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The Place of Computer Technology in The Production And Management of Alternative Energy: A Case For Solar Energy.

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Abstract

The place of computer technology in alternative energy generation, distribution and utilization for developing society is explored in this work. Ranging from the design process whereby software is developed for use for rapid prototyping to conservation and distribution process, efficiency of energy distribution process is optimized by closely monitoring and controlling processes involved through data collection, interpretation and necessary control. In this paper, the place of computer technology in sustainable alternative energy is narrowed down to solar energy whereby a computer system is automatically harnessed to gather data from an existing solar installation on possible amount of solar radiation within a locality over a period of time, record the amount of energy consumed per period of time, check the charging and discharging rate of solar batteries used through the photovoltaic cells, and shut down supply temporarily when no power is drawn. The body of this paper presents a brief bottom top design of a prototype 5KVA solar inverter interfaced with a computer system with a data base for automatic data storage and as well exhibit some control over the inverter for optimum efficiency. The work pays more attention to the interface points as well as the software development rather than the design of the inverter itself.

Keywords: computer technology, alternative energy, efficiency, data collection, solar radiation

1.0 Introduction

In our modern industrial society we have grown accustomed to having energy 'on tap'. The reality is that almost all energy used to run our consumer society comes from fossil fuels - coal, oil and gas - and these are finite and non-renewable resources. Because fossil fuel resources are limited to the high rate at which they are extracted cannot be sustained for much longer. Now can our planet sustain the consequences of extracting and burning them at an increasing rate without ending in ecological disaster. We are just beginning to appreciate the extent of the environmental problems created by the energy extravagances of wealthy industrial countries. In Europe forests are dying from acid rain laden with sulphur and nitrogen oxides from burning coal. Marine and bird lives are blighted by innumerable accidental and intentional oil spills. Urban populations are often smothered in a haze of unhealthy smog. The 'convenience' for some to commute by car poses a life threat to others with respiratory weaknesses. We are being overtaken by a far more-reaching consequence of burning fossil fuels. The emission of great volumes of gases is adding to the natural greenhouse effect of the atmosphere, trapping more of the sun's energy and causing the earth to become warmer. This is destabilizing the climate of our planet. Carbon dioxide from combustion of fossil fuels is a major contributor to global warming. Also established systems of food and water supply, and forestry and fishing industries are put at risk by the likely destabilization of the climate. As ocean waters expand with warming, coastal lands could be inundated by rising sea levels forcing communities to withdraw to higher ground. People living on Pacific islands would have to migrate en masse to the continents. A quarter of the world's population consumes the lion share of world energy supplies. The average person in a rich country uses more than ten times as much energy as a person in a very poor country though averages disguise inequities between rich and poor within the same country, city and even street (MAUM, 1997). The need for a sustainable and renewable energy source cannot be underplayed.

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On the other hand, meeting the increasing demand for energy poses many challenges: increasing efficiency, developing new supplies, safeguarding the environment and improved and affordable cost. Computer technology (hardware and software) will play a critical role in meeting these challenges. Enhancing efficiency and energy deliverability is greatly tied to good and intelligent softwares, which brings computer technology into play.

2.0 Alternative And Sustainable Sources Of Energy

Sustainable energy is the provision of energy such that it meets the needs of the present without compromising the ability of future generations to meet their needs. Sustainable Energy has two key components: renewable energy and energy efficiency (REEP, 2004). A broader interpretation may allow inclusion of fossil fuels as transitional sources while technology develops, as long as new sources are developed for future generations to use. A narrower interpretation includes only energy sources which are not expected to be depleted in a time frame relevant to the human race, which can potentially also include nuclear power if it is utilized differently from the current manner.

Alternative energy is an umbrella term that refers to any source of usable energy intended to replace fuel sources without the undesired consequences of the replaced fuels (on site renewable energy). The term "alternative" presupposes a set of undesirable energy technologies against which "alternative energies" are opposed. As such, the list of energy technologies excluded is an indicator of what problems that the alternative technologies are intended to address. Controversies regarding dominant sources of energy and their alternatives have a long history. The nature of what were regarded as alternative energy sources has changed considerably. And today because of the variety of energy choices and differing goals of their advocates, defining some energy types as "alternative" is highly controversial. In general, alternative energy is that which is produced without the undesired consequences of the burning of fossil fuels, such as high carbon dioxide emissions, the major contributing factor of global warming according to the Intergovernmental Panel on Climate Change. Sometimes, the less comprehensive meaning of "alternative energy" also excludes nuclear energy. Official use of the term excludes nuclear energy(MNEA Act 593, 2002).

Alternative sources of energy however are considerably more attractive in many ways than nuclear power and related sources.

Alternative sources include Biomass Energy, Wind Energy, Solar Energy, Geothermal Energy, and Hydroelectric Energy. Energy efficiency is also critically important in delivering an economically and environmentally acceptable but **sustainable** source of energy for the 21st century. To raise energy use in the world's poor countries to the level of the rich industrial countries using fossil fuels would require increasing their supply five times. That could be done only by destroying the biosphere on which we all depend for our existence. If we are to have a more equitable sharing of natural energy resources, without further endangering the environment, then wealthy nations will have to cut back greatly on their fossil fuel consumption. Global warming is the spur to doing what should have been done long ago:

i stop profligate use of energy
ii Share the earth's resources more fairly among the living and generations to come.

3.0 Discussion On The Use Of Computer Technology In A Sustainable Alternative Energy.

3.1 Smart Grid

Recently acclaimed smart energy initiative which greatly enhances energy efficiency thrives on computer technology and embedded systems. The term "smart energy" refers generally to actions and technologies that are used to improve the efficiency of energy consumption. Energy demand and costs are increasing rapidly, so utility companies are focusing on adopting communications and networking technologies to help consumers monitor and reduce their energy consumption, (Smart Energy Initiative, 2010). The Smart Grid is realized by merging data from islands of automation to achieve a total end-to-end system view, integrating information technology and operational technology. A smart grid delivers electricity from suppliers to consumers using two-way digital technology to control appliances at consumers' homes to save energy, reduce cost and increase reliability and transparency. Such a modernized electricity network is being promoted by many governments as a way of addressing energy independence, global warming and emergency resilience issues. Smart meters may be part of a smart grid, but alone do not constitute a smart grid.

A smart grid includes an intelligent monitoring system that keeps track of all electricity flowing in the system. It also incorporates the use of superconductive transmission lines for less power loss, as well as the capability of integrating alternative sources of electricity such as solar and wind. When power is least expensive a smart grid could turn on selected home appliances such as washing machines or factory processes that can run at arbitrary hours. At peak times it could turn off selected appliances to reduce demand. Similar proposals include *smart electric grid*, *smart power grid*,*intelligent grid* (or *intelligrid*), *FutureGrid*, and the more modern *intergrid*and *intragrid*(Wikipedia).

In principle, the smart grid is a simple upgrade of 20th century power grids which generally "broadcast" power from a few central power generators to a large number of users, to instead be capable of routing power in more optimal ways to respond to a very wide range of conditions, and to charge a premium to those that use energy at peak hour. This of course is technology in display. Computer technology surely takes an upper part here as a great need for database design is ensured.

2.0 Computer Technology In Sustainable Enegy Management.

Power supply cannot be said to be sustainable if the cost is beyond the reach of the masses. It must be affordable and available with no negative environmental impact. Computer technology, if properly and efficiently harnessed can help reduce production cost by facilitating automatic production process thereby saving labor cost while reducing production time by developing Software for process control and production automation. This does not only fasten production but remove possible human error as well as reduces man power, hence conserving cost.

Beside this, a feedback system to the computer from the renewable energy source is used to gather data over a period of time such that prediction is made on possible amount of energy derivable within the geographical area for stipulated time. This is very important for renewable energy. With this, the most efficient and sustainable renewable energy management technique can be arrived at.

Not only this, in a stand-alone system, whereby the generated energy is used in an enclosure, a feedback from the user to a central computer system can help keep track of power consumption and as well initiate a shut down process in case of overload or any other unpleasant occurrence. Knowledge of power consumption will also enhance prediction of best renewable source for such locality as well as predicts efficiency. By this, it becomes possible to determine pick consumption period and then plan different tariff for such time.

As illustrated in figure 1, consumers 1 to 'n' are connected to the super conductive transmission line through their various smart meters. Wireless communication is ensured between the smart meters and the central computer system situated at the control room. Communication from different smart meters is differentiated by different communicating frequencies. The central computer system keeps track of energy usage, energy demand estimate per consumer, fault detection, credit availability among others. Other data are equally gathered from the renewable energy source, this include, solar radiation over time, total power generated, battery drain time, generated voltage and so on.

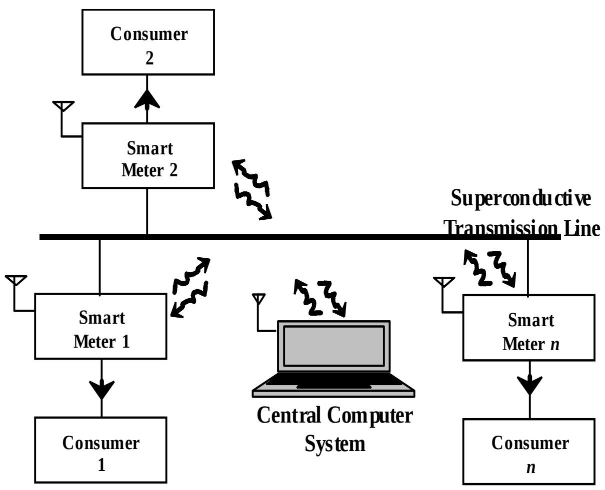


Figure 1: A conceptualized model of System communications design.

Trouble shooting and servicing of energy source can be greatly improved with computer technology. With the right software and hardware interfaces, the state of the device at any point in time can be predicted with suggestion made by the system for possible maintenance or servicing as predicted by the software.

In commercial setup, tracking of users' data, payment and proceed account are properly kept, thereby reducing fraud and poor service rendering.

4.0 Computer Technology In The Generation And Management Of A 5kva Solar Inverter.

The effect of computer technology in a 5KVA solar power generation is briefly discussed, believing that same can be extended to higher power and other alternative energy sources. The block diagram for the design is shown in figure 3. Individual block is briefly explained below.

4.1 Photovoltaic Array.

A **solar cell** is a device that converts the energy of sunlight directly into electricity by the **photovoltaic effect**. Assemblies of cells are used to make solar panels, solar modules, or photovoltaic arrays. The power output of a solar array is measured in watts or kilowatts. In order to calculate the typical energy needs of the application, a measurement in watt-hours, kilowatt-hours or kilowatt-hours per day is often used. A common rule of thumb is that average power is equal to 20% of peak power, so that each peak kilowatt of solar array output power corresponds to energy production of 4.8 kWh per day (24 hours x 1 kW x 20% = 4.8 kWh)(Gupta *et al.*, 2009). To make practical use of the solar-generated energy, the electricity is most often fed into the electricity grid using inverters (grid-connected photovoltaic systems); in stand-alone systems, batteries are used to store the energy that is not needed immediately. Twenty six pieces of 200watts solar panels are connected in parallel to form 5,600watts solar array which converts sun energy into electrical energy. This is fed through solar charge control to charge the batteries.

4.2 Solar Charge Control

The solar charge controller is built around an embedded system, it ensures batteries are not overcharged but charged to its maximum capacity. Its composition primarily include: microprocessor, tyristor, general purpose diodes, resistors, and liquid crystal display. The direct current (voltage) generated by the solar panels is fed into its main input. It has multiple charge inputs where the battery terminals from the five battery banks are fed. The right bank to be charged is selected automatically through the control circuit.

4.3 Battery Bank

This consists of five different sets of batteries. Such that each set can be separately charged or selected to power the inverter at any time. Each set consists of six pieces of 12V, 200AH solar batteries connected in parallel to give 2V, 600AH. The selection of which one to be charged by the panel or used by the inverter is ensured by the embedded system. This is a microcontroller which samples the voltages on each regularly and thus automates selection. This arrangement enhances twenty four hour a day supply.

4.4 Overload Detector Circuit

An overload detector circuit, situated at the output of the inverter enables automatic power shut down whenever the load appear near the maximum capacity of the inverter and at the same time supply power back to the microcontroller via the data selector and the analogue to digital converter (ADC) for the computer system to use the data to enable possible control. The primary winding of a specially wounded 12V transformer serves as an output (elastic) fuse to the load, such that an induce current builds across it as load is applied. This in turn induces the secondary winding which produces some voltage in return. The amount of induced voltage is proportional to the load applied. A voltage conditional circuit, built around some general purpose diodes, resistor, potentiometer and opto-coupler was use to condition this induced voltage to that which is compatible with the ADC and the microcontroller.

4.5 Solar Radiation Meter.

Data bank in the system keeps daily record of solar radiation in the locality. The circuit here works like sun photometer. The same solar panel used for charging is used as the sensor. The circuit is configured such that it interprets sun intensity as voltage proportional to current. The current is of course directly proportional to sun radiation as sensed by the solar panel. Data from this circuit is digitized through the ADC and fed into the microcontroller which then transmits it to the computer system where it is kept in a data bank. Figure 1 shows a simplified presentation of this arrangement.

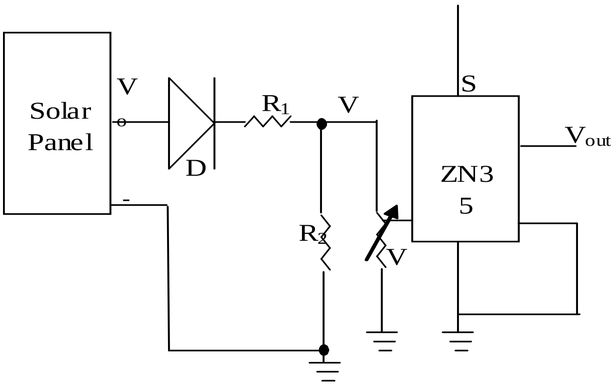


Figure1: Solar radiation circuit

D_1 is a general purpose diode
$R_1 = R_2$ (½ watts 100k resistor)
Vo = ½ Vs, where Vs is the solar panel output at time t.
V_R. is a potentiometer used to condition Vo to a maximum of 5v at maximum sun's intensity.
V_R feeds the input of the optocoupler which directly biases its internal light emitting diode (LED). The higher the sun intensity, the more the V_R and the brighter the LED, hence the higher the V_{out}. This implies that V_{out} varies with sun intensity. V_{out} is fed to the data selector, which feeds the ADC and from ADC to the microcontroller which processes the data and feed the computer system via MAX232. The data is kept in the database and can be retrieved at will.

4.6 Level Converter (MAX 232)

Interacting through the level converter, the pc keeps track of the power being drawn from the load and initiates a shut down if above preset value. The embedded program in the microcontroller takes care of this preset value, 5000watts for a 5kva inverter. The MAX232 from Maxim was the first IC which in one package contains the necessary drivers (two) and receivers (also two), to adapt the RS-232 signal voltage levels to TTL logic. Figure 2 depicts its pin configuration. It became popular, because it just needs one voltage (+5V) and generates the necessary RS-232 voltage levels (approx. -10V and +10V) internally. The TTL/CMOS INPUT receives signal from the microcontroller while RS-232 OUTPUTS feed the transformed data to the computer system. RS-232 INPUTS on the other hand receives data from the computer and feed same to the microcontroller through the TTL/CMOS OUTPUTS.

```
    + - -v- -+
C1+  -|1    16|-  Vcc
V+  -|2    15|-  GND
C1-  -|3    14|-  T1out
C2+  -|4    13|-  R1in
C2-  -|5    12|-  R1out
V-  -|6    11|-  T1in
T2out  -|7    10|-  T2in
R2in  -|8     9|-  R2out
    +--------+
```

Figure 2: Pin Configuration of MAX232

4.7 The Embedded System.

Atmel 8951 microcontroller is used here. This receives various data (such as power consumption, battery banks voltages, solar radiation) from the solar power generator and feed same to the computer via a level converter MAX232. Two ways communication with the system USB port is ensured through a serial to parallel converter cable. Figure four shows the pin configuration of the Microcontroller.

Its features include: (Wikipedia)

i. 256 Bytes Internal RAM
ii. 64 KB External Program Memory Space
iii. 64 KB External Data Memory Space
iv. 32 Programmable I/O Lines
v. Three 16-Bit Timer/Counter
vi. Six Vector, two levels Interrupt Architec ture
vii. Programmable Serial Channel
viii. Separate Transmit/Receive Baud Rate Ca pability
ix. On-chip oscillator and clock circuitry

The AT89C52 is a low power, high performance CMOS 8-bit microcontroller with 8Kbytes of Flash programmable and erasable read only memory (PEROM). This device is compatible with the industry standard 8051 and 8052 instruction set and pin-out. The on-chip Flash allows the program memory to be quickly reprogrammed using a non

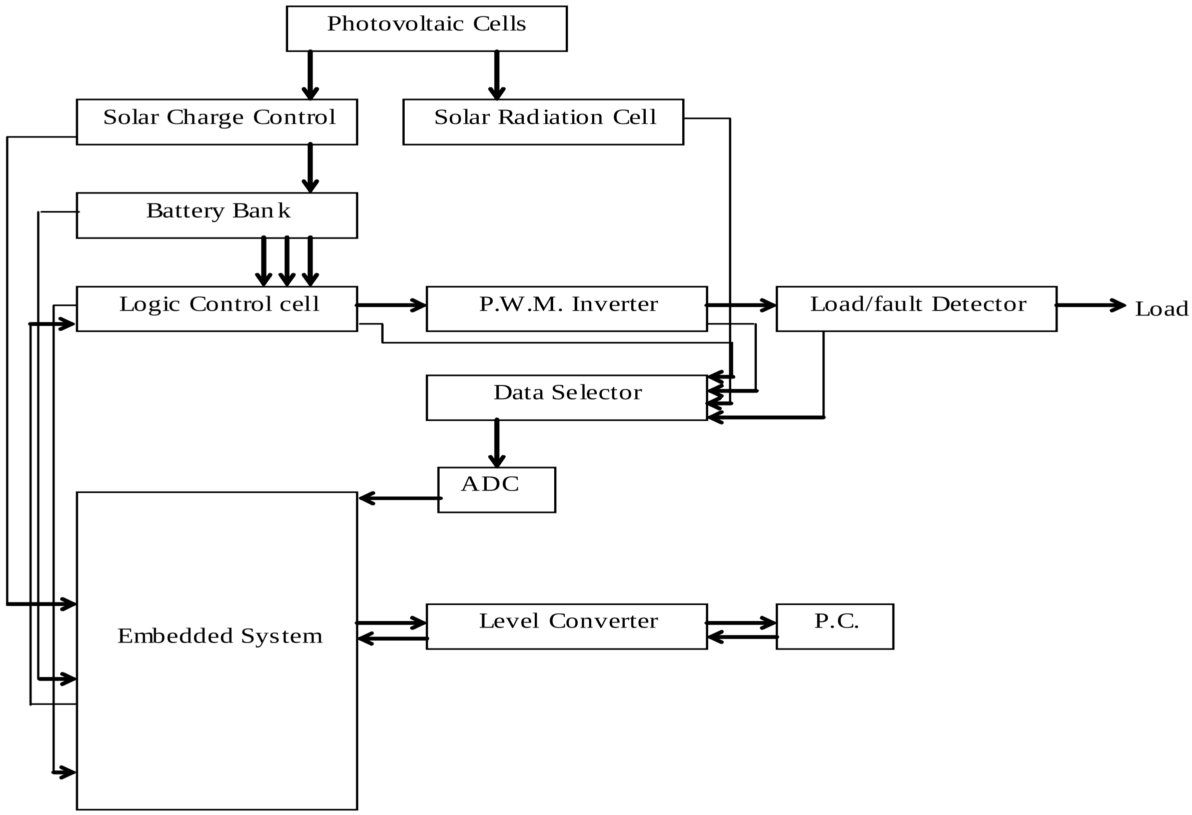


Figure 3: Block diagram of computer enhanced 5kva solar power generator (www.eldi@awka.org).

volatile memory programmer. By combining an industry standard 8-bit CPU with Flash on a monolithic chip, the 8952 is a powerful microcomputer which provides a highly flexible and cost effective solution to many embedded control applications (Rashid,). In addition, the 8952 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The Idle Mode stops the CPU while allowing the RAM, timer/counters, serial port and interrupt system to continue functioning (Mohan and Robins,). The Power down Mode saves the RAM contents but freezes the oscillator disabling all other chip functions until the next hardware reset.

In this design port 0 of the microcontroller is used for the ADC. Port 1bit 0-3 are used for the data selector outputs, the transmit and receive bits of port 3 were connected to the level converter (MAX232). The remaining bits in ports in 3 are used for other control.

Visual basic .net software package is employed to develop the computer program. Structured Query Language (SQL) is used with Oracle for the data base. Based on the nature of data received the system outputs control signals to the solar power generator as appropriate. Device shut down is initiated whenever an attempt to draw beyond its capacity is made. It also determines the right battery bank to be used at any point in time. Data received from the battery can help predict its efficiency.

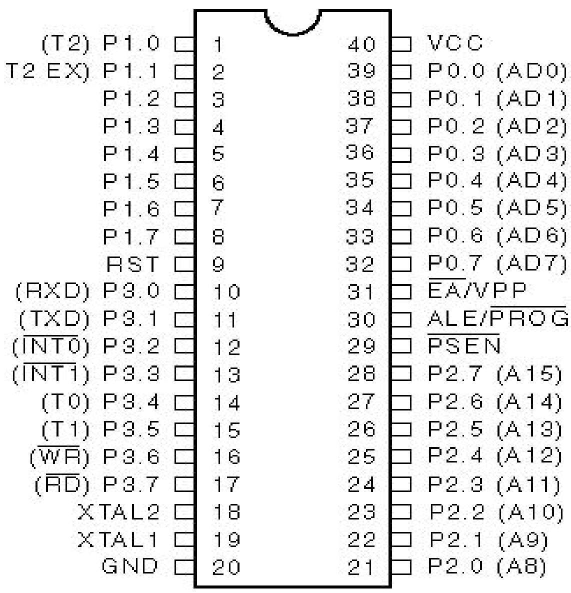


Figure 4: Pin configuration of Atmel 8952

Analysis of data gathered from solar radiation over time is used to determine possible amount of solar power derivable over a period of time. The graph

of radiation against time among other means helped derive maximum power for optimum utilization. At the same time constant monitoring of power consumption helps work out comprehensive energy plan for such location.

4.8 Software Development and Device Simulation

Some steps were followed in the software development for the embedded C program as the programmer is required to plan the program before coding begins (MNEA Act 593, 2002). This process involves:-

i. Reviewing the program specifications and requirements
ii. Designing the program
iii. Coding the Program
iv. Testing the Program
v. Documenting the Program

These processes were observed in the cause of this work.

4.8.1. Program Algorithm

These are pictorial representation of step by step procedures in developing computer programs (MNEA Act 593, 2002). This schematic model is normally used to describe the step involved in developing a computer program where top-down or bottom-up design is involved. In this program, a top-down method of design is employed as it focuses on the big picture and helps users and systems analyst reach an early agreement on what the major functions of the new system are. Extract of the program algorithm used for this design is shown in figure 4.

4.8.2 Program Coding

The third step is coding the program. Here the program is coded in embedded C programming language.

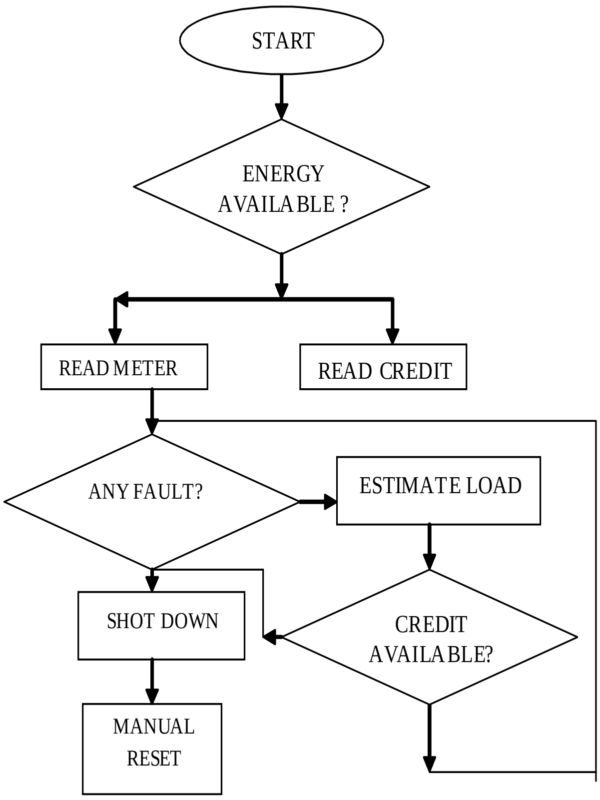
Program coding is the process of writing the necessary instructions in the language selected to solve the problem defined and analyzed in the stages of software development. Embedded C programming language was used here, as it is highly compatible with the chosen microcontroller. A Micro C compiler was used and the program was written, built and necessary debugging was done.

Testing and debugging are vital steps in developing computer program. While testing is the process of making sure that the program performs as intended, debugging is the process of locating and eliminating errors. Error free program are built or ran and various useful files were generated, however only the HEX file is of interest in this case.

4.8.3 Choice of Programming Language

The choice of the language was made due to certain factors, and the factors include:

i. Compatibility with the underlying hardware (the micro controller)
ii. Ability to execute the programs in window environment which is more users friendly
iii. Flexibility and object oriented nature of the program.



5.0 Conclusion

This paper has presented a brief illustration of the place of computer technology in the management of a sustainable alternative energy for a developing society. Computer technology enables greater efficiency in energy management and pricing, fault detection and isolation is enhanced, energy wastage prevention is ensured especially where feedback from user to supplier exists as it is the case with smart energy initiative. It is therefore recommended that every independent energy provider explore this technology to enhance service delivery of a more reliable and robust alternative energy source.

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