SMART ENERGY MANAGEMENT SYSTEM FOR DOMESTIC APPLICATIONS IN PAKISTAN

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Abstract—Modern lifestyle has put natural resources under unprecedented strain. The ever increasing demand for energy asks for not only increase in the production of energy but for ways and means to efficiently manage energy from various sources. Pakistan is experiencing the worst energy crisis in its history that has crippled its economy and impeded its GDP growth. Absence of any potent government effort to resolve the crisis has forced the households to look for alternate sources of energy. The solutions employed by the household range from gas powered generator units to solar and wind power units. Fluctuations in gas supply have necessitated the diversity of power sources. Households employing diverse sources of energy need a system that can efficiently manage the available sources of energy to meet the baseline and peak load requirements by using a cost effective mix of the available sources. This paper proposes a smart energy management system that provides the household with a cost effective mix of energy from the available power sources i.e. solar, wind, gas powered generator and the utility (grid).

Keywords*- Efficiently, Energy, management system, Crisis, Fluctuations, Cost effective.*

I. INTRODUCTION

As a matter of fact, demand for energy around the globe is increasing day by day [1]. Though it is very hard to go in parallel as in the form of enhancing the energy production, yet another option there is the proper management of all the available resources in the form of proper utilization according to their presence and keeping in view the economical pattern [2].

This situation demands for an intelligent and time efficient management system to utilize the available sources of energy and distribute the load according to their availability [3], [4].

As mentioned earlier, handling the whole load throughout by the available power from the Grid may not be possible due to the ever growing demand for power around the globe in general and in Pakistan for particular. So other available resources e.g. energy from the wind, solar and gas run generator to be used in such a way to take the load according to the availability of the sources and keeping in view their cost and weather factor especially for wind and solar systems [5].

Maximum energy from sun can be extracted by using the best possible design of solar tracking system [6].

Similarly maximum possible contribution from the wind energy according to the meteorological conditions of Pakistan can be there if the low wind speed profiles are introduced for the purpose [7]. The presence of such available sources demands for a hybrid system for their utilization and proper management [7].

Various energy management systems and novel techniques have been designed and proposed for the purpose, which hybrid mostly two sources into a single package [7]. Such kinds of systems lack the opportunity to take advantage of natural resource all in one.

This paper proposes a solution for the increasing demand in energy in the form of a switching and management circuitry all in a single package keeping in view the availability of sources and the economical pattern. The sources under consideration for the proposed design on the basis of this paper are wind, solar, gas run generator and the power available from the grid. These sources may or may not be available at the same time and in such a situation this piece of work proposes a switching and management circuitry to switch between the sources on the basis of their availability and cost both set by the priority set and demand for the load. The switching part of the circuit switches in between the sources labeled as source S1, S2, S3 and S4 and this switching may be set according to a predefined priority set which is flexible in the sense that a reset option is always there while the management part of the circuit manages the load according to its demand in the form of overload and under load.

II. SYSTEM OVERVIEW

The components used in the circuitry package include an eleven pin relay Sara ANK 3P-N and a relay socket of PF113A. The main purpose of the relay is to switch in between the assigned sources, which comes in the switching part of the project.

For the management part of the circuitry thermal overload relay LR2K0306 is used. The main feature of this relay is to ensure that when any discrete source gets overloaded or under loaded it compensates the load by switching to alternative source. The energy management system is summarized in figure 1.

As shown in figure 1, the sources can be selected on the basis of their readily availability and that fulfill the

economic aspect as well. For example in areas where the solar energy is available in abundance we can set its priority to default and the next abundant source will be used as second priority and so on.

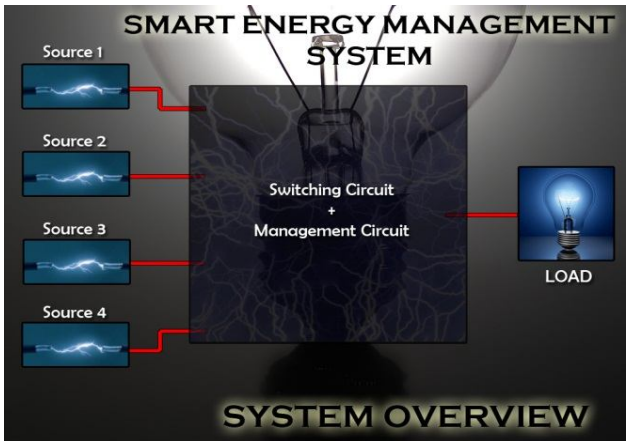

Figure.1. Overview of energy management system

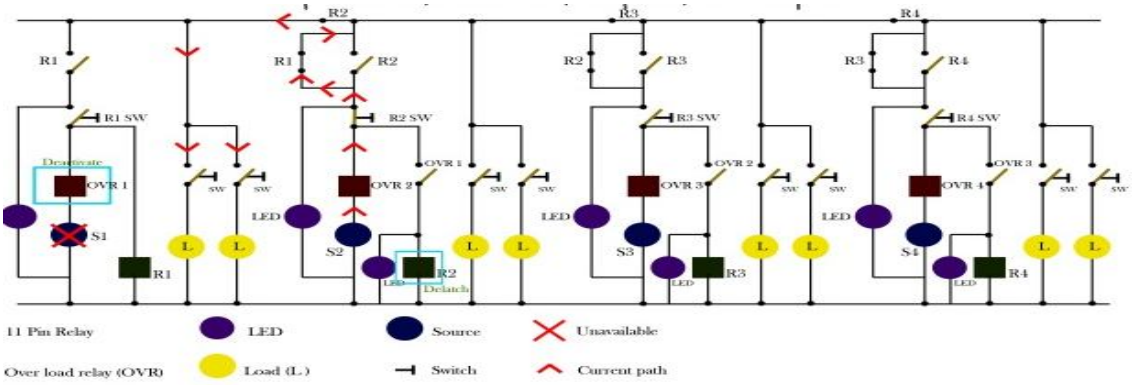

Figure 2. Source S1 is unavaailable

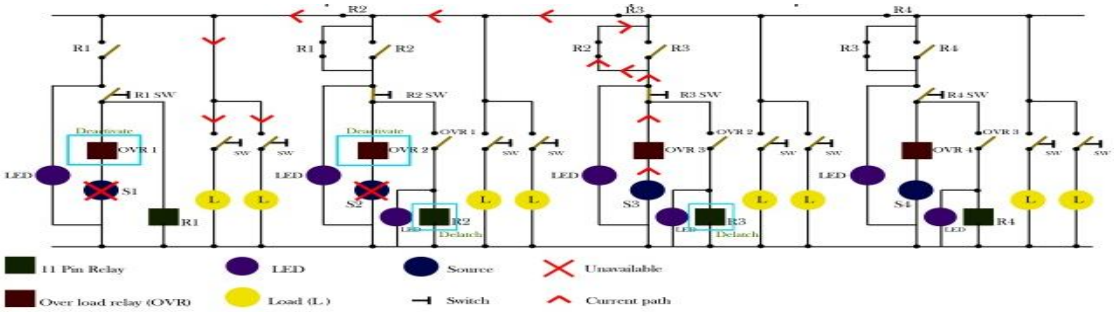

Figure 3. Sources S1 and S2 both are unavailable

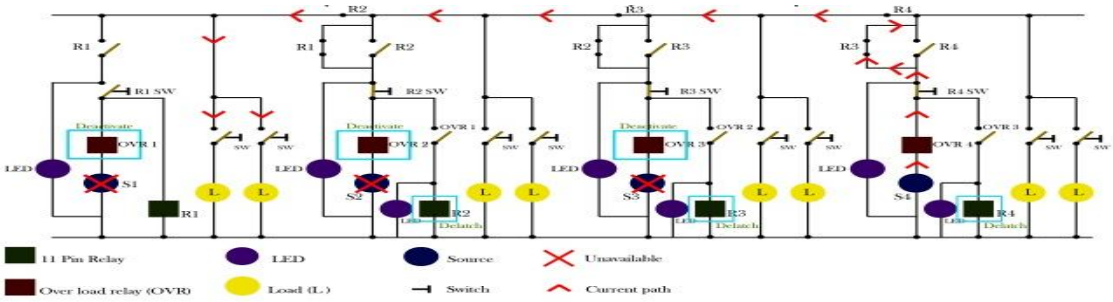

Figure 4. Sources S1, S2 and S3are unavailable

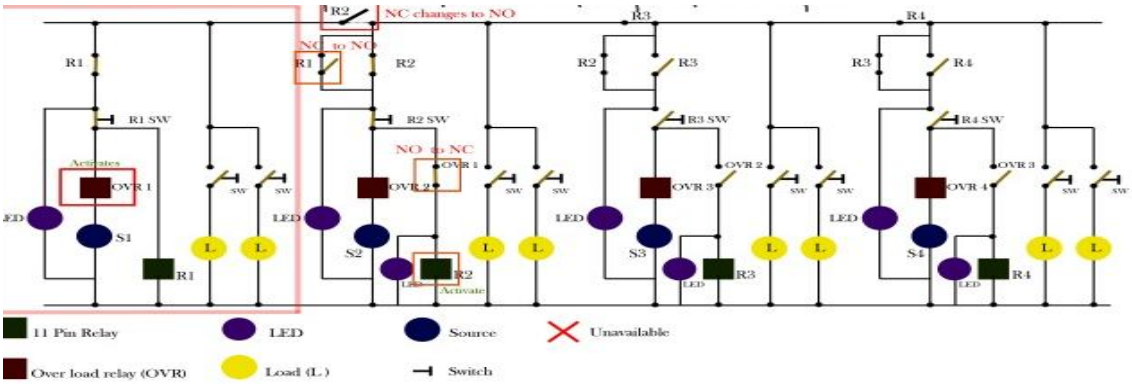

Figure 5. Source S1 is overloaded

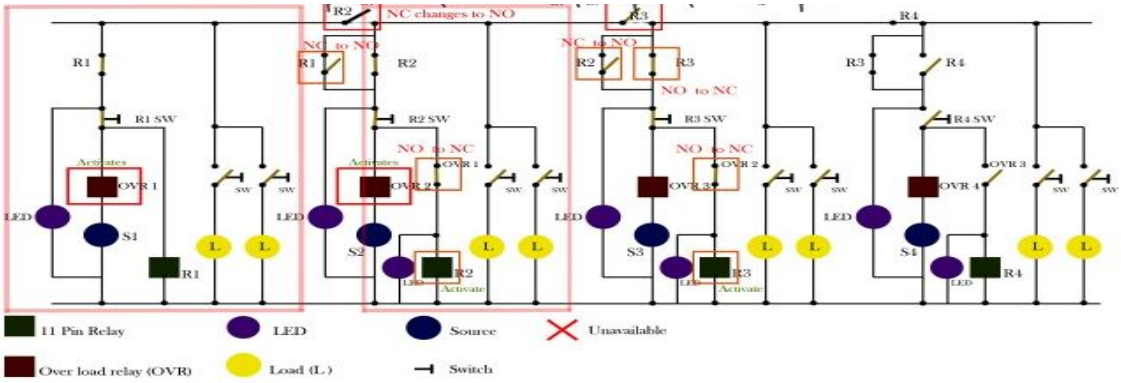

Figure 6. Source S2 is overloaded

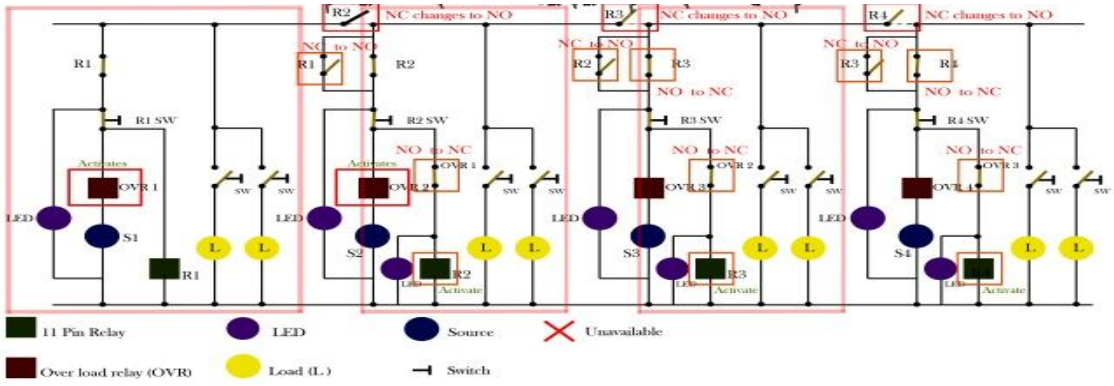

Figure 7. Source S3 is overloaded

A. Working of Switching and management circuit

The switching circuit is actually an uninterruptable power supply (UPS) with multi sources that provides emergency power to a load when the input power source typically mains power fails.

The management circuit manages the load according to the capacity. The circuit ensures if the load exceeds the
capacity of the source it would be compensated by the second available source.

B. Various Cases of Circuit Functionality

Looking at the switching part of the circuit, when the first source (S1) becomes unavailable then the load that is being upheld by the first source is compensated by the second source by means of the following path as shown in figure 2.

As Source S1 is cut off, over load relay OVR1 deactivates which results in de-latching of relay R2 and hence the current is supplied to the load through normally closed (NC) contact of R2.

As a second scenario when sources S1 and S2 are unavailable, it results in deactivating over load relays OVR1 and OVR2 which would ultimately delatch relays R2 and R3

and the current is supplied to the load by means of normally closed (NC) contacts of relays R3 and R2.
In the third scenario when sources S1, S2 and S3 are unavailable it results in deactivating over load relays OVR1, OVR2 and OVR3 which would ultimately delatch relays R2, R3 and R4 and the current supplied to the load by means of normally closed (NC) contacts of R4, R3 and R2

Analyzing the management part of the circuit through case1, 2 and 3 described in figures 5, 6 and 7 we have three possible cases under consideration. When Load on source (S1) exceeds its limit then the extra load is compensated by the second source in such a way as shown in figure 5.

TABLE. 1

	Switching Circuit									
	Source 1	Source 2	Source 3	Source 4	Overload 1	Overload 2	Overload 3	Overload 4	Relay 1	Relay 2	Relay 3	Relay 4
Case 1	unavailable	available	available	available	Deactivate	Load dependent	Load dependent	Load dependent	delatched	delatched	Overload 2 dependent	Overload 3 dependent
Case 2	unavailable	unavailable	available	available	Deactivate	Deactivate	Load dependent	Load dependent	delatched	delatched	delatched	delatched
Case 3	unavailable	unavailable	unavailable	available	Deactivate	Deactivate	Deactivate	Load dependent	delatched	delatched	delatched	delatched

Table for Switching Circuit

TABLE 2.

	Management Circuit									
	Source 1	Source 2	Source 3	Source 4	Overload 1	Overload 2	Overload 3	Overload 4	Relay 1	Relay 2	Relay 3	Relay 4
Case 1	available	available	available	available	activate	load dependent	load dependent	load dependent	latched	latched	Overload 2 dependent	Overload 3 dependent
Case 2	available	available	available	available	activate	Activate	load dependent	Load dependent	latched	latched	latched	Overload 3 dependent
Case 3	available	available	available	available	activate	activate	activate	Load dependent	latched	latched	latched	latched

Table for Management Circuit

As the load exceeds, the over load relay OVR1 gets activated which results in changing the normally open (NO) contact of over load OVR 1 into normally closed (NC) contact which latches relay R2 and ultimately changes the normally closed (NC) contact of relay R2 into normally open (NO) contact and hence it distributes the load on the second source (S2).

As a second situation on management side when load on Source (S2) exceeds then the extra load is compensated by the second source in such a way as shown in figure 6.

As the load exceeds, the over load relay OVR2 gets activated which results in changing the normally open (NO) contact of over load relay OVR2 into normally closed (NC) contact which latches relay R3 and ultimately changes the normally closed (NC) contact of relay R3 into normally open (NO) contact and hence it distributes the load on the third source (S3).

When load on Source (S3) exceeds its capacity, the extra load is compensated by the second source in such a way as shown in figure 7.

As the load exceeds the over load relay OVR3 gets activated which results in changing the normally open (NO) contact of over load relay OVR3 into normally closed (NC) contact which latches relay R4 and ultimately changes the normally closed (NC) contact of R4 into normally open (NO) contact and hence it distributes the load on the fourth source(S4).

C. Prototype Design

On the basis of proposed design and available sources the prototype is developed and tested for various available sources and under different operating conditions. This prototype is shown in figure 8. The whole experimental process on the proposed design tested for switching as well as management purposes is summarized in table 1 and table 2.

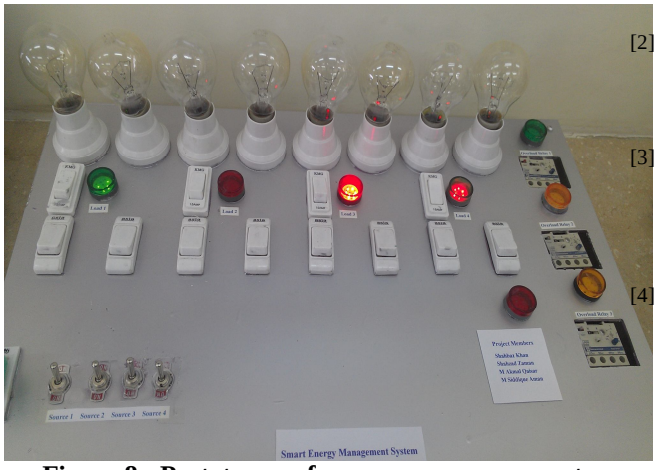

Figure.8 Prototype of energy management system

III. CONCLUSION

The main goal of the project is to utilize and manage the sources which are readily available to us in our daily life according to our requirements. The management part of the project consists of a switching and management circuit. The purpose of the switching Circuit is to provide uninterruptable power supply with multi sources that provides emergency power to a load when the input power source typically main power fails, in addition to this it is also capable in varying degrees of correcting common utility problems.

The management circuit manages the load according to capacity. This circuit ensures if the load exceeds the capacity of the source it would be compensated by the second available source according to the priority set. The goal is achieved using relay logic.

IV. FUTURE RECOMMENDATIONS

For future advancement the relay logic can be replaced by programmable logic controller and micro controller. Further the thermal overload relay LR2K0306 can be replaced with a more precise over load relay e.g. E45 DU for accurate and fast switching. The advanced controllers and fast relays will shorten the delay time between switching in between the available sources.

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