ADRES@WORLD

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ABSTRACT

Autonomous Decentralized Renewable Energy System (ADRES) would approach the reality through ADRES@world. The feasibility of concept for developing an autonomous decentralized renewable energy system has been studied in the previous "concept" phase of the project ADRES and now the aim is bringing the concept to the reality. In this paper the result of last study and the idea of new project will be presented.

INTRODUCTION

Nowadays about 1.6 Billion people are living without electricity which is corresponding to 25 percent of the world population (Source IEA). World energy outlook indicates that in business as usual scenario and without any modification in energy political attitude, in 2030 there are still 1.3 Billion people, 16% of population, without electricity. Since the energy consumption in the form of fossil fuels altering the Earth's climate and increasing the greenhouse gas emission, establishment of centralized and fossil based energy system just for solving the electricity shortage problem and short-term economic effort, should not be repeated.

Integration of renewable energies or rather exploit the regional resources like wind power, photovoltaic, hydro energy can be a solution for making sustainable energy system. Intermittent nature of renewable energies and their non-dispatchable feature calls for a new approach and consequently new trend of electric demand load profile.

In ADRES concept project, three main columns has been highlighted.

1- Integrated of renewable regional resources
2- Innovative grid management
3- improving efficiency and demand side management (DSM)

For reaching the major of the project, available renewable resources in three regions in Austria has been forecasted. Energy units have been sized for ADRES settlement considering the new approach.

Trend of demanded energy should change in the way that when the energy is available it should be consumed.

In other word dynamic demand in this power system is needed.

This paper focuses on developing a method of predicting household daily energy consumption profile for planning and strategic design of RE system for residential buildings in ADRES settlement.

DYNAMIC LOAD PROFILE

Dynamic Demand in a power system means to match the load demands to an electrical power generation. The idea is that by monitoring the frequency of the power grid, individual, intermittent loads would switch on or off at needed moments to balance the overall system load with available generation, reducing critical power mismatches. As this switching would only advance or delay the appliance operating cycle by a few seconds, it would be non-intrusive to the electricity customers. In this regards using the standard load profile (H0) is not helping to assess the feasibility of dynamic demand concept. The high resolution model like end-use model including extended data such as household composition, user behavior, location and design of household and usage pattern of each individual appliance in the household is required. Since there is not enough information available in utilities and there are not enough studies in this regards, a survey of electricity customers and measurement campaign has been carried out in Austria.

Survey and data set preparation

Prepared questionnaire has been distributed among electricity customers. Sampling fraction of the collected data is 8 in 10000. Comparing the size of households in ADRES sample with Statistics Austria (2008), shows that except single families the sample in this study seems representative (figure1).

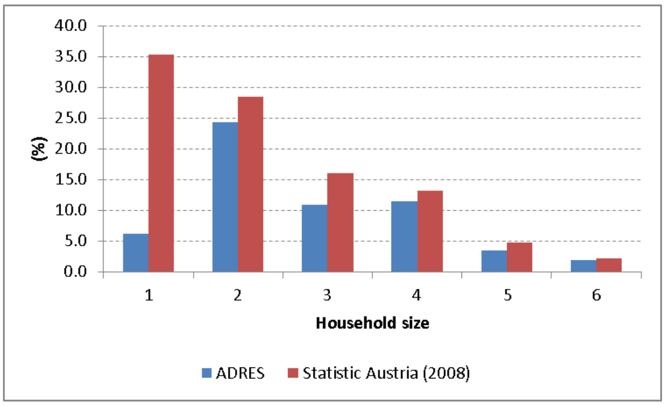

Figure 1: size of HH in ADRES sample vs. statistic Austria

Data set is including the demographic information, age of household electrical appliances, their energy label and frequency of use in each household. Also flexibility of people for shifting their load in different device categories has been asked. Collected data has been analyzed from two points of view.

1- Estimating the energy saving potential
2- Assessing the user behavior

Figure 2 indicates the number of devices which are older than 5 years and their annual energy saving potential in a case of replacing the old devices with most efficient one available in the market.

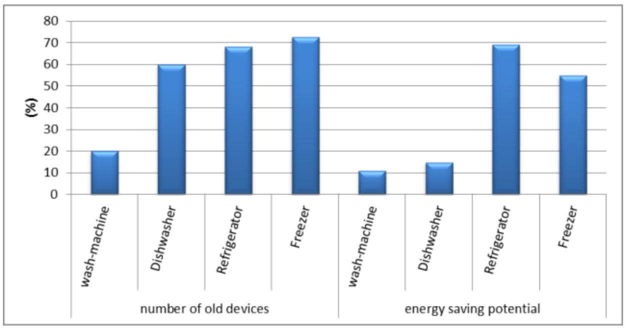

Figure 2: age of devices and their saving potential

If it is considered all cooling devices which have been bought in last 5 years have energy label A++, there is still about 70% of refrigerators and freezers in the households that have energy saving potential of 189 and 164 kWh/a respectively for each stock.

In Austria in 2008 there was 3.6.million. households. Considering from the result of ADRES sample, 1.2 and 0.9 refrigerator and freezer for each household respectively, 4.3 and 3.2 million stock of refrigerator and freezer existed in Austria in 2008. Replacing the inefficient one with efficient A++ energy class would save almost 0.9 TWh each year. Analyzing the data set using stepwise variable selection indicates the effect of demographic factors on the usage frequency and using time of devices. In the other word user behavior changes when number of people, age of children, working time, living area and type of building change. In this regard data clustering has been done and different family categories have been defined based on selected factors.

Measurement campaign

In order to extract user behaviour another data set including the measurement of possible individual devices was needed. Data set was collected by TUWien and EnergieAG-OÖ in duration between 2009~02010 and encompasses 2 weeks summer and 2 weeks Winter for 113 person in 21 detached, 8 semi-detached houses and 10 apartments. The time resolution of measured data is 1second. The data set is limited to 40 dwellings in Upper Austria but is a unique one.

Based on result of measurement, status vector indicating On/Off/Standby situation for each measured device has been calculated. Data has been categorized into defined family clusters.

Probability distribution function for each device in each family cluster for two types of day (weekday /weekend) and two seasons (winter/summer) has been calculated. Figure 3 shows probability distribution of some chosen devices among all households in different day type and season. Different colour blue, red, green and black are identifying winter weekend, winter weekday, summer weekend and summer weekday respectively.

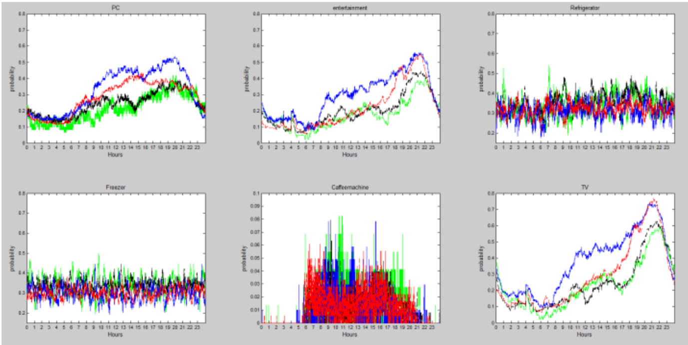

Figure 3 : probability distribution function for weekday and weekend during winter and summer

ADRES DEMAND LOAD PROFILE MODEL

Based on all gathered data, demand load profile has been simulated using a bottom up end-use model. It is necessary to define the usage pattern for each device according to family clusters. Patterns of energy use of the appliances are generated with a two-state non-homogeneous Markov chain with transition probabilities determined from a detailed set of date-base in measured households.

In the Markov–chain model it is assumed that a device can function in one of two states: (1) ON, (2) OFF. Although standby mode exists in the data base for each device, it is considered that ADRES household's electrical appliances have no standby energy consumption and state (3), standby mode, has been ignored in Markov model. Each device must get one of these states in every discrete time step k=1,...,Ti. Transition probability matrices have been calculated for weekday and weekend in summer and winter and they vary with time to produce diurnal fluctuations.

Figure 4 illustrate the electricity demand model structure.

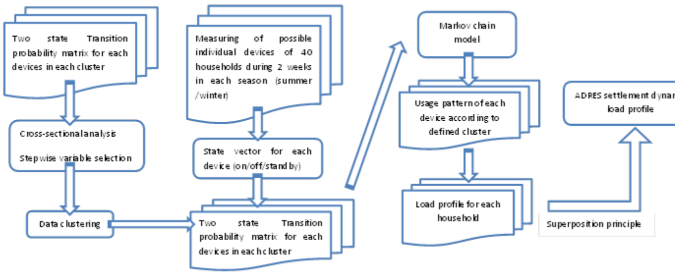

Figure 4: electricity demand model structure in ADRES

Given a complete set of transition probabilities, a realization for one device can be made by assuming an initial state, generating a uniform random number in each time step and comparing this with the transition probabilities to determine which transition is taking place.

RESULT

Figure 5 shows the total load profile of ADRES settelment with 200 housheholds for weekday and weekend in winter and summer. For model validation the traditional pattern from standardized load profile (H0) has been calculated. Simulated load in summer in comparison with standard profile has lower consumption; the reason is some of households or rather one of family clusters have left the measurement champain in summer and the user behavior Markov chain vector is missing for related family group in ADRES settlement in summer.

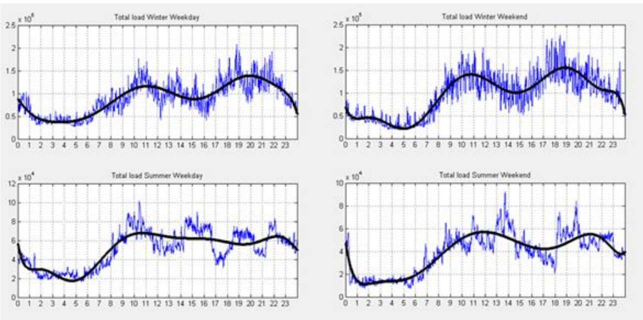

Figure 5: simulated load profile for winter and summer for weekday and weekend

Another reason which cause the lower amount of power consumption is the energy consumption of all individual measured devices in one household during one day is half of total daily energy consumption of that household. Energy consumption of lighting has not been considered.Unique characteristic of this model is that load profile of each household in the settlement and usage pattern of each device in each household is accessible.

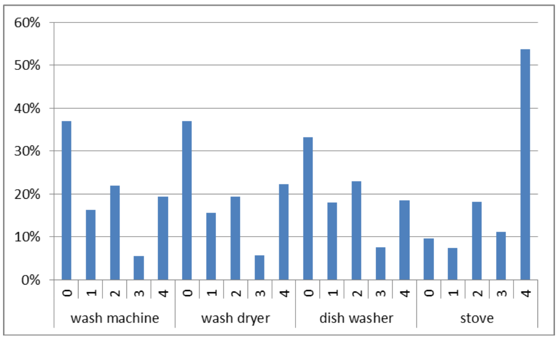

Figure 6 : flexibility degree for shifting the time of use

Regarding the conducted survey, people announced their flexibility in shifting the different devices.(Figure 6.) for each device, numbers 0 to 4 explain the degree of flexiblity. The smaller the number the haigher the inclination to shift the time of functioning the device.

According to result of simulation model the potential of shiftable washing devices has been presented in figure 7.

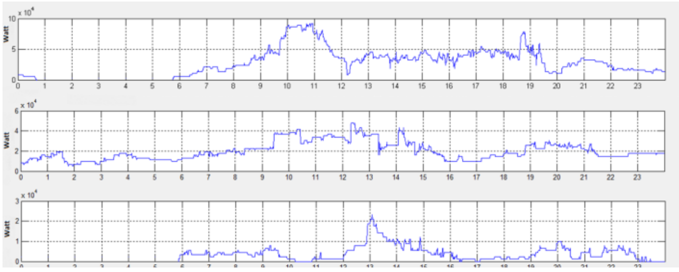

Figure 7: potential of shifting the use of devices (minute resolution)

Figure 8, 9 are referring to the result of measurement of photovoltaic unit and small wind turbine respectively. Based on measurement, average power fluctuation of PV units in different time resolutions is presenting. Obviously bigger unit size causes higher instant power oscillation. Figure 9 clearly shows that most of fluctuations in small wind turbines are occurring between 0.1to 1 and 1 to 5 percent of nominal power of the unit.

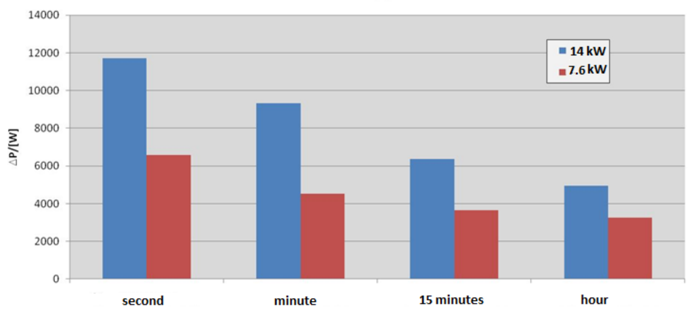

Figure 8: maximum power fluctuation of PV unit

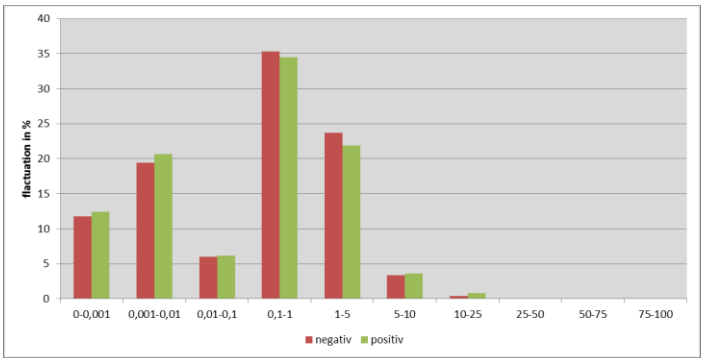

Figure 9: Frequency of power oscillation in percentage of the total installed power

Having simulated dynamic load profile and forecasted renewable generation is helping to simulate an autonomous energy system.
In a normal frequency, state energy system is operating normally. When demand exceeds production, the frequency decreases, whereas if generation is greater than demand, the frequency increases. Since there is a limited possibility of storing excess power generated, the demand must be flexible enough to change the real-time consumption levels. Dividing the household devices into several priority groups based on user inclination and using the grid frequency as an indicator of system power balance could lead to simulated autonomous settlement.
In ADRES concept project generation, consumption and grid have been simulated separately in order to assess the possible scenarios in each side without considering the effect of other part of the system.
The aim of ADRES@word is following the ADRES project and simulating a labour size autonomous decentralized renewable energy system and brings the ADRES ideal to reality.

CONCLUSION

In this paper result of ADRES project focusing on the electric demand load profile has been presented.
In the case of frequency drop in power system, delaying the heat storage devices like refrigerator. Freezer, boiler etc. will reduce the load 16 to 250 kW according to different time of the day.
Washing devices in the critical grid situation would help to save 8 to 160 kW of the demand.
Diming the light, reducing the contrast and brightness of TVs and PC monitors, reducing the power of cooking stoves, electric kettles etc. also can support the system in the emergency situation.
The feasibility of concept has been analysed in ADRES and know it should be taken to the reality through ADRES@world.
The overall object of ADRES@world is developing a robust energy system (plug&play) for island-grid with applications in rural electrification. In this regard the collaboration with UNIDO (United Nations Industrial Development Organization) has been requested.
Other advantages of ADRES energy system will be decarbonization of energy generation system in remote regions like in Canada and applicability to emergency supply in interconnected systems in case of blackouts.
For ADRES@world a simulation model will be developed for mentioned application and functionality will be demonstrated.
In the next step results of simulation would be verified in the micro-grid-lab. In micro-grid-lab via virtual instrument (VI) energy system will be monitored and result of monitoring would be returned to simulation process.
This control-monitoring loop will be repeated to enhance the performance of the mini-grid. Finally the verified results will be prepared for application in reality.
ADRES@world would be an international project. Aim of this paper on one hand is presenting the result of concept phase and idea of following work. On the other hand our intention is reaching one of the most important goals of our working group which is strengthening the international cooperation and developing the innovative ideas in the level of international, worldwide projects.

ACKNOWLEDGMENTS

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