Adaptive Electricity Scheduling in Micro grids

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Abstract—Micro grid (MG) is a promising component for future smart grid (SG) deployment. The balance of supply and demand of electric energy is one of the most important requirements of MG management. In this paper, we present a novel framework for smart energy management based on the concept of quality-of-service in electricity (QoSE). Specifically, the resident electricity demand is classified into basic usage and quality usage. The basic usage is always guaranteed by the MG, while the quality usage is controlled based on the MG state. The micro grid control centre (MGCC) aims to minimize the MG operation cost and maintain the outage probability of quality usage, i.e., QoSE, below a target value, by scheduling electricity among renewable energy resources, energy storage systems, and macro grid. The problem is formulated as a constrained stochastic programming problem. The Lyapunov optimization technique is then applied to derive an adaptive electricity scheduling algorithm by introducing the QoSE virtual queues and energy storage virtual queues. The proposed algorithm is an online algorithm since it does not require any statistics and future knowledge of the electricity supply, demand and price processes. We derive several “hard” performance bounds for the proposed algorithm, and evaluate its performance with trace-driven simulations. The simulation results demonstrate the efficacy of the proposed electricity scheduling algorithm.

***Index Terms*—Smart grid, Micro grids, distributed renewable energy resource, Lyapunov optimization, stability**

I. INTRODUCTION

In this paper, we first introduce a general architecture of energy management system (EMS) in a home area network (HAN) Based on the smart grid and then propose an efficient scheduling method for home power usage. The home gateway (HG) receives the demand response (DR) information indicating the real-time electricity price that is transferred to an energy management controller (EMC). With the DR, the EMC achieves an optimal power scheduling scheme that can be delivered to each electric appliance by the HG. Accordingly, all appliances in the home operate automatically in the most cost-effective way.

II. EXISTING SYSTEM

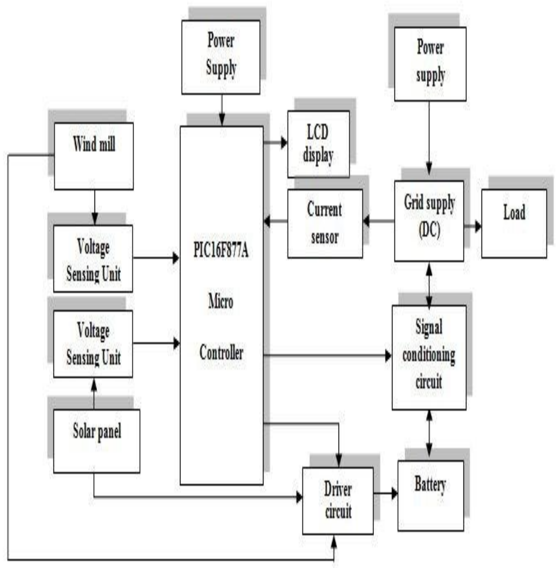
Now days, the non renewable energy only used for home appliance. There is no scheduling method is available. Hence any problem in the grid such as over voltage, under voltage will affect the load. In order to overcome this, we introduced a adaptive electrical scheduling using micro grid. Some of the drawback of the existing system as

- The manual work is needed.
- Power consumption.
- Demand for Non renewable energy source

III. PROPOSED SYSTEM

In this system we use the scheduling method using micro grid .as micro grid has the function to provide power to the small region by independent or with combining with the areas main electrical grid .here we use renewable energy to combine with the micro grid .hence when there is any problem with main supply it automatically switched to the renewable source to provide power to the source so, continuous power supply is possible. Renewable energy such as solar, wind is used. To attain our proposed system need to use PIC16F877A, RTC, current sensor, GSM, battery, windmill, LCD, buzzer. Normally load takes power supply from grid. RTC is nothing but real time clock it has information like time and date and calendar. We fix the peak time in controller. Controller reads the data from RTC. Whenever peak time persist Wind power is allocated to the user. GSM is used for sends the message about the power usage of the user at a peak time. Voltage sensor is used to measure the line voltage. Here current sensor is used for protect the devices from faults like 1.over voltages 2.under voltage. If any one of the above problem happens the controller will trip the relay by providing power supply to the load from battery and also information send to the user by GSM and intimate with help of buzzer and LCD. Controller status and everything is displayed in LCD. The whole process is controlled by microcontroller.

IV. BLOCK DIAGRAM



V.WORKING PRINCIPLE

In this proposed system renewable energy sources are used. Renewable energy sources are 1.wind 2.solar.voltage sensing unit is used to measure the generated power from the wind and solar. If we get more wind power compare to solar, battery will be charged by wind power. Otherwise battery will be charged by solar power. Signal conditioning unit consist of relay regulators. Regulator is used to provide specified voltage to the battery. Current sensor is connected to the grid. Based on current sensor two operation are taken place. 1. Whenever current value exceeds the threshold value battery shares power with grid to meet the demand.2.Whenever current value below the threshold value battery is charged by dc grid via signal conditioning units. Controller status and everything is displayed in LCD.

A. PIC16F877A:

In the micro controller unit we are going to use PIC 16F877A microcontroller which is used to read the sensor values. based on the sensor value controller control SMS and driver unit. In the communication part data conversion is done internally in the controller. The controller also converts the data to serial communication for wire.

B. Power Supply Unit:

The supply of 5V DC is given to the system which is converted from 230V AC supply. Firstly, the step down transformer will be used here for converting the 230V AC into 12V AC. The microcontroller will support only the DC supply, so the AC supply will be converted into DC using the bridge rectifier. The output of the rectifier will have ripples so we are using the 2200uf capacitor for filtering those ripples. The output from the filter is given to the 7805 voltage regulator which will convert the 12V DC into 5V DC. The output from the regulator will be filtered using the 1000uf capacitor, so the pure 5V DC is getting as the output from the power supply unit. Here we are using the PIC microcontroller which will be capable of getting the supply of 5V DC so we have to convert the 230V AC supply into 5V DC supply.

C. LCD:

The display unit is mainly achieved by the 16X2 LCD. A liquid crystal display (LCD) is a flat panel display, electronic visual display, or video display that uses the light modulating properties of liquid crystals (LCs). LCs does not emit light directly. The monitored data from the environment is viewed in the display

D. Current sensor:

Current sensor is used to measure the current flow in the transmission line. A current sensor is a device that detects and converts current to an easily measured output voltage, which is proportional to the current through the measured path. When a current flows through a wire or in a circuit, voltage drop occurs. Also, a magnetic field is generated surrounding the current carrying conductor. Both of these phenomena are made use of in the design of current sensors. Thus, there are two types of current sensing: direct and indirect. Direct sensing is based on Ohm's law, while indirect sensing is based on Faraday's and Ampere's law.

E. Voltage sensor:

A Bridge Rectifier is used to convert the AC in to DC. Capacitors are available to filter the converted voltage. Converted voltage is sampled by variable resistor. Multiply output with some factor to get the exact output.

VI. DISCUSSION

A. Quality of Service:

Quality of Service is a metric of how reliable a distributed system (electrical power system) provides its commodity (electrical power) to the standards required by the users. It is calculated as a (MTBF) of the power system as viewed from the loads. A failure is defined as any interruption in service, or commodity parameters (Power Quality) outside of normal limits, those results in the load equipment not being capable of operating properly. The time is usually specified by an operating cycle, Design Reference Mission (DRM), Concept of Operation (CONOPS) or an Operational Architecture. Quality of Service is a reliability-like metric; as such the calculation of QOS metrics does not take into account survivability events such as battle damage, collisions, fires, or flooding. Quality of Service does take into account equipment failures and normal system operation transients. A typical cause of normal system operation causing a QOS failure is the shifting of sources for the commodity such as shifting to/from shore power (without first paralleling) or manually changing the source of power using a manual bus transfer (MBT). Also note that not all interruptions in service will cause a QOS failure. Some loads, such as refrigerators and chill boxes, will keep their contents cold even if power is interrupted for several minutes. In this case, a QOS failure will not occur as long as power is restored in time to prevent significant heating of the contents. Note that the optimal configuration of a distributed system may differ for QOS considerations and for survival ability considerations. In the electric plant for example, an important QOS consideration is the ability to preserve power to loads when a generation element trips off line while damage to the distribution system and the ability to preserve power to vital mission systems loads is of major interest in the survivability analysis. For QOS reasons, many ships operate with their electric plant paralleled in peacetime steaming and only shift to the more survivable split plant configuration under threat conditions.

B. Un-interruptible Load:

Un-interruptible Load is a proposed QOS term for categorizing electrical loads (Other proposed QOS load categories are Short-Term Interrupt and Long-Term Interrupt loads). An electrical load would be classified as an uninterruptible load if it cannot tolerate power interruptions of 2 seconds. Un-interruptible Loads should be capable of tolerating transient interruptions of power of up to 10 ms in duration to enable standby power systems to switch. Uninterruptible loads are typically provided a Standby Power System, an Uninterruptible Power Supply, or auctioneering DC diodes. Quality of Service Load Shedding is not performed on Uninterruptible Loads (Quality of Service Load Shedding is explained in paragraph III F).

C. Short Term Interrupt Load:

An electrical load is classified as a short-term interrupt load, if it can tolerate power interruptions greater than 2 seconds but cannot tolerate interruptions of greater than 5 minutes. The two second limit is based on providing sufficient time for electromechanical switchgear to clear faults in a coordinated manner, conduct Quality of Service Load Shedding of Long -Term -Interrupt Loads, and to reconfigure the electrical plant. The five minute limit is a nominal time in which a standby generator should be capable of starting and power. Quality of Service Load Shedding is not performed on Short Term Interrupt Loads.

D. Long Term Interrupt Load:

An electrical load is classified as a long-term interrupt load, if it can tolerate power interruptions greater than 5 minutes. Quality of Service Load Shedding is performed on Long Term Interrupt Loads. Generally, standby generators should come on line within 5 minutes and restore power

VII. SIMULATION STUDY

We demonstrate the performance of the proposed adaptive MG electricity scheduling algorithm through extensive simulations. We simulated an MG with 500 residents, where the electricity from DRERs is supplied by a wind turbine plant. We use the renewable energy supply data from the Western Wind Resources Dataset published by the National Renewable Energy Laboratory [13]. The ESS's consists of 100 PHEV Li-ion battery packs, each of which has a maximum capacity of 16 kWh and the minimum energy level is 0. The battery can be fully charged or discharged within 2 hours [14]. The residents' pre-agreed power demand is uniformly distributed in [2 kW, 25 kW], and the quality usage power is uniformly distributed in [0, 10 kW]. The MG works in the grid-connected mode and may purchase/sell electricity from/to the macro grid. The utility prices in the macro grid are obtained from [15] and are time-varying. We assume the sell price by the broker is random and below the purchasing price in each time slot. The time slot duration is 15 minutes. The MGCC serves a certain level of quality usage according to the adaptive electricity scheduling policy. The QoSE target is set to δ n= 0.07 for all residents.

The control parameter is V = V max, unless otherwise specified.

A. Algorithm Performance:

We first investigate the average QoSEs and total MG operation cost with default settings for a five-day period. We use MATLAB LP solver for solving the sub-problems (22) 7 and (23). For better illustration, we only show the QoSEs of three randomly chosen users.. It can be seen that all the average QoSEs converge to the neighbourhood of 0.08 within 200 slots, which is close to the MG requested criteria δ n = 0.07. In fact the proposed scheme converges exponentially, due to the inherent exponential convergence property in Lyapunov stability based design [9]. We also plot the MG operation traces from this simulation .The energy for serving quality usage from the DEREs are plotted in Fig. 6(A). It can be seen that the DRERs generate excessive electricity from slot 150 to 200, which is more than enough for the residents. Thus, the MGCC sells more electricity back to the macro grid and obtains significant cost compensation accordingly. In Fig. 6(B), we plot the traces of electricity trading, where the positive values are the purchased electricity (marked as brown bars), and the negative values represent the sold electricity (marked as dark blue bars). The MG operation costs are plotted in Fig. 6(C). The curve rises when the MG purchases electricity and falls when the MG sells electricity. From slot 150 to 200, the operation cost drops significantly due to profits of selling excess electricity from the DEREs. The operation cost is $418.10 by the end of the period, which means the net spending of the MG is $418.10 on the utility market. We then examine the energy levels of the batteries in Fig. 4. We only plot the levels of three batteries in the first 50 time slots for clarity. The proposed control policy charges and discharges the batteries in the range of 0 to 16 kWh, which falls strictly within the battery capacity limit. It can be seen that the amount of energy for charging or discharging in one slot is limited by 2 kWh in the figure, due to the short time slots comparing to the 2-hour fully charge/discharge periods. For longer time slot durations and batteries with faster charge/discharge speeds, the variation of the energy level in Fig. 4 could be higher. However, Theorem 2 indicates that the feasibility of the battery management constraint is always ensured, if the control parameter V satisfies $0 < V \leq V$ max. We next evaluate the performance of the proposed adaptive control algorithm under different values of control parameter V. For different values V = {V max, V max/2, V max/4}, the QoSEs are stabilized at 0.081, 0.061, and 0.055, and the total operation cost are $418.10, $625.69, and $717.75, respectively. We find the QoSE decreases from 0.081 to 0.055, while the total operation cost is increased from $418.10 to $717.75, as V max are decreased. This demonstrates the performance congestion trade-off as in Theorem 4: a larger V leads to a smaller objective value (i.e., the operating cost), but the system is also penalized by a larger virtual queue backlog, which corresponds to a higher QoSE. On the contrary, a smaller V favours the resident quality usage, but increases the total operation cost. In practice, we can select a proper value for this parameter based on the MG design specifications. It would be interesting to examine the case where the residents require different QoSEs. We assume 5 residents with a service contract for lower QoSEs. We plot the average QoSEs of three residents with V = V max/2 in Fig. 5. Resident 1 prefers an outage probability δ 1 = 0.02, while residents 2 and 3 require an outage probability δ 2 = δ 3= 0.07. It can be seen in Fig. 5 that resident 1's QoSE converges to 0.015, while the other two residents' QoSEs remains around 0.063.

VIII. CONCLUSION

In this paper, we developed an online adaptive electricity scheduling algorithm for smart energy management in MGs by jointly considering renewable energy penetration, ESS management, residential demand management, and utility market participation. We introduced a QoSE model by taking
into account minimization of the MG operation cost, while maintaining the outage probabilities of resident quality usage. We transformed the QoSE control problem and ESS management problem into queue stability problems by introducing the QoSE virtual queues and battery virtual queues. The Lyapunov optimization method was applied to solve the problem with an efficient online electricity scheduling algorithm, which has deterministic performance bounds. Our simulation study validated the superior performance of the proposed approach.

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IX. REFERENCES

[1] Y. Huang, S. Mao, and R. M. Nelms, "Adaptive electricity scheduling in micro grids," in Proc. IEEE INFOCOM'13, Turin, Italy, Apr. 2013, pp. 1–9.

[2] Whitehouse.gov, "Battery and electric vehicle report," Jul. 2010, [online] Available: http://www.whitehouse.gov/files/documents/Battery-and-Electric-Vehicle-Report-FINAL.pdf.

[3] X. Fang, S. Mishra, G. Xue, and D. Yang, "Smart grid - the new and improved power grid: A survey," IEEE Commune. Surveys & Tutorials, vol. PP, no. 99, pp. 1–37, Dec. 2011.

[4] J. Huang, C. Jiang, and R. Xue, "A review on distributed energy resources and micro grid," ELSEVIER Renewable and Sustainable Energy Reviews, vol. 12, no. 9, pp. 2472–2483, Dec. 2008.
[5] H. Farhangi, "The path of the smart grid," IEEE Power and Energy Magazine, vol. 8, no. 1, pp. 18–28, Jan.-Feb. 2010.
[6] S. Shao, M. Pipattanasomporn, and S. Rahman, "Demand response as a load shaping tool in an intelligent grid with electric vehicles," IEEE Trans. Smart Grid, vol. 2, no. 4, pp. 624–631, Dec. 2011.
[7] E. Fumagalli, J. W. Black, I. Vogelsang, and M. Ilic, "Quality of service provision in electric power distribution systems through reliability insurance," IEEE Trans. Power Systems, vol. 19, no. 3, pp. 1286–1293, Aug. 2004.
[8] L. Tassiulas and A. Ephremides, "Stability properties of constrained queuing systems and scheduling policies for maximum throughput in multi hoc radio networks," IEEE Trans. Autom. Control, vol. 37, no. 12, pp. 1936–1948, Dec. 1992.
[9] J. Slotine and W. Li, Applied Nonlinear Control. Prentice Hall, 1991.
[10] T. T. Kim and H. Poor, "Scheduling power consumption with price uncertainty," IEEE Trans. Smart Grid, vol. 2, no. 3, pp. 519–527, Sept. 2011.
[11] M. Neely, E. Modiano, and C. Rohrs, "Dynamic power allocation and routing for time-varying wireless networks," IEEE J. Sel. Areas Commune, vol. 23, no. 1, pp. 89–103, Jan. 2005.
[12] M. J. Neely and R. Urgaonkar, "Opportunism, backpressure, and stochastic optimization with the wireless broadcast advantage," in Asilomar Conference on Signals, Systems, and Computers'08, Pacific Grove, CA, Oct. 2008, pp. 1–7.
[13] The National Renewable Energy Laboratory, "Western wind resources dataset," [online] Available: http://wind.nrel.gov/Web nrel/.
[14] S. B. Peterson, J. F. Whitacre, and J. Apt, "The economics of using plug-in hybrid electric vehicle battery packs for grid storage," J. Power Sources, vol. 195, no. 8, pp. 2377–2384, 2010.
[15] "The Electric Reliability Council of Texas," [online] Available: http://www.ercot.com/.
[16] M. He, S. Murugesan, and J. Zhang, "Multiple timescale dispatch and scheduling for stochastic reliability in smart grids with wind generation integration," in Proc. IEEE INFOCOM'11, Shanghai, China, Apr. 2011, pp. 461–465.
[17] B. Karimi and V. Namboodiri, "Capacity analysis of a wireless backhaul for metering in the smart grid," in Proc. IEEE INFOCOM'12, Orland, FL, Mar. 2012, pp. 61–66.
[18] Z. Lu, W. Wang, and C. Wang, "Hiding traffic with camouflage: Minimizing message delay in the smart grid under jamming," in Proc. IEEE INFOCOM'12, Orland, FL, Mar. 2012, pp. 3066–3070.
[19] M. A. Rahman, P. Bera, and E. Al-Shaer, "Smart analyzer: A non invasive security threat analyzer for AMI smart grid," in Proc. IEEE INFOCOM'12, Orland, FL, Mar. 2012, pp. 2255–2263.
[20] H. Ma, H. Li, and Z. Han, "A framework of frequency oscillation in power grid: Epidemic propagation over social networks," in Proc. IEEE INFOCOM'12, Orland, FL, Mar. 2012, pp. 67–72.
[21] H. Liang, B. J. Choi, W. Zhuang, and X. Shen, "Towards optimal energy store-carry-and-deliver for PHEVs via V2G system," in Proc. IEEE INFOCOM'12, Orland, FL, Mar. 2012, pp. 1674–1682.