Dynamic Load Management System for Smart Micro-Grid System

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***Abstract*—*This paper presents the development of an intelligent dynamic energy management system (I-DEMS) for a smart micro-grid. An evolutionary adaptive dynamic programming and reinforcement learning framework is introduced for evolving the I-DEMS online. The I-DEMS is an optimal or near-optimal DEMS capable of performing grid-connected and islanded micro-grid operations. The primary sources of energy are sustainable, green, and environmentally friendly renewable energy systems (RESs), e.g., wind and solar; however, these forms of energy are uncertain and nondispatchable. Backup battery energy storage and thermal generation were used to overcome these challenges.*

1. INTRODUCTION

Distributed generation located close to demand delivers electricity with minimal losses. This power may therefore have a higher value than power coming from large, central conventional generators through the traditional utility transmission and distribution infrastructure [6]. With the use of renewable distributed generation, the dependency on fossil fuels and on their price can be minimized. This step will also lead to a significant reduction of carbon dioxide emissions, which is required in several government programs. If, in addition, distributed generation and consumption in a certain area are integrated into one system, reliability of the power supply may be increased significantly, as shown in figure 1. The importance and quantification of these benefits has been recognized, although these are yet to be incorporated within the technical, commercial, and regulatory framework .

A micro-grid is a small grid that can operate as a part of a larger grid or that can operate independently of the larger grid[7]. A stand-alone micro-grid never connects to a larger grid. In this paper, we consider autonomous micro-grids, whether attached to a larger grid or not. Because autonomous micro-grids operate themselves and hide their internal characteristics from external markets, micro-grids are a natural fit with service orientation. Micro-grids can manage their own storage, conversion, and recycling of energy. They can choose to buy when energy is abundant and inexpensive. A micro-grid able to do so is inherently adapted for DR events. So long as transactions clear in real time, virtual micro-grids share almost all characteristics with actual micro-grids.Micro-grids integrate modular distributed energy sources, such as wind, solar, and fuel cells, with storage devices and controllable loads to form a low-voltage distribution system [8]. A micro-grid can be defined as a small-scale, self-supporting network driven by on-site generation sources with the ability to separate from an external grid for sustainability or energy security purposes. They improve grid reliability and supply sustainable and quality electric power. Micro-grids can be connected to a main power network or operated autonomously, similar to the power systems of physical islands [9].Smart micro-grids promise a newapproach for electric power generation through the clusters of small distributed on-site generators. There may be numerous advantages in developing micro-grids, including the following:

1) To manage growing demand without overloading existing electricity infrastructure or expanding capacity;
2) To reduce frequency and duration of grid disruption through distributed energy resource management system and self-healing functionality;
3) To ensure energy securitythrough self-sustainability;
4) To address climate change by utilizing clean energy resources.
5) To supply electric power to areas where local utility is unable to provide reliable service or have access to customers.

II. METHODOLOGY

Dynamic Load Management is an innovative approach to managing load at the demand-side. It incorporates the conventional energy use management principles represented in demand-side management, demand response, and distributed energy resource programs and merges them in an integrated framework that simultaneously addresses permanent energy savings, permanent demand reductions, and temporary peak load reductions. This is accomplished through a system comprising smart end-use devices and distributed energy resources with highly advanced controls and communications capabilities that enable dynamic management of the system as a whole. The components build upon each other and interact with one another to contribute to an infrastructure that is dynamic, fully-integrated, highly energy-efficient, automated, and capable of learning.

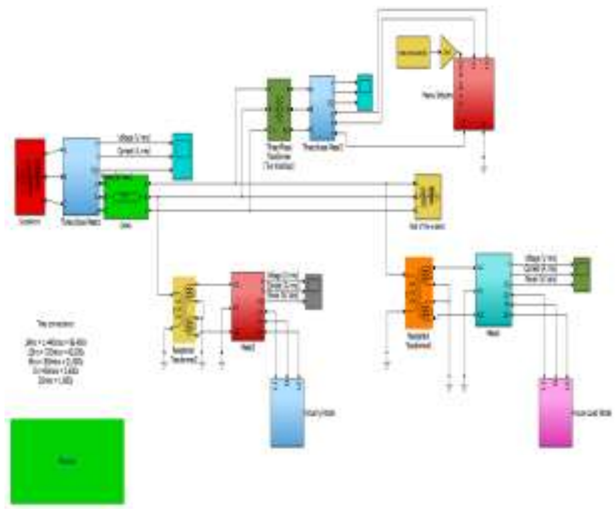

Figure-1 simulation Model for smart Micro-grid

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III.PERFORMANCE ANALYSIS

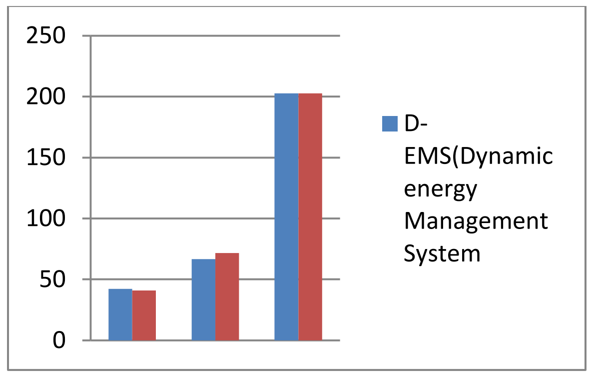


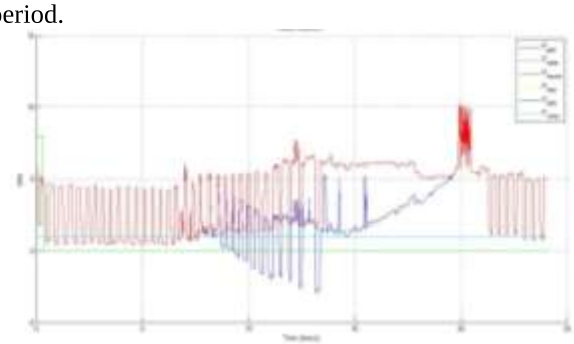
Figure-2 Graph showing comparison between D-EMS and I-EMS

Sr. no.	Parameter	D-EMS	I-EMS
1	Battery charging in kWh	42.38	40.97
2	Battery discharging in kWh	66.7	71.53
3	Power consumption in kWh	202.7	202.7

Table-1 Comparison of D-Dems And I-Dems Controllers.

In the graph performance analysis of two systems namely D-EMS (Dynamic energy Management System and I-EMS (Intelligent Management System) is shown. Three parameters are considered for making their comparison like battery charging in kWh, battery discharging in kWh and power consumption in kWh.

PerformanceAs shown in Fig 3, the graph for power consumption for heavy industry is shown. The results show the graph for power consumption in MW with respect to time in hours. Results for power consumption in various sectors like grid, solar, house, fuel, UPS and wind are considered. Power consumption for house sector shows a steady rate of 5MW to 7MW for 18 hours but increases steadily to 10MW after completing 20 hours. Power consumption rate for UPS varies steadily between the time periods of 10-15 hours. Power consumption for solar resource is 0 MW throughout while for wind is 1 MW throughout the time period.



Figurer-3 Power (MW) Vs Time (hr) graph showing results for heavy industry

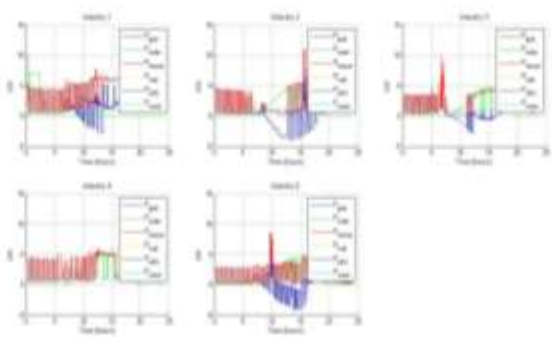


Figure-4 Power (kW) Vs Time (hr) graph showing results for five different industries

Fig shows graphical representation of different industries depicting the power consumed with respect to time. In all the five graphs, it can be concluded that power consumed for residential sector shows a steady rate between 0 kW to 5 kW whereas the power consumed for UPS sector is between the range of -5 kW to 2 kW on an average of 15 hrs.

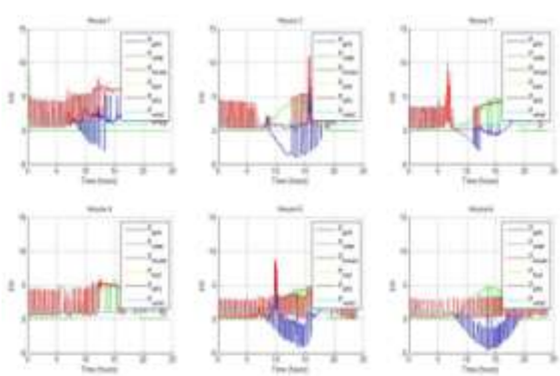


Figure-5 Power (kW) Vs Time (hr) graph showing results for six residential sectors

Fig.5shows graphical representation of different residential sectors depicting the power consumed in kW with respect to time. In all the six graphs, it can be concluded that power consumed for residential sector shows a steady rate between 0 kW to 5 kW whereas the power consumed for UPS sector is between the range of -5 kW to 2 kW on an average of 15 hrs. Power consumption for solar shows a gradual increase at an average time period of 10-15 hours and gradually decreases from 15-20 hour.

IV. CONCLUSION

The development of an I-DEMS for smart micro-grid operation has been introduced. The ADHDP approach, based on joined concepts of adaptive dynamic programming and reinforcement learning, was used to develop an optimal control policy and an approximate cost-to-go function for micro-grid operation, with variable and uncertain renewable energy generation and varying CL and controllable load documents. A modified evolutionary computing learning approach was introduced to speed up the convergence for finding near-optimal control policy and cost-to-go function during online operation as it becomes necessary to enhance performance.The execution of the I-DEMS was contrasted with that of a DEMS created utilizing a DT-based approach under observed and concealed operating conditions. The I-DEMS, while fulfilling the essential goal of meeting 100% of the CL demand requirements, still managed to improve the energy dispatched to controllable burdens, and its dispatch system broadened the lifecycle of the battery. This means that micro-grids of the future can be overseen intelligently to be self-sustainable, reliable, and environmental friendly. Future work will concentrate on extending the I-DEMS framework to include dynamic state prediction, and on carrying out a real-time implementation to arrange the set-point active power dispatches with reactive power controls.

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