GREEN COMPUTING FOR SUSTAINABILITY: A CASE STUDY OF HIMACHAL PRADESH UNIVERSITY, SHIMLA, INDIA

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ABSTRACT

Purpose/Motivation: Himachal Pradesh University, Shimla, India is located in the state of Himachal Pradesh, Western Himalayan Region of India. The Information Communication Technology (ICT) infrastructure including Campus Wide Optical Fibre Network (CWOFN) backbone in Himachal Pradesh University, Shimla, has been working efficiently with high performance. Its networking design was implemented in such a way that it provides redundant optical fibre connectivity. Despite best efforts, always faced challenges due to failure of power from time to time. This network backbone Implemented eight years ago, no steps were taken towards green computing for sustainability, for better solution. The objective of this paper is to achieve "Green Computing for Sustainability on the campus of Himachal Pradesh University, Shimla, India".

Methodology/Design: The CWOFN Backbone has been designed with best state of the art Technologies and redundancies features. Now campus Network has been redesigned w.r.t Green Computing for ICT sustainability for providing clean services on 24 × 7 × 365 basis. One of the major steps has been taken for reducing electrical energy consumption by using solar panels/lamps, solar-based network switches, etc. Details of the complete network redesign has been depicted in this study.

Research Limitations: Unavailability of reliable data of such case studies in other campuses. However, this pertains to the case study of Himachal Pradesh University, Shimla only w.r.t green computing for sustainability.

Findings: By redesigning of campus network and Implementing green computing for sustainability, following are the findings:

1. Use of clean and uninterrupted solar energy for smooth functioning of campus network backbone with high and efficient performance on 24 × 7 × 365 basis.
2. Able to reduce electrical energy.

Implications: Integrating green computing technology with highly sustainable energy-saving practices in Himachal Pradesh University, Shimla. Following are the implications:

1. save funds for electricity bills
2. save environment
3. reduce carbon emissions
4. effective eco-friendly and sustainable solution.

Originality/Value: This real case study is original and done for the first time in the Himachal Pradesh University, Shimla India, which is extremely useful for Green computing sustainability.

Keywords: green; computing; sustainable; Information Communication Technology; ICT; campus network optical fibre.

INTRODUCTION

In today's world of Information Communication Technology (ICT), reliable and efficient access to information has become an important asset in the quest to achieve an advantage with the help of ICT tools. Computer networking technologies are the glue that binds various elements of ICT together. According to Olivier Bonaventure (2011), Networking allows one computer to send information to and receive information from another. We can classify network technologies as belonging to one of two basic groups.

- As per Tenebaum (2003) and James and Kieth (2010), Local Area Network (LAN), technologies connect many devices that are relatively close to each other, scattered around the campus having different buildings.
- Wide Area Network (WAN) technologies connect a smaller number of devices that can be many kilometers apart.

In comparison to WANs, LANs are faster and more reliable, but improvements in technology continue to blur the line of demarcation. Optical Fibre cables have allowed LAN technologies to connect devices tens of kilometers apart, while at the same time greatly improving the speed and reliability within LAN and WAN.

As far as the technologies are concerned, Ethernet technology has been a relatively inexpensive, reasonably fast and very popular in LAN technology for several decades. Two scientists at Xerox PARC, Metcalfe and Boggs (1975), developed Ethernet Technology beginning in 1972 and specifications based on this work appeared in IEEE as 802.3 standard in 1980. Ethernet has been most widely deployed network technology globally.

Keeping above-mentioned technologies in consideration, these have been deployed in the Himachal Pradesh University, Shimla. A live ICT project study for the implementation of Campus Wide Optical Fibre Network (CWOFN) in the Himachal Pradesh University, Shimla, India has been depicted. This network backbone is extremely helpful for providing internet facility and e-journals to the academic community of this university campus.

Green Information Technology (IT): all ICT infrastructure consumes much more power. According to Agrawal and Agrawal (2012) clearly mentioned that survey undertaken by International Data Corporation, higher and higher energy costs were the most pressing reasons for the adoption of Green IT. As per Nagaraju (2013), the ever increasing use of computers and ICT infrastructure has resulted in more and more increasing power consumption, generating great amount of heat, large emission of Green House gases viz. CO_2, methane, Nitrous oxides Fluorocarbon, etc., which continue to have harmful impact on our environment and natural resources in terms of air pollution, land pollution, release of hazardous materials like lead, hg, Cd. It may be noted that several toxic materials are used while manufacturing computers and its devices. At the time of disposal, all these items produce bigger danger towards the degradation of environment, unless they are properly recycled.

Interestingly, a typical single computer consumes about 0.65 KWh in use, 0.35 KWh in standby/ hibernated mode. Assuming that a computer works 220 working days with 12 hrs in operation, 12 hrs in standby mode and 24 hrs in hibernated mode for the remaining 145 days, it will consume 1716, 924, 104 KWh of electricity, respectively. Further, it has been worked out that 1 KWh produces 0.51 Kg of CO_2, which amounts to producing total one ton of CO_2 in a year, as per McBrayne and Lanyon-Hogg (2007). Furthermore, according to Rick Hind (2010) and Greenpeace legislative directions, 20–50 million tons of computer gear and cell phones are dumped into landfills each year, fastest growing segment of waste.

In view of these problems and challenges, various initiatives have been taken at the Global and National level by the various countries at the government level, non-government level, Global agencies and by industries towards creating 'Green and Clean IT' to develop energy efficient and eco-friendly technologies as per OECD (2009).

Thus, Green IT is not a product that one can install and forget, nor it is an application which one can implement overnight. Rather, it is actually a way to look at the entire IT infrastructure, during its whole vicious cycle, having no (minimum) polluting effect on the environment. In this context a few global standards, like Energy Star as per Nagaraju (2013), Restriction of Hazardous Substances (RoHS) have been established.

In this direction, the main challenge remains adopting and implementing a Green IT strategy leading to *diffusion of Green IT innovation.* Various measures towards Green IT may be briefly mentioned, supported with the policies and its compliance for IT transition, as follows:

- Reality check of IT infrastructure.
- Server virtualisation and cloud computing.
- Be energy smart-use Solar power for your computers by Chopra (2008).
- Systematic disposal of e-waste.
- Use of Photonic Integrated Circuit technology (which has terabit per second capacity). The 'Grid' based on this technology is found to be 10,000 times faster than broadband connection as per Hob pages (2008).

Global Scenario: Japan's new action plan towards a zero-based society is tackling e-waste, which a adopted to directives in respect of restriction of the use of certain hazardous substances in electronic equipments (RoHS) and on the electronic waste. The United Kingdom (UK) has one of the largest government Disposal Service Authority (DSA) which is a integral part of defence equipment support and is responsible for reuse, resale and recycling of ICT equipments. IT industry is also applying green standards to their own operations to compensate for carbon emissions created by its data centres. Google and Intel started the climate saver computing initiative in 2007. CISCO also most of this green initiatives by Eco-Board. The global e-sustainability has been established for enabling impact of ICT for sustainability development. Denmark, USA and Japan, European commission and other developed countries have started action plan for green IT according to Wang (2008). Other non-government organisations have also taken lead in this direction.

In India, Manufactures Associate of Information Technology (MAIT) (2011) report, 0.33 million tons of e-waste and additional 3.5 million tons came through illegal import from developing countries. The planning commission from govt. of India has also cleared the proposal to build more than 50 smart IT cities in India by 2018, as per report Smart Cities (2018). In terms of planning the green buildings, housing IT green infrastructure of the green global standards.

Costing of PV System: in Germany in 2011, the price of a residential PV system with a capacity of between 2 kW and 5 kW averaged USD 3777/kW, including installation. In Italy, Portugal and Spain, the price of the equivalent PV system is USD 5787/kW on average, which is about the same as the average in the USA of USD 5657/kW. Larger PV systems with a capacity of between 5 kW and 10 kW in Germany cost USD 3600/kW on average, including installation in 2011. In other countries, such as Italy and Portugal, the average price is USD 5314/kW. In the USA, the average price for these systems is USD 5433/kW, as per, Renewable Energy Technologies (2012).

Photovoltaic is one of the fastest growing renewable energy technologies today and is projected to play a major role in global electricity production in the future. Driven by attractive policy incentives (e.g. feed-in tariffs and tax breaks), the global installed PV capacity has multiplied by a factor of 37 in 10 years from 1.8 GW in 2000 to 67.4 GW at the end of 2011, a growth rate of 44% per year, as depicted Figure 1, As per source – EPIA (2012). With reference to new capacity installations in 2011, it was 27.7 GW, two-thirds more than the new capacity added in 2010. Assuming an average capacity factor of 0.2 would imply that solar PV in 2011 produced 118 TWh of electrical power. This rapid expansion in capacity has led to significant cost reductions, Kersten (2011).

Here we shall restrict ourselves, the campus as objective, to utilising solar power to achieve 'Green computing for sustainability' on the campus of HP University, Shimla, in two steps:

1. Handling network switches at 16 sites.
2. Managing servers, computers, etc., in each building.

Section 2, of this paper discusses the network architectural design of Optical Fibre Backbone on the campus in detail. Section 3 deals with the various subject aspects of 'Green computing' including the global and national level perspective and policies. Section 4 presents the methodology and Green IT architecture, HP University, Shimla, India. Findings of the paper are outlined in Section 5. Implications and conclusion are given in the final section.

Campus Network Design of Himachal Pradesh University: the CWOFN of Himachal Pradesh University is having a very efficient topology with redundancy feature and network design is depicted in Figure 2 consisting of

- Core level.
- Zonal level.
- Edge level/Departmental Level as per Kumar et al. (2012).

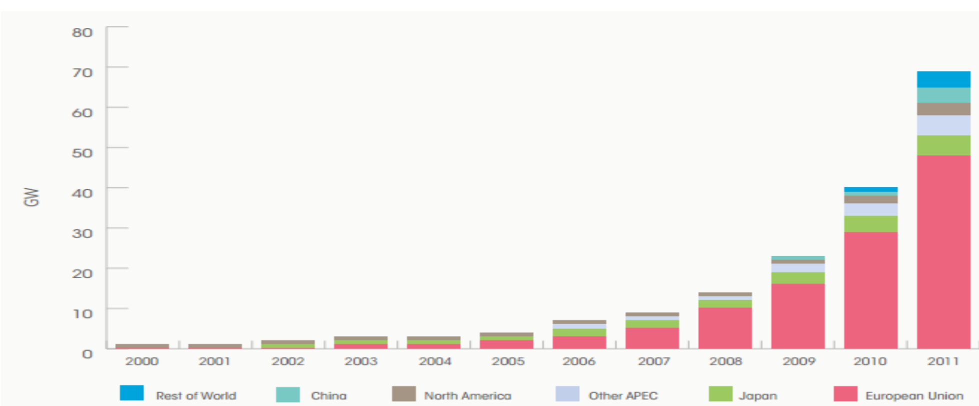


Figure 1 Evolution of global cumulative installed capacity, 2000–2011

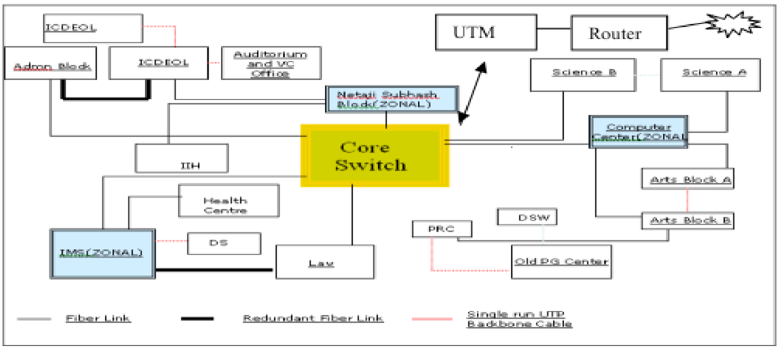


Figure 2 Network design of HP University, Shimla

Network architecture design of Himachal Pradesh University, Shimla is very secure, redundant, reliable and scalable. CWOFN is a hierarchical network topology. The network is divided into three basic different components depending upon the load processing capacity:

- *The department level* (Data Link layer switches) is responsible for the processing the layer 2 traffic of the concerned department. For this purpose a 3 com switches that is, 4400, layer 2 has been deployed.
- *Zonal level* (Network Layer Switches) is responsible for handling complete inter-departmental (Zone wise) traffic within the university campus. To get this job done, university has used 3 Com switch-5500, 10/00/1000 *layer 3* device (Shown in blue colour, in Figure 1).
- *Core Switch* (Multi-Layer Switches) is responsible for all inter zone and outside world traffic over WAN of the University. A 3 Com make, model 7700, 10/100/1000 Mbps switch has been deployed as core switch connecting all the buildings in a star topology (Shown in yellow colour in Figure 1).

On the basis of hilly topography of university campus, it has been divided into three zones, in order to cater the load of each zone, an independent layer 3 switch has been deployed. In total, university has used layer 3 devices catering the need of respective zone. University has also ensured the route wise and logical redundancy in the campus network, so as to provide uninterrupted services to their users. For inter-building backbone connectivity, Terrabyte Optical Fibre has been laid between buildings and CAT6 cable (Gigabit) has been used within buildings for connectivity. Implementing individual Virtual LAN (VLAN) for each and every department has ensured department wise data security.

For providing the ubiquitous ICT facility to the users, University has implemented a pilot project of integration of Wi-Fi over CWOFN facility in the University Institute of Information Technology of Himachal Pradesh University. Wireless access points of 3 com make with a/b/g (maximum speed 54 mbps and nine users handling capacity on real network) compatibility has been used. The low capacity access points were used due to low density regions in the Himachal Pradesh University. A sufficient scope for future extension has been made in the network. Security and efficient utilisation of the network has been ensured by deploying of Unified Treat Management (UTM) Devices.

It clearly depicts that star topology which has been chosen due to reasons mentioned above. This star topology is originating from the multilayer core switch in such a way that the campus is divided into three different zones by implementing Layer 3 switches in Neta Ji Subhash Building, Computer Centre building and management building. These switches cater the needs of the respective zones, which is convenient, if the network packets are travelling intra-zone and this traffic is not coming to the core switch until and unless it is essentially required to travel within different zones on campus LAN or travel over WAN. In total six segments of OFC are originating out of the core switch connecting all the buildings in a star topology. Each Zone has complete redundancy feature which has been depicted by the Optical Fibre Cable. Thus the essential architecture on the campus consists of:

Transmission Media: the architecture used the single mode OFC as the backbone and CAT-6 in networking within the buildings/departments through layer 2 switches.

Core Switch: high performance main core switch (7700 3 Com), having a capacity of 4096 VLANs capability, has been used with switching capacity/backplane of 96 Gbps. This has a maximum aggregate system throughput of 179 Mbps. This core has the redundant power supply.

Layer 3 Switch: high performance layer 3 switch (5500 3 Com switch) These are Zonal switches placed in campus with 3 Zonal (blue in Figure 1).

Layer 2 Switch: high performance layer 2 Switch (4400 Switch 3 Com). These are departmental switches located in different buildings in the campus (Table 3).

Table 1 Green Computing Step-I (Reality Check)

S.No.	*Switch Detail*	*Type of Switch*	*No of Switches Installed in the campus*	*Power of switches*	*KWh on (working for 24 hr)*
1	7700 3 Com	Multilayer (24 Port)	1	550 Watt	13,200
2	5500 3 Com	Layer 3 Switch (24 Port)	2	74 Watt	1776
3	4400 3 Com	Layer 2 Switch (24 port)	24	105 Watt	2520
4	4400 3 Com	Layer 2 Switch (48 port)	02	120 Watt	2880
Total Consumption in Watt				3358 Watt	20,376 KWh per day

Since, 1 KWh produces 0.51 Kg of CO_2, therefore 20,376 KWh produces 10,391.76 CO_2 per day and it produces 3.792×10^5 Kg of CO_2, Annually. This is the first step to save these CO_2 annually, make green environment.

Table 2 Green Computing Step-II (Reality Check)

S.No.	*Items*	*No.*	*Av. Power of each*	*Total Av. Power in W*	*KWh (working for av. 10 hrs)*
1	Server's (16 Blade)	03	2530 W	7590 W	75,900
2	Computer Desk top (with LCD Monitor)	450	200 W	90,000 W	900,000
3	Laptop	150	65 W	9750 W	97,500
4	Printer (laser Printer)	300	200 W (While printing) Idle time-10 W	60,000 W	600,000
5	Scanner	20	20 W	400 W	4000
Total Power in Watt Consumption				167,740/-	1,677,400

Since, 1 KWh produces 0.51 Kg of CO_2, therefore 1,677,400 KWh produces 855,474 kg CO_2 per day and it produces 3.122×10^8 Kg of CO_2 Annually. This is the second step to save these CO_2 annually, make green environment.

Hierarchical star topology or Tree topology is formed into a network by hierarchical in-series connection of multiple star topologies. In practice, it may consist of a combination of fibre optic cables and UTP (CAT5/6) cables, depending on the demands placed on the individual transmission links. Figure 1, schematic representation hierarchical star topology is being shown below which has been implemented in the HP University, Shimla during 2007.

Topology: the most relevant and meaningful topology today is Hierarchy star topology supported by tree/ring topology, which has the following advantages:

- Higher performance.
- Easy to set up and to expand.
- In case of any non-central failure, it will have very little effect on the network. In case of any central failure, routing/communication will still be possible with their respective zonal switch.
- Easy to detect faults.
- Data Packets are sent quickly as they do not have to travel through any unnecessary nodes.
- Integration with wireless (Wi-Fi) implementation is possible at any stage.

Security Architecture: security has several dimensions which are to be tackled in totality. Recent work of success emphasised on how research institutions can have almost complete IT security architecture. The common elements include network security, host security, middleware, directory services and application-based security. Moreover the security architecture must be adapted to keep pace with the constantly evolving technology. The basic steps suggested are as follows:

- Network security which focuses on reducing security risks on 'front door' and enforcing policy through the design and configuration of firewalls, routers and other network equipments.
- Eliminate network components that still use shared Ethernet.
- Use multiple firewalls within the network.
- Implement intrusion detection systems at key points within the network to monitor threats and attacks.
- Implement a virtual private network concentrator for off-campus and wireless access.
- Bandwidth monitoring must be implemented.
- Establish Virus protection with an automated update service on critical systems.
- Perform a risk assessment to identify the most important computers to protect.
- Have and use a networking scanning utility to create a profile for each computer and then disable the network services that are needed on the computers identified.
- Monitor security alerts and develop mechanisms for quickly patching systems.
- Develop a central authentication service to replace host-based password files.

Green Computing: Green ICT is effectively a transition which requires planning to find a way for IT infrastructure. The end objective of Green ICT is to lower operational cost, increase in the efficiency of IT infrastructure without negatively effecting the environment.

Green computing, Green ICT, as per International Federation of Green (IFG) ICT and IFG Standard and its sustainability, is the study with practice of environmentally sustainable computing, ICT practices IT accordingly to Green Technology (2009). Murugesan (2008), notes that Green IT

> "is the study and practice of designing, manufacturing, using, and disposing of computers, servers, and associated subsystems—such as monitors, printers, storage

devices, and networking and communications systems, efficiently and effectively no impact on the environment".

Murugesan lays out the following four pillars along which he believes the environmental effects of computing should be addressed as follows:

- *Green Use*: reducing the energy consumption of computers and other systems as well as using them in an environmentally sound manner.
- *Green Disposal*: refurbishing and reusing old computers, recycling unwanted computers with other electronic equipment.
- *Green Design*: designing energy efficient, environmentally friendly components, computers, servers with cooling equipments.
- *Green Manufacturing*: manufacturing electronic components, computers, associated subsystems with no impact on the environment.

These four pillars cover a number of central areas and activities.

Green computing is all about the efficient use of computers and computing. Green computing can also develop solutions that offer benefits by aligning all IT processes and practices with the core principles of sustainability, which are to reduce, reuse and recycle and finding innovative ways to use IT in business processes to deliver sustainability benefits across the enterprise and beyond, according to Saha (2014).

Owing to global warming, various regulations and laws related to environmental norms forces manufacturers of I.T equipments to meet various energy requirements. Green computing is a well-balanced and sustainable approach towards the achievement of a greener, healthier and safer environment without compromising technological needs of the current and future generations.

The goals of green computing are quite similar to green chemistry which are to reduce the use of hazardous materials, maximise energy efficiency during the product's lifetime, and promote the recyclability or biodegradability of non-operational products and factory waste as per Saha (2014). Departments of many corporate are investing both time and money in green computing initiatives to reduce the environmental impact of their IT operations.

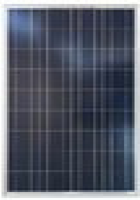
The issue of *Green computing* includes the following:

- Environment and ICT.
- Adoption of Green Computing.
- Green Computing Design and Architecture (Power Consumption, Goals of green computing, Metrics of Green, solutions of green computing, regulation and industry initiative.
- *Green ICT standard and regulations*: Electronic Product Environment Assessment Tool (Epeat), Energy Star 4.00 and RoHS, Waste Form Electric and Electronic equipment (WEEE) Law, Industry associations related, Green Grid.

Methodology

Green Computing (Re) Design and its Architecture: the CWOFN Backbone has been designed with best state of the art Technologies and redundancies features. Now campus Network has been redesigned w.r.t Green Computing for ICT sustainability for providing clean services on 24 × 7 × 365 basis. Following are steps taken toward green computing.

Step I – Solar Panels for Network Switches: one of the major steps has been taken for reducing electrical energy consumption by using solar panels, solar-based network switches, etc. Details of the complete network redesign has been depicted in Table 3. This shows that 4 × 100 Wp solar panels, Figure 3a would be placed in 14 different buildings at each switch location and 4 × 250 Wp solar panels, Figure 3b would be placed as there is a more requirement of power at these two switch locations in two buildings. By implementing these solar panels as per Table 1, CO_2 of 3.792×10^5 Kg would be saved, annually.


(a)


(b)

Figure 3 (a) 100 Wp and (b) 250 Wp

Details of the complete network redesign with solar panels has been depicted in Table 3.

Table 3 Network Switch Details (Steps proposed towards Green Power)

S.No.	*Building Name*	*Location/Deptt.name*	*Switch's Installed*	*Solar Panel (Wp)*	*Total Power (Solar Panel)*
1	ICEDEOL Hostel	BA/BCom Deptt	1	100 × 4 Wp	400 Wp
2	Admin Block	FO Office first floor	1	100 × 4 Wp	400 Wp
		Register office second floor	1	100 × 4 Wp	400 Wp
3	ICWDEOL	Ground floor computer	1	100 × 4 Wp	400 Wp
		2nd floor computer lab	2	250 × 4 Wp	1000 Wp
4	Auditorium and V.C Office	Computer room	1	100 × 4 Wp	400 Wp
5	Neta Ji Subash	Uiit	1	100 × 4 Wp	400 Wp
		MCA	1	100 × 4 Wp	400 Wp
		Bio-Science	1	100 × 4 Wp	400 Wp
		Bio-Technology	1	100 × 4 Wp	400 Wp
6	Central Library	Cyber café (Server Room)	2	250 × 4 Wp	1000 Wp
		Ground floor	1	100 × 4 Wp	400 Wp
		First floor	1	100 × 4 Wp	400 Wp
		Second floor	1	100 × 4 Wp	400 Wp
7	Science-B	Groung floor lab	1	100 × 4 Wp	400 Wp
8	Science-A	Chemistry Deptt.	1	100 × 4 Wp	400 Wp
		Mathematics Deptt.	1	100 × 4 Wp	400 Wp
9	Computer Centre	Ground floor	1	100 × 4 Wp	400 Wp
10	Arts-A	Room No-305-2nd floor	1	100 × 4 Wp	400 Wp
11	Arts-B	Chairman room-pub. Admin	1	100 × 4 Wp	400 Wp
12	PRC	Ground floor	1	100 × 4 Wp	400 Wp
13	Old PG Centre	Computer room	1	100 × 4 Wp	400 Wp
14	Ghandi Bhawan	2nd basement MBA	1	100 × 4 Wp	400 Wp
		Chairman room first floor	1	100 × 4 Wp	400 Wp
15	Law	Ground floor	1	100 × 4 Wp	400 Wp
		Second floor	1	100 × 4 Wp	400 Wp
16	Health Centre		1	100 × 4 Wp	400 Wp

Watt peak (Wp) capacity [1000 Wp = 1 kWp)]. Wp is not the regular power output, but instead the maximum capacity of a module under optimal conditions.

In addition to above solar panels, 12V/20A Maximum Power Point Tracking (MPPT) Solar Controller with Charge Function would also be installed with panel given in Figure 4.

Figure 4 MPPT solar controller with charge function

Step II-Solar Panels for Server/Computer Systems: there are different labs, server room and system available with teachers and staff. For this purpose a grid of 20 KW would be implemented for each buildings, where there are computer labs, server, etc., by implementing this as per Table 2. HP Universtiy, Shimla would be able to achieve more than 80% of green computing and able to save another 3.122×10^{8} Kg of CO_2, Annually as per Table 2.

Advantages for Green Power:

- The prerequisite for solar power is – the sun!
- Solar power can be produced on almost all roofs and open space.
- Apart from the environmental aspects photovoltaic offers itself as a profitable investment.
- *Solar power is a modern way of generating electricity*: regenerative and economical as well as clean and environmentally friendly.
- Every photovoltaic system leads to a reduction of emissions of green house gases by the saving of coal, oil and gas. A 1 kWp solar power system saves the environment approximately 850 kg CO_2 emissions every year!
- The installation of a typical 10 kW roof system can be completed within three to four days. After commissioning maintenance is hardly needed.
- The solar modules are stable and extremely durable. For sensitive components such as inverters long-term maintenance contracts can be concluded.
- Photovoltaic modules have a long performance guarantee – usually between 20 and 25 years.
- The energy payback time, that is the time needed to produce again the energy used in the manufacture of the PV system, is between 3 and 4 years for crystalline solar modules and between 1.5 and 2.5 years for thin-film modules.
- Solar energy has the highest long term potential of all renewable energy sources.

Findings

By redesigning of campus network and Implementing green computing for sustainability, following are the important findings:

- Able to provide uninterrupted power supply to network switches during day from solar panels on 24×7 basis. There is a more demand of power during day time. If there is a power failure during day time then this solution would be extremely useful. Users in the campus would be satisfied with such services.
- To provide clean power to these network switches for smooth function.

- Less damage of switches due to variation of voltage.
- Less power consumption and save energy.

There is limitation of this solution, when it is cloudy during raining season, thundering of clouds w.r.t of safely of these panels. This study pertains to Green powering to network switches in Step I. In the Step II green power will be used for Server, computers, etc., in the campus. Unavailability of reliable data of such case studies in other campuses. However, this pertains to the case study of Himachal Pradesh University, Shimla only w.r.t green computing for sustainability.

IMPLICATIONS AND CONCLUSION

Integrating green computing technology with highly sustainability and energy-saving practices in Himachal Pradesh University, Shimla, following are the implications:

- By implementation of green computing, HP University, Shimla would be able to save 7.094×10^{13} kg of CO_2 annually as per Steps I and II.
- Clean and Uninterrupted power supply to network switches and thus to have smooth internet/network services for all users in campus.
- Less power consumption.
- Reduce carbon emissions.
- Effective eco-friendly and sustainable solution.
- Saving environment.
- Saving funds on electricity bills.

Future Plans: it is highly recommended to use server virtualisation, cloud computing, systematic disposal for e-waste.

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BIOGRAPHICAL NOTES

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