Class-14

GREEN COMPUTING

28th October, 2022

Negative Impact of Technology on the Environment

1. Mining For Minerals

Mining is responsible for deforestation, landscape degradation, water pollution, and the release of vast quantities of Co2 and Co into the air [Machinery-Fuels-Water consumption]

Technology is Mineral Intensive

Around 35 different materials are used in smartphones
Plastic is, after silicon, the second most-used material.
Iron, aluminium, copper, lead, zinc, tin, nickel, and barium (finished products)

2. Massive Energy Use & Carbon Footprint

[Production and transport- Use of device]

3. e-waste

Display

A mobile device's glass screen is very durable because glassmakers combine its

Electronics and Circuitry

The content of copper in a mobile device far exceeds the amount of any other

Examples of mineral commodities used in mobile devices

Mineral commodity	Leading global sources by decreasing tonnage in 2014	Mineral source(s)	Applicable properties of the commodity	Where the commodities are used in a mobile device
Germanium	China[1]	Sphalerite	Conducts electricity	Battery, display, electronics and circuitry, and vibration components.
Graphite	China, India	Graphite	Resists heat, conducts electricity and heat, resists corrosion, and has a high performance-to-weight ratio	Battery anodes.
Indium	China, Republic of Korea	Sphalerite	Transparent and conducts electricity	Liquid crystal displays.
Lithium	Australia, Chile, Argentina, China	Amblygonite, petalite, lepidolite, and spodumene	Chemically reactive and has a high performance-to-weight ratio	Battery cathodes.
Platinum-group metals	South Africa, Russia, Canada	More than 100 different minerals	Conducts electricity	Circuitry, capacitors, and plating.
Potassium	Canada, Russia, Belarus	Langbeinite, sylvite, and sylvinite	Strengthens glass	Screen glass.
Rare-earth elements	China	Bastnäsite, ion adsorption clays, loparite, monazite, and xenotime	Highly magnetic; blue, green, red, and yellow phosphors; and optical-quality glass	LED phosphors, screens, speakers, and vibration motors.
Sand, industrial	China,[2] United States	Silica sand	Gives glass clarity	Screen glass and semiconductors.
Silicon	China	Quartz	Conducts electricity	Semiconductors.
Silver	Mexico, China, Peru	Argentite and tetrahedrite	Conducts electricity	Circuitry.
Tantalum	Rwanda, Brazil, Congo (Kinshasa)	Columbite and tantalite	Stores electrical charge well	Capacitors.
Tin	China, Indonesia, Burma, Peru	Cassiterite	Transparent and conducts electricity	Liquid crystal displays and circuit board solder.
Tungsten	China	Scheelite and wolframite	Highly dense and durable for vibrator's weight component	Vibrator.

[1]People's Republic of China, hereinafter referred to as China.

[2]China is the world's largest producer of industrial sand; however, available information is inadequate to formulate a reliable estimate of output levels.

Banner image courtesy of freevector-archive.com

Bastnaesite is a source of rare-earth elements used to produce magnets in speakers, microphones, and vibration motors.

IT's Impact on Environment

- Energy consumption
- CO_2 emissions
- Disposal of retired equipment
- ...
- But also resulted in more efficient utilization of resources and reduction in pollution.

Energy Cost of PCs

- Typical large university/company spends ~$2M/yr on electricity for its PCs.
- Shut off computer at night?

KWH & Google Search

- One Google search → 0.0003KWH.
  - @10 cents/KWH → 0.003 cents
  - $>10^9$ searches/day → >$3M/day
- 1hr of laptop → 0.05KWH
- 1hr ceiling fan → 0.1KWH
- 1hr coffee maker → 1.1KWH
- Schneider, IEEE Spectrum, June 2011

Semi conductor Manufacturing Plants can use as much water as a small city.

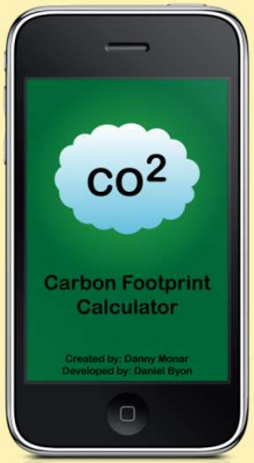
The construction of an average 24-kg computer and 27-cm monitor requires at least 240 kg of fossil fuel, 22 kg of chemicals and 1,500 kgs of water – or 1.8 tons in total, the equivalent of a rhinoceros or sports utility vehicle

Computer manufacturing is much more materials-intensive than making a car or refrigerator, which need only one or two times their weight in fossil fuels.

Challenges

"Moore's law“: Gordon Moore, co-founder Intel, predicted that **computer processing power roughly doubles** every two years.

ICT accounts for **2% of of global CO_2 Emission**



‘ state-of-the-art’ machines threatened by **obsolescence**.

Approx **50 million tons of**

e-trash generated a year worldwide, according to the UN Environment Programme.

Green Computing

In 1992 the US environmental protection agency launched Energy star a labeling program
Designed to promote and recognize energy efficiency in monitors, climate control equipments etc

The term green computing was coined shortly after energy star began

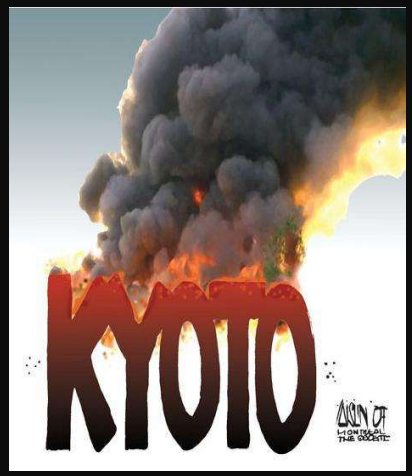
Green computing is the environmentally responsible and Eco friendly use of computers and their resources

It is the study of designing, manufacturing, using and disposing of computing devices in such a way that reduces environmental impact

Green Computing

- Why
  - –Computer Energy is Often Wasteful
    - •Leaving the computer on when not in use (CPU and fan consume power, screen savers consume power)
  - –Insufficient Power and Cooling Capacities
    - •Data centers have insufficient cooling capacities.
  - –Pollution
    - •Manufacturing techniques
    - •Packaging
    - •Disposal of computers and components
  - Toxicity
    - •There are toxic chemicals used in the manufacturing of computers and components which can enter the food chain and water!

Global Effect



Climate Change

e-waste

Green Computing

Three areas of focus

Purchase/Disposal

Responsible computer purchase and disposal considerations

Energy use

Energy use and efficient ways to computing

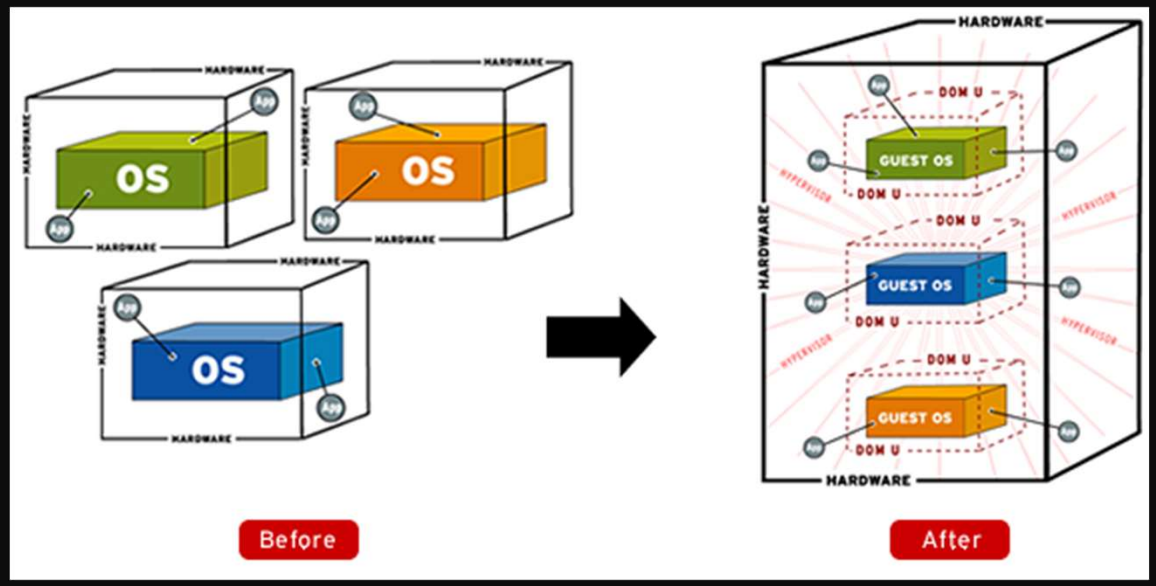
Reducing waste

Using computers to reduce the use of natural resources.

Green Purchasing??

Approaches To Green Computing

1. *Virtualization* : The process of running two or more logical computer systems on one set of hardware



Virtualization helps a company / enterprise lower power and cooling consumption, by reducing the number of machines and servers it needs

Virtualization platforms can run across hundreds of interconnected physical computers and storage devices, to create an entire virtual infrastructure.

2. Power Management

Computers	
Desktop Computer	60-250 watts
On screen saver	60-250 watts (no difference)
Sleep / standby	1 -6 watts
Laptop	15-45 watts

- *Turn off computers and printers when not in use.*
- *Make sure computer is set to sleep when not in use.*
- *Laptops should be preferred over desktops.*

  - *CRT Monitor (17") uses 80 watts.*
  - *LCD Monitor (17") uses 35 watts.*
  - *LED Monitor (17") uses 25 watts.*

LEDs – Rare and Expensive
LCDs preferred for general users.

Energy Star Rated Computer – 80% energy Efficient.
Without Energy Star Rated Computer – 70% Efficient.

3. Algorithm Efficiency : *The efficiency of algorithms has an impact on the amount of computer resources required for any given computing function*

Co_2 Released per search:

Google Search ≈ 0.20gm

Microsoft Live Search ≈ 0.32gm

Yahoo Search ≈ 0.26gm

AOL Search ≈ 0.37gm.

Efficient Algorithm for Search Engines

Less CO2 release.

4. Material Recycling

Disposal of the computing devices constitute 20-50 million tons per year (about 5% of the total waste of the planet) --- e-waste

- *e-waste handling*
- *Reuse*
- *Refurbish*

Where are we going to pull all of it?


Green Use
Reducing the energy consumption of computers and other information systems as well as using them in an environmentally sound manner
Green Disposal
Refurbishing and reusing old computers and properly recycling unwanted computers and other electronic equipment
Green Computer
Green Design
Designing energy-efficient and environmentally sound components computers, servers, cooling equipment, and data centers
Green Manufacturing
Manufacturing electronic components computers, and other associated subsystems with minimal impact on the environment

How to save energy while working on the internet ??

- **Blackle** is a website powered by Google Custom Search and created by Heap Media, which aims to save energy by displaying a black background and using grayish-white font color for search results.
- Blackle saves energy because the screen is predominantly black
- Set Blackle as your homepage.

Thick and Thin Client ?

A thick client is a computer that does not require a connection to a server system to run .

They can benefit from being connected to a network and a server

But the thick client (office computer) is largely independent

"Thin Clients are small, silent devices that communicate with a central server giving a computing experience that is largely identical to that of a PC".

- no hard drives or internal moving parts,
- minimum processing power with a relatively small amount of RAM.
- information sent to the central server which processes the information and returns an updated image to the terminal's screen.
- All applications are stored and run on the server.

Thin Client : Clear Advantages over Thick Client ?

Smaller, lighter equipment that uses fewer

1. **materials** : plastics, precious metals,
2. **energy :** (kWh) : during its use and manufacture (embodied energy)
3. **creates less waste :** (CO_2 and solid material) waste during its use, manufacture and disposal.
4. **uses less process water**

Thick Clients

PC and 17" monitor required 20kgs of materials.

A PC and Monitor's life cycle will include the disposal of 37kgs of non hazardous waste and 0.7kgs of hazardous waste.

The production of a PC & monitor will consume..

3,244 mega joules of energy and 920 litres of process water

Create..

193 kgs of greenhouse gases, also release heavy metals, contribute to acid rain and other air, soil and water pollutants.

Purchase Price of Thin V's Thick
low spec PC costs £400 : Thin client costs £210 Assume
PC life = 5yrs, thin client life = 7yrs.

Energy Savings of Thin V's Thick
Thick Client PC : 75W : Thin Client : 5W energy.

However, Thin Client doesn't always deliver in terms of computing efficiency and involves cost related to additional terminals, hardware, software purchase etc.,

Advantages of Thick Client over Thin Client
In terms of PC's, no need to connect to a server
(virtual servers need to be on 24 x 7)

Queen Margaret University (Edinburgh) saved £50,000 in energy costs alone (at halfway stage) due to thin Client

Infosys

Microsoft | Environment

WIPRO Applying Thought

- Wipro Info tech became the first Indian company to launch environment-friendly range of products named as Wipro Green Ware .
- Infosys framed an Eco club for its employees to reduce its carbon emission.
- Decided to plant one tree for every new employee.

acer hp DELL ViewSonic See the difference

- Leading vendors like Hewlett-Packard, Dell and Acer are adopting green computing by rolling out energy efficient computers made from recyclable materials.
- View sonic in partnership with a range of ISO 14001 certified recyclers offer customers several options and incentives to recycle used products

A Canadian company, Userful Inc. has come up with a solution of multi-sharing that turns 1 computer into 10.This reduces CO_2 emissions by up to 15 tons per year per system and reduce electronic waste by up to 80%.

Companies including Hewlett-Packard Co., Dell Inc., IBM Corp., Sun Microsystems Inc., Advanced Micro Devices Inc., Xerox Corp. have started using less toxic material in products.

Recent Trends In Green Computing Paradigm

Government initiatives have been enforced in the European Union, Japan and a few U.S. states.

Some states, like Texas, require tech companies to offer free recycling programs.

Companies like Yahoo! plan to become “carbon neutral” in the near future.

How can I make my computer Green?

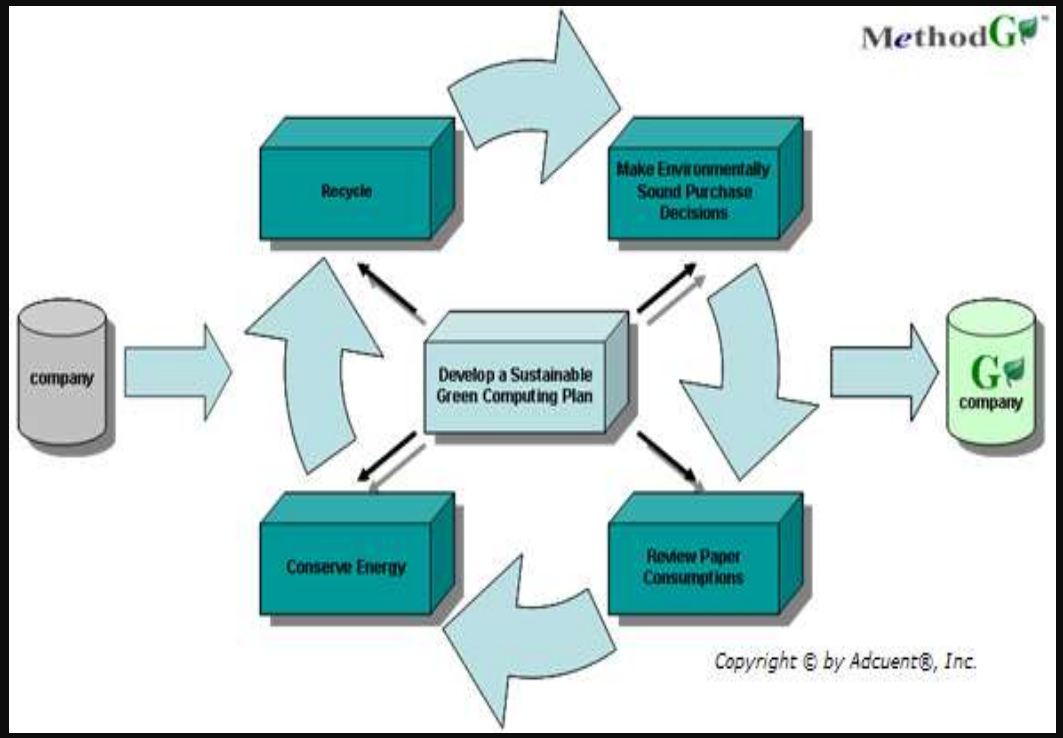
Develop a sustainable green computing plan. ...
Recycle. ...
Make environmentally sound purchase decisions. .
Reduce Paper Consumption. ...
1 ton of office paper -- 24 trees ; 1 tree makes 16.67 reams of paper
1 ream uses 6% of tree ; 1 ton of recycled paper saves 17 trees
Conserve energy

Benefits of green computing

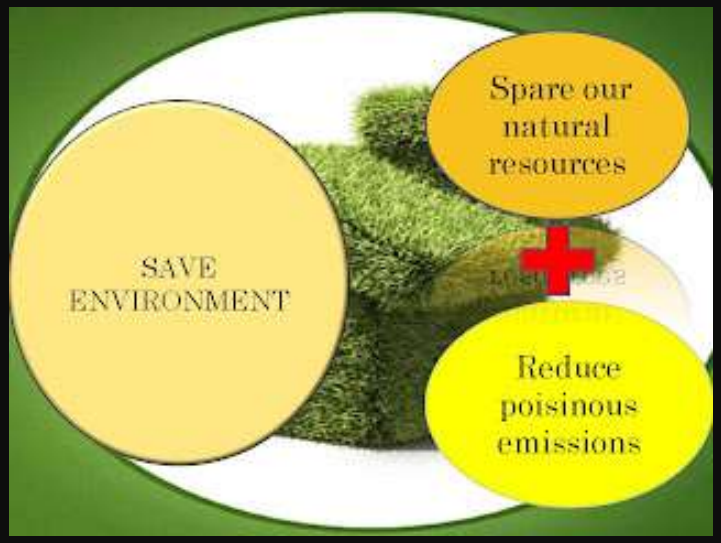
Reduced environmental impact (less GHG emissions, less e-waste, fewer virgin resources needed for manufacturing new devices)
lower energy costs.
longer lasting computing devices.
reduced health risk for computer workers and recyclers

In Summary

Refers to environmentally sustainable computing



New Paradigm of designing the Computer systems Which considers Processing Performance & also the energy efficiency



e-Waste

What is E-waste?

Electronic Waste (e-Waste) - waste electronic/electrical goods which are not fit for their originally intended use. such as computers, cellular phones, stereos, refrigerators, air conditioners, other consumer durables, etc.

Is e-Waste Hazardous?

e--waste is not hazardous waste per-se. However, the hazardous constituents present in the e-waste render it hazardous when such wastes are dismantled and processed, and pose hazard to health and environment.

A pile of electronic waste on a road side in Guiyu, China

Electronic waste in Guangdong, China As much as 4,000 tonnes of toxic e-waste are discarded every hour. Vast amounts are routinely and often illegally shipped as waste from Europe, USA and Japan to places where unprotected workers recover parts and materials.

Toxic constituents in e-waste

COMPONENTS	CONSTITUENTS
➢ Printed circuit boards	Lead & cadmium
➢ Cathode ray tubes (CRTs)	Lead oxide & Cadmium
➢ Switches & flat screen monitors	Mercury
➢ Computer batteries	Cadmium
➢ Capacitors and transformers	Poly Chlorinated Bi-phenyls (PCB)
➢ Printed circuit boards, plastic casings cable	Brominated Flame Retardant
➢ Cable insulation/coating	Poly Vinyl Chloride (PVC)

…fast growing consumption of EEE is leading to creation of e-waste

Recycling scenario in India

- E-waste recycling is presently concentrated in the informal (unorganized) sector
  - No organized collection system prevails
  - Operations are mostly illegal
  - Processes are highly polluting
  - Recycling operations engage in:
    - dismantling
    - sale of dismantled parts
    - valuable resource recovery
    - export of processed waste for precious metal recovery

…expected to rapidly change with formal recyclers setting operations

Concerns: Informal Recycling

- *High-risk backyard operation*
- *Non- efficient and Non-environmentally sound technologies*
- *Occupational and environmental hazards*
- *Loss of resources due to inefficient processes*
- *Impacts vulnerable social groups- Women, children and migrant labourers*

Rotten eggs: e-waste from Europe poisons Ghana's food chain

Toxins from old computers, fridges and other electronic goods are polluting chicken eggs [dioxins & PCB] in an area where 80,000 people live

A man carries electronic waste at the Agbogbloshie dumpsite in Accra

https://www.theguardian.com/global-development/2019/apr/24/rotten-chicken-eggs-e-waste-from-europe-poisons-ghana-food-chain-agbogbloshie-accra

Need for a separate/dedicated legislation

- *E-waste is 'distinct' as it is an end-of-consumption waste while hazardous waste results from a distinct industrial process*
- *Environment Protection Act provides for separate regulations for waste with 'distinct' characteristics - Biomedical Wastes (M&H) Rules- 1998 , lead acid batteries, the Batteries (M&H) Rules- 2001 etc.*
- *The e-waste value chain is rather complex as it involves multiple players - producers, distributors, retailers, end consumers, collection system, recyclers*
- *e-waste recycling involves refurbishment for reuse, dismantling and precious metal recovery which is a complex process*

Legislations/Framework governing e-waste

- Various legislations cover different aspects of e-waste
  - The hazardous waste (management and handling) rules, 1998 as amended in 2008 for Toxic content - registration mandatory for recyclers
  - Municipal Solid Waste Management & Handling Rules for non-Toxic content
  - **Basel convention** for regulating trans-boundary movement
  - Foreign Trade policy restricts import of second-hand computers and does not permit import of e-waste
  - 'Guidelines' by Central Pollution Control Board (2008)

…however there is no dedicated legislation for environmentally sound Management of e-waste

e-Waste guidelines: Salient features

- The guidelines notified in April 2008 - basic guidance document identifying and recognizing fundamental principles:
  - Producer Responsibility
  - RoHS (Restriction on Hazardous Substances)
  - Best practices
  - Insight into technologies for various levels of recycling
- The guidelines explicitly mention the need for a separate legislation for implementing 'Producer Responsibility'

...however these are only voluntary and not mandatory

India's New E-Waste Rules Could Require Businesses to Recycle 80% by 2025

The draft rules would also introduce a system of tradable certificates similar to carbon credits.

VIRAJ GAUR

Published: **26 May 2022, 6:34 PM IST**

TECH NEWS

2 min read

16 Sustainable concept computers for green computing in the future

1. O Project by Dell:

Its skin composed of biodegradable polymers made from bamboo and cornstarch. Its other components too can be returned to the manufacturer for recycling when the model gets obsolete.

2. Biodegradable Desktop computer by Dell

Designed using high-end laser projection technology and with onboard CD drives. doesn't need peripherals such as a monitor or keyboard as it is projected on the floor. its body is carved from bio decomposable starch-based polymer

The electrical parts can be returned to the manufacturing firm when obsolete

3. Solar laptop concept by Nikola Knezevic:

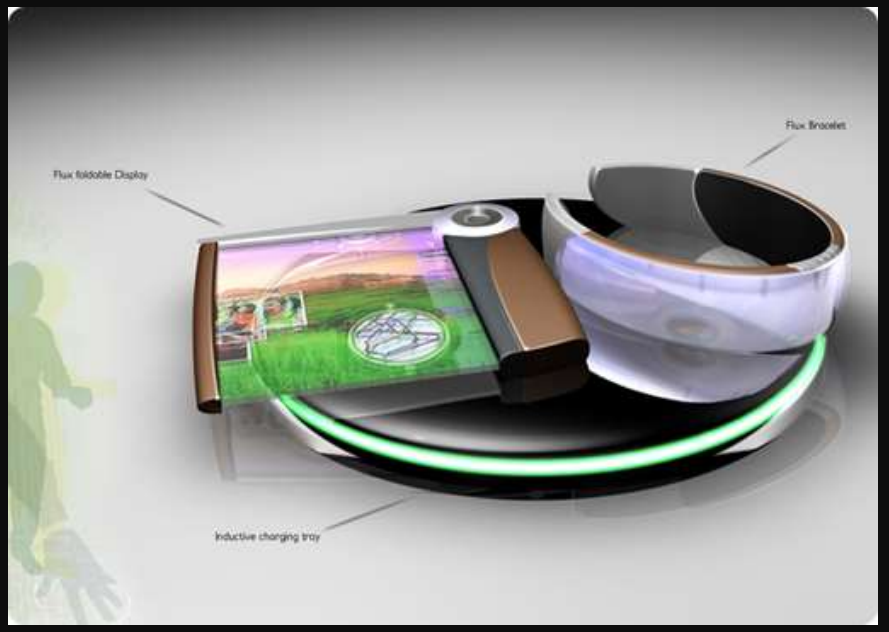
Laptop has attached to its top half a solar panel. This can be folded out to catch sunlight irrespective of whether the laptop is in its open or closed position. This solar panel would thus help harness solar energy. Therefore, it ensures a fully topped up battery pack and a saving on the electricity bill.

4. Environmentally Friendly EVO PC Concept:

It basically consists of two parts – the EVO Base Unit and the EVO Client module. Moreover, the EVO PC is a virtual computer with all upgrades, support and maintenance happening on a remote server. The EVO Base Unit houses connectors to peripherals, network functioning, and power.

5. Flux PC Eco-Friendly Computing System:

The concept is designed around a portable display that interfaces with a wearable bracelet holding the necessary digital information. it also helps interface wirelessly with other computers



6. Lawn PC is a green computing concept:

Designed basically to generate and run on its own harnessed power. it has in its design recyclable grass blades with circuits and solar cells. These are incorporated to help harness power, which can, therefore, save almost 876 KWh power per year.

7. Igglu modular PC concept makes upgrading simple and clean

Designed from standard reusable and recyclable products the high performance, PCI drives, graphic cards, RAM and hard drives

8. Compaq EOS sustainable desktop encourages recycling by easing disassembly

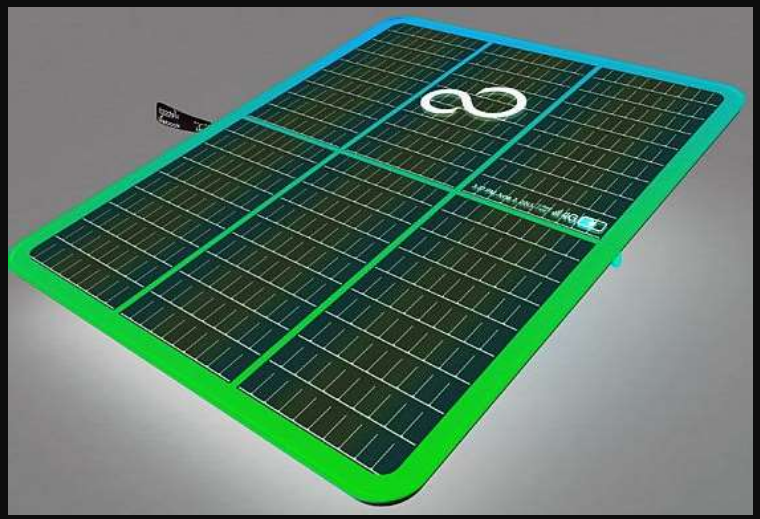
low cost as well as has minimal carbon footprint. this also encourages partial recycling as and when required. Furthermore designed to consume less desk-space. HP in a bid to encourage recycling also offers a take back policy in addition to using biodegradable bio-resins and aluminum within its assembly.

9. ‘Bento’ solar-powered concept computing

A modular and solar powered computing system with features of a smartphone, tablet computer and notebook, all rolled into one. device with integrated solar panels to charge the inbuilt lithium ion battery features a 15 inch OLED screen and a smart-phone. tablet and smartphone can be disengaged and used independently when the battery is fully charged.

10. Lifebook Leaf multipurpose laptop concept

Based on solar power, this computer has a thin OLED touch screen which can be folded like a laptop or spread out flat.
the exterior is made of a shatterproof and optically sensitive polycarbonate
also has a 4G module.



11. Ecofriendly desktop computer that never becomes obsolete

has no screws within its inside which therefore minimizes waste and saves space. With exteriors made of plastic lumber and matte white plastic, the exterior of this system is very thin. The unique design aids the computer to merge harmoniously with the home furniture

12. Avant-grade tablet styled computer keeps e-waste at bay

is environmentally sustainable with facility for upgrading features and other miscellaneous hardware thereby reducing e-waste and overall consumption. Facilitated with an OLED display with stylus input, this concept minimizes the need of peripherals rendering this computer handy and portable.

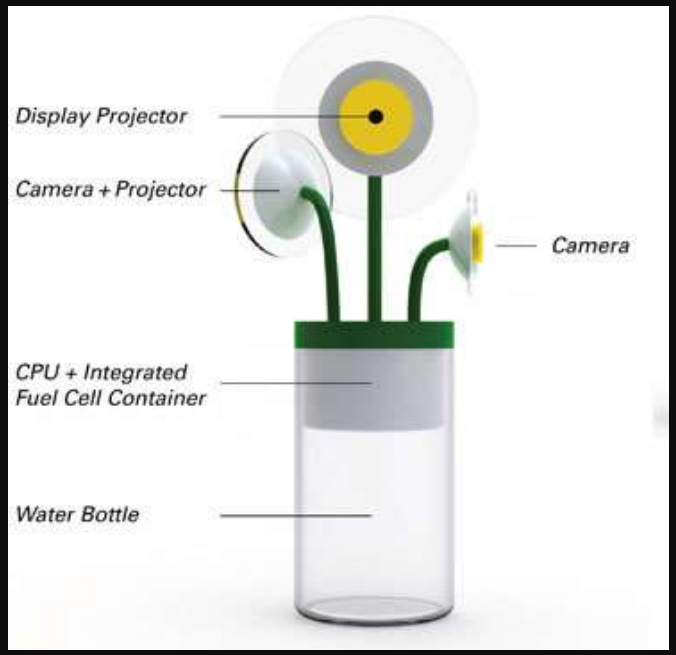
13. Recyclable paper laptop for green computing

Made from pulp materials and recycled paper packed in layers,. Considering its unique design and modeling concept, this computer is definitely recyclable as well as easily upgradeable.

14. Napkin PC – 'Green' computer to encourage group interaction

has a base station for interface control and a Pen for giving out commands The availability of multiple interfaces on this system renders multi tasking easier as well.

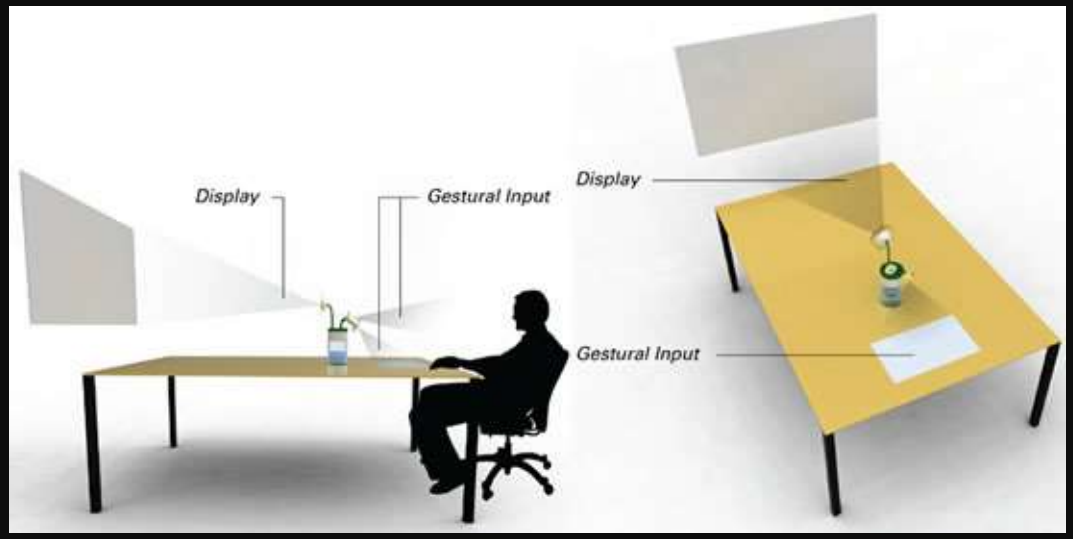
15. Power Flower PC concept for an eco friendly geek!



Getting its feed from the hydrogen fuel cell, the components extend upward, like daises growing towards the sky. The clean, pure, white base of the CPU and fuel cell power supply screws into the bottom of the green field. This in turn rests atop of the clear water container with the white base inset within it.

As power is generated, water drips out of the white base and gets collected in the clear water container. It is ingeniously designed to make it look like random drops of rain falling from leaves after a downpour. Free of other power sources or peripherals and cables or physical sockets, it does manage to accommodate Wi-Fi and Bluetooth.

And getting rid of the keyboard and mouse, a camera captures the movements and gestures of the user on the desk. Also a face camera, which also houses a microphone and speaker, is directed at the person's face. Also the need of a monitor is eliminated as a small display device projects the image on a nearby surface.!



Instead of watering it, you will be able to receive water from it. Which can be reused for drinking, cooking, or even watering real flowers

16. Solar-powered clamshell PC might urbanize rural India

Designed for rural India, this mini PC has a small LCD screen that can roll out of the main body, this solar powered mini PC has facilities for providing online help to the farmers.

For those wanting to give presentations the PC also has a built-in LED projector. With wi-fi connectivity and onboard storage battery that can be charged using its solar panels, this PC is not just green but is also capable of revolutionizing rural India.