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An Alternate to the Problem of complete load Shedding Using Smart Energy Meter

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Abstract: **The power system of our country is dealing with severe issues of energy crisis in Generation, Transmission, and distribution network. The increasing crisis in the energy system is due to technical losses as well as uncontrolled non-technical losses. These all have raised the problem of load shedding for several hours daily. A smart meter in co-operated with the smart grid is presented to counter these issues and provide alternate for complete load shedding problem. This paper proposes an alternate method to counter the load shedding problem through GSM-based smart Meter. The designed meter provides a method to limit the load of a consumer during peak hours. A concept of "Partial load shedding" is introduced in the proposed system. In the partial load shedding, users are allowed to only use their critical loads during peak hours of power demand. This peak time is defined by the utility grid and a signal is sent to consumer's meter through GSM to indicate about peak demand. furthermore, through the modern technology of GSM based energy meter, the consumer will be alarmed to reduce its load than normal dedicated load during the peak hours of load shedding, otherwise, the supply will be cut off after a particular time of the alarm. The proposed system can be implemented with very minimal cost as most of the equipment is already present so there will be no need to upgrade the whole network.**

Index Terms— Load shedding, Partial Load shedding, Smart Energy Meter, Smart Grid.

I. INTRODUCTION

Load shedding is the sequential shedding of power when the utility company is unable to meet the demand of consumers to avoid any failure of the system, especially during peak hours. Different reasons are causing load shedding, some of them are lack of generating capacity, improper planning, lack of adequate transmission and distribution network or it may be theft and mismanagement of power. The major cause of load shedding is improper planning by planning departments. The energy demand of any country is pre-planned, based on the growth of population, increase in per capita income, the expected growth of GDP and increasing number of industries in the country. If the planning department extrapolates all those factors correctly, they would accurately predict the amount of energy demand for future 20 to 30 years. But due to inadequate planning, the gap of supply and demand of electricity can cause troubles. Load shedding has been a major problem of many countries specially Pakistan. Our economy is severely influenced by load shedding. Not only the planning departments are responsible, but some responsibility lies with consumers too. Load shedding facing consumers find alternate means to battle heat of hot summers by running their fans and lit up their nights with UPS and by other means[1]. Throughout the last decade, supply-side constraints have led to significant power shortages in Pakistan. It's at its peak, this amounted to more than 7GW of additional demand gap, which caused the power grid to be offline for a long time a day[2].Pakistan is struggling from power shortages and building in Pakistan absorb 54% of the electricity generated, while the country is ranked 7th in the list of nations most affected by extreme weather events. Pakistan should not only produce more power, but must also use renewable energy resources to achieve the goal of sustainable growth of future[3].

To address the problem of the load shedding by government, serious measures need to be taken and major investments in the power sector need to be made. Particular attention needs to be paid to today's transmission and distribution scenario, as opposed to generation. According to the Pakistan Economic Survey 2019-20, installed electricity generation capacity reached 37,402 MW in 2020. The maximum combined demand from residential and industrial estates is almost 25.000 MW, while the transmission and distribution capacity is approximately 22.000 MW [4]. However, these are long-term initiatives that need constant attention such that the entire transmission and distribution network will need to be fully replaced in the next 8 to 10 years. There is also a desperate need for a short-term solution to deal with the issue of load shedding. Electrical power distribution companies allow their customers to take advantage of heavy loads, including air conditioning, heating, electric motors, iron and so on in off-peak hours instead of peak hours. Its effect can however be reduced by controlling it. Optimization of capital available[4-6]

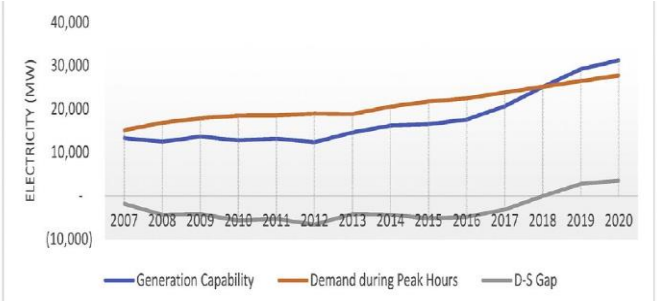

Fig.1. Supply and demand gap of electricity in Pakistan[7].

II. SMART ENERGY METER

The Smart Meter is a modern means of communication using GSM-based technology that allows management and line connections. Bilateral contact is given, as is the monitoring of power directly in the distribution system. Hardware has been developed to make it easier for the service provider to take immediate action when changing usage level[8]. It enables the energy grid to continually track the pattern of usage of various customers and to better control supply and demand for electricity. As the energy reform and economic activity drives price value all over the world, utilities are

doing their utmost to accommodate the smart meter generation that provides a way to measure the information site by allowing all companies to charge different prices depending on the time of use during the day. [9]. These more up-to - date smarter meters are now replacing regular electricity meters. These smart meter use different communication technologies such as Wi-Fi, Zigbee protocol, Power line carrier communication PLCC, and GSM networks. Such an integrated meter infrastructure, also known as (AMI). It allows two-way communication[10].

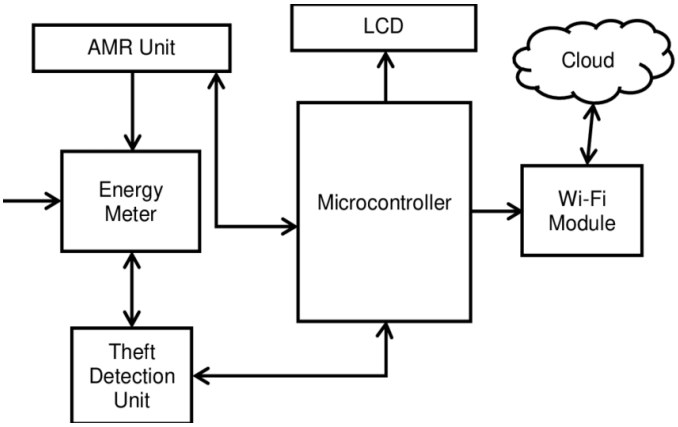

Fig.2. A simple smart Energy Meter[8]

III. Concept Of Partial Load Shedding

This paper presents a novel idea to reduce the problem of complete load shedding of electricity while maintaining the reliability of the utility grid. For this purpose, a smart energy meter is designed using Arduino microcontroller. GSM is used in the proposed system for two-way communication of meter with the utility grid. Proteus software is used to simulate the proposed model. A novel concept of partial load shedding is presented in the paper to face the problem of load shedding. The authors of [11] have discussed a method in which the load of consumer is continuously monitored and if consumer uses more load then particular allocated load its supply will be cut. In partial load shedding the consumer is only allowed to use its critical load. Partial load shedding condition is initiated by the utility grid during peak hours of demand. It helps utility grid to reduce its peak demand to a value that its system can satisfactorily manage without cutting of the complete supply to particular consumers. To initiate the partial load shedding condition the utility grid will first send an SMS to the smart meters of a particular area where the load is to be reduced. After receiving that particular message, the microcontroller in the smart meter will start to compare the reading of current that is flowing at that moment with a preset amount of current already stored in the microcontroller. After comparison If the reading of the current being measured at the moment is greater than the present value of current then first the meter will initiate an alarm to the user. This alarm will signal the user to reduce its load, the alarm will signal for two complete minutes and if the consumer reduces its load from the predefined value within those two minutes then the consumer will be allowed to use that reduced load for a time being. After the peak demand time is over another signal will be sent to the consumer which will signal that consumer can use whatever load demanded. But if the consumer did not reduce its load from the predefined value within those two minutes of alarm then the supply of that consumer will be cut off. That supply will again not return until utility grid sends a second signal which indicated the off-peak time of demand. The predefined value of load current will be decided according to o the connected load and demand factor of consumer.

$$\text{Diversity Factor (DF)} = \frac{\text{Sum of Individual Max Demand}}{\text{Maximum Demand of the System}} \quad (1)$$

The load and the diversity factor are very closely related to each other.[18] The demand factor is the ratio of the sum of maximum demand of the system to the system's whole connected load.

$$\text{Demand Factor} = \frac{\text{Sum of Maximum Demand}}{\text{Total Connected Load}} \quad (2)$$

Normally consumer will be allowed only to use loads of smaller power rating so that the current should not increase beyond the predefined value during load shedding time. But it will be the choice of consumer to us whatever load is required but the value of current should not go beyond predefined value during peak load shedding hours.

IV. Proposed Smart Meter

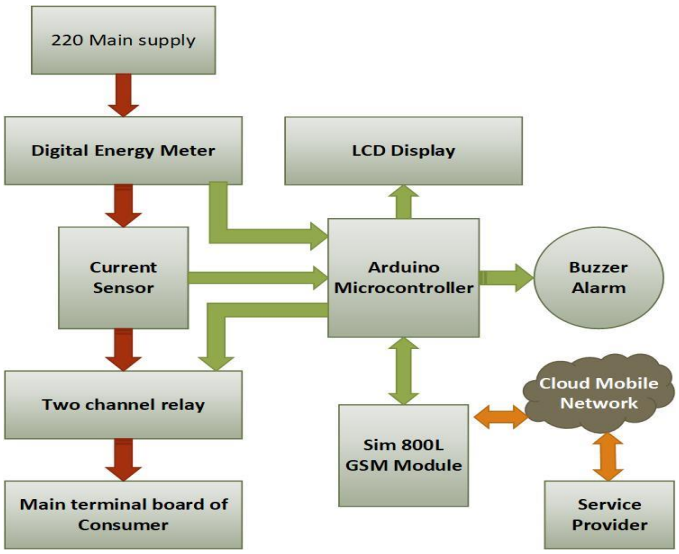

Fig.3. Block Diagram of Proposed Smart Energy Meter

The figure 3 shows the block diagram of the proposed system the red arrows indicate the power circuit voltage and current while the green arrow shows the control circuitry. The 220v from the PMT comes first into the ordinary digital meter. The output from the digital meter is then connected with the current sensor ACS712 which measure the amount of current of load and send a signal to Arduino microcontroller. After the current sensor, the supply goes to two-channel relay which is controlled with Arduino. After the relays module the supply

goes into the main terminal board of consumer. The pulses from the digital meter are utilized to measure the energy consumed blinking of led sends a signal to Arduino and if blinks reach to 3200 then one unit/KWh of energy is consumed. The formula for the energy counting is as.

V. Unit Calculation

In order to calculate the energy from the pulses of digital Energy meter we have to count the pulses of meter. Different meters are designed to generate different number of pulses per KWh of energy consumption, some measure 1 KWh of energy on 1600 pulses some on 2400 pulses and some on 3200 pulses. The meter used in the proposed system measures 1 KWh on 3200 pulses So,
3200imp/kWh= 1 unit.

Unit Consumption = No. of pulses/3200 Unit
Case Study: If no. of pulses is 1000 then unit consumption can be calculated as follows,
Unit Consumption = No. of pulses/3200

A. = 1000/3200 = 0.3125 Unit

The amount of energy consumed by the consumer will be sent to the utility grid through automatic meter reading (AMR). The authors of [12]have developed a working prototype of the GAPMR system that was built to demonstrate the effectiveness and efficiency of automatic meter reading, billing and notification through the use of GSM network.

VI. Comparison With Existing Meters

	Existing Smart Meter	Proposed Smart Meter
Information on usage of energy	YES	YES
Remote reading and billing	YES	YES
Remote supply connection or dis-connection	YES	YES
Remote reconfiguration	YES	YES
Peak load limitation	NO	YES
Home automation	NO	YES
Alarm system for peak hours	NO	YES

VII. Theft Control With Proposed Meter

The proposed smart energy meter can also be used to detect and control the theft of electricity. The theft of electricity is mostly done either by tempering of meter to run slowly or deliberately shut down of meter during a period of the day so that the utility security could not detect it. Having an illegal connection of electricity is another way of stealing electricity which most of people do to avoid the heavy payment of the bill. Worldwide economies lose billions due to theft of electricity every year. Figure 4 shows the loss of economies due to the theft of electricity. According to the report of Northeast Group it reported 89.3 billion US dollar losses have been occurred during the year 2015 in all over the world[12].

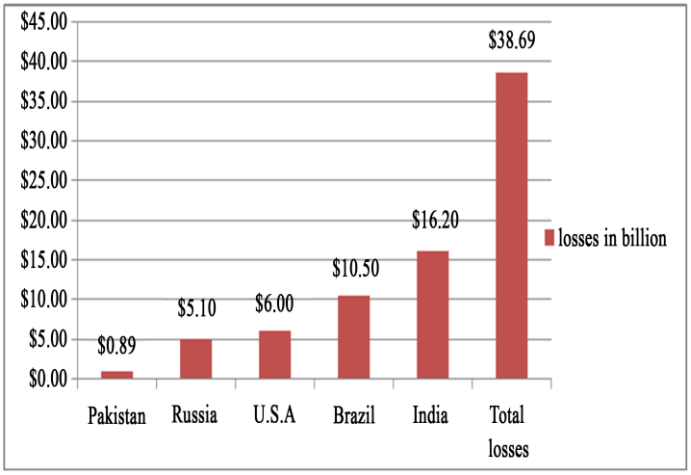

Fig. 4.Loss of Economies due to theft of Electricity[13]

The theft of electricity can be detected by using a three-phase smart meter called intermediate monitor meter on each Pole-Mounted Transformer (PMT) so that the total amount of energy output from the PMT can be measured. This reading will be compared with the sum of all reading of consumer smart meters connected with that PMT. The difference in both readings will indicate the theft. The authors of [14] have discussed a method for detection and control of non-technical loses using intermediate monitor meter method which is employed using IOT in a smart grid. This method of monitoring is shown in figure 6.

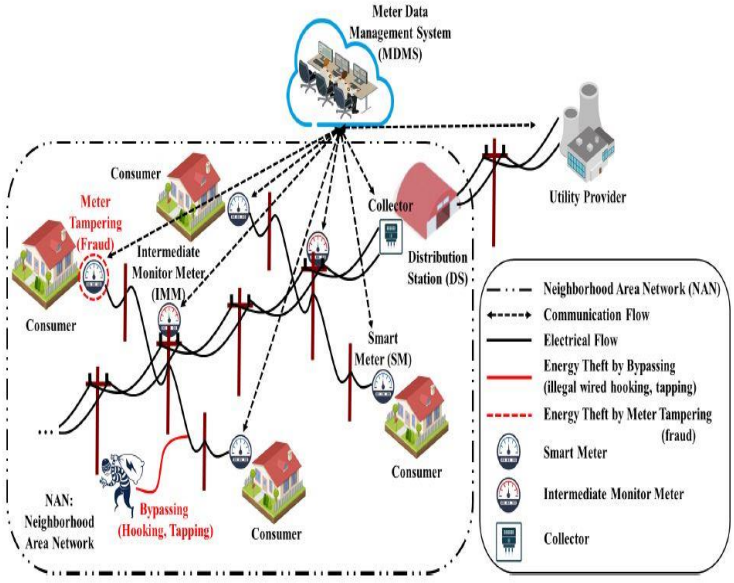

Fig.5.Theft detection with intermediate monitor meter[14]

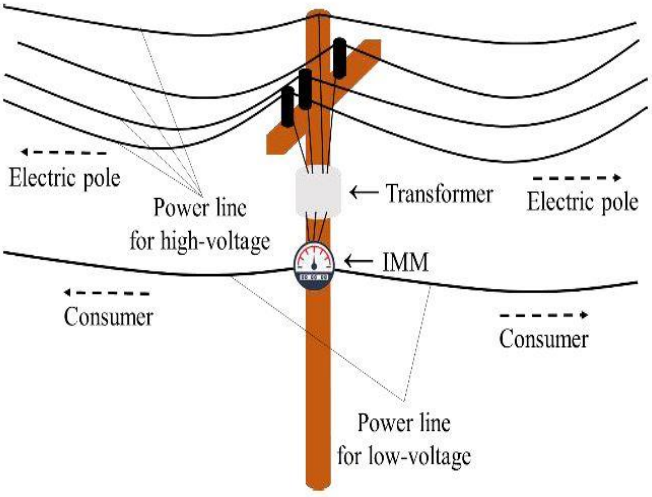

Fig.6. Intermediate Monitoring Meter on PMT[14]

VIII. SIMULATION

Following the concept of the project and partial load shedding the simulation was done on proteus software to observe the effectiveness of the proposed system. The simulation provided satisfactory results. Arduino AT mega 328 is used as a main microcontroller for the proposed system. The Arduino sketch was made according to the desired flow chart of the system on the Arduino IDE software. The flow chart of the proposed system is illustrated in figure 6.

The virtual terminal tool of proteus was used to demonstrate the communication of message in simulation as there was no other tool to represent as a mobile phone for communication with Arduino through the GSM module. The ACS712 current sensor is used to measure the current of the load. A pulse generator is used to simulate for the pulses of an energy meter to measure the energy consumed by the load. The optocoupler is the simulation is used to provide isolation between the pulses of Energy meter and Arduino microcontroller. These pulses of the meter are then counted by Arduino as discussed earlier in section V. The 20x4 LCD display is used to show the Energy Meter readings, Preset Value of the current, present value of current flowing through the load and number of messages sent to the utility grid. The LCD also shows the time when the load shedding condition is sent to the Energy meter. To represent the load of consumer an AC motor is used which is also connected with a relay that will operate in load-shedding condition if the load is not decreased. To vary the current of the load a potentiometer is used which will vary the load voltage an accordingly the load current will vary.

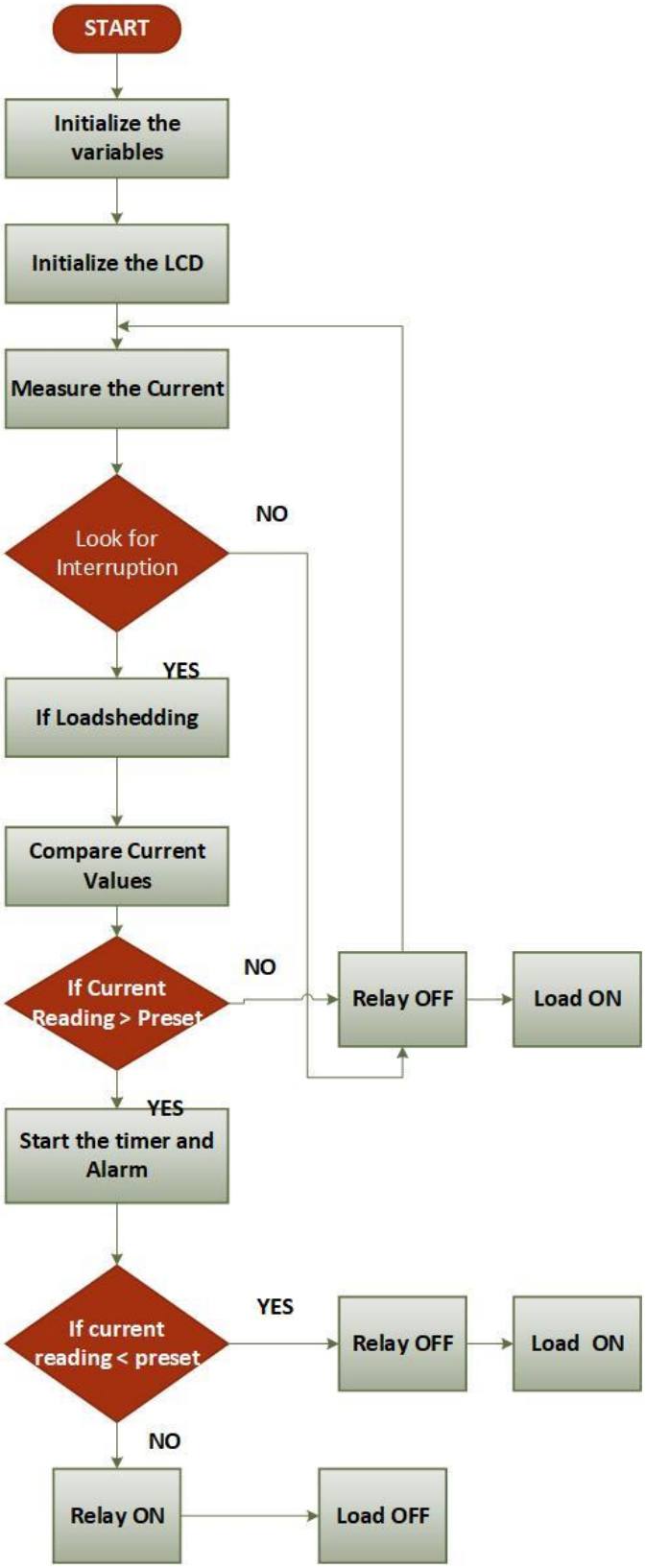

Fig.7. Flow Chart of Proposed Smart Meter

IX. Results And Discussions

The figure 8 shows the simulation model of proposed smart energy meter. In simulation the message was sent to Smart Meter through serial monitor. The figure below shows the connection of GSM and its current situation. Finding Network was printed on LCD screen when the GSM was trying to connect to the network.

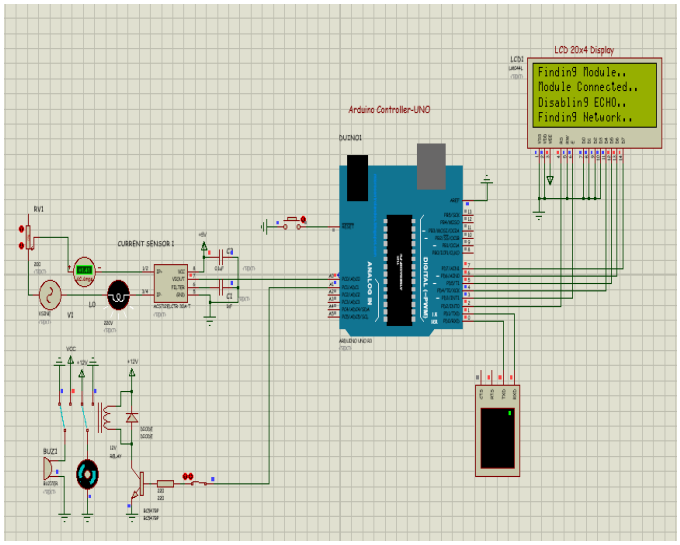

Fig.8.Simulation result of Proposed Smart Meter

This figure 9 below shows the reading of current being measured in Amps and it also shows a preset value of current which is set to one ampere in this simulation. This preset value will be used when load shedding message is sent to Arduino through GSM. The load of Motor is connected which is supplied from 220v supply and controlled through Arduino relay module.

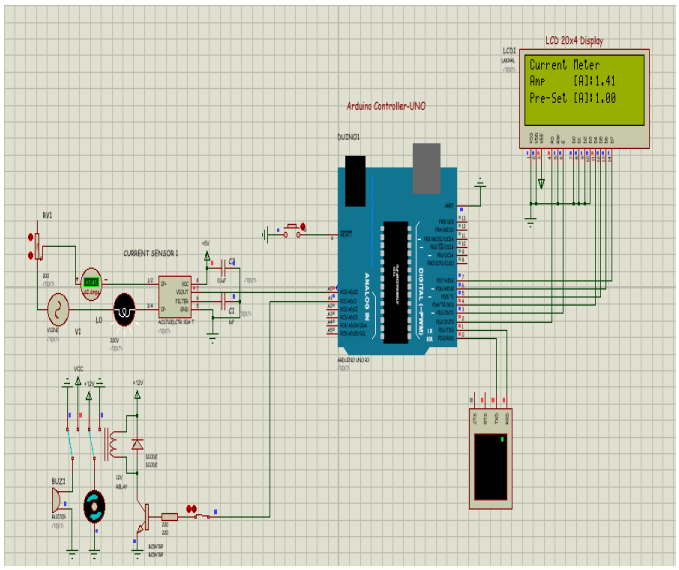

Fig.9. Simulation result of Proposed Smart Meter

Figure 10 shows the reading of energy meter and amount of energy that has been consumed. As the meter reading reaches 10% of 1 KWH unit of energy the Arduino sends the message through GSM. The reading will be sent to a preset number stored in Arduino. In this way the reading of energy meter is read and sent to utility grid through GSM.

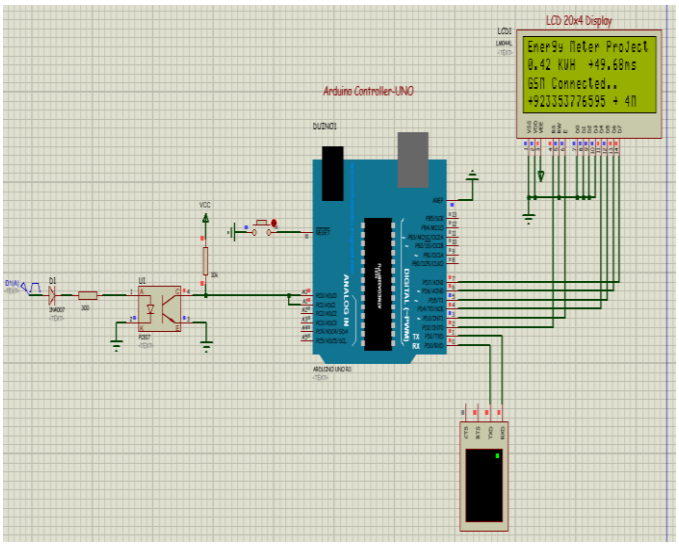

Fig.10.Simulation Result with Energy Meter Reading

X. Conclusion

Smart Metering is emerging technology, the smart meter techniques are implemented day by day across the world. Software-based meters have been presented to provide a better monitoring system, load controlled system, detecting power theft. In this model, bilateral communication is provided between user and service provider with help GSM based technology. With help of GSM-based smart energy meter, which is near future of grid station, proper and reliable access can be reached to control the loads remotely and to know the real value of energy consumption. In this proposed Simulation, automation of load side demand management is provided to the user to run their critical loads during peak hours timing rather go for any other alternatives which could be more costly for consumers. This smart technology reduces human error and enhances the efficiency of the conventional system by reducing power theft by implementing software-based energy meter. It also reduces human efforts as compared to the conventional grid station. This hardware model consists of three premier functions to provide a reliable monitoring system, eliminate the power theft by reducing the illegal connections or direct hooking, better automation of load management by smart technology. with the help of a smart meter technology and access is given to the service provider, to supply the specific amount of power to that user who pay well and cut off the supply at once from those who are not participating in the billing . This proposed hardware an efficient and economical solution for the losses in power system.

REFERENCES

[1]. Ahmad, A., et al., *Impact of wide-spread use of uninterruptible power supplies on Pakistan's power system.* Energy Policy, 2016. **98**: p. 629-636.

[2]. Kazmi, H., et al., *Electricity load-shedding in Pakistan: Unintended consequences, opportunities and policy recommendations.* Energy Policy, 2019. **128**: p. 411-417.

[3]. Zubair, M.J.J.o.R. and S. Energy, *Analysis of net-zero energy housing society in Gwadar Pakistan to mitigate the load shedding problem.* 2018. **10**(6): p. 065906.

[4]. Kalair, A., et al., *Comparative study of HVAC and HVDC transmission systems.* 2016. **59**: p. 1653-1675.

[5]. Khan, N., N. Mariun, and N.J.L.i.E. Abas, *Photon Fuelled Electric Power Plants.* 2008. **18**.

[6]. Khan, N., Z. Saleem, and N.J.L.i.E. Abas, *Endorsement of new SI unit prefixes for space, time, energy and matter.* 2008. **18**(1): p. 107.

[7]. Naeem Nawaz, S.M. and S. Alvi, *Energy security for socio-economic and environmental sustainability in Pakistan.* Heliyon, 2018. **4**(10): p. e00854.

[8]. Gungor, V., et al., *Smart Grid and Smart Homes: Key Players and Pilot Projects.* IEEE Industrial Electronics Magazine, 2012. **6**(4): p. 18-34.

[9]. Rashed Mohassel, R., et al., *A survey on Advanced Metering Infrastructure.* International Journal of Electrical Power & Energy Systems, 2014. **63**: p. 473-484.

[10]. Huh, J.-H., S. Otgonchimeg, and K. Seo, *Advanced metering infrastructure design and test bed experiment using intelligent agents: focusing on the PLC network base technology for Smart Grid system.* The Journal of Supercomputing, 2016. **72**(5): p. 1862-1877.

[11]. Memon, A.A., et al., *Real time monitoring and supervisory control of distribution load based on generic load allocation: a smart grid solution.* 2014. **33**(2).

[12]. Tan, H.R., C. Lee, and V. Mok. *Automatic power meter reading system using GSM network*. in *2007 International Power Engineering Conference (IPEC 2007)*. 2007. IEEE.

[13]. Hussain, Z., et al., *Methods and techniques of electricity thieving in pakistan.* 2016. **4**(9): p. 1-10.

[14]. Kim, J.Y., et al., *Detection for Non-Technical Loss by Smart Energy Theft With Intermediate Monitor Meter in Smart Grid.* IEEE Access, 2019. **7**: p. 129043-129053.

[15]. Bhutta, Zafar (11 June 2019). *"Installed power production capacity rises"*. The Express Tribune. *Retrieved 4 June 2020*

[16]. Rehman, Maha (3 September 2018). "Pakistan's electricity generation has increased over time. So why do we still not have uninterrupted supply?". *DAWN.COM*. Retrieved 4 June2020

[17]. Mehta VK. *Principles of Power System, S. Chand*. New Delhi, India: Chand (S.) & Co Ltd; 2004.

[18]. (2014) World Loses $89.3 Billion to Electricity Theft Annually, $58.7 Billion in Emerging Markets. WASHINGTON, Dec. 9. http://www.prnewswire.com/news-releases/world-loses-893-billion-to-electricity-theft-ann