi: 10.1109/TPWRS.2007.901468.
[51] A. Molina-Garcia, R. Torres, J. L. Munoz, and N. Encinas, "Application of controller area networks to direct load control in residential areas," in *2007 IEEE Lausanne Power Tech*, Lausanne, Switzerland, 2007, pp. 1970–1974. doi: 10.1109/PCT.2007.4538619.
[52] L. Yao, W.-C. Chang, and R.-L. Yen, "An iterative deepening genetic algorithm for scheduling of direct load control," *IEEE Trans Power Syst*, vol. 20, no. 3, pp. 1414–1421, 2005, doi: 10.1109/TPWRS.2005.852151.
[53] C.-M. Chu, T.-L. Jong, and Y.-W. Huang, "A direct load control of air-conditioning loads with thermal comfort control," *in Power Eng. Soc. Gen. Meet.*, San Francisco, CA, 2005, pp. 664–669. Accessed: Jun. 12, 2005. [Online]. Available: https://www.scopus.com/inward/record.uri?eid=2-s2.0-27144527371&partnerID=40&md5=cca516f3c674db83419ffc5e52f6f508
[54] K.-Y. Huang and Y.-C. Huang, "Integrating direct load control with interruptible load management to provide instantaneous reserves for ancillary services," *IEEE Trans Power Syst*, vol. 19, no. 3, pp. 1626–1634, 2004, doi: 10.1109/TPWRS.2004.831705.
[55] H.-T. Yang, S.-C. Chen, and W.-N. Tsai, "Classification of direct load control curves for performance evaluation," *IEEE Trans Power Syst*, vol. 19, no. 2, pp. 811–817, 2004, doi: 10.1109/TPWRS.2004.825884.
[56] A. Wehbe and H. Salehfar, "Direct load control for reducing losses in the main and laterals of distribution systems," *in Proc IEEE Power Eng Soc Trans Distrib Conf*, Chicago, IL, 2002, pp. 1593–1598. Accessed: Jul. 21, 2002. [Online]. Available: https://www.scopus.com/inward/record.uri?eid=2-s2.0-0038000572&partnerID=40&md5=599ba953b8088999fe643c185c649d33
[57] A. Molina, A. Gabaldón, J. A. Fuentes, and F. J. Cánovas, "Approach to multivariable predictive control applications in residential HVAC direct load control," *in Proc IEEE Power Eng Soc Trans Distrib Conf*, Seattle, WA, 2000, pp. 1811–1816. Accessed: Jul. 16, 2000. [Online]. Available: https://www.scopus.com/inward/record.uri?eid=2-s2.0-0037625210&partnerID=40&md5=ff8985259eaa548d1c181fe6106a14c6
[58] Ng. Kah-Hoe and G. B. Sheblé, "Direct load control - a profit-based load management using linear programming," *IEEE Trans Power Syst*, vol. 13, no. 2, pp. 688–695, 1998, doi: 10.1109/59.667401.
[59] K. Y. Huang, H. T. Yang, C. C. Liao, and C.-L. Huang, "Fuzzy dynamic programming for robust direct load control," *Proc Int Conf Energy Manage Power Delivery EMPD*, vol. 2, pp. 564–569, 1998.
[60] W.-C. Chu, B.-K. Chen, and C.-K. Fu, "Scheduling of direct load control to minimize load reduction for a utility suffering from generation shortage," *IEEE Trans Power Syst*, vol. 8, no. 4, pp. 1525–1530, 1993, doi: 10.1109/59.260955.
[61] D.-C. Wei and N. Chen, "Air conditioner direct load control by multi-pass dynamic programming," *IEEE Trans Power Syst*, vol. 10, no. 1, pp. 307–313, 1995, doi: 10.1109/59.373916.
[62] M. A. A. Pedrasa, M. M. Oro, N. C. R. Reyes, and J. R. I. Pedrasa, "Demonstration of direct load control of air conditioners in high density residential buildings," *in 2014 IEEE Innovative Smart Grid Technologies - Asia (ISGT ASIA)*, Kuala Lumpur, Malaysia, 2014, pp. 400–405. doi: 10.1109/ISGT-Asia.2014.6873825.
[63] J. Kondoh, N. Lu, and D. J. Hammerstrom, "An evaluation of the water heater load potential for providing regulation service," *IEEE Trans Power Syst*, vol. 26, no. 3, pp. 1309–1316, 2011, doi: 10.1109/TPWRS.2010.2090909.
[64] C. Y. Chang et al., "Experiences of direct load control using ripple signals in Taiwan power system," *in IEE Conf Publ, Anon, Ed.*, Stevenage, United Kingdom: IEE, 1998, pp. 591–596. Accessed: Nov. 11, 1997. [Online]. Available: https://www.scopus.com/inward/record.uri?eid=2-s2.0-0031988624&partnerID=40&md5=4904cc0f23c1db3bce536362a8dd4676
[65] R. Azami and A. F. Fard, "Impact of demand response programs on system and nodal reliability of a deregulated power system," *in IEEE Int. Conf. Sustainable Energy Technol., ICSET*, Singapore, 2008, pp. 1262–1266. doi: 10.1109/ICSET.2008.4747200.
[66] M. W. Gustafson, J. S. Baylor, and G. Epstein, "Estimating air conditioning load control effectiveness using an engineering model," *IEEE Trans Power Syst*, vol. 8, no. 3, pp. 972–978, 1993, doi: 10.1109/59.260904.
[67] T. Tran-Quoc, J. C. Sabonnadière, N. Hadjsaid, Ch. Kieny, and K. Le, "Air conditioner direct load control in distribution networks," *in IEEE Bucharest PowerTech: Innovative Ideas Toward Electr. Grid Future*, Bucharest, 2009. doi: 10.1109/PTC.2009.5281987.
[68] N. Ruiz, I. Cobelo, and J. Oyarzabal, "A direct load control model for virtual power plant management," *IEEE Trans Power Syst*, vol. 24, no. 2, pp. 959–966, 2009, doi: 10.1109/TPWRS.2009.2016607.
[69] E. T. Arntzen, B. H. Chowdhury, and J. J. Cupal, "A low-cost microcomputer based direct load control scheme for small electric utilities," *Electr Power Syst Res*, vol. 34, no. 1, pp. 19–28, 1995, doi: 10.1016/0378-7796(95)00953-F.
[70] I. M. El-Amin, A. R. Al-Ali, and M. A. Suhail, "Direct load control using a programmable logic controller," *Electr Power Syst Res*, vol. 52, no. 3, pp. 211–216, 1999, doi: 10.1016/S0378-7796(99)00029-2.
[71] H.-T. Yang and K.-Y. Huang, "Direct load control using fuzzy dynamic programming," *IEE Proc Gener Transm Distrib*, vol. 146, no. 3, pp. 294–300, 1999, doi: 10.1049/ip-gtd:19990317.
[72] N. E. Ryan, J. T. Powers, B. A. Smith, and S. D. Braithwait, "Generalizing direct load control program analysis: Implementation of the duty cycle approach," *IEEE Trans Power Syst*, vol. 4, no. 1, pp. 293–299, 1989, doi: 10.1109/59.32491.
[73] A. Molina, A. Gabaldón, J. A. Fuentes, and C. Álvarez, "Implementation and assessment of physically based electrical load models: Application to direct load control residential programmes," *IEE Proc Gener Transm Distrib*, vol. 150, no. 1, pp. 61–66, 2003, doi: 10.1049/ip-gtd:20020750.
[74] B. E. Purvis and M. Chow, "Analysis of direct load control using multiple linear regression techniques," *in Conf Proc IEEE SOUTHEASTCON*, Piscataway, NJ, United States: Publ by IEEE, 1991, pp. 454–458. Accessed: Apr. 08, 1991. [Online]. Available: https://www.scopus.com/inward/record.uri?eid=2-s2.0-0025749394&partnerID=40&md5=bdf27465b7068a65e9db47fa968d7b82
[75] M. T. Bina and D. Ahmadi, "Aggregate domestic demand modelling for the next day direct load control applications," *IET Gener. Transm. Distrib.*, vol. 8, no. 7, pp. 1306–1317, 2014, doi: 10.1049/iet-gtd.2013.0567.
[76] L. Yao and H.-R. Lu, "Optimization of two-way direct load control based on fuzzy linear programming," *in IEEE Int Conf Fuzzy Syst*, Hong Kong, 2008, pp. 1894–1901. doi: 10.1109/FUZZY.2008.4630628.
[77] T. Facchinetti and M. L. Della Vedova, "Real-time modeling for direct load control in cyber-physical power systems," *IEEE Trans. Ind. Inf.*, vol. 7, no. 4, pp. 689–698, 2011, doi: 10.1109/TII.2011.2166787.
[78] A. Molina-Garcia, J. A. Fuentes, E. Gómez-Lázaro, A. Bonastre, J. C. Campelo, and J. J. Serrano, "Application of wireless sensor network to direct load control in residential areas," *in IEEE Int Symp Ind Electron*, Caixanova - Vigo, 2007, pp. 1974–1979. doi: 10.1109/ISIE.2007.4374910.
[79] H. T. Yang, S. C. Chen, and P. C. Peng, "Genetic k-means-algorithm-based classification of direct load-control curves," *IEE Proc Gener Transm Distrib*, 2005, pp. 489–495. doi: 10.1049/ip-gtd:20045006.
[80] K. Bhattacharyya and M. L. Crow, "A Fuzzy based load model for power system direct load control," *in IEEE Conf Control Appl Proc*, Piscataway, NJ, United States: IEEE, 1995, pp. 27–32. Accessed: Sep. 28, 1995. [Online]. Available: https://www.scopus.com/inward/record.uri?eid=2-s2.0-0029508228&partnerID=40&md5=2c435ac0ad9d6d68ce958a3b184b6441

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and
content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

[81] K. D. Le, R. F. Boyle, M. D. Hunter, and K. D. Jones, "A procedure for coordinating direct-load-control strategies to minimize system production costs," *IEEE Trans. Power Appar. Syst.*, vol. PAS-102, no. 6, pp. 1843–1849, 1983, doi: 10.1109/TPAS.1983.317793.

[82] O. Alamos and H. Rudnick, "Genetic algorithm model to control peak demand to defer capacity investment," *in IEEE Power Energy Soc. Gen. Meet.*, San Diego, CA, 2012. doi: 10.1109/PESGM.2012.6344706.

[83] W. Kempton, C. Reynolds, M. Fels, and D. Hull, "Utility control of residential cooling: resident-perceived effects and potential program improvements," *Energy Build.*, vol. 18, no. 3–4, pp. 201–219, 1992, doi: 10.1016/0378-7788(92)90014-8.

[84] M. Rastegar, M. Fotuhi-Firuzabad, and F. Aminifar, "Load commitment in a smart home," *Appl. Energy*, vol. 96, pp. 45–54, 2012, doi: 10.1016/j.apenergy.2012.01.056.

[85] S. Horowitz, B. Mauch, and F. Sowell, "Forecasting residential air conditioning loads," *Appl. Energy*, vol. 132, pp. 47–55, 2014, doi: 10.1016/j.apenergy.2014.06.029.

[86] D. Caprino, M. L. Della Vedova, and T. Facchinetti, "Peak shaving through real-time scheduling of household appliances," *Energy Build.*, vol. 75, pp. 133–148, 2014, doi: 10.1016/j.enbuild.2014.02.013.

[87] Z. Yu, "A temperature match based optimization method for daily load prediction considering DLC effect," *IEEE Trans Power Syst*, vol. 11, no. 2, pp. 728–733, 1996, doi: 10.1109/59.496146.

[88] ZuweiYu, A. M. Breipohl, F. N. Lee, and R. Adapa, "An analytical method for comparing natural diversity to DSM controlled diversity," *IEEE Trans Power Syst*, vol. 11, no. 3, pp. 1201–1208, 1996, doi: 10.1109/59.535591.

[89] Ming Yuan Cho, Shih Wei Gau, and Cha Win Huang, "Development of microprocessors based demand control system for industrial and commercial customer," *in Conf Rec Ind Commer Power Syst Tech Conf*, New Orleans, LA, 2001, pp. 1–6. Accessed: May 15, 2001. [Online]. Available: https://www.scopus.com/inward/record.uri?eid=2-s2.0-0035211496&partnerID=40&md5=9cee702e04bf4daa515eb4d969b1b627

[90] Y.-C. Chang and H.-C. Tu, "An effective method for reducing power consumption-optimal chiller load distribution," *in Proceedings. International Conference on Power System Technology*, Kunming, China, 2002, pp. 1169–1172. doi: 10.1109/ICPST.2002.1047586.

[91] K. Y. Huang, "Demand subscription services - An iterative dynamic programming for the substation suffering from capacity shortage," *IEEE Trans Power Syst*, vol. 18, no. 2, pp. 947–953, 2003, doi: 10.1109/TPWRS.2003.811167.

[92] J. A. F. Moreno, A. M. García, A. G. Marín, E. G. Lázaro, and C. A. Bel, "An integrated tool for assessing the demand profile flexibility," *IEEE Trans Power Syst*, vol. 19, no. 1, pp. 668–675, 2004, doi: 10.1109/TPWRS.2003.821446.

[93] Y.-C. Chang, "An outstanding method for saving energy - Optimal chiller operation," *IEEE Trans Energy Convers*, vol. 21, no. 2, pp. 527–532, 2006, doi: 10.1109/TEC.2006.871358.

[94] H.-R. Lu and L. Yao, "On-line load optimization for two way load management system," *in 2006 IEEE International Conference on Systems, Man and Cybernetics*, Taipei, Taiwan, 2006, pp. 3250–3255. doi: 10.1109/ICSMC.2006.384619.

[95] C.-M. Chu, T.-L. Jong, and Y.-W. Huang, "Mitigating DLC constraints of air-conditioning loads using a group-DLC method," *in 2007 IEEE Power Engineering Society General Meeting, PES*, Tampa, FL, 2007. doi: 10.1109/PES.2007.385626.

[96] S. Tiptipakom and W.-J. Lee, "A residential consumer-centered load control strategy in real-time electricity pricing environment," *in North Am. Power Symp., NAPS*, Las Cruces, NM, 2007, pp. 505–510. doi: 10.1109/NAPS.2007.4402357.

[97] K. Le, T. Tran-Quoc, J. C. Sabonnadière, C. Kieny, and N. Hadjsaid, "Peak load reduction by using air-conditioning regulators," *in Proc Mediterr Electrotech Conf MELECON*, Ajaccio, 2008, pp. 713–718. doi: 10.1109/MELCON.2008.4618519.

[98] L. Yao and H.-R. Lu, "A two-way direct control of central air-conditioning load via the internet," *IEEE Trans Power Delivery*, vol. 24, no. 1, pp. 240–248, 2009, doi: 10.1109/TPWRD.2008.923813.

[99] J. Lei, H. Ning, and L. Yao, "A new method of load-shedding control on centrifugal water chiller sequencing," *in IEEE Conf. Ind. Electron. Appl., ICIEA*, Xi'an, 2009, pp. 3204–3209. doi: 10.1109/ICIEA.2009.5138793.

[100] S. Bashash and H. K. Fathy, "Modeling and control insights into demand-side energy management through setpoint control of thermostatic loads," *in Proceedings of the 2011 American Control Conference*, San Francisco, CA, USA, 2011, pp. 4546–4553. doi: 10.1109/acc.2011.5990939.

[101] N. Lu, "An evaluation of the HVAC load potential for providing load balancing service," *IEEE Trans. Smart Grid*, vol. 3, no. 3, pp. 1263–1270, 2012, doi: 10.1109/TSG.2012.2183649.

[102] T. Logenthiran, D. Srinivasan, A. M. Khambadkone, and H. N. Aung, "Multiagent system for real-time operation of a microgrid in real-time digital simulator," *IEEE Trans. Smart Grid*, vol. 3, no. 2, pp. 925–933, 2012, doi: 10.1109/TSG.2012.2189028.

[103] N. Lu and Y. Zhang, "Design considerations of a centralized load controller using thermostatically controlled appliances for continuous regulation reserves," *IEEE Trans. Smart Grid*, vol. 4, no. 2, pp. 914–921, 2013, doi: 10.1109/TSG.2012.2222944.

[104] E. Vrettos, S. Koch, and G. Andersson, "Load frequency control by aggregations of thermally stratified electric water heaters," *in IEEE PES Innovative. Smart Grid Technol. Conf. Europe*, Berlin, 2012. doi: 10.1109/ISGTEurope.2012.6465893.

[105] C. G. Quintero M. and J. R. Jimenez Mares, "An analysis of Intelligent Demand Management criteria applied in a building case study," *in IEEE Int. Symp. Altern. Energies Energy Qual., SIFAE - Conf. Proc.*, Barranquilla, 2012. doi: 10.1109/SIFAE.2012.6478881.

[106] M. Sullivan, J. Bode, B. Kellow, S. Woehleke, and J. Eto, "Using residential AC load control in grid operations: PG&E's ancillary service pilot," *IEEE Trans. Smart Grid*, vol. 4, no. 2, pp. 1162–1170, 2013, doi: 10.1109/TSG.2012.2233503.

[107] Y. Zhang and N. Lu, "Demand-side management of air conditioning cooling loads for intra-hour load balancing," *in IEEE PES Innovative Smart Grid Technol. Conf., ISGT*, Washington, DC, 2013. doi: 10.1109/ISGT.2013.6497905.

[108] M. M. Fouda, Z. M. Fadlullah, N. Kato, A. Takeuchi, and Y. Nozaki, "A novel demand control policy for improving quality of power usage in smart grid," *in 2012 IEEE Global Communications Conference (GLOBECOM)*, Anaheim, CA, USA, 2012, pp. 5154–5159. doi: 10.1109/GLOCOM.2012.6503938.

[109] Y. Zhang and N. Lu, "Parameter selection for a centralized thermostatically controlled appliances load controller used for intra-hour load balancing," *IEEE Trans. Smart Grid*, vol. 4, no. 4, pp. 2100–2108, 2013, doi: 10.1109/TSG.2013.2258950.

[110] W. Zhang, J. Lian, C.-Y. Chang, and K. Kalsi, "Aggregated modeling and control of air conditioning loads for demand response," *IEEE Trans Power Syst*, vol. 28, no. 4, pp. 4655–4664, 2013, doi: 10.1109/TPWRS.2013.2266121.

[111] J. L. Mathieu, M. Kamgarpour, J. Lygeros, and D. S. Callaway, "Energy arbitrage with thermostatically controlled loads," *in 2013 European Control Conference (ECC), Zurich, Switzerland*, 2013, pp. 2519–2526. doi: 10.23919/ecc.2013.6669582.

[112] F. Shahnia, M. T. Wishart, and A. Ghosh, "Voltage regulation, power balancing and battery storage discharge control by smart demand side management and multi-objective decision making," *in 2013 Australasian Universities Power Engineering Conference (AUPEC)*, Hobart, TAS, Australia, 2013. doi: 10.1109/aupec.2013.6725405.

[113] M. Negnevitsky and K. Wong, "Demand-side management evaluation tool," *IEEE Trans Power Syst*, vol. 30, no. 1, pp. 212–222, 2015, doi: 10.1109/TPWRS.2014.2329323.

[114] S. M. S. Basnet, H. Aburub, and W. Jewell, "Residential demand response program: Predictive analytics, virtual storage model and its optimization," *J. Energy Storage*, vol. 23, pp. 183–194, 2019, doi: 10.1016/j.est.2019.02.024.

[115] S. E. Hosseini, A. Ahmarinejad, M. Tabrizian, and M. A. Bidgoli, "Resilience enhancement of integrated electricity-gas-heating networks through automatic switching in the presence of energy storage systems," *J. Energy Storage*, vol. 47, 2022, doi: 10.1016/j.est.2021.103662.

[116] D. R. Prathapaneni and K. Detroja, "Optimal design of energy sources and reverse osmosis desalination plant with demand side management for cost-effective freshwater production," *Desalination*, vol. 496, 2020, doi: 10.1016/j.desal.2020.114741.

[117] C. Lang and E. Okwelum, "The mitigating effect of strategic behavior on the net benefits of a direct load control program," *Energy Econ.*, vol. 49, pp. 141–148, 2015, doi: 10.1016/j.eneco.2015.01.025.

[118] Q. Wang, J. Liao, Y. Su, C. Lei, T. Wang, and N. Zhou, "An optimal reactive power control method for distribution network with soft normally-open points and controlled air-conditioning loads," *Int J Electr Power Energy Syst*, vol. 103, pp. 421–430, 2018, doi: 10.1016/j.ijepes.2018.06.027.

[119] A. K. Erenoğlu, İ. Şengör, O. Erdinç, A. Taşcıkaraoğlu, and J. P. S. Catalão, "Optimal energy management system for microgrids considering energy storage, demand response and renewable power generation," *Int J Electr Power Energy Syst*, vol. 136, 2022, doi: 10.1016/j.ijepes.2021.107714.

[120] V. Sharifi, A. Abdollahi, and M. Rashidinejad, "Flexibility-based generation maintenance scheduling in presence of uncertain wind power plants forecasted by deep learning considering demand response programs

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and
content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

portfolio," *Int J Electr Power Energy Syst*, vol. 141, 2022, doi: 10.1016/j.ijepes.2022.108225.

[121] S. Mohseni, A. C. Brent, and D. Burmester, "A demand response-centred approach to the long-term equipment capacity planning of grid-independent micro-grids optimized by the moth-flame optimization algorithm," *Energy Convers. Manage.*, vol. 200, 2019, doi: 10.1016/j.enconman.2019.112105.

[122] D. Wang et al., "An energy-constrained state priority list model using deferrable electrolyzers as a load management mechanism," *Appl. Energy*, vol. 167, pp. 201–210, 2016, doi: 10.1016/j.apenergy.2015.10.129.

[123] D. Patteeuw, G. P. Henze, and L. Helsen, "Comparison of load shifting incentives for low-energy buildings with heat pumps to attain grid flexibility benefits," *Appl. Energy*, vol. 167, pp. 80–92, 2016, doi: 10.1016/j.apenergy.2016.01.036.

[124] S. Wang and R. Tang, "Supply-based feedback control strategy of air-conditioning systems for direct load control of buildings responding to urgent requests of smart grids," *Appl. Energy*, vol. 201, pp. 419–432, 2017, doi: 10.1016/j.apenergy.2016.10.067.

[125] R. Adhikari, M. Pipattanasomporn, and S. Rahman, "An algorithm for optimal management of aggregated HVAC power demand using smart thermostats," *Appl. Energy*, vol. 217, pp. 166–177, 2018, doi: 10.1016/j.apenergy.2018.02.085.

[126] C. Wei, J. Xu, S. Liao, Y. Sun, Y. Jiang, and Z. Zhang, "Coordination optimization of multiple thermostatically controlled load groups in distribution network with renewable energy," *Appl. Energy*, vol. 231, pp. 456–467, 2018, doi: 10.1016/j.apenergy.2018.09.105.

[127] E. Fernandez, M. J. Hossain, and M. S. H. Nizami, "Game-theoretic approach to demand-side energy management for a smart neighbourhood in Sydney incorporating renewable resources," *Appl. Energy*, vol. 232, pp. 245–257, 2018, doi: 10.1016/j.apenergy.2018.09.171.

[128] F. L. Müller and B. Jansen, "Large-scale demonstration of precise demand response provided by residential heat pumps," *Appl. Energy*, vol. 239, pp. 836–845, 2019, doi: 10.1016/j.apenergy.2019.01.202.

[129] J. Xu et al., "Demand side industrial load control for local utilization of wind power in isolated grids," *Appl. Energy*, vol. 243, pp. 47–56, 2019, doi: 10.1016/j.apenergy.2019.03.039.

[130] H. Hui, Y. Ding, Y. Song, and S. Rahman, "Modeling and control of flexible loads for frequency regulation services considering compensation of communication latency and detection error," *Appl. Energy*, vol. 250, pp. 161–174, 2019, doi: 10.1016/j.apenergy.2019.04.191.

[131] G. Lankeshwara, R. Sharma, R. Yan, and T. K. Saha, "Control algorithms to mitigate the effect of uncertainties in residential demand management," *Appl. Energy*, vol. 306, 2022, doi: 10.1016/j.apenergy.2021.117971.

[132] D. Fischer, T. Wolf, J. Wapler, R. Hollinger, and H. Madani, "Model-based flexibility assessment of a residential heat pump pool," *Energy*, vol. 118, pp. 853–864, 2017, doi: 10.1016/j.energy.2016.10.111.

[133] M. S. H. Nizami, A. N. M. M. Haque, P. H. Nguyen, and M. J. Hossain, "On the application of home energy management systems for power grid support," *Energy*, vol. 188, 2019, doi: 10.1016/j.energy.2019.116104.

[134] A. Bostan, M. S. Nazar, M. Shafie-khah, and J. P. S. Catalão, "Optimal scheduling of distribution systems considering multiple downward energy hubs and demand response programs," *Energy*, vol. 190, 2020, doi: 10.1016/j.energy.2019.116349.

[135] T. G. Hlalele, J. Zhang, R. M. Naidoo, and R. C. Bansal, "Multi-objective economic dispatch with residential demand response programme under renewable obligation," *Energy*, vol. 218, 2021, doi: 10.1016/j.energy.2020.119473.

[136] J. A. Rama Curiel and J. Thakur, "A novel approach for direct load control of residential air conditioners for demand side management in developing regions," *Energy*, vol. 258, 2022, doi: 10.1016/j.energy.2022.124763.

[137] F. Zhang and R. De Dear, "Thermal environments and thermal comfort impacts of direct load control air-conditioning strategies in university lecture theatres," *Energy Build.*, vol. 86, pp. 233–242, 2015, doi: 10.1016/j.enbuild.2014.10.008.

[138] V. Tomat, M. Vellei, A. P. Ramallo-González, A. González-Vidal, J. Le Dréau, and A. Skarmeta-Gómez, "Understanding patterns of thermostat overrides after demand response events," *Energy Build.*, vol. 271, 2022, doi: 10.1016/j.enbuild.2022.112312.

[139] A. Battegay et al., "Impacts of direct load control on reinforcement costs in distribution networks," *Electr Power Syst Res*, vol. 120, pp. 70–79, 2015, doi: 10.1016/j.epsr.2014.09.012.

[140] A. N. M. M. Haque, P. H. Nguyen, T. H. Vo, and F. W. Bliek, "Agent-based unified approach for thermal and voltage constraint management in LV distribution network," *Electr Power Syst Res*, vol. 143, pp. 462–473, 2017, doi: 10.1016/j.epsr.2016.11.007.

[141] R. Tang, S. Wang, and C. Yan, "A direct load control strategy of centralized air-conditioning systems for building fast demand response to urgent requests of smart grids," *Autom Constr*, vol. 87, pp. 74–83, 2018, doi: 10.1016/j.autcon.2017.12.012.

[142] R. Tang, S. Wang, and K. Shan, "Optimal and near-optimal indoor temperature and humidity controls for direct load control and proactive building demand response towards smart grids," *Autom Constr*, vol. 96, pp. 250–261, 2018, doi: 10.1016/j.autcon.2018.09.020.

[143] S.-V. Oprea and A. Bâra, "Edge and fog computing using IoT for direct load optimization and control with flexibility services for citizen energy communities," *Knowl Based Syst*, vol. 228, 2021, doi: 10.1016/j.knosys.2021.107293.

[144] J. Evora, J. J. Hernandez, and M. Hernandez, "A MOPSO method for direct load control in smart grid," *Expert Sys Appl*, vol. 42, no. 21, pp. 7456–7465, 2015, doi: 10.1016/j.eswa.2015.05.056.

[145] F. Verrilli, G. Gambino, S. Srinivasan, G. Palmieri, C. Del Vecchio, and L. Glielmo, "Demand side management for heating controls in Microgrids," *in IFAC-PapersOnLine, Elsevier B.V.*, 2016, pp. 611–616. doi: 10.1016/j.ifacol.2016.03.123.

[146] R. Barreto, P. Faria, C. Silva, and Z. Vale, "Clustering direct load control appliances in the context of demand response programs in energy communities," *IFAC-PapersOnLine*, vol. 53, no. 2, 2020, pp. 12608–12613. doi: 10.1016/j.ifacol.2020.12.1827.

[147] J. Wang, X. Chen, J. Xie, S. Xu, K. Yu, and L. Gan, "Control strategies of large-scale residential air conditioning loads participating in demand response programs," *CSEE J. Power Energy Syst.*, vol. 8, no. 3, pp. 880–893, 2022, doi: 10.17775/CSEEJPES.2019.02500.

[148] H. Akter, H. O. R. Howlader, A. Nakadomari, M. R. Islam, A. Y. Saber, and T. Senjyu, "A short assessment of renewable energy for optimal sizing of 100% renewable energy based microgrids in remote islands of developing countries: A case study in Bangladesh," *Energies*, vol. 15, no. 3, 2022, doi: 10.3390/en15031084.

[149] S. Xiang, H. Yang, and B. Cao, "An evaluation of domestic electric water heaters for frequency control," *Front. Energy Res.*, vol. 10, 2022, doi: 10.3389/fenrg.2022.962361.

[150] K. Tamashiro et al., "Investigation of home energy management with advanced direct load control and optimal scheduling of controllable loads," *Energies*, vol. 14, no. 21, 2021, doi: 10.3390/en14217314.

[151] H. Akter, H. O. R. Howlader, A. Y. Saber, P. Mandal, H. Takahashi, and T. Senjyu, "Optimal sizing of hybrid microgrid in a remote island considering advanced direct load control for demand response and low carbon emission," *Energies*, vol. 14, no. 22, 2021, doi: 10.3390/en14227599.

[152] M. Obi, C. Metzger, E. Mayhorn, T. Ashley, and W. Hunt, "Nontargeted vs. targeted vs. smart load shifting using heat pump water heaters," *Energies*, vol. 14, no. 22, 2021, doi: 10.3390/en14227574.

[153] S. A. Saleh, R. Ahshan, M. Haj-Ahmed, J. L. Cardenas-Barrera, J. Meng, and E. Castillo-Guerra, "Energy not-served-based method for assessing smart grid functions in residential loads," *IEEE Trans Ind Appl*, vol. 58, no. 2, pp. 1720–1729, 2022, doi: 10.1109/TIA.2022.3146105.

[154] S. Lu, W. Gu, S. Ding, S. Yao, H. Lu, and X. Yuan, "Data-driven aggregate thermal dynamic model for buildings: A regression approach," *IEEE Trans. Smart Grid*, vol. 13, no. 1, pp. 227–242, 2022, doi: 10.1109/TSG.2021.3101357.

[155] R. Fan, R. Sun, and Y. Liu, "A reduction approach for load pickup amount considering thermostatically controlled loads," *in 2021 IEEE Sustainable Power and Energy Conference (iSPEC), Nanjing, China*, 2021, pp. 1634–1638. doi: 10.1109/iSPEC53008.2021.9736052.

[156] M. Liu, Y. Li, S. Gao, X. Wang, D. You, and H. Liu, "Application cases of building central air conditioning loads participating in power grid peak shaving through direct control," *in 2021 6th Asia Conference on Power and Electrical Engineering (ACPEE)*, Chongqing, China, 2021, pp. 1102–1106. doi: 10.1109/ACPEE51499.2021.9437133.

[157] P. Yazdkhasti and C. P. Diduch, "Design of a smart controller agent for demand-side management with low payback effect," *2021 IEEE 9th International Conference on Smart Energy Grid Engineering (SEGE)*, Oshawa, ON, Canada, 2021, pp. 42–47. doi: 10.1109/SEGE52446.2021.9535058.

[158] H. Huang et al., "Research on joint optimal scheduling of air conditioning load and electric vehicle under demand response," *in E3S Web Conf.*, vol. 257, 2021. doi: 10.1051/e3sconf/202125701058.

[159] X. Gong, E. Castillo-Guerra, J. L. Cardenas-Barrera, B. Cao, S. A. Saleh, and L. Chang, "Robust hierarchical control mechanism for aggregated thermostatically controlled loads," *IEEE Trans. Smart Grid*, vol. 12, no. 1, pp. 453–467, 2021, doi: 10.1109/TSG.2020.3009989.

[160] W. Mendieta and C. A. Canizares, "Primary frequency control in isolated microgrids using thermostatically controllable loads," *IEEE Trans. Smart Grid*, vol. 12, no. 1, pp. 93–105, 2021, doi: 10.1109/TSG.2020.3012549.

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and
content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

[161] J. A. Sa'ed, Z. Wari, F. Abughazaleh, J. Dawud, S. Favuzza, and G. Zizzo, "Effect of demand side management on the operation of PV-integrated distribution systems," *Appl. Sci.*, vol. 10, no. 21, pp. 1–26, 2020, doi: 10.3390/app10217551.

[162] M. Khorram, M. Zheiry, P. Faria, and Z. Vale, "Energy consumption management in buildings in the context of voluntary and mandatory demand response programs in smart grids," *in IEEE PES Innovative. Smart Grid Technol. Conf. Europe*, 2020, pp. 275–279. doi: 10.1109/ISGT-Europe47291.2020.9248750.

[163] S. Xiang, L. Chang, B. Cao, and Y. He, "Group-based control for domestic electric water heaters using quantum-inspired evolutionary algorithm," *in 2020 IEEE Energy Conversion Congress and Exposition (ECCE)*, Detroit, MI, USA, 2020, pp. 2752–2758. doi: 10.1109/ECCE44975.2020.9236062.

[164] S. Bahrami, Y. C. Chen, and V. W. S. Wong, "Deep reinforcement learning for direct load control in distribution networks," *in 2020 IEEE Power & Energy Society General Meeting (PESGM)*, Montreal, QC, Canada, 2020. doi: 10.1109/PESGM41954.2020.9281703.

[165] S. Xiang, S. Xiang, L. Chang, B. Cao, Y. He, and C. Zhang, "A novel domestic electric water heater control method," *IEEE Trans. Smart Grid*, vol. 11, no. 4, pp. 3246–3256, 2020, doi: 10.1109/TSG.2019.2961214.

[166] F. Rajabi, A. Salami, and M. Azimi, "Hierarchical and multi-level demand response programme considering the flexibility of loads," *IET Gener. Transm. Distrib.*, vol. 14, no. 6, pp. 1051–1061, 2020, doi: 10.1049/iet-gtd.2019.1397.

[167] P. Herath and G. K. Venayagamoorthy, "Distributed demand response management," *in 2020 Clemson University Power Systems Conference (PSC)*, Clemson, SC, USA, 2020. doi: 10.1109/PSC50246.2020.9131298.

[168] G. R. Aghajani and I. Heydari, "Energy management in microgrids containing electric vehicles and renewable energy sources considering demand response," *J. Oper. Auto. Power Eng.*, vol. 9, no. 1, pp. 34–48, 2021, doi: 10.22098/joape.2021.5854.1438.

[169] Z. A. Shah, H. F. Sindi, A. Ul-Haq, and M. A. Ali, "Fuzzy logic-based direct load control scheme for air conditioning load to reduce energy consumption," *IEEE Access*, vol. 8, pp. 117413–117427, 2020, doi: 10.1109/ACCESS.2020.3005054.

[170] X. Kong, B. Sun, B. Sun, J. Zhang, S. Li, and Q. Yang, "Power retailer air-conditioning load aggregation operation control method and demand response," *IEEE Access*, vol. 8, pp. 112041–112056, 2020, doi: 10.1109/ACCESS.2020.3003278.

[171] C. Jin, C. Yan, R. Tang, H. Cai, and R. Zeng, "A fast building demand response method based on supply–demand coordination for urgent responses to smart grids," *Sc. Tech. Built Environ.*, vol. 25, no. 10, pp. 1494–1504, 2019, doi: 10.1080/23744731.2019.1653626.

[172] W. Xu, L. Ge, X. Bai, S. Zhang, Y. Liang, and X. Ge, "A load management optimization strategy for smart distribution network considering time-of-use electricity price and load control," *in 2019 IEEE Sustainable Power and Energy Conference (iSPEC)*, Beijing, China, 2019, pp. 1475–1479. doi: 10.1109/iSPEC48194.2019.8975060.

[173] K. Sakurama and H.-S. Ahn, "Network-based distributed direct load control guaranteeing fair welfare maximisation," *IET Control Theory Appl.*, vol. 13, no. 17, pp. 2959–2968, 2019, doi: 10.1049/iet-cta.2018.6102.

[174] S. Paul, Y. Narendra Babu, and N. Prasad Padhy, "Day ahead bi-level direct load control in smart residential apartment building: A Stackelberg game approach," *in 2019 International Conference on Computing, Power and Communication Technologies, GUCON 2019*, Radisson BluGreater Noida, India, 2019, pp. 691–696. Accessed: Sep. 27, 2019. [Online]. Available: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85085523577&partnerID=40&md5=c54828e4b871d2939f9f27926d2f9f6c

[175] L. Meng et al., "Research on scheduling model and control strategy of ice storage air conditioning in urban power grid," *in IOP Conf. Ser. Earth Environ. Sci.*, vol. 295, 2019. doi: 10.1088/1755-1315/295/5/052003.

[176] S. Sharma, A. Verma, and B. K. Panigrahi, "Coordinated voltage control through optimal dispatch of responsive building loads," *in 2019 IEEE International Conference on Environment and Electrical Engineering and 2019 IEEE Industrial and Commercial Power Systems Europe (EEEIC / I&CPS Europe)*, Genova, Italy, 2019. doi: 10.1109/EEEIC.2019.8783981.

[177] Y. Chen, F. Luo, Z. Dong, K. Meng, G. Ranzi, and K. P. Wong, "A day-ahead scheduling framework for thermostatically controlled loads with thermal inertia and thermal comfort model," J. *Mod. Power Syst. Clean Energy*, vol. 7, no. 3, pp. 568–578, 2019, doi: 10.1007/s40565-018-0431-3.

[178] O. Erdinc, A. Tascikaraoglu, N. G. Paterakis, and J. P. S. Catalao, "Novel incentive mechanism for end-users enrolled in DLC-based demand response programs within stochastic planning context," *IEEE Trans Ind Electron*, vol. 66, no. 2, pp. 1476–1487, 2019, doi: 10.1109/TIE.2018.2811403.

[179] M. J. Siddarth Sankar and K. Rahul Sharma, "Modified 0-1 knapsack problem for demand side management," *Int. J. Innov. Technol. Explor. Eng.*, vol. 8, no. 6 Special Issue 4, pp. 1–4, 2019, doi: 10.35940/ijitee.F1001.0486S419.

[180] A. Taşcikaraoğlu, N. G. Paterakis, O. Erdinç, and J. P. S. Catalão, "Combining the flexibility from shared energy storage systems and DLC-based demand response of HVAC units for distribution system operation enhancement," *IEEE Trans. Sustainable Energy*, vol. 10, no. 1, pp. 137–148, 2019, doi: 10.1109/TSTE.2018.2828337.

[181] W. Kou, K. Bisson, and S.-Y. Park, "A distributed demand response algorithm and its application to campus microgrid," *in 2018 IEEE Electronic Power Grid (eGrid)*, Charleston, SC, USA, 2018, doi: 10.1109/eGRID.2018.8598668.

[182] G. Zhang, S. T. Tan, and G. Gary Wang, "Real-time smart charging of electric vehicles for demand charge reduction at non-residential sites," *IEEE Trans. Smart Grid*, vol. 9, no. 5, pp. 4027–4037, 2018, doi: 10.1109/TSG.2016.2647620.

[183] S. Cheng, Z. Liu, T. Huang, X. Jiang, and R.-J. Wai, "Optimal planning of hybrid energy generation system in the microgrid considering direct load control," *in 2017 International Conference on Fuzzy Theory and Its Applications (iFUZZY)*, Pingtung, Taiwan, 2017, pp. 1–5. doi: 10.1109/iFUZZY.2017.8311802.

[184] W. Zheng, W. Wu, B. Zhang, and C. Lin, "Distributed optimal residential demand response considering operational constraints of unbalanced distribution networks," *IET Gener. Transm. Distrib.*, vol. 12, no. 9, pp. 1970–1979, 2018, doi: 10.1049/iet-gtd.2017.1366.

[185] F. Luo, Z. Y. Dong, K. Meng, J. Wen, H. Wang, and J. Zhao, "An operational planning framework for large-scale thermostatically controlled load dispatch," *IEEE Trans. Ind. Inf.*, vol. 13, no. 1, pp. 217–227, 2017, doi: 10.1109/TII.2016.2515086.

[186] L. Yao, Z. Damiran, and W. H. Lim, "Direct load control of central air conditioning systems using fuzzy optimization," *in 2016 IEEE 16th International Conference on Environment and Electrical Engineering (EEEIC)*, Florence, Italy, 2016, doi: 10.1109/EEEIC.2016.7555797.

[187] O. Kilkki, I. Seilonen, K. Zenger, and V. Vyatkin, "Incentives for shaping the consumption profile of a group of consumers with energy storage devices," *in 2016 IEEE PES Innovative Smart Grid Technologies Conference Europe (ISGT-Europe)*, Ljubljana, Slovenia, 2016, pp. 1-6, doi: 10.1109/ISGTEurope.2016.7856253.

[188] F. Luo et al., "Optimal dispatch of air conditioner loads in southern China region by direct load control," *IEEE Trans. Smart Grid*, vol. 7, no. 1, pp. 439–450, 2016, doi: 10.1109/TSG.2014.2388233.

[189] A. Salami and M. M. Farsi, "Demand side management using direct load control for residential and industrial areas," *in 2015 International Congress on Electric Industry Automation (ICEIA 2015)*, Shiraz, Iran, 2015, pp. 11–16. doi: 10.1109/ICEIA.2015.7165839.

[190] R. Sato and T. Namerikawa, "Power system stabilization by direct load control based on strategy-proofness and individual rationality," *in 2015 American Control Conference (ACC)*, Chicago, IL, USA, 2015, pp. 5913–5918. doi: 10.1109/ACC.2015.7172267.

[191] L. Zhu, Z. Yan, W.-J. Lee, X. Yang, Y. Fu, and W. Cao, "Direct load control in microgrids to enhance the performance of integrated resources planning," *IEEE Trans Ind Appl*, vol. 51, no. 5, pp. 3553–3560, 2015, doi: 10.1109/TIA.2015.2413960.

[192] Q. Cui, X. Wang, X. Wang, and Y. Zhang, "Residential appliances direct load control in real-time using cooperative game," *IEEE Trans Power Syst*, vol. 31, no. 1, pp. 226–233, 2016, doi: 10.1109/TPWRS.2015.2391774.

[193] H. Hao, B. M. Sanandaji, K. Poolla, and T. L. Vincent, "Aggregate flexibility of thermostatically controlled loads," *IEEE Trans Power Syst*, vol. 30, no. 1, pp. 189–198, 2015, doi: 10.1109/TPWRS.2014.2328865.

[194] E. Oliveira, C. H. Antunes, and A. Gomes, "A hybrid multi-objective GRASP+SA algorithm with incorporation of preferences," in *2014 IEEE Symposium on Computational Intelligence in Multi-Criteria Decision-Making (MCDM)*, Orlando, FL, USA, 2014, pp. 32–39. doi: 10.1109/MCDM.2014.7007185.

[195] S. E. Shafiei, T. Knudsen, R. Wisniewski, and P. Andersen, "Data-driven predictive direct load control of refrigeration systems," *IET Control Theory Appl.*, vol. 9, no. 7, pp. 1022–1033, 2015, doi: 10.1049/iet-cta.2014.0666.

[196] W. Guo, J. Wen, F. Luo, and Y. Zheng, "Peak load reduction by thermostatically controlled load dispatch with thermal comfort model," *in 10th International Conference on Advances in Power System Control, Operation and Management, APSCOM 2015*, Hong Kong; China, 2015. [Online]. Available: https://www.scopus.com/inward/record.uri?eid=2-s2.0-84997235831&partnerID=40&md5=755f2f471054e846f7b047d27018a3e4

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and
content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

[197] S. Sofana Reka and V. Ramesh, "Demand side response modeling with controller design using aggregate air conditioning loads and particle swarm optimization," in *9th International Conference on Advanced Computing and Communication Technologies, ICACCT 2015*, New Delhi, India, 2015, vol. 452, pp. 573-581, [Online]. Available: https://www.scopus.com/inward/record.uri?eid=2-s2.0-84976498592&doi=10.1007%2f978-981-10-1023-1_57&partnerID=40&md5=53ff2abbaef5ad1ef6094ca3ca58d02f

[198] A. Garrab, A. Bouallegue, and R. Bouallegue, "An agent based fuzzy control for smart home energy management in smart grid environment," *Int. J. Renew. Energy Res.*, vol. 7, no. 2, pp. 599–612, 2017.

[199] A. Chauhan and R. P. Saini, "Size optimization and demand response of a stand-alone integrated renewable energy system," *Energy*, vol. 124, pp. 59–73, 2017, doi: 10.1016/j.energy.2017.02.049.

[200] M. H. Amrollahi and S. M. T. Bathaee, "Techno-economic optimization of hybrid photovoltaic/wind generation together with energy storage system in a stand-alone micro-grid subjected to demand response," *Appl. Energy*, vol. 202, pp. 66–77, 2017, doi: 10.1016/j.apenergy.2017.05.116.

[201] D. R. Prathapaneni and K. P. Detroja, "An integrated framework for optimal planning and operation schedule of microgrid under uncertainty," *Sustain. Energy Grids Netw.*, vol. 19, 2019, doi: 10.1016/j.segan.2019.100232.

[202] A. Krkoleva Mateska, V. Borozan, P. Krstevski, and R. Taleski, "Controllable load operation in microgrids using control scheme based on gossip algorithm," *Appl. Energy*, vol. 210, pp. 1336–1346, 2018, doi: 10.1016/j.apenergy.2017.06.049.

[203] E. Georges, B. Cornélusse, D. Ernst, V. Lemort, and S. Mathieu, "Residential heat pump as flexible load for direct control service with parametrized duration and rebound effect," *Appl. Energy*, vol. 187, pp. 140–153, 2017, doi: 10.1016/j.apenergy.2016.11.012.

[204] L. Zheng and L. Cai, "A distributed demand response control strategy using lyapunov optimization," *IEEE Trans. Smart Grid*, vol. 5, no. 4, pp. 2075–2083, 2014, doi: 10.1109/TSG.2014.2313347.

[205] K. Zhou and L. Cai, "A dynamic water-filling method for real-time HVAC load control based on model predictive control," *IEEE Trans Power Syst,* vol. 30, no. 3, pp. 1405–1414, 2015, doi: 10.1109/TPWRS.2014.2340881.

[206] J. L. Mathieu, S. Koch, and D. S. Callaway, "State estimation and control of electric loads to manage real-time energy imbalance," *IEEE Trans Power Syst*, vol. 28, no. 1, pp. 430–440, 2013, doi: 10.1109/TPWRS.2012.2204074.

[207] S. Bashash and H. K. Fathy, "Modeling and control of aggregate air conditioning loads for robust renewable power management," *IEEE Trans Control Syst Technol*, vol. 21, no. 4, pp. 1318–1327, 2013, doi: 10.1109/TCST.2012.2204261.

[208] M. Pied, M. F. Anjos, and R. P. Malhamé, "A flexibility product for electric water heater aggregators on electricity markets," *Appl. Energy*, vol. 280, 2020, doi: 10.1016/j.apenergy.2020.115168.

[209] M. Miara, D. Günther, Z. L. Leitner, and J. Wapler, "Simulation of an air-to-water heat pump system to evaluate the impact of demand-side-management measures on efficiency and load-shifting potential," *Energy Technol.*, vol. 2, no. 1, pp. 90–99, 2014, doi: 10.1002/ente.201300087.

[210] B. P. Bhattarai, B. Bak-Jensen, J. R. Pillai, and M. Maier, "Demand flexibility from residential heat pump," *in 2014 IEEE PES General Meeting | Conference & Exposition*, National Harbor, MD, USA, 2014. doi: 10.1109/PESGM.2014.6939348.

[211] J. Salpakari and P. Lund, "Optimal and rule-based control strategies for energy flexibility in buildings with PV," *Appl. Energy*, vol. 161, pp. 425–436, 2016, doi: 10.1016/j.apenergy.2015.10.036.

[212] B. Qela and H. T. Mouftah, "Peak load curtailment in a smart grid via fuzzy system approach," *IEEE Trans. Smart Grid*, vol. 5, no. 2, pp. 761–768, 2014, doi: 10.1109/TSG.2013.2289922.

[213] D. Wang, K. Meng, X. Gao, C. Coates, and Z. Dong, "Optimal air-conditioning load control in distribution network with intermittent renewables," *J. Mod. Power Syst. Clean Energy*, vol. 5, no. 1, pp. 55–65, 2017, doi: 10.1007/s40565-016-0254-z.

[214] A. Molina-Garcia, J. A. Fuentes, E. Gomez-Lazaro, A. Bonastre, J. C. Campelo, and J. J. Serrano, "Development and assessment of a wireless sensor and actuator network for heating and cooling loads," *IEEE Trans. Smart Grid*, vol. 3, no. 3, pp. 1192–1202, 2012, doi: 10.1109/TSG.2012.2187542.

[215] C. Chen, J. Wang, and S. Kishore, "A distributed direct load control approach for large-scale residential demand response," *IEEE Trans Power Syst*, vol. 29, no. 5, pp. 2219–2228, 2014, doi: 10.1109/TPWRS.2014.2307474.

[216] W. Bomela, A. Zlotnik, and J.-S. Li, "A phase model approach for thermostatically controlled load demand response," *Appl. Energy*, vol. 228, pp. 667–680, 2018, doi: 10.1016/j.apenergy.2018.06.123.

[217] W. Cui et al., "Evaluation and sequential dispatch of operating reserve provided by air conditioners considering lead-lag rebound effect," *IEEE Trans Power Syst*, vol. 33, no. 6, pp. 6935–6950, 2018, doi: 10.1109/TPWRS.2018.2846270.

[218] F. Sehar, M. Pipattanasomporn, and S. Rahman, "A peak-load reduction computing tool sensitive to commercial building environmental preferences," *Appl. Energy*, vol. 161, pp. 279–289, 2016, doi: 10.1016/j.apenergy.2015.10.009.

[219] [L. Cheng, Y. Wan, L. Tian, and F. Zhang, "Evaluating energy supply service reliability for commercial air conditioning loads from the distribution network aspect," *Appl. Energy*, vol. 253, 2019, doi: 10.1016/j.apenergy.2019.113547.

[220] M. H. Christensen, R. Li, and P. Pinson, "Demand side management of heat in smart homes: Living-lab experiments," *Energy*, vol. 195, 2020, doi: 10.1016/j.energy.2020.116993.

[221] S. You and H. Segerberg, "Integration of 100% micro-distributed energy resources in the low voltage distribution network: A Danish case study," *Appl Therm Eng*, vol. 71, no. 2, pp. 797–808, 2014, doi: 10.1016/j.applthermaleng.2013.11.039.

[222] M. Babar, T. P. I. Ahamed, E. Al-Ammar, and A. Shah, "Consolidated demand bid model and strategy in constrained direct load control program," *in 2015 IEEE 8th GCC Conference & Exhibition*, Muscat, Oman, 2015. doi: 10.1109/IEEEGCC.2015.7060013.

[223] H. Mortaji, S. H. Ow, M. Moghavvemi, and H. A. F. Almurib, "Load shedding and smart-direct load control using internet of things in smart grid demand response management," *IEEE Trans Ind Appl*, vol. 53, no. 6, pp. 5155–5163, 2017, doi: 10.1109/TIA.2017.2740832.

[224] J. M. Lujano-Rojas, G. Zubi, R. Dufo-López, J. L. Bernal-Agustín, E. García-Paricio, and J. P. S. Catalão, "Contract design of direct-load control programs and their optimal management by genetic algorithm," *Energy*, vol. 186, 2019, doi: 10.1016/j.energy.2019.07.137.

[225] M. A. A. Pedrasa, T. D. Spooner, and I. F. MacGill, "Scheduling of demand side resources using binary particle swarm optimization," *IEEE Trans Power Syst*, vol. 24, no. 3, pp. 1173–1181, 2009, doi: 10.1109/TPWRS.2009.2021219.

[226] A. Sepulveda, L. Paull, W. G. Morsi, H. Li, C. P. Diduch, and L. Chang, "A novel demand side management program using water heaters and particle swarm optimization," *in 2010 IEEE Electrical Power & Energy Conference*, Halifax, NS, Canada, 2010. doi: 10.1109/EPEC.2010.5697187.

[227] G. Sharma, L. Xie, and P. R. Kumar, "Large population optimal demand response for thermostatically controlled inertial loads," *in 2013 IEEE International Conference on Smart Grid Communications (SmartGridComm)*, Vancouver, BC, Canada, 2013, pp. 259–264. doi: 10.1109/SmartGridComm.2013.6687967.

[228] D. S. Callaway, "Tapping the energy storage potential in electric loads to deliver load following and regulation, with application to wind energy," *Energy Convers. Manage.*, vol. 50, no. 5, pp. 1389–1400, 2009, doi: 10.1016/j.enconman.2008.12.012.

[229] O. Erdinç, A. Taşcikaraogɩlu, N. G. Paterakis, Y. Eren, and J. P. S. Catalão, "End-user comfort oriented day-ahead planning for responsive residential HVAC demand aggregation considering weather forecasts," *IEEE Trans. Smart Grid*, vol. 8, no. 1, pp. 362–372, 2017, doi: 10.1109/TSG.2016.2556619.

[230] M. Liu and Y. Shi, "Model predictive control of aggregated heterogeneous second-order thermostatically controlled loads for ancillary services," *IEEE Trans Power Syst*, vol. 31, no. 3, pp. 1963–1971, 2016, doi: 10.1109/TPWRS.2015.2457428.

[231] N. Mahdavi, J. H. Braslavsky, M. M. Seron, and S. R. West, "Model predictive control of distributed air-conditioning loads to compensate fluctuations in solar power," *IEEE Trans. Smart Grid*, vol. 8, no. 6, pp. 3055–3065, 2017, doi: 10.1109/TSG.2017.2717447.

[232] J. Hu et al., "Load following of multiple heterogeneous TCL aggregators by centralized control," *IEEE Trans Power Syst*, vol. 32, no. 4, pp. 3157–3167, 2017, doi: 10.1109/TPWRS.2016.2626315.

[233] F. Luo, J. Zhao, H. Wang, X. Tong, Y. Chen, and Z. Y. Dong, "Direct load control by distributed imperialist competitive algorithm," *J. Mod. Power Syst. Clean Energy*, vol. 2, no. 4, pp. 385–395, 2014, doi: 10.1007/s40565-014-0075-x.

[234] Z. Zhu, J. Tang, S. Lambotharan, W. H. Chin, and Z. Fan, "An integer linear programming based optimization for home demand-side management in smart grid," *in 2012 IEEE PES Innovative Smart Grid Technologies (ISGT)*, Washington, DC, USA, 2012. doi: 10.1109/ISGT.2012.6175785.

[235] Z. Klaić, K. Fekete, and D. Šljivac, "Demand side load management in the distribution system with photovoltaic generation," *Teh. Vjesn.*, vol. 22, no. 4, pp. 989–995, 2015, doi: 10.17559/TV-20141205092803.

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and
content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2024.3349965

[236] N. Erdogan, F. Erden, and M. Kisacikoglu, "A fast and efficient coordinated vehicle-to-grid discharging control scheme for peak shaving in power distribution system," *J. Mod. Power Syst. Clean Energy*, vol. 6, no. 3, pp. 555–566, 2018, doi: 10.1007/s40565-017-0375-z.

[237] K. Mahmud, M. S. H. Nizami, J. Ravishankar, M. J. Hossain, and P. Siano, "Multiple home-to-home energy transactions for peak load shaving," *IEEE Trans Ind Appl*, vol. 56, no. 2, pp. 1074–1085, 2020, doi: 10.1109/TIA.2020.2964593.

[238] L. Kang, G. Wang, Y. Wang, and Q. An, "The power simulation of water-cooled central air-conditioning system based on demand response," *IEEE Access*, vol. 8, pp. 67396–67407, 2020, doi: 10.1109/ACCESS.2020.2986309.

[239] K. Al-Jabery, Z. Xu, W. Yu, D. C. Wunsch, J. Xiong, and Y. Shi, "Demand-side management of domestic electric water heaters using approximate dynamic programming," I*EEE Trans Comput Aided Des Integr Circuits Syst*, vol. 36, no. 5, pp. 775–788, 2017, doi: 10.1109/TCAD.2016.2598563.

[240] S. Lin et al., "Grouping control strategy for aggregated thermostatically controlled loads," *Electr Power Syst Res*, vol. 171, pp. 97–104, 2019, doi: 10.1016/j.epsr.2019.02.005.

[241] J. Wang, X. Chen, J. Xie, S. Xu, K. Yu, and L. Gan, "Dynamic control strategy of residential air conditionings considering environmental and behavioral uncertainties," *Appl. Energy*, vol. 250, pp. 1312–1320, 2019, doi: 10.1016/j.apenergy.2019.04.184.

[242] P. Paudyal and Z. Ni, "Smart home energy optimization with incentives compensation from inconvenience for shifting electric appliances*," Int J Electr Power Energy Syst*, vol. 109, pp. 652–660, 2019, doi: 10.1016/j.ijepes.2019.02.016.

[243] S. Bashash and H. K. Fathy, "Transport-based load modeling and sliding mode control of plug-in electric vehicles for robust renewable power tracking," *IEEE Trans. Smart Grid*, vol. 3, no. 1, pp. 526–534, 2012, doi: 10.1109/TSG.2011.2167526.

[244] H. Jörge, C. H. Antunes, and A. G. Martins, "A multiple objective decision support model for the selection of remote load control strategies," *IEEE Trans Power Syst*, vol. 15, no. 2, pp. 865–872, 2000, doi: 10.1109/59.867186.

[245] M. J. Ritchie, J. A. A. Engelbrecht, and M. J. Booysen, "Centrally adapted optimal control of multiple electric water heaters," *Energies*, vol. 15, no. 4, 2022, doi: 10.3390/en15041521.

[246] A. Gomes, C. H. Antunes, and A. G. Martins, "A multiple objective evolutionary approach for the design and selection of load control strategies," *IEEE Trans Power Syst*, vol. 19, no. 2, pp. 1173–1180, 2004, doi: 10.1109/TPWRS.2003.821623.



EMRE OZKOP (M'13–SM'17) received a B.Sc.E. degree in electrical and electronics engineering from Gazi University, Ankara, Turkey, in 2003, and the M.Sc.E. and Ph.D. degrees in electrical engineering in 2006 and 2012, respectively both from Karadeniz Technical University (KTU), Trabzon, Turkey. He is an Associate Professor at the Department of Electrical and Electronics Engineering at KTU. His research interests include power electronics, intelligent control systems, protection and grounding systems, renewable energy systems operation, control and protection, and smart grids.

This work is licensed under a Creative Commons Attribution 4.0 License. For more information, see https://creativecommons.org/licenses/by/4.0/