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A Study to Propose an Optimized Home Load Energy Management System by Dwelling Model Using Informative Control Module

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Abstract

To accomplish sustainable goals in the home environment, the control side must manage electrical loads as efficiently as possible. In order to prevent system failure, load shedding is the "skill" of regulating load demand by reducing loads in instances where the demand is greater than the total generation. Even though power companies advise customers to limit their usage during peak hours on their monthly usage, neither the customers nor the utilities are aware of this. It is obvious how time-consuming and exhausting it is to manually turn on and off the high load during peak and off-peak hours and remind consumers when those times are. The current study suggests a control strategy based on a suitable load definition, context awareness of user behaviors, and the persuasion skills of ubiquitous systems. Beyond other advantages, the primary goal is to improve the scenario of load shading. This work refers to a hardware prototype to validate the suggested control module. The findings demonstrate that the suggested plan enables effective peak shaving during the day. Electric utilities in developing nations may swiftly deploy the suggested system as a single extra instrument or bridge to existing energy meters in order to reverse the load shedding trend.

Keywords
Non-Renewable energy, Residential load, Smart load management, Internet of Things and Load forecasting.

1. Introduction
Energy resources are characterized as renewable and nonrenewable. Human society depends on both nonrenewable and renewable energy sources to run on a daily basis. Renewable resources can naturally regenerate themselves, whereas nonrenewable resources cannot, which is how these two types of resources vary from one another. This translates to the fact that nonrenewable resources are scarce and cannot be used responsibly ("Nonrenewable Resources | National Geographic Society") Oil, natural gas, coal, and nuclear energy are the four main categories of nonrenewable energy. Fossil fuels are a term that refers to coal, natural gas, and oil together. The term "fossil fuels" refers to the fossilized remains of plants and animals that were produced deep within the Earth over millions of years. They are located in sedimentary and geological layers below earth. The remains of plants and animals were converted into crude oil (also known as petroleum), coal, and natural gas by the combined action of pressure and heat.

Around 300 to 360 million years ago, during a period known as the Carboniferous Period, plants and animals that later evolved into fossil fuels were alive.Through the process of photosynthesis, solar energy is stored in plant tissues, which animals later devour, adding the stored energy to their own bodies. The energy in the plant and animal remnants originated from the sun. This locked energy is released via the burning of fossil fuels. Crude oil is a fossil fuel that is used to make polymers and liquid fuels for vehicles, mostly gasoline and diesel. It is extracted by wells from rocks discovered beneath the surface of the Earth. A lot of people use natural gas to heat their homes, and to cook. It is located close to oil resources below the surface of the Earth and primarily comprises of methane. The same wells that are used to extract crude oil can also be utilized to pump out natural gas. A solid fossil fuel called coal is used to power factories and heat homes. It can be discovered in marshes that have been petrified and buried under sedimentary rock. Coal must be dug up from the ground because it cannot be extracted like crude oil or natural gas because it is solid. Radioactive materials, primarily uranium, which are taken from mined ore and subsequently refined into fuel, are the source of nuclear energy. Unfortunately, nonrenewable fuels are currently the main source of energy for human civilization.Fossil fuels account for over 80% of the total energy consumed worldwide each year. Fossil fuels are essential for human existence because these are both energy-dense and inexpensive to process. But aside from their scarcity, one of the main issues with fossil fuels is that when they are burned, carbon dioxide is released into the atmosphere(“Nonrenewable Resources | National Geographic Society”). The pinnacle of the world's demand has not yet been reached. However, as global energy consumption increases year over year, so does the use of fossil fuels. The whole demand for renewable energy from industry and population just cannot be met. More than 1% more fossil fuels are consumed globally every year. Due to the growing demand, waiting for fresh fossil fuels to emerge is not an option because fossil fuels were created millions of years ago. These resources will shortly run out. Despite originating millions of years ago and been used for only about 200 years, fossil fuel sources are rapidly depleting. It is also clear that the precise date these fuels will run out is yet undetermined.Researchers keep finding new reserves, but because there aren't many of them, they can't keep up with demand at the present and anticipated levels in the future. Research based on 2015 data (Figure 1) indicates that the following is the current prediction for when the supplies will be depleted(“When will fossil fuels run out?”).

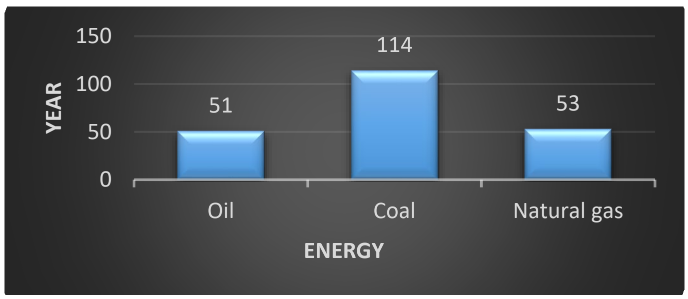

Figure 1. Shelf life of non-renewable energy sources(“When will fossil fuels run out?”)

Early on, population growth, industrialization, and rising living standards all contributed to a major rise in the world's consumption of primary energy. Although it is anticipated that this tendency will continue, by 2100, the world's energy consumption may have doubled. If rapid economic growth is maintained at the same rate as population growth, daily energy consumption will likewise rise significantly(Gulagi *et al.* 2020). A huge amount of energy is used to generate electricity. The electricity generation process is very much dependent on nonrenewable energy sources.

From the pie chart (Figure 2) almost 76% of the total power generation aka electricity generation sources are nonrenewable. Electricity provided by wind and solar sources made up 10% of the total amount produced in 2021. 38% of the electricity in the world was produced from clean sources (solar, wind, and others). The use of non-renewable energy sources is still close to 62%, though. According to the U.S. Energy Information Administration, coal, nuclear power, and natural gas made up the majority of the country's electrical generation in 2020. Renewable energy sources like wind, hydropower, solar, biomass, wind, and geothermal are also used to generate electricity (“Alternative Fuels Data Center: Electricity Production and Distribution”).

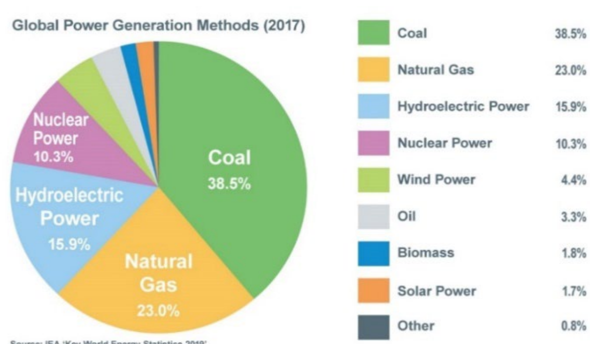

Figure 2. Contribution of energy sources to power generation(“The Journey of Electricity”)

Now comes at Bangladesh point of view. One of the South Asian nations that is developing quickly is Bangladesh. With a population density of roughly 1079 people per km2, it is likewise one of the nations with the highest population densities. From 1996 to 2016, the average annual GDP growth rate was 5.7%, reaching a peak of 7.1% in that year. From 2016 through 2041, the GDP is anticipated to increase at an average growth rate of 6.1%, according to the Government of Bangladesh (GoB). On the other hand, from 2004 to 2015, the average annual increase rate for electricity demand was 9.7%. Because rising energy consumption is frequently linked to rising living standards and increased national economic activity, the historical growth in GDP and electricity demand are coupled. The increase in electrical access from 40.6% in 2004 to 68.2% in 2015 illustrates this (Gulagi *et al.* 2020). Over 97% of Bangladesh's population now has access to power as the country's energy generation capacity recently reached 23,436 MW (Bhuiyan *et al.* 2021). And according to current data of 2022 access rate to power goes almost 100%. So, to meet this huge demand a large amount of electricity is needed to generate. According to JICA Survey Team power demand is increasing at a high rate, which is shown below through a graph (Figure 3).

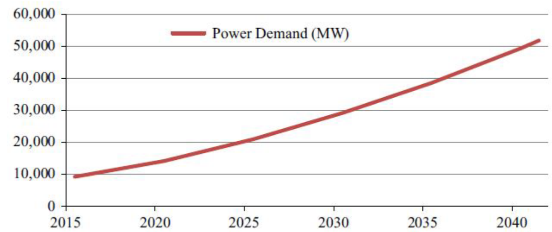

Figure 3. Increasing demand of electricity in Bangladesh(Dey and Tareque, 2019)

On the other side due to a lack of domestic reserves, Bangladesh has historically relied on fossil fuels to generate its power. If this dependence persists, more fossil fuels will need to be imported to meet the country's rising need for electricity. In addition to increasing economic pressure on Bangladesh, a significant reliance on imported gas, coal, and oil raises severe concerns about the country's long-term energy security (Gulagi *et al.* 2020).Bangladesh's power industry is reliant on fossil fuels such coal, natural gas, heating oil, and diesel. During the 2019–20 fiscal year, Bangladesh generated power mostly from natural gas (71.82%), furnace oil (13.25%), diesel (0.20%), coal (4.16%), and renewable energy sources (1.23%). About 9.34% of the electricity used this year was imported from the closest nation via a grid line (Bhuiyan *et al.* 2021). Due to its high energy content, natural gas has been seen as a suitable primary source to produce electricity. Compared to the burning of coal and oil, natural gas produces less carbon dioxide (CO2). Natural gas currently provides 23% of the world's electricity, and that percentage will rise until 2041.Natural gas is used to generate 64% of the nation's electricity. However, only 12.88 TCF of natural gas is stored in 26 gas fields across the nation, significantly less than the necessary demand. The total daily capacity for gas production is 274 million standard cubic feet (MMSCFD). While the current national gas demand is approximately 4221 MMSCFD. If no additional natural gas sources are found, Bangladesh's natural gas supply will run out in the following ten years, according to data on annual usage (Das *et al.* 2020). There are some other electricity generation power plants, which are run by diesel andcoal. These two are alsonon-renewable energy, if additional reserve couldn't find, existingamount will run out soon.

It is obvious that the main sources of power generation will run out within a few decades.Although shifting to renewable power generation system is another solution, but inBangladesh's perspective, it is very lengthy process to meet this huge demand of electricitywith renewable energy source, because most of the power plants are based on fossil fuel andmaking renewable energy-based power plant is very time consuming and costly action. As it is already known, about the inadequacy of energy, and the manifestation of this scenariois today's frequent load shedding.

1.1 Objectives

The main focal point is the efficient, smart, and optimized usage of non-renewable energy.To establish the ideology"Smart Home Energy Management System" is the proposedapproach to improve the situation of load shading and efficient use of electricity. Bydeveloping an informative panel with the facility of reviewing the daily consumptionlevels, customer can take advantage of the consumption level control which will be able toprevent unexpected electric trips by balancing the demand and supply across the region.

2. Literature Review

Now a days “Smart home energy management system” is a very emergent technology in terms of optimizing the usage of energy. Much research has been done on this topic in order to effectively monitor and control electricity generation, storage, and consumption in smart homes, SHEMS is identified (Zhou et al. 2016). Some papers related to this work are reviewed here.

In (Rasheed et al. 2015), the authors suggested mathematical models for household energy unit optimization to maintain user preferences while providing the best possible control over the main residential energy loads. To efficiently coordinate the use of various household appliances and bring the consumer's electricity bill below a predetermined target level while maintaining their comfort, a comprehensive optimization-based ADR controller has been proposed in home energy management systems enable remote control, planning, and real-time monitoring of household electricity consumption(Althaher et al. 2015). These technologies actively contribute to the new power grid paradigm by giving conventional homes "smart" characteristics. Home energy management systems are mostly used for real-time consumption monitoring and appliance operation scheduling to reduce energy costs or in accordance with other predetermined criteria (Leitao et al. 2020). The fundamental goal of a model that has been put forth is to prevent variety loss while utilizing an IoT-based smart regulating system in the home and workplace to regulate lights, fans, air conditioners, and other electronic items by introducing a new controller system. Priority will be given to the proposed project at this stage of controlling electric devices in the house or workplace using a daily companion smartphone application for Android. The suggested method is too likely to be able to view the crucial temporal data of energy use for each device, which can motivate users to save money in an entertaining way (Moniruzaman e Hasan 2020). In order to reduce the cost of electricity billing and the peak to average ratio with the least amount of peak load and nearly the ideal horizontal load distribution throughout the 24 hours of the day, demand side management (DSM) technique was applied in the optimization of appliance load scheduling in the smart grid environment (Meikandasivam et al.2019). By taking into account a number of variables, including energy costs, environmental concerns, load profiles, and customer comfort, demand response (DR) tools was used to shift and reduce demand to improve household energy usage (Shareef et al. 2018). Demand response methods have become a potent DSM tool foroptimizing consumer energy consumption patterns while also increasing overall energy market efficiency (Srinivasan et al. 2017). For reducing demand on home HVAC systems, the fuzzy logic technique (FLA) utilizing wireless sensors and smart grid incentives has been given in a study (Keshtkar et al. 2015). The FLA is integrated with PCTs to allow for intelligent load reduction decisions that preserve thermal comfort while considering pricing, outdoor temperature, and occupancy. The AMI devices provide dependable two-way communication between power utilities and residential consumers under the smart grid paradigm (Kahrobaee et al. 2013). By adjusting their electricity usage during times of high demand in response to changes in electricity pricing, smart homes have the possibility to manage demand-side resources. Economic advantages include lower electricity bills, better home appliance utilization efficiency, and residential energy conservation (Tsui and Chan 2012). In order to effectively monitor and control electricity generation, storage, and consumption in smart homes, the best energy management system is known as a "smart HEMS (Han, Choi, Park, et al. 2011), (Son et al. 2010). The communication and sensing methods used in HANs allow for the remote real-time monitoring and management of multiple operational modes of smart home devices, as well as the information collecting for energy consumption from all household appliances (Hanet al. 2011). Additionally, HEMS can offer energy storage and management services for HESS and DERs, as well as the status of home appliances' optimal use (Lee et al. 2011).In order to govern the energy input and output of 20 homes in Japan, an energy controller system was constructed. This gateway regulates the A/C and lights and gives customers information on energy usage. To cut down on energy use and costs associated with electricity, an intelligent HEMS with DR was created (Shareef et al. 2018). In this study, the priority and comfort levels of four household appliances—the air conditioner, the water heater, the electric car, and the clothes dryer—were taken into consideration.

3. Methods

In Bangladesh, the consumption of electricity is calculated by multiplying total usage of electricity in unit (KWh) with the tariff value. Due to the insufficient information of usage, consumers are using all their devices without scheduling the usage pattern considering the demand and supply state of that moment. When there is an imbalance situation in demand and supply side, the load shedding occurs. In this chapter, a module structure is introduced that helps the consumer to monitor the usage and get a pattern of usage to avoid unnecessary load shedding during summer season. Also, the power saving percentage in terms of the persons in a single house is calculated.

Table 1. Load descriptions of home appliances(Rauf and Khan 2017)

Load Definition	Appliance	Priority	Usage time
Primary	Ceiling fan, LED bulb, Mobile, Personal computer, Chargers	First	Full day
Necessary	Refrigerator, Freezer, Pump motor	Second	Full day / On demand
Luxury	Air conditioner, Television, Washing machine, Electric oven, Electric Iron, Water heater	Third	On demand

In order to represent the dynamic environment in which a high number of actuations may be anticipated, the incorporation of an ontological description of energy loads as well as energy supply, might be considered as advantageous(Kofler *et al.* 2011). There are some load descriptions of appliances (Table 1) which are used in almost every house. The common appliances are LED bulb, ceiling fan, electric cocker, TV, personal computer, mobile phone, refrigerator, small gadget chargers, pump motor, washing machine, electric oven,electric iron etc. From them ceiling fan, LED bulb, mobile, personal computer, chargers are classified as 'Primary'. Refrigerator, freezer, and water pump motor classified as 'Necessary'. And air conditioner, television, washing machine, electric oven, electric Iron, water heater is classified as 'Luxury' load.

3.1 Proposed Methodology

Due to the lack of monitoring of usage at home, an informative module is proposed for better understanding the usage. Retrieve the dwelling/user model algorithm from the informative module, the data was collected from houses consisting of the member of 1 person, 2 persons, 3 persons and 4 persons. The data of daily consumption was collected from those houses and then it was optimized by the following module algorithm to calculate the saving percentage of electricity. A total of 10 days of usage was collected from each house. Finally created a dataset with 40 values, the saving percentage was obtained.

3.2 Proposed Informative Control Module

Dedicated hardware makes it possible for the integration of both old and new appliances with ease while maintaining the devices' autonomy and flexibility (Kim et al. 2007). To the best utilize of electricity, this informative module gives optimized solutions to the consumer as well as the grid operators. The key advantages of this module to the consumer are 1. Cut the expenditure with the metering mode, 2. Easy to operate and effective in use, 3. Remove the load shedding issue by using scheduling power and 4. Make a balance between demand and supply(Butt et al. 2021).

It also has some advantages to the utilities or to the distribution company also. These are1. Maintain specific amount of load in respective feeder, 2. Align prices with cost of generation by reducing load consumption, 3. Reliable supply of power, 4. Lower the demandand 5. Efficient use of electricity. The energy and comfort optimization in smart home control involves a high and complicated casuistry with a high dependency on users' habits. Tools for finding patterns in behavior and improving the effectiveness of predictive controllers include clustering (Iglesias and Kastner 2013). Reviewing users' roles and seeing them as active players who are incorporated into control is a desirable strategy. Based on these considerations, the Informative Module's design investigates the notion of utilizing technology's pervasiveness and persuasive power to encourage individuals to adopt more energy-efficient habits at home (Intille 2002). A well-designed system may display the appropriate information at the appropriate moment without being intrusive, increasing users' awareness of the present energy reality and their own energy behavior.Improvements in behavior are anticipated as a result of providing people with useful information about the upcoming problem("Electricity load management in smart home control | AIVC").

• Compatibility with energy usage: The system indicates whether the current hour and day are excellent or bad for energy usage using real-time data on spot costs. Additionally, tendencies are displayed, allowing judgments for the upcoming days to be reliably predicted.
• Evolution of self-consumption: Comparing recent consumption to that of earlier weeks, months, seasons, and years might inspire users. Through an indirect evaluation of their own behaviors, people can identify unsustainable patterns and malfunctioning technology.

• Comparison to industry standards: Similar to this, benchmarks provided and updated by linked repositories, services, and servers enable users to examine their energy habits and compare them to the average rates in their neighborhood, city, or nation (e.g., to know the expected consumption per inhabitant or square meter).
• Guidance and suggestions on energy: It is possible to offer individualized counsel as well as general suggestions and news on lifestyle, health, and energy.

The microcontroller (Arduino UNO) and current sensors, such as Current Transformer (CT) and ACS712, make up the design system for managing the home load. This method will assist in automatically turning off luxury household appliances during busy times. This microcontroller system will assist in turning on the loads at off-peak times and incentivize the user to use the power. This will have a straightforward, economical, and consumer-friendly design.

3.3 Design of Informative Control Module

A current transformer, analog to digital converter, Arduino UNO microcontroller, power supply, LCD, relay drivers, and relay in accordance with load current make up the key parts of the suggested methodology. Instead of using a current transformer, an ACS712 IC may be utilized as a current sensor. The feedback loop between the controller and current sensor is linked. The controller also has a real-time clock and a timer linked as input. As the controller's output, an LCD will show the load's value and current time. The output of the current sensor is related to heavy loads and is based on how much current is flowing through the load. The occurrence of off-peak hours will be signaled by a buzzer.Proposed control systems’ equipment cost is given below (Table 2).

Table 2. Equipment cost for informative control module. (BUTT et al. 2021)

Serial no	Item no	Quantity	Per unit cost (BDT)	Total (BDT)
1	LCD 20*4	1	250	250
2	Power supply	2	110	220
3	Arduino cables	2	65	130
4	Switch board	1	85	85
5	Relay	5	65	325
6	Converter	1	130	130
7	ACS712	3	110	330
8	Arduino Mega	1	700	700
9	Other components	1	80	80
			Total	2250

To build an informative panel for better visibility of uses, the required materials are LCD 20*4, power supply, 4 cables, switch board, relay, converter, ACS712, Arduino mega and some miscellaneous components which costs not more than 2250 Tk as per the current market rates. There are needed one unit of LCD 20*4, two units of power supply, two units of Arduino cables, one unit of switch board, five units of relay, one unit of converter, three units of ACS712 module, one unit of Arduino mega and some other equipment.

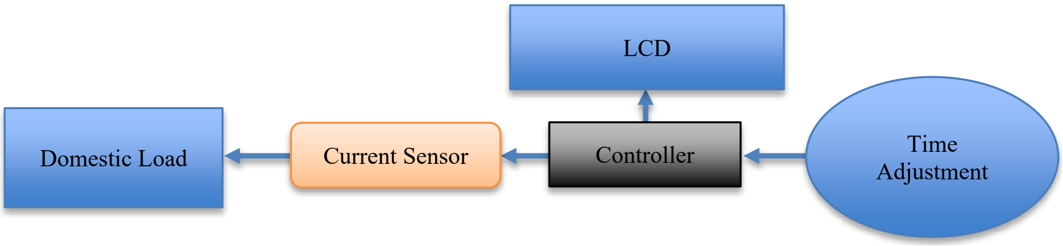

Figure 4. Informative control module block diagram(Butt et al. 2021).

The informative control module consists of a controller, sensor, time adjustment device and a display. The controller will maintain the connection with the smart grid system which provides the real time data of demand and supply to the controller. After passing the information from grid to controller, the sensor will decide how much power is available at this time to run the necessary and luxury load. According to the priority (Table 1), sensor controls the load, and the display will show the result of current condition.The display will show the current day and hour assessment of usage. Also, the user behavior assessment will show in the display. In the news portion, the message from the distribution authority or statistics of energy consumption will show.

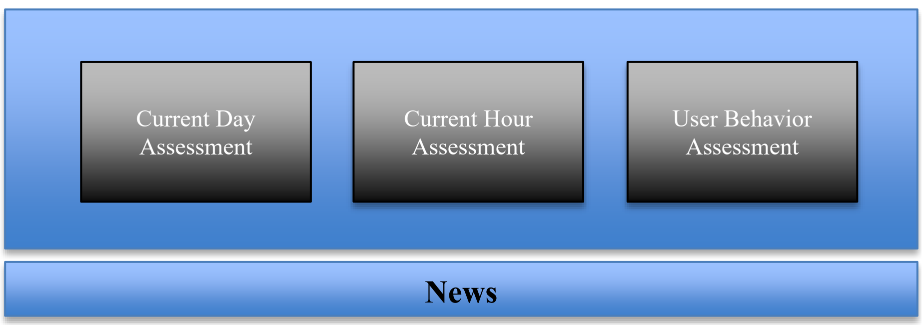

Figure 5. Main LCD screen of informative module for energy information. ("Electricity load management in smart home control | AIVC")

The display of the module will show the reading at different states of electricity. Module reading for active and nonactive appliances at different conditions are given below (Table 3).

Table 3. Module Reading for active and inactive appliances (BUTT et al. 2021)

State	**Primary**	**Necessary**	**Luxury**	**Voltage**	**Frequency**
All load is off	0.00	0.00	0.00	220.20	51.50
All load is on during off-peak time	0.40	0.41	0.40	220.20	49.50
During peak hour Luxury load turned off	0.41	0.41	0.00	218.80	50.00
Necessary load turned off to meet the load requirement during peak time	0.41	0.00	0.00	223.50	50.50
Protection of electrical appliance against low voltage	0.00	0.00	0.00	150.70	50.00

The device display module works on the basis of load definition. When all loads are off, the reading of primary, necessary and luxury loads are 0.00. In the state when all loads are on during off-peak time, based on the active elements of house, the readings of primary, necessary and luxury loads are 0.40, 0.41 and 0.40. Similarly, during peak hour the luxury load turned off. The other reading shows for primary and necessary which are 0.41 and 0.41. In the state when to meet the load requirement during peak time, the necessary load also turned off. Only primary load reading is showing then, that is 0.41. Also, for protecting electrical appliance against low voltage, all loads are turned off.After establishing the proposed module, different types of load definitions are described here. The flow diagram of informative module is also described in this section. By using the dwelling/user model algorithm, the saving percentage is calculated and analyzed with the previous state.

3.4 Operation

For different state of electricity, this device will give some notifications as followed-

1. Peak time will start soon. Please reduce your usage (about 1 min before the peak time)
2. Peak time has started. Keep the limit within loads (when the peak load starts)
3. Luxury load has been disconnected because of the peak hours (if the load is higher than primary load)
4. Necessary load has been disconnected because of peak hours (if the load is still higher than primary load)
5. Off-peak time starts (when peak hours are over)
6. There is some problem with voltages (if voltages are less than 180 V)

3.5 Dwelling/User Model

The design of dwelling/user model consists of some functions. The algorithm is described below ("Electricity load management in smart home control | AIVC") –

Step 1: Schedule function, H[m,n]. m is the present day and n is the present hour. The value of this function is 0 and 1. If the schedule function is active, the value is 1, otherwise 0.

Step 2: Normalized typical consumption, C[n]. The value of this function is also 0 and 1.

Step 3: Daily consumption function, C'[m,n] = H[m,n]C[n]. Model consumption function, C"[m,n]= (C'[m,n] $\hat{C}$M) / C[n], where, $\hat{C}$ is the average total daily consumption, M is the total simulated days.

Step 4: Measuring the Standby load function, S[m,n], which represents the load when all the electric appliances are in the inactive state, not in the power cut stage. Primary load function, P[m,n], which refers to the total load for the appliances consumed defined as a primary load. Necessary load function, N[m,n], refers to the total load for the appliances consumed defined as a necessary load.

The Luxury load function, L[m,n] represents the total load for the appliances consumed defined as a luxury load.The Load power, powj is the rating load for luxurious appliances. Running time, runtj is the total run time per day of the luxury appliances and Supply period, suppj is the total supply period of electricity. The Luxury load function, L[m,n] = (powj * runtj) / suppj. The Load summation function, G[m,n] = C"[m,n] + S[m,n] + P[m,n] + N[m,n]. And Simulated scheduling function, $\hat{H}$ = H[m,n] / M. K[m,n] is the distributed load for the consumption of standby and necessary loads taking the schedule into consideration. K[m,n] = G[m,n] when H[m,n] = 0, G[m,n] – (S[m,n] + N[m,n] + L[m,n])*$\hat{H}$ when H[m,n] = 1

Step 5: Calculating the daily Priority load, A[m,n] = K[m,n] – (S[m,n] + N[m,n])

4. Data Collection

Real time data was collected from the houses consisting of 1, 2, 3 and 4 dwellers of family. Table4 are showing the data of daily consumption, $\hat{C}$ of 10 days for each family –

Table 4. Daily electricity consumption according to the number of dwellers

Day	4 Dwellers (in KWh)	3 Dwellers (in KWh)	2 Dwellers (in KWh)	1 Dweller (in KWh)
1	11.5	8.67	7.58	5.87
2	10.8	8.53	7.99	5.5
3	9.54	8.98	7.35	5.83
4	9.86	8.64	7.38	5.99
5	9.99	9.57	7.66	6.12
6	10.3	8.64	7.36	6.01
7	10.1	8.99	7.18	5.68
8	10.6	9.42	7.38	5.39
9	10	8.85	7.23	5.66
10	10.8	9.01	7.78	5.95

5. Results and Discussion

5.1 Numerical Results

Applying the dataset collected from Bangladeshi residents in the algorithm, the daily saving percentage is described in Table 5.

Table 5. Daily saving percentage according to the number of dwellers

Day	Saving Percentage for 4 Dwellers	Saving Percentage for 3 Dwellers	Saving Percentage for 2 Dwellers	Saving Percentage for 1 Dweller
1	20.62	22.75	17.92	16.83
2	21.85	23.09	17.05	17.91
3	24.5	22.01	18.46	16.92
4	23.77	22.82	18.39	16.51
5	23.48	20.73	17.75	16.17
6	22.93	22.82	18.43	16.45
7	23.25	21.99	18.87	17.36
8	22.29	21.05	18.39	18.27
9	23.46	22.31	18.75	17.44
10	21.78	21.94	17.51	16.62

From this Table 5, the average percentage of saving electricity for 4 dwellers is 22.79, for 3 dwellers 22.15, for 2 dwellers 18.15 and for 1 dweller 17.05. Since the study is observed during the summer season, it can be said that the average saving percentage for summer season is 20.04.According to the information of Northern Electricity Supply Company Ltd., The average electricity growth rate (monthly) in summer season is 0.007944013.

5.2 Graphical Results

Figure 6 shows that the optimized data (September – October '2022 and April – May '2023) is less than the consumption of previous year (September – October '2021 and April – May '2022) in summer season. This observation is made based on the data of monthly consumption distributed by Northern Electricity Supply Company Ltd. (NESCO) at Rajshahi City Corporation area. Here, data of total seven Sales &Distribution (S&D) Center has analyzed.

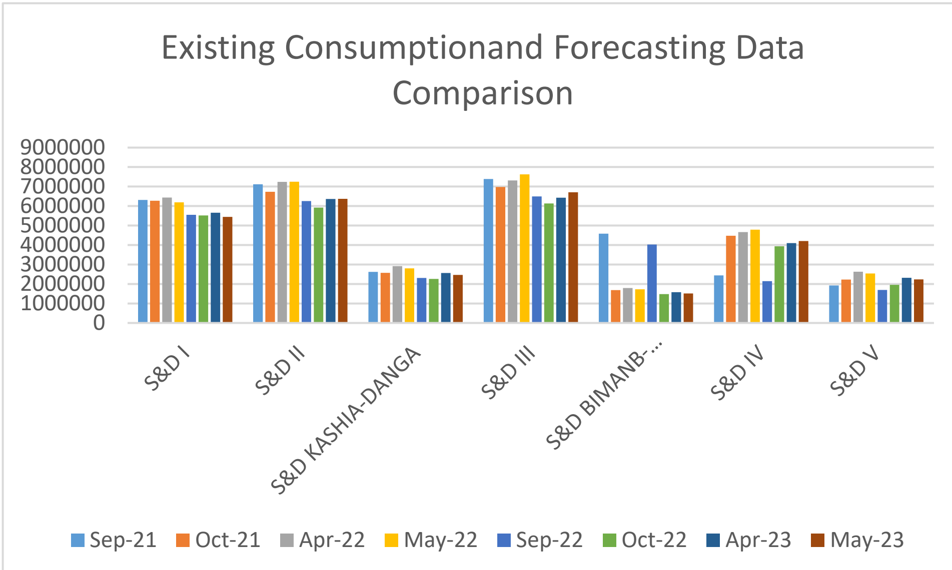

Figure 6. Existing and Forecasting Data Comparison

5.3 Proposed Improvements

To get the best benefit from this device, an integrated smart grid system is necessary. In this work, the study of informative control panel and the saving percentage is described. To discuss the smart grid management system and to get more accurate results, further research is needed with more data from in house survey to analyze the saving percentage with another algorithm.

6. Conclusion

What the proposed technique will actually accomplish is quite difficult to quantify. According to a static scenario used in the model, the benefits are fictitious but might vary if the recommendations were to be adopted widely. Despite this, the advantages are clear, and the energy environment has to increase support for home-side load control in order to increase the flexibility and sustainability of electricity management and its market. To ensure the effective and optimized use of renewable energy, there is no way to create a usage pattern that supports low carbon emission and energy security. The best-case scenario presented in this work provides a smart control system that enables a fair and cooperative energy management, an automated management of energy loads based on a load definition, awareness of other home applications and user habits and informative capabilities that bring energy feedbacks within users' reach and increase user awareness that validate the objective of this study.

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