61-E-LEM-0412

Dynamic Load Profile in ADRES project

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Keywords : energy efficiency, Dynamic Load profile, Bottom up Algorithm, autonomous decentralise renewable energy system

Abstract :
This paper presents some primary results of an autonomous decentralise regenerative energy system (ADRES) project in the field of Demand Side Management. In ADRES project unlike recent power systems, load is following exist generation. Therefore instead of regulating the power generators, load will be adopted itself in the real time system with accessible generation.

1. Introduction

Recently increasing the price of oil and limit resources of this energy source cause the thinking of a new infrastructure in power system.
Also regarding Kyoto protocol and preventing environmental effects it is necessary to use more renewable energy sources in the generation side.
On the other hand the electricity demand in European countries is still increasing 2-3 % per year [2]. According to EU directive on energy efficiency, member states must reach 20 percent reduction in their energy consumption till 2020 [1].
So there is a need to improve end use efficiency, demand side management and promotion of using renewable energy.
It is obvious that not only the power generation system but also the demand side need some changes to cope with new system in future.
ADRES concept is an autonomous decentralise regenerative energy system which has a solution for mentioned problems. The main goal of this project is developing and testing an autonomous decentralized renewable energy system in integrated approach. Focus of this paper is in the field of energy efficiency and load responsibility in the household sector.
For reaching this aim questionnaire has been prepared and distributed between electricity customers. The information of 217 customers has been gathered. In order to attain to the goal of mentioned Directive, at first the saving potential in household sector must be studied.

After finding the reduced load profile, the load profile which is compatible with amount of generation at each time, must obtained.

2. Statistic survey

There are lots of studies regarding energy saving potential in different countries. As energy users behaviour differently according their life style, economic level and Energy policy in their country, it is not possible to extend the result of these studies for all other places. Hence for gathering the information about user behaviour in Austria, questionnaire has been prepared and distributed between electricity customers. Among 217 contributor 32.7% single, 16.6% Couple, 35% Family and15.7% family which is living with retired people.

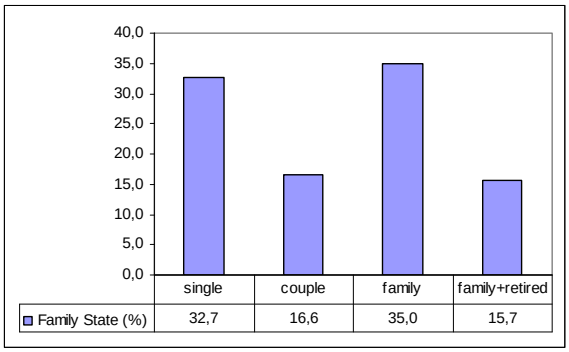


Fig.1:Family status of contributor

Fig.1 shows the family status of the people who is involving in this scientific study.Analyse of gathered information give a perspective of electrical appliances which is used in the household and their age of use in the household.

Among the white goods which use in each household the result of this survey shows the potential of energy saving just by replacing the old devices with new efficient one.

Fig.2 to Fig.6 shows saving potential in each device.

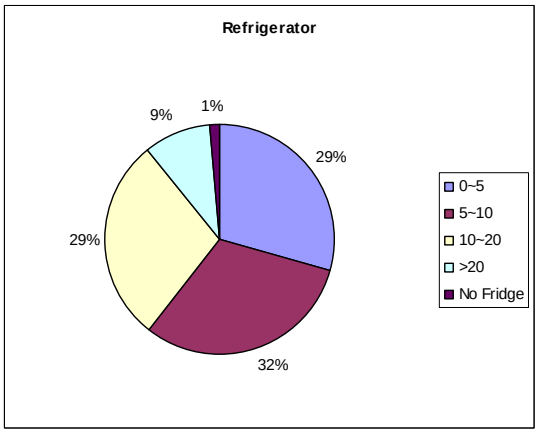


Fig.2:distributed age of Refrigerator

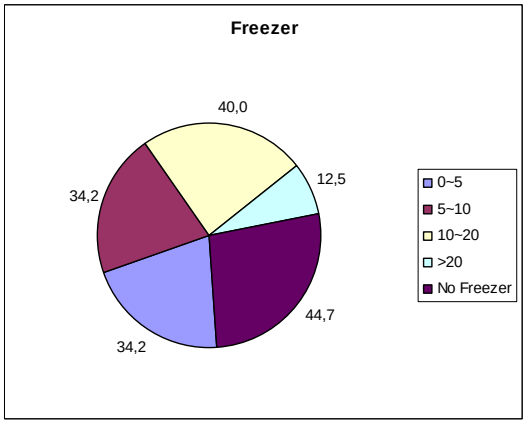


Fig.3:distributed age of Freezer

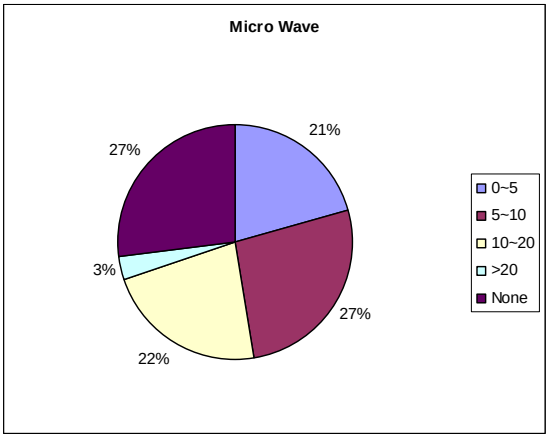


Fig.4: distributed age of Micro wave

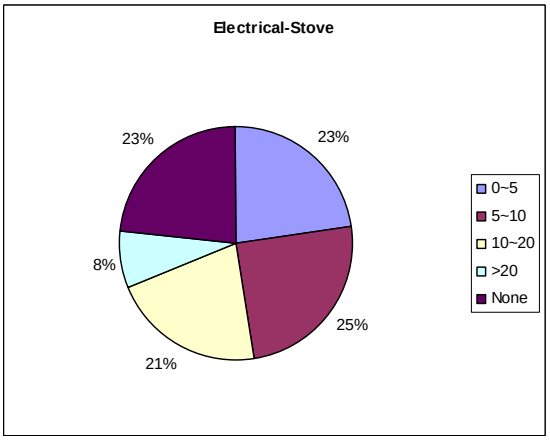


Fig.5: distributed age of Electrical stove

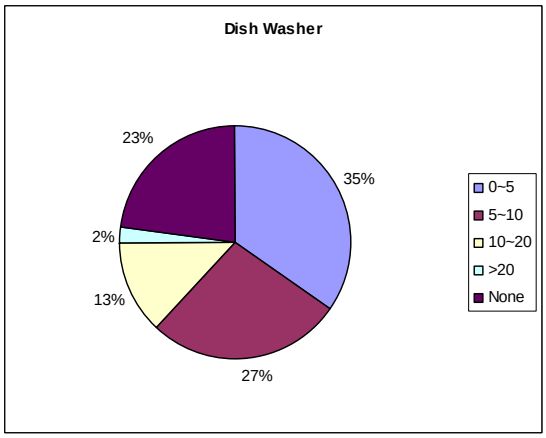


Fig.6:distributed age of Dishwasher

Concise result, declare that about 38% of Refrigerators, 52.5% Freezers, 25% Micro waves, 15% Dishwashers and 29% stoves are using more than 10 years. The energy labelling schedule shows that most of the devices at that duration are in the B or C energy labelling category. According to Fig.7 there is a big difference in amount of their energy consumption.

Just by replacing the old refrigerator with A++ one it is possible to save 60% of its energy consumption. As sharing the energy consumption of cooling devices in the household in Austria is about 22% of the total energy consumption of the household and they are accounting as a base load in the household this replacement cause about 9% energy reduction in each household.

There is the same situation with the other electrical appliances. Not only using the efficient appliances help to reduce the energy consumption but also result of survey shows that there are more than one device in each type. Fig.8 indicates the saturation of electric devices in the household.

Fig.8 explains that all households have wash machine. Dishwasher, stove, micro wave and freezers still are under saturation line. Per each household amount of TV and fridge respectively is 1.7 and 1.2.

TV is account as an entertainment devices in the household so it isn't necessary to have more than one in each home, also if customers select the volume of their refrigerator correctly they wouldn't need two or more device.

So there is the potential in energy reduction by omitting the extra unnecessary appliances in households.

Till now just effect of user behaviour has explained, but last survey in ADRES project shows that the power consumption in standby mode of electrical devices although is not too much per each single device in household, is considerable in the total amount of energy consumption. Result of this study declares 7.8% saving potential by reducing standby power consumption. Applying the mentioned items and using a bottom up algorithm a new improved load profile for ADRES household obtained.

Total energy consumption in a normal family household will reduce from 4500 KWh/yr to 3000 KWh/yr [6].

3. Load response in ADRES concept

After finding the reduced load pattern for private sector, for making the secure and reliable grid in the autonomous power system with limited sources load profile must be dynamic.

For making balance between generation and consumption when the frequency is going up and down, end use appliances can play an important rule. Instead of regulating frequency of grid through the governor action which needs unlimited energy resources, it is possible to control the energy consumption of each single device in the household. So frequency measurement in grid will consider as a matter of match or mismatching between the production and consumption. For making the grid secure and reliable, energy consumption of all household appliances will be controlled and shifted in a particular time. As freezers and refrigerators are considered as base load they would act as frequency regulator tools in the ADRES grid. For this purpose a simple model for freezers and refrigerator has obtained. In ADRES concept

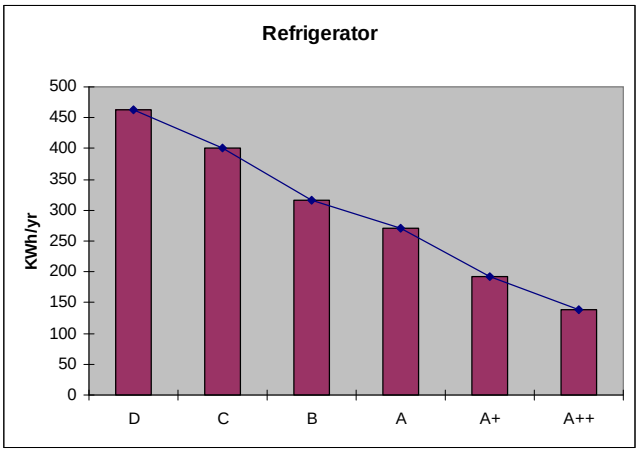
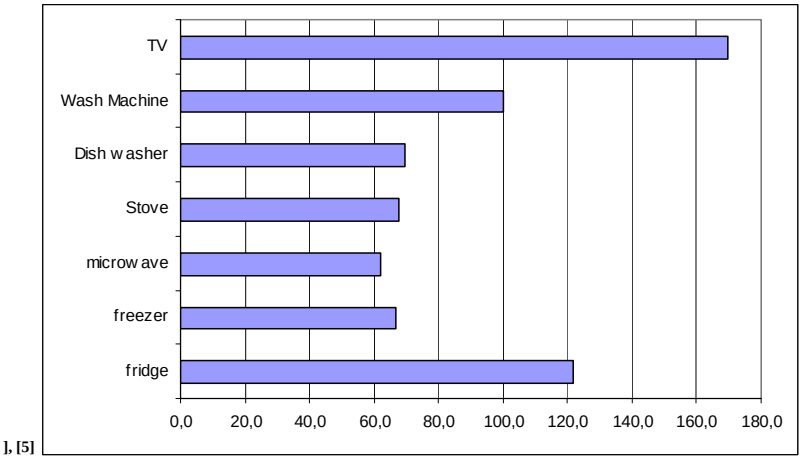


Fig.7: Energy consumption according to energy labelling [3], [4



], [5]

Fig.8: Saturation of electric devices in the household

load shedding won't use which means we don't interrupt customer with random black out.

When the frequency is going high, end use section, consumes energy at highest possible rate otherwise for keeping the grid secure loads will be reduced.

We can divide the household devices in three categories:

1- which are turn on and off like lights, TV, micro wave, …
2- which are run in a cycle like dishwasher, wash machine
3- which are tick away in the background like refrigerator and freezer

In this paper as freezer and refrigerator is such a base load in all households and it is relatively independent from user behaviour, they are acting as balance tool between generation and consumption.

In other word these cooling devices works as short term energy storage in the autonomous regenerative energy system.

Some measurements have been done for refrigerators. An energy model extracted from the result of these measurements.

From the refrigerators energy model it is obvious that in the normal situation the compressor is working 8 minute and going off for 20 minute. As the duty cycle of refrigerator is $2/5$, power consumption of one refrigerator with 100 W compressors in the normal grid operation at frequency of 50 Hz is about 40 W.

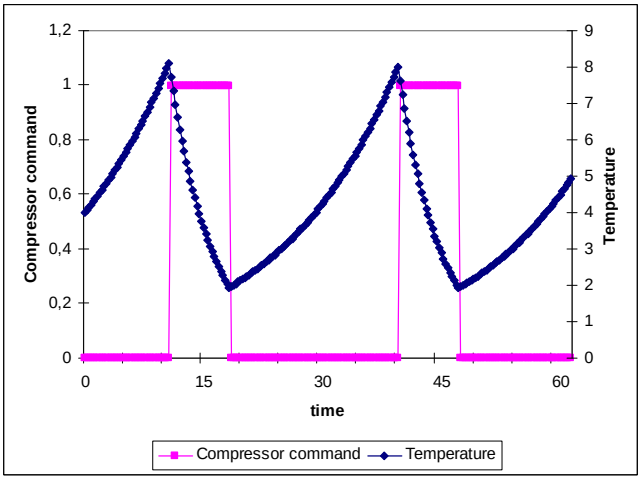


Fig.9: Function of refrigerator in normal frequency

When the frequency in the grid is dropped, it means load consumption is more than the generation. So the compressor of cooling devices must go off. If we consider the grid in the scale of ADRES project 100,000 dwelling, in the normal operation needs 4 MW for providing the cooling demand. If the frequency dips then grid control will reduce the number of operating compressors in the grid. So by making the 20% of the active refrigerators off, the load of the grid reduce to 2.8MW.

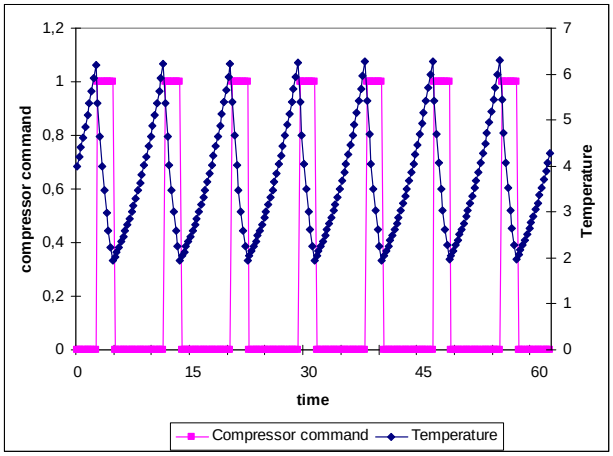


Fig.10: Function of refrigerator in the high frequency

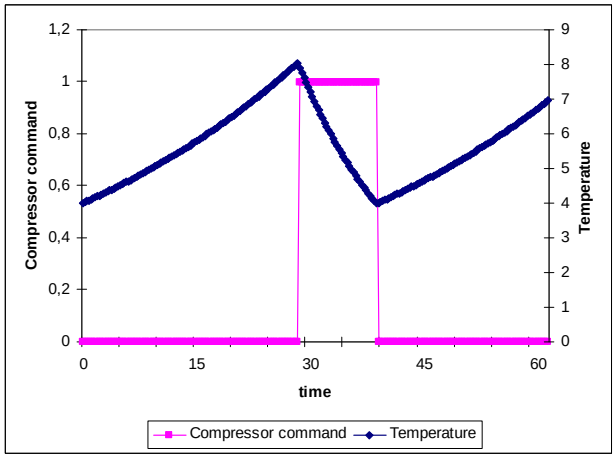


Fig.11: Function of refrigerator in dropped frequency

As the main duty of cooling devices is keeping the foods in the ambient temperature, operation state of compressor can be controlled with temperature set points.

When the frequency dropped, temperature set points will be adjusted on higher limit of ambient temperature and in the case of frequency increasing cooling device will act as a storage system and temperature inside the refrigerator will keep at minimum possible boundary.

Result of simulation shows that in the normal grid frequency inside temperature of refrigerator is kept between 2 and 8 degree. When the load of grid is going off, refrigerator

acts as storage system. Fig.10 shows the change of temperature set points between 2 and 6 degree.

In the worse case when the load is more than generation compressor will try to prevent the foods from ruining.

4. Conclusion

This paper explains the first result of ADRES project which has not finished yet. In the first phase of this project ADRES concept is assessing and all possible scenarios will be investigated. ADRES project including three different working packages:

-End-use efficiency (electrical, thermal and mobility

-exclusive use of renewable energy sources [7]

-innovative grid management

This paper focuses on the end use efficiency, saving potential in the private sector and approach for making a dynamic load profile.

Results shows that there is a big saving potential in the household sector in Austria which is possible to reach partly by changing the old appliances, eliminate the extra unnecessary devices and other part is reachable by applying new technology in manufacturing the new electric devices with low standby power consumption.

5. Acknowledgement

The project “ADRES-Concept” is founded by the “Klima- und Energiefonds” under Research Program “ENERGIE DER ZUKUNFT” which was originated by Austrian government.

6. References

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