Project Title: Feasibility study for designing and implication of demand response in residential sector

Department:	Energy Management Group	***Employer:***	(Font:Times New Roman 10)
Project/Program Manager:	Maryam Bodaghi	***Executor:***	(Font:Times New Roman 10)
Project Financial Code:	817200	***Project Quality Code:***	PENPN14
Type of Project/Program:	fiduciary contract	***Assistant:***	Vice President For Research

Project Staff: Maryam Bodaghi, Vahab mkarizadeh, Mohammadreza Salimian

---

Keywords:
Demand Response- Residential Sector- Demand Side Management-Peak Load- Distribution Network- Load Management- Smart Meter- AMI

Project Necessity:
In current structure of electricity industry, a ways to balance supply and demand is to implement demand-side management programs alongside generation expansion planning. The household sector in our country accounts for about 70% of the total subscribers, 40% of the total annual energy consumption and also about 70% of the peak load. This study is performed in order to examine demand response programs that can be used in residential sector. The purpose of this study is to find a suitable demand response program in residential sector, its technical and economic requirements and the possibility of using them in Iran.

Project Goals:

The objectives of this project can be stated as follows:

- Identification and analysis of controllable household loads in residential sector
- Estimation of demand response potential in the residential sector
- Investigating necessary infrastructure to implement demand response programs, especially direct load control
- Estimating cost of implementing demand response programs in residential sector according to the current infrastructures
- Estimation costs and revenues from the implementation of demand response programs in residential sector for the electricity industry
- Check how to set up a contract with the home department to run this program

Abstract:

After competitiveness of the electricity industry, economic performance of the network has always been one of the most important issues in the use of power systems. As a result, strategies such as demand side management and demand response in power system have been defined and used to optimize power consumption. The purpose of implementing demand response programs is to improve electricity consumption and reduce difference between peak and valley loads during the day and achieve economic goals such as reducing investment in construction of new power plants and increasing electricity generation capacity. However, successful implementation of these programs, especially in residential sector with a large number of subscribers, is associated with many problems. This study examines the experiences of implementing demand response programs in residential sector, examines the infrastructure required to implement these programs and extracts its technical and economic specifications.

In the first chapter, different types of demand response programs are reviewed and the characteristics of each one are presented. Demand response programs can be divided into different aspects. In general, these programs can be categorized in terms of control mechanism, proposed incentives and decision variables. In the first group, the program is divided into two groups, centralized and scattered, in terms of control mechanism. In centralized demand response programs, subscribers have no connection with each other and are directly connected to the network operator. While in the distributed control mechanism, the subscribers interact with each other and the operator uses this interaction to obtain information about the amount of energy consumption. The benefits of implementing burden response programs have led to these programs being implemented at various levels in developed countries. Depending on their infrastructure, each country implements certain types of demand response programs. Therefore, in this chapter, the practical experience of implementing burden response programs in the United States, the United Kingdom, Italy, Spain, South Korea, the United Arab Emirates, Australia, Singapore and Japan is reviewed. In the continuation of the first chapter, two examples of the mechanism of implementation of these programs in residential sector by Edison, SCE and Wisconsin power companies in the United States are examined.

According to the latest energy balance sheet published in 2016, the total final energy consumption in 2016 was equal to 1006.3 million barrels of crude oil equivalent and the share of the household sector was about 30.42% of the total final energy consumption of the country. This year, residential sector has the largest share of energy consumption among other consumer sectors. In addition, in 2016, the share of electricity consumption by household subscribers among other subscribers with a figure of 34%, slightly exceeded the industry and ranked first. In 1396, the share of household and industrial sectors in the total electricity consumption in the country was 32.7 and 33%, respectively. Due to the high share of residential sector in energy consumption, energy management in this sector is of great importance. Energy consumption in residential sector consists of energy consumption for lighting, space heating and cooling, water heating, cooking, electricity consumption by home appliances, elevators and other energy-intensive appliances. In Iran, natural gas is often used for water and space heating and cooking. In the second chapter of this study, first the electrical equipment used in residential sector and their average power are examined and then this equipment is divided into types of controllable and uncontrollable equipment. In this division, programmable loads are those loads whose start-up time can be shifted from peak hours to non-peak hours. The time of using these devices can be planned in advance according to the limitations of the residents of the houses as well as the economic factors. However, it should be noted that if these devices start working, they cannot be stopped until the end of the work cycle. Washing machines, dishwashers, vacuum cleaners, etc. fall into this category of household loads. Some appliances do not have the ability to change the time of use. However, by changing the duty cycle, the energy consumption of these devices can be reduced during peak hours. For example, the time to use the air conditioner in the summer cannot be changed because the device enters the circuit to meet the cooling needs of residents when the weather is hot. Changing the work cycle (changing the operation from fast to slow speed in water coolers and reducing the thermostat temperature or operating in fan mode in gas coolers) can be effective in reducing the energy consumption of this equipment. These equipments are temperature controllable in correction. Unplanned loads are a group of necessary loads that are always in the circuit as a base load (such as refrigerators and freezers) or do not have the ability to change the usage time and reduce energy consumption. The use of these appliances should be avoided in home load

management. These devices are used during the day and according to the needs that have arisen, and it is not necessarily possible to transfer the time of their use to low load hours. For example, using the TV to watch a specific program during the day cannot be transferred to the late hours of the night or holidays. Refrigerators, televisions, computers, cooking appliances (microwaves, tea makers, electric samovars and rice cookers) and LED lamps fall into this category. In the following, the potential of load reduction or displacement in each of the five climates of the country has been investigated and finally the effect of this change on the peak load of the national electricity network has been evaluated and analyzed.

The third chapter of this study is dedicated to reviewing the technologies required in demand response programs and offers for implementing demand response programs with existing facilities in the country. The equipment used in demand response programs can be divided into three groups: control, monitoring and communication equipment. The monitoring system includes smart meters, smart meters (AMI), energy management systems (EMS) and energy information systems, which are introduced in Chapter 3.

The costs of implementing a demand response program can be divided into two parts: equipment costs and participation costs. It should be noted that most of the costs of cargo response programs, especially costs related to customer inconvenience and reprogramming, cannot be calculated and estimated numerically. The cost of investing in activating technologies is actually the cost of investing in the installation of equipment such as smart meters. In the fourth chapter, first, the cost of installing a smart meter, load control switch and remotely controllable thermostat is estimated. Reducing electricity consumption due to the implementation of demand response programs, leads to a reduction in demand and consequently savings in production, transmission and distribution costs, which is also calculated. In this study, it is assumed that in 1398, a smart meter was installed for all new home subscribers and in the last year, all home subscribers will be equipped with a smart meter. The annual growth rate of the number of home subscribers equipped with smart meters per year has been calculated according to its values in 1398 and 1420, and using this growth rate, the total number of home subscribers equipped with smart meters per year has been calculated. Using this information, the discounted current value of energy saving costs, construction of transmission and distribution lines, as well as reduction of network gaps, resulting from the installation of intelligent metering equipment and consumption management in demand response programs until 1420 in total about It is estimated at 246 thousand billion IRR. It is noteworthy that in the estimate, the potential for energy savings is estimated only in the hot 4 months of the year, while with the implementation of demand response programs, the consumption culture of subscribers has changed and the reduction of energy consumption in other seasons is far from Not expected. In addition, the reduction of costs due to the lack of need to read the meter and the reduction of blackouts are not taken into account in the calculations. To estimate the cost-benefit of implementing demand response programs, the cost of creating the infrastructure needed to implement demand response programs has also been estimated.

The final chapter of this study is dedicated to summarizing the obtained results and also providing executive solutions for implementing demand response programs in residential sector and general suggestions for overcoming obstacles and achieving the potentials of demand response programs in residential sector.

According to the studies conducted in this study, technical barriers are the most important problems in implementing demand response programs in residential sector. In general, advanced metering systems, direct load control switches and smart thermostats can be considered as the main technologies activating demand response programs in residential sector. Studies have shown that the use of technologies that enable demand response programs has significantly improved the response rate of subscribers to price dynamic signals. However, the main challenge is how to use these technologies and the standards required for their performance.

After solving the technical challenges, the next issue is how to divide the profits for different actors in the value chain. In the load accountability program, the cost and income of each of the actors, including the consumer, intermediary companies (here distribution companies), network operator and manufacturer must be specified. In addition to the technical problems and challenges associated with the role of different market players, you still have to think about the third challenge, which is how to activate subscribers, especially home subscribers. Studies show that if subscribers are not actively involved in the use of meters and smart equipment, the potential of these technologies to reduce the load is very limited. Hence, changing subscribers' attitudes from passive to active behavior plays a very important role in the success of burden response programs.

To engage consumers, in designing demand response programs, the electricity subscriber and his needs must also be understood. Common trust in the market, lack of common comfort and also providing sufficient information about demand response programs, consumption profiles and energy saving solutions are the needs of subscribers. The European Energy Regulatory Council (CEER) considers mutual trust in the market to be an important issue in accountability. If the subscriber does not have sufficient trust in the market, this issue appears as a potential obstacle leading to a decrease in the willingness to participate in the load accountability program. Lack of subscribers' information about market performance can also hinder their participation. Therefore, providing information to subscribers about how the market works fairly, as well as the economic and environmental benefits of participating in load accountability programs can be effective in gaining subscribers' trust to participate in a win-win game. After gaining the trust of the subscribers, the existence of a specific contract with clear rules and regulations, in addition to attracting the participation of electricity consumers in residential sector, facilitates the estimation of the potential for load reduction at the time of peak load. This contract is actually the relationship between the consumer, which determines the change in power consumption in exchange for received signals, and the company mediating the response. This contract actually explains the relationship between the consumer, who determines the change in power consumption in exchange for the received signals, and the intermediary company (here it can be a distribution company), which is the other party and sends the signals. Slowly The parties to the contract must be clearly identified so that after signing it, the issue of accountability is the only focus of each party. Finally, providing advice to consumers who participate in the burden response program is a useful step to empower them to play an active role in burden response programs. In the continuation of this chapter, suggestions for implementing demand response programs in residential sector are presented.

Steps and Methodologies:

Step 1 - Literature review of implementing demand response programs in the residential sector

Step 2 - estimating the potential for demand response in the domestic sector in the country

Step 3 - Assess the technical and operational needs of demand response programs

Step 4 - Estimate the cost of installation and use of equipment needed to implement demand response programs in residential sector and calculate the benefits of production, transmission and distribution

Step 5 - Suggestions for setting up a contract with subscribers to implement a demand response program in the residential sector

Main Results (technical outputs, patents, papers, books, reports, etc.):

Project reports in 5 stages