CONCLUSIONS AND FUTURE SCOPE

6.1 CONCLUSIONS
The rate at which information and communication technology devices are being produced is proportional to the increase in the energy consumed and heat dissipated by these devices that poses the problem of an energy crisis and exacerbation of the greenhouse gas problem and global warming. We cannot escape the fact that the world is becoming more and more dependent upon the use of ICT, and that personal computers are one of the means. It is predicted that the sales of computers are increasing explosively, therefore reducing the energy consumption of electronic systems as well as personal computers are the biggest challenge for researchers and scientists. This emerging issue of the power dissipation has imposed a very significant question on the system and software design and it is believed that in the future there will be a great demand for energy-sustainable software.

Energy consumption is now becoming an emerging area as a dominant performance measure of the computer systems in place of considering the speed of the system. In the computer systems, the energy management can achieve it variety of ways and these methods vary from hardware to software. We have focused on the various techniques required to minimize the energy consumption by the computer systems. These techniques are getting from hardware centric to operating system centric as the software based techniques are easy to implement as well as they are flexible too. We have also discussed the case scenario of Microsoft Windows power schemes and showed the various discrepancies of these power schemes. We found that most of the time these power schemes are not configured properly and all the power saving modes defined by these schemes consume the 3W – 15W of energy in these modes, which is critical from energy saving point of view. We have also presented the general view of DVFS scheduling algorithms, which are more common in modern computer systems for the energy-aware computing and focus mainly on the abstraction of CPU utilization, the
prediction of the trend in CPU utilization, and the association of the voltage and
frequency values with CPU utilization. From the various discussed approaches the
hardware and software based approaches are getting more attention in this direction. In
future, the operating system should supply a module to do power profiling as well as
supply configurable accuracy.

For designing an energy efficient computer system, ultimately require the
development of fundamental frameworks, algorithmic techniques, and principles that
can be used to guide practical solutions. For the proposed energy sustainable
framework, we have considered the principle of user centric management as personal
computers, televisions, personal media gadgets etc. All these systems are user centric as
they receive inputs from the user and deliver services to them, so their energy
management must be user centric. The main objective of the proposed techniques is to
structure concepts, strategies, and activities to design an energy-sustainable power
scheme. We have implemented the proposed energy sustainable user centric framework
for personal computers, which monitors system workload as well as the user behavior
and represents a good alternative for the existing power schemes of Windows operating
system. This framework is very much user centric as during login to the system it tries
to know the user consensus by knowing the approximate user’s work time on the
machine and implements the two different modes of working for this framework. The
main objective of this framework is to structure concepts, strategies, and activities to
design an energy-sustainable power scheme. This framework is useful for both the
desktops and laptops. The unique characteristic of this framework is that it required
minimal input and calculations for saving energy. We have also compared the
functioning of existing power scheme in Windows operating systems for the proposed
user centric energy sustainable framework and it is find that the proposed modes, Swift
mode and Exhaustive mode detects the human activity on the computer system in an
effective manner and based on the time value supplied by the user during login to the
system. In our comparison results, we have found that Swift mode provides more than
66% of energy savings and exhaustive mode provides more than 93% of energy savings
over existing power scheme in Windows operating system. For the designed energy
sustainable framework, we have proposed two algorithms known as Swift mode
algorithm and USSA algorithm. These algorithms are based on user interactions with
the computer system. Swift mode algorithm tries to know the user consensus before
starting work on the computer system by prompting the user to enter time for login duration and continue its working till the login duration time comes at end. Once the given login duration time expires, the algorithm again tries to know the user consensus. In case, user is available, a new login time value may be supplied otherwise algorithm will switch the computer system to hibernate or shutdown mode to minimize energy consumption. However, the proposed ESSA algorithm is very much different in its functioning with the swift mode and claims for more energy saving. This algorithm constantly tracks the total CPU usage of all running processes on a computer system and whenever it is found that the computer system is in idle mode or the user of the system has left the computer inactive, the algorithm switches the state of the system from idle or inactive to hibernate or shutdown. The working principle of the proposed algorithm is based on determining whether the system is idle or in an inactive state because theoretically at that time the percentage of total CPU usage should be zero, otherwise, as indicated by our various results for cluster machines, it should be below the threshold limit defined by the user to enable the system make the decision to hibernate or shutdown.

In the several performance evaluation results for the proposed framework, we have observed the constant behaviour of the application under swift mode and exhaustive mode. We have observed that there is no any problem regarding memory leakage and garbage collection is performed regularly after a certain period of time. In thread monitoring analysis, threads are created accordingly as the events occurred in both the modes and any unnecessary user threads are not created during the execution of proposed framework. During CPU performance, the analysis methods are executed equal to supplied login duration time and no method or process is noticed for CPU over utilization which in turn is responsible for overall system slowdown. Therefore, these performance evaluation results revealed that the proposed algorithm achieved the proposed goals both theoretically and practically for designing a complete energy-sustainable framework and algorithms. However, the suggested changes can be incorporated into the power schemes of operating systems. We also hope that our framework and algorithms will be useful to the researchers and scientists for the development of a comprehensive solution for the energy-sustainable computing.
6.2 FUTURE SCOPE

Beyond the discussed framework and algorithms in this work, the proposed energy sustainable framework has potential challenges such as the implementation of this kind of framework into Windows operating systems is a tricky process. In the presented work, we apparently restrict ourselves to the percentage of total CPU usage for performing user-centric energy management. However, during the analysis and finding of our results using CPU utilization, we have not considered the usage of primary memory and other peripherals which is not covered in this work but it can play decisive role in making decision by the proposed framework and can be considered into account in the future works. In another decisive factor for the proposed energy sustainable framework that is we have obtained the various results on a Virus and Trojans free-computer systems whereas the presence of Virus and Trojans can increase the total CPU utilization so this can be a situation where user is not present on the machine and proposed algorithm fails to make decision. So, this can also be taken into account in the future works.

In another approach about the scalability of the proposed framework, as at present it is very much restricted to personal computers only and in future works, we can use it for servers, mobile devices and other more user-centric devices like TV etc. by proposing or enhancing the current algorithms and framework. We can extend this work to make it more users-centric by introducing the concept of image processing. As we know that modern mobile devices and computers are equipped with webcam facility in them, which can use it to know the presence of the user on the machine. We hope that, this concept will not only strengthen our ESSA algorithm but also will be able to make more appropriate decision to minimize energy consumption.