# Multiagent Approach for Power Management with Distributed Generation

Ashok S
Department of Electrical Engineering
National Institute of Technology Calicut
Calicut, India
ashoks@nitc.ac.in

***Abstract*** **The increasing energy demand, economic and environmental concern leads to the effective utilization of existing grid. The efficient energy management techniques and the usage of renewable energy resources lead to the modernization of grid into smart grid. Smart grid provides efficient, reliable and intelligent two way system from source side to consumer side and vice versa. The high level penetration of renewable energy sources in the domestic sector brings new operational challenges of handling and processing a huge amount of time series data at the household and utility level in the implementation of an autonomous DSM program. Coordinated decision making systems are required to implement incentive based autonomous DSM program. Agent based approach provide greater flexibility in decision making and automated control functionality. Multiagent systems are used in wide range in the engineering applications to construct resilient long lasting system or as a modeling approach.**

## I. Introduction

The power generation using grid connected solar photovoltaic and wind generators are increasing day by day in the distribution level. The reliability and stability of the distribution system is affected by the intermittent nature of renewable energy. The uncertainty is a challenge in the design and operation of electrical systems that include renewable power generation. Demand Side Management (DSM) programs in efficient utilization of renewable energy results in the reduction of the adverse effect due to intermittent nature of renewable power generation [1-2].

The electricity demands as well as renewable power generation are dynamic in nature and the forecasting methods like neural network, fuzzy logic, ANN Fuzzy helps to fix this issue. The accuracy of forecasting is affected by the intermittency of renewable sources and to overcome this complex forecasting engines and a mechanism for large scale time series data management are required [3,4].

The implementation of demand side management programs such as load shifting has become an active topic with the increased integration of rooftop solar PV and wind generators in the domestic sector, and several shifting algorithms have been proposed. Such algorithms enable effective utilization of resources with minimum storage measures in a grid structure with a large number of renewable energy sources. The existing forecasting approaches used in the load-shifting scheme face the difficulty of prediction noise in a situation where both the sources and the loads are dynamic. A real-time approach that is independent of forecasting is more suitable to handle such a situation. The implementation of a centralized load-shifting program on the consumer side is minimal due to the operational challenge of handling a huge amount of time series data for the execution of the program in domestic-level situations with the large-scale integration of renewable energy sources. Additionally, the complexity of a centralized system increases with the application of a dynamic load-shifting program [6].

Under such situations, a localized scheme is more effective than the existing centralized methods for demand side management. The advantage of the localized scheme is the reduced amount of data exchange between the devices of the user and the utility. The shifting operations in the localized scheme can be achieved without the intervention of the utility by using smart metering, communication equipment and the associated hardware and software at the consumer side. Thus, the overall communication burden is reduced. Indeed, a huge amount of data transfer is required because the measurement of the demand and generation is performed on a timely basis in any household [6,7].

In this paper, DSM program based on multi-agent system is presented. The multi-agent system used a single software framework for the implementation of a DSM program at the household with utility level access and monitoring facility. The key focus of this approach is to enable meter data management, higher level of monitoring, verification and execution of dynamic operations in a single framework.

## II. Multi-Agent System

Multiagent technology (MAS) is a relatively new concept in the field of artificial intelligence. The technology has already matured from a level of laboratory experiments to industrial applications. The multiagent system can be applied to wide range of engineering applications including power system restoration, protection, distributed energy resources handling, demand side management, distribution system automation etc.The demand side management is an approach to match the supply and demand by reshaping the demand curve or load curve or both. The main target of the DSM is to encourage the customer participation in reducing the peak load burden on the system and shifting of the peak according to the generation. The example for such mechanism is demand response (DR) in which the system motivates end users to alter their load pattern to reduce the overall peak of the system. The customer in return gets incentives either as a direct pay off such as reduction in monthly electricity charges or a service incentive such as free energy consultancy. The DR can also be treated as a load shaping tool in distribution grids with high penetration of plug-in loads such as electric vehicles [8,9].

The multiagent application in demand side management can be achieved by developing a framework to utilize the DR potential of the residential customers using a house load management module integrated into the smart meters. (Fig.1)

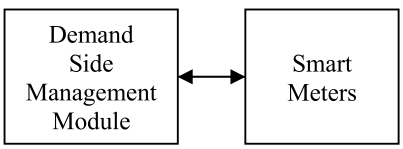


**Fig.1.** Demand Side Module and Smart Meters

This module schedules the operation of the connected loads in two stages. In the first stage the optimal load curve based on the market price will be decided and in the second stage load loads are rearranged such that the pre-scheduled energy expenses are not exceeded. The multiagent system helps to develop a model for real time management of grid connected micro grid using optimal scheduling of the resources and demand side management. It decides the operating point of DER and also executes DSM. It schedules the DER in two folds. In the first stage an outline of the set points is obtained based on the day ahead hourly forecast of load, generations and market price. In the second stage the set points obtained in the first fold are fine adjusted by taking real time data into consideration (Fig.2) [10,11].

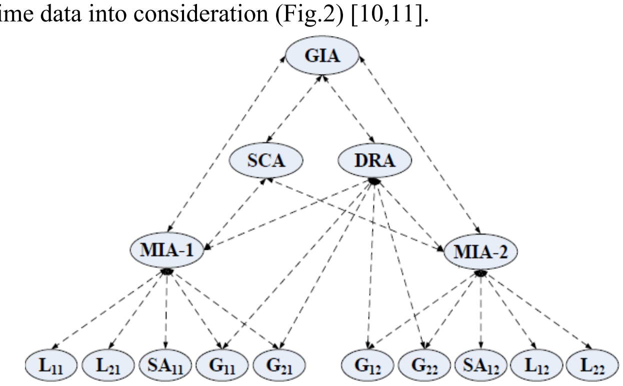


**Fig.2.** Multiagent approach in power management

By incorporating multiagent system the energy management system become intelligent. The agent based intelligent energy management system (IEMS) maintains two virtual energy markets i.e., global and local markets and allows customers to participate in DR. Local market is a virtual market environment maintained within a micro grid to facilitate internal trading where as global market is maintained among the micro grid to facilitate agents of different micro grids to practice trading with each other and or with the utility grid (Fig.3).

The frame work also includes demand response in energy balance. Demand Response motivates the end users to slide the operation of some other loads to the time frame where the electricity prices are low and maximum energy is being extracted from renewable energy source. Therefore it promotes effective utilization of energy generated from renewable sources. In general the loads owned by end users can be grouped into two categories elastic and in elastic loads. The elastic loads are those which can be shifted to subsequently time frames or curtailed without causing discomfort to their owners whereas inelastic loads cannot be shifted [12-14].

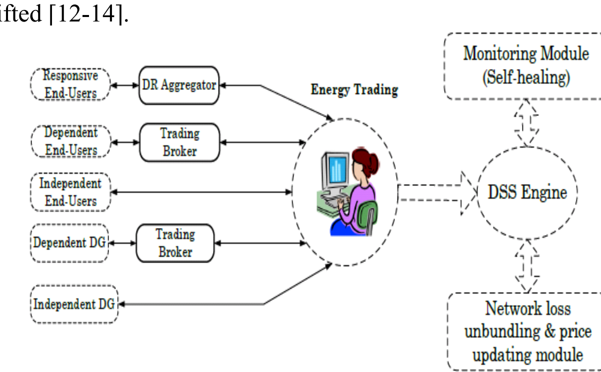


Fig.3. Intelligent Energy Trading

## III. Intelligent Power Management Using Multi-Agent Framework

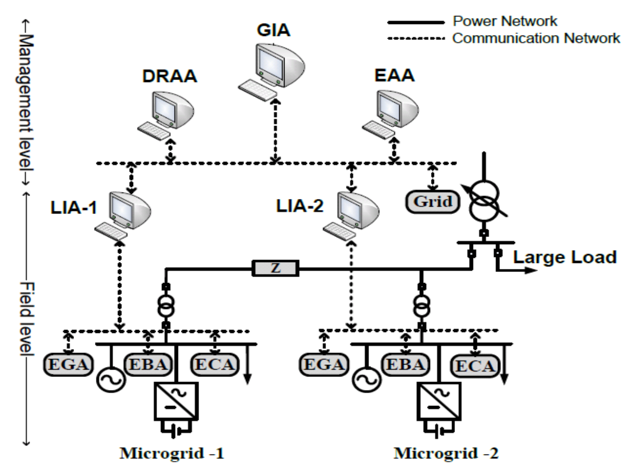


**Fig.4.** Agent based energy management Agent based Demand Side Management Framework (ADSMF) shown in Fig. 4.

contains various agents viz., GIA, Local Intelligent Agent (LIA), Demand Re-sponse Aggregation Agent (DRAA), Energy Aggregator Agent (EAA), Energy Consumer Agent (ECA), Energy Generator Agent (EGA) and Energy Bufer Agent (EBA). Despite having individual goals, the agents co-ordinate with each other to make the developed framework acceptable and feasible. The agent hierarchy given in the framework contains two levels viz., Field level and management level. The agents in the Field level represent the owners of the generation, load, and storage entities in the developed energy market environment. The agents on the top level are instrumental in successfully making contracts between traders across the system, processing DR participation requests, and optimally managing ESSs [15-19].

## IV. Conclusions

A multi-agent approach in cloud computing framework is presented in the work to address the operational issues in the implementation of DSM program in a grid structure consists of large number of grid connected renewable energy sources. The dynamic renewable energy factor introduced in the model is an indicative of the power fluctuations owing to renewable energy generation. The controllable loads are operated as directed by the energy manager based on the reference value of dynamic renewable energy factor. In brief, the method is adopted to impart greater flexibility in the dynamic load shifting program.

## *References*

1. Aghaei J, Alizadeh MI. Demand response in smart electricity gridsequipped with renewable energy sources. Renew Sustain Energy Rev2013;18:64–72.

[2] Moura PS, de Almeida AT. The role of demand-side management in the grid integration of wind power. Appl Energy 2010;87(8):2581–8.

[3] De Giorgi MG, Ficarella A, Tarantino M. Assessment of the benefits of numerical weather predictions in wind power forecasting based on statistical methods. Energy 2011;36:3968–78.

[4] Andreas S. Modeling storage and demand management in power distribution grid. Appl Energy 2011;88:4700–12.

[5] Adel M, Kalogirou SA. Artificial intelligence techniques for photovoltaic applications: a review. Prog Energy Combust Sci 2008;34:574–632.

[6] Alessandro DG, Laura P. An event driven smart home controller enabling consumer economic savings and automated demand management. Appl.Energy 2012;96:92–103.

[7] Remco V, Carlo BM, Zofia L, Lauens V. Does controlled electric vehicle charging substitute cross-border transmission capacity? Appl Energy 2014;120:169–80.

[8] Middelberg A, Zhang J, Xia X. An optimal control model for load shifting-with application in the energy management of a colliery. Appl Energy 2009;86(7–8):1266–73.

[9] Li XH, Hong SH. User expected price based demand response algorithm for a home to-grid system. Energy 2014;64:437–49.

[10] Schroeder A. Modeling storage and demand management in power distribution grids. Appl Energy 2011;88(12):4700–12.

[11] Valenzuela J, Thimmapuram PR, Kim J. Modeling and simulation of consumer response to dynamic pricing with enabled technologies. Appl Energy 2012;96:122–32.

[12] Kremers E, Duraana JM, Barambones O. Emergent synchronisation properties of a refrigerator demand side management system. Appl Energy 2013;101: 709–27.

[13] Emilio A, Raffaele B, Marco C. The role of communication systems in smart grids: architectures, technical solutions and research challenges. Comput Commun 2013;36(17):1665–97.

[14] Masa-Bote D, Castillo-Cagigal M, Matallanas E, Caamano-Martin E, Gutierrez A, Monasterio-Huelin F, et al. Improving photovoltaics grid integration through short time forecasting and self-consumption. Appl Energy 2014;125:103–13.

[15] Finn P, Fitzparick C. Demand side management of industrial electricity consumption: promoting the use of renewable energy through real-time pricing. Appl Energy 2014;113:11–21.

[16] Rajeev T, Ashok S. Dynamic pricing based on a cloud computing framework to support the integration of renewable energy sources. IET J Eng. Available: <http://www.thejournalofengineering.org/>.

[17] Ashok S, Banerjee R. Load-management applications for the industrial sector. Appl Energy 2000;66(2):105–11.

[18] Ashok S. Peak-load management in steel plants. Appl Energy 2006;83:413–24.

[19] H. S. V. S. K. Nunna and S. Ashok, "Optimal management of microgrids," Innovative Technologies for an Efficient and Reliable Electricity Supply (CITRES), 2010 IEEE Conference on, Waltham, MA, 2010, pp. 448-453. doi: 10.1109/CITRES.2010.5619795