Chapter

Introductory Chapter: Green Computing Technologies and Industry in 2021

Albert Sabban

1. Introduction to green computing technologies

Almost every person has more than one computing device. So, there are in our world milliards of computing devices that consume a huge amount, of megawatts. It is crucial to design energy-efficient computers, servers and Tablets. Computer engineers should design and manufacture green computers, servers, Tablets, and other computing devices. The computer industry design and manufacture every year new computing devices. Appropriately disposing, recycling of unwanted computing devices and electronic equipment is a crucial task in creating a green environment.

Green computing is the environmentally responsible use of computers and their resources. Green computing may be considered as the research and study of developing, designing, engineering, producing, using, and disposing of computing modules and devices to reduces environmental hazards and pollution. Computer designers, developers, manufacturing companies and vendors are investing in developing green computing modules and devices by reducing the use of hazard materials and improving the recycling process of computing and digital modules. Green computing is also known as green information technology (green IT).

In 1992 the Environmental Protection Agency (EPA) launched the Energy Star program that boosted Green computing practices.

Green computing practices include the development of environmentally green production practices, efficient energy consumption computers, usage of energy harvesting technologies, and enhancing disposal and recycling procedures.

Green computing main topics and initiatives:

- **Energy Consumption** - Minimizing the electricity consumption of computers and their peripheral devices and using them in an eco-friendly manner

- **Green disposal:** Disposing and recycling, unwanted computing devices

- **Green development and design:** Design and development of energy-efficient computers, servers, printers, projectors, and other digital devices. Usage of energy harvesting technologies in the computer industry.

- **Green manufacturing:** Recycling electronic components and modules during the manufacturing of computers and their peripheral devices. Minimizing waste during the manufacturing of computers and other subsystems to reduce the environmental impact of these activities

The book presents new subjects and innovation in green computing technologies and in green computing and electronics industries. The main topics presented in the book are listed.

- Green computers, electronics, and computing technologies
- Green renewable energy in computers and electronics
- Developing and manufacturing of energy-efficient computers, servers and Tablets
- Recycling and green disposal of computers and digital devices
- Low electricity consumption computers, smartphones, servers and Tablets
- Green production of green computers and digital devices

It is obvious in 2021 to most of the world population that Green Computing Technologies are crucial in protecting our universe from environmental hazards and pollution. In the last century, the world has suffered from rapid changes in climate, water pollution, and air pollution. The universe suffers from severe droughts, seawater acidification, rising seawater levels, increased depletion of groundwater reserves, air pollution, rivers pollution, and global rise of earth temperature. The rapid spread of diseases, viruses, macro-parasites, and the extinction of animal species are the direct result of environmental changes. Most of these changes are irreversible. Countries, governments, communities, and citizens should act rapidly to save the planet. In the last decade we notice that kids and young people lead around the world initiatives to decrease air pollution, water pollution and climate changes.

The private cars industry, electronic industry, high tech computing industry, and the communication industry in the last century depleted and ruined the world natural resources. Computers waste, electronic waste, plastics, and food garbage contain dangerous chemicals that pollute air, soil, rivers water, sea water, and groundwater. These toxic materials cannot be removed from fishes, vegetables, fruits, and other food products. These toxic chemicals can be found in fruits, vegetables and other food crops, fishes, meat, and corps grown on polluted soil. Toxic waste, polluted water, polluted air, and climate changes affect severely first children health and grownup health. The universe oceans, rivers, seas, and lakes suffer from plastic and chemical waste. Chemical toxics and plastic waste kill the ocean and sea habitats in our planet. Hazard materials, chemical toxics, and plastic waste kill fishes, birds, and other creatures. Plastic waste poses choking and strangulation hazards. Plastic particles are making their way into the bottom of the food chain. Fishes and other species swallow plastic waste and become contaminated. These creatures are subsequently harvested for human consumption. The contaminated fishes and creatures, hazard toxics, are served in our plate and reach our stomach.

Green computing, green electronics, green energy, recycling, and waste management and are the important crucial topics and challenges in green technologies, green industry, green research and in green innovation. The book is divided to three sections. Section one presents innovations in green computing and electronic systems. Section two presents green devices and technologies. Innovation in green computing technologies and computing industry are presented in section 3.

2. Green computing and electronics technologies

Green electronics and computing are in continuous growth in the last twenty years. The communication, wireless communication, electronics, and computing industries are facing increasing pressure from governments and legislation to remove toxic and hazardous material from their devices. There is a continual worldwide environmental movement to use green materials, green energy, and green components in production of communication, electronic devices, and computers. There are global series of activities that outline targets for electronic devices re-use and recycling. In green computing and green electronic industries, the use of hazardous materials such as cooper, lead, plastic materials, and other toxic materials is not permitted or limited to decrease pollution and to improve recycling process.

Computers, communication devices, and electronics manufacturers are encouraged and challenged to develop electronic devices that are green and environmentally friendly. Green communication and electronics manufacturing focuses on using green materials, renewable energy, using efficient green devices, using energy harvesting units, reduction number of parts in modules and systems, recycling green materials, recycling energy, and recycling mechanical and electronic components. The book will describe and present development and production of green efficient devices that use green energy in computing and electronic industry. In this regard, energy harvesting technologies that can be employed to produce, recycle, and store green energy are presented in this book. On the other hand, it will present green computing systems and devices that are important factors in developing greener computing and electronic industry. Computers, cell phones and other electronic devices contain toxic hazardous materials that endanger the environment and, consequently, threaten the human health. Recycling of computer and electronic waste minimize the amount of toxic hazardous materials in the environment. Computers developers and manufacturers should handle and take care of electronic waste seriously with first majority. Computers, smart phones, and electronics manufacturers are challenged to reduce the amount, of computers and electronic waste and the number of parts in the system, by designing products that minimize the amount, of parts in the system and of harmful substances and to use parts and components that can be recycled. Computers developers and manufacturers are encouraged to develop products with a longer lifecycle. This book intends to provide the reader with a comprehensive presentation of green computing, green environmental technologies as a global universal standard for projects managers, developers, system engineers and manufacturers.

Main Activities in Green Electronics and Computing

- Green energy
- Minimization in energy consumption
- Green materials
- Electronic waste
- Recycling

3. Green computing- cloud storage and computing services

Cloud storage cut energy consumption, computing expenses such us storage maintenance tasks, and purchasing additional storage capacity. Cloud storage

provides greener computing services. Cloud storage is a service package in which data is stored, managed, backed up remotely and made available to users over a network and internet services. Cloud storage is based on a virtualized infrastructure with accessible interfaces. Cloud-based data is stored in servers located in data centers managed by a cloud provider. A file and its associated metadata are stored in the server by using an object storage protocol. The server assigns an identification number, ID, to each stored file. When file needs to be retrieved, the user presents the ID to the system and the content is assembled with all its metadata, authentication, and security. The most common use of cloud services is cloud backup, disaster recovery, and archiving infrequently accessed data. Cloud storage providers are responsible for keeping the data available and accessible, and the physical environment protected and running. People and organizations buy or lease storage capacity from the providers to store and archive data files. Cloud storage services may be accessed via cloud computers and web services that use application programming interface, API, such as cloud desktop storage and cloud storage gateways.

There are three main cloud-based storage architecture models public, private and hybrid.

Public cloud storage services provide a multi customer storage environment that is most suited for data storage. Data is stored in global data centers with storage data spread across multiple regions or continents.

Private cloud storage provides local storage services to a dedicated environment protected behind an organization's firewall. Private clouds are appropriate for users who need customization and more control over their data.

Hybrid cloud storage is a mix of private cloud and third-party public cloud services with synchronization between the platforms. The model offers businesses flexibility, and more data deployment options. An organization might, for example, store actively used and structured data in a local cloud, and unstructured and archival data in a public cloud. In recent years, a greater number of customers have adopted the hybrid cloud storage model. However, hybrid cloud storage presents technical, business and management challenges. For example, private workloads must access and communicate with public cloud storage suppliers, so solid network connectivity and compatibility are very important issues in this case.

Advantages of Cloud Storage

- By using cloud storage companies can cut their energy consumption, computing expenses such us storage maintenance tasks, and purchasing additional storage capacity.

- Cloud storage provides users with immediate access to a broad range of resources and applications hosted in the infrastructure of another web service interface.

- Cloud storage can provide the benefits of greater accessibility, rapid deployment, strong protection for data backup, reliability, archival and disaster recovery purposes.

- Cloud storage is used as a natural disaster proof backup. Usually there are at least two backup servers located in different places around the world.

- Cloud storage can be used for copying virtual machine images from the cloud to a desired location or to import a virtual machine image from any designated location to the cloud image library.

- Storage availability and data protection are provided by cloud storage services. So, depending on the application, the additional technology efforts, and cost to ensure availability and protection of data storage can be eliminated.

Disadvantages of Cloud Storage

- Decrease in the security level of the stored data.
- Increasing the risk of unauthorized physical access to the data.
- In cloud-based architecture, data is replicated and moved frequently so the risk of unauthorized data recovery increases dramatically.
- It increases the number of networks that the data should travel over them. This disadvantage does not exist in a local area network (LAN) or in a storage area network.
- Data stored on a cloud requires a wide area network.
- A cloud storage company have many customers and thousands of servers. Therefore, a larger team of technical staff with physical and electronic access to almost all, the data at the entire facility. Encryption keys that are kept by the service user, as opposed to the service provider, limit the access to data by service provider employees. An amount, of keys have to be distributed to users via secure channels for decryption. The keys should be securely stored and managed by the users in their devices. Storing these keys requires expensive secure storage.
- Cloud storage is a rich resource for both hackers and national security agencies. The cloud store data from many different users and organizations. Hackers see it as a very valuable target.
- Cloud storage sites have faced lawsuit from the owners of the intellectual property uploaded and shared in the site. Piracy and copyright problems may be enabled by sites that permit file sharing.
- Cloud storage companies are not permanent and the services and products they provide can change.
- Cloud storage companies can be purchased by other foreign larger companies, can go bankrupt and suffer from an irrecoverable disaster.

Cloud Computing.

Cloud computing is an internet computing service that provides shared computer resources, stored data to computers and other devices, and computer processing resources on demand. **Cloud computing** provide access to a shared pool of configurable computing devices such as servers, computer networks, data storage devices, computing applications, and other services. Cloud computing relies on sharing of computing resources. **Cloud computing** services can be rapidly provisioned and released with minimal management effort. Cloud computing and storage solutions provide users and enterprises with various capabilities to store and process their data in privately owned data centers. Cloud computing allows companies to avoid high infrastructure costs such as servers and expensive software. Cloud computing allows companies to get their applications up and running faster,

with improved manageability and less maintenance costs. Information technology teams can rapidly adjust resources to meet unpredictable business demands. Cloud computing applies high-performance computing power to perform tens of trillions of computations per second. Cloud computing allow organizations to focus on their core businesses instead of spending time and money on computer networks. **Cloud computing** and storage solutions cut companies energy consumption.

4. Green renewable energy

Solar energy, wind energy, water energy, and biology fuel are examples of green renewable energy. Nuclear energy, fuel, hydrogen, coal, natural gas, and oil are nonrenewable energy resources. Light, wind, electromagnetic energy, are employed to produce green renewable energy.

4.1 Solar energy

The radiation of the sun is used to produce solar energy. The sun is an infinite limitless source of solar energy. Solar cells convert energy from natural light into electrical energy through the process of photovoltaics. Using solar energy to generate electricity minimize the consumption of coal and fuel. Using solar energy results in a significand reduction in air and environmental pollution. Solar energy farms are presented in **Figure 1**.

Advantage of Green Solar Energy

- does not emit green-house gases
- Solar energy is Green and clean energy.
- Solar energy offers decentralization of power.
- Solar energy is environment friendly. Solar energy does not rely on constantly mining raw materials. Solar energy does not result in the destruction of forests and eco-systems that occurs with many fossil fuel operations.

Figure 1.
Solar energy farms.

- Solar panels produced today carry a 25 to 30 years warranty.
- Solar energy is not degradable.
- Solar light is a free natural resource
- Solar energy does not require expensive and ongoing raw materials like oil, coal, or gas. Solar energy requires significantly lower operational labor than conventional power production. Raw materials should not be constantly extracted, refined, and transported to the power plant.
- Oil, coal, and gas used to produce conventional electricity is often transported cross-country or internationally. This transportation has additional costs, including monetary costs, and pollution costs of transport. These costs are avoided with solar energy.
- On grid means If the house remains connected to the state electricity facility it is called on grid connection. If the house has no connection to the state electricity facility it is called off grid connection. In this case the facility, house, company, business, or a community is relying only on solar energy. The ability to produce electricity off the grid is an important advantage of solar energy for isolated communities, facilities, and rural areas. Solar energy can be produced on or off the grid. Installing power long power lines are significantly difficult and very expensive in these rural areas.
- The sun is an unlimited free commodity that can be sourced from several locations. One of the major advantages of solar energy is the ability to bypass the linkage between politics status and energy price. However, in the fuel markets there is a strong linkage between politics status and energy price. Price of Solar energy is less affected to price manipulations of politics status, war, and international relations. However, politics status manipulations doubled the price of fuel in the past fifty years.

Disadvantage of Solar Energy

- Depend on the weather and sun light
- Expensive installation and maintenance
- Consume large area
- Development and production of solar cite is expensive
- solar energy production is relatively inefficient. The efficiency of solar panels is less than 30%. This means that a huge amount of surface area is required to produce adequate electricity.
- Solar electricity storage technology is expensive, bulky, and more appropriate to small scale home solar panels than large solar farms.

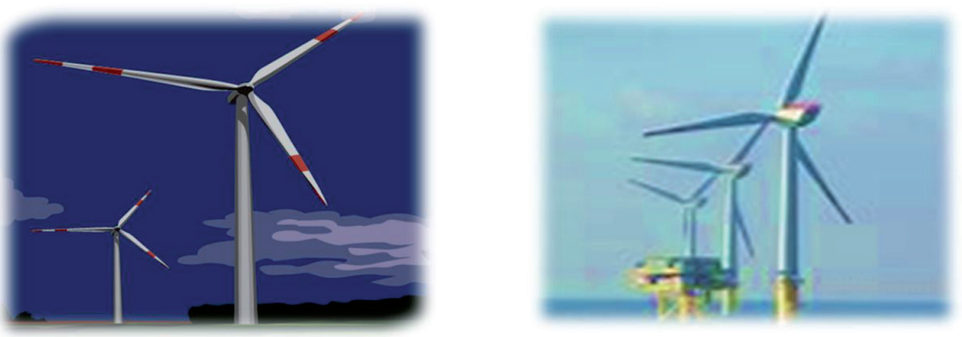
4.2 Wind energy

Global efforts to combat climate change, such as the Paris Agreement, renewable energy is seeing a continues growth. Cumulative wind capacity around the world

increased from around 20,000 megawatts to more than 500,000 megawatts in the last fifteen years. Wind power is a popular sustainable, renewable source of power that has a small impact on the environment compared to burning coal or fuel. Wind energy uses the wind to provide mechanical power through wind turbines to turn electric generators for electrical power. The wind kinetic energy is used to operate electric turbines and windmills. The turbine's blades spin clockwise when the wind blows, capturing energy. When the wind blows the main shaft of the wind turbine, connected to a gearbox within the nacelle, is triggered to spin. The gearbox sends the wind energy by the gearbox to the generator. The wind energy is converted to electricity. However, windmills cannot be operated in a residential area. Offshore wind turbines provide steady, reliable clean energy in several countries. **Figure 2** presents wind energy cites. Wind is a clean source of renewable energy that produces no air or water pollution. Wind energy disadvantages include complaints from locals that wind turbines are ugly and noisy. The turbines rotating blades kill birds and bats.

Advantage of Wind Energy

- Wind energy is a green and clean energy. Wind energy turbines operation does not directly emit any CO2 or greenhouse gases
- Wind energy is plentiful, readily available, and capturing its power does not deplete our valuable natural resources.
- Not degradable
- Wind power is cost-effective in many regions. Wind energy is cheap.
- Wind energy offers decentralization of power.
- Wind energy is environment friendly. Wind energy does not rely on constantly mining raw materials. Wind energy does not result in the destruction of forests and eco-systems that occurs with many fossil fuel operations.
- Wind is a free natural resource
- Wind energy does not require expensive and ongoing raw materials like oil, coal, or gas. Wind energy requires significantly lower operational labor than conventional power production. Raw materials should not be constantly extracted, refined, and transported to the power plant.



(a) (b)

Figure 2.
a. Country wind energy farm b. offshore wind energy cite

- The wind is an unlimited free commodity that can be sourced from several locations. One of the major advantages of wind energy is the ability to bypass the linkage between politics status and energy price. However, in the fuel markets there is a strong linkage between politics status and energy price. Price of wind energy is less affected to price manipulations of politics status, war, and international relations. However, politics status manipulations doubled the price of fuel in the past fifty years.

- Oil, coal, and gas used to produce conventional electricity is often transported cross-country or internationally. This transportation has additional costs, including monetary costs, and pollution costs of transport. These costs are avoided with solar energy.

Disadvantage of Wind Energy

- Depend on the weather and wind velocity
- Cannot be operated in a residential area
- Consume large area
- Development and production of wind energy cite is expensive, land is expensive.
- Noisy
- Dangerous to birds, bats, and animals

Table 1 presents global wind farms database.

4.3 Hydropower, water energy

Waterfalls and fast running water flow may be used to generate electric energy. Water Energy cite is presented in **Figure 3**. Water flow kinetic energy is converted to electric energy. In the late 19th century, hydropower became a source for generating electricity. The first commercial hydroelectric power plant was built at Niagara Falls in 1879. In 1881, streetlamps in the city of Niagara Falls were powered by hydropower. Hydroelectricity can be used to store energy in the form of potential energy between two areas with different heights with pumped-storage hydroelectricity. Water is pumped uphill into cites during periods of low demand. This energy can be released to generate energy when demand is high.

Hydropower Energy Sources

- Rain fall generates water flow
- Waterfalls generate hydropower energy
- High water levels, low water levels and water stream can be used to generate hydropower energy

Hydropower Energy Advantages

- Hydroelectricity is green and clean energy compared to other sources of energy.

- Hydroelectricity is not degradable
- Water is a free natural resource
- Hydroelectricity is cheap energy compared to other sources of energy
- Hydroelectricity does not pollute the environment

Disadvantage of Hydropower Energy

- Hydropower energy cites depend on rain fall, snow, the weather, and water stream

Area	Listed capacity	Entries	Prices
World	884.2 GW	32,293	1250 €
Offshore	344.5 GW	986	200 €
Africa	8.8 GW	125	75 €
Americas	207.1 GW	3,165	400 €
Asia	328.2 GW	4,612	400 €
Europe	324.4 GW	24,195	800 €
Oceania	15.7 GW	196	100 €
Germany	70,800 MW	11,131	350 €
Brazil	36,476 MW	678	205 €
USA	136,490 MW	1,778	350 €
China	205,567 MW	2,528	350 €
United Kingdom	55,171 MW	1,171	345 €
France	22,252 MW	1,574	350 €
India	33,399 MW	914	205 €
Japan	25,107	391	105 €

Table 1.
Global wind farms database.

Figure 3.
Hydropower energy cite.

- Difficult to be installed and operated in a residential area
- Hydropower energy cites usually are limited to areas with waterfalls
- Hydropower energy cites consume large area
- Development and production of water hydroelectricity is expensive.

4.4 Energy harvesting

The continuous growth in production of portable RF systems increase the consumption of batteries and electrical energy. Batteries and conventional electrical energy increase the environmental pollution. In last twenty years, the trend of using free space energy such us light, heat, electromagnetic energy, vibration, muscle motion and other energy sources, has become very attractive and useful. Several inventions and methods to produce electricity from green energy sources have been presented, see [1–3]. RF harvesting may be useful and recharge batteries only if we collect as much RF energy as possible. In this case, energy harvesting units can eliminate the need to charge batteries by using electrical cables. It is crucial to harvest RF energy from several RF devices and systems. Wideband or multiband antennas should be used to harvest as much electromagnetic energy as possible. The energy harvesting antenna must meet the system requirements. Due to low electromagnetic energy densities in free space, efficient antennas should be used. The antennas should radiate efficiently at a specific frequency range and polarization. The antenna should receive efficiently electromagnetic waves from a wide angular angle. To meet this requirement the antenna radiation pattern should have a wide beam width. Printed antennas were used to harvest RF energy as presented in the literature, [4–10]. Electromagnetic energy harvesting systems capture waves propagating in the air. This RF energy is stored and used to recharge batteries and other electrical devices. In the last decade there is a huge increase in the amount of RF power in the air. The amount, of electromagnetic waves in the air in 2017 was 11 Exa-bytes per month. The amount, of electromagnetic waves in the air in 2019 was 33 Exa-bytes per month. However, the predicted amount, of electromagnetic waves in the air in 2025 will be around 165 Exa-bytes per month, **Table 2**. **Table 2** presents the expected amount of RF wave in the air for 2G, 3G, 4G, and 5G networks. 5G devices are forecast to account for 45% of the universe mobile data traffic by 2025.

Energy harvesting system is shown in **Figure 4**. The electromagnetic harvesting unit consists of an antenna, a rectifying circuit, and a rechargeable battery. The RF harvesting energy system operates as a Dual Mode harvesting unit. The Low Noise

Year	Total amount of RF wave in free space EB per month	Amount of RFwave in free space EB per month 2G, 3G, 4G	Amount of RF wave in free space EB per month 5G
2017	11	11	0
2019	33	33	0
2021	60	50	10
2023	100	75	25
2025	164	85	79

Table 2.
Amount, of electromagnetic waves in the air from 2017 up to 2025.

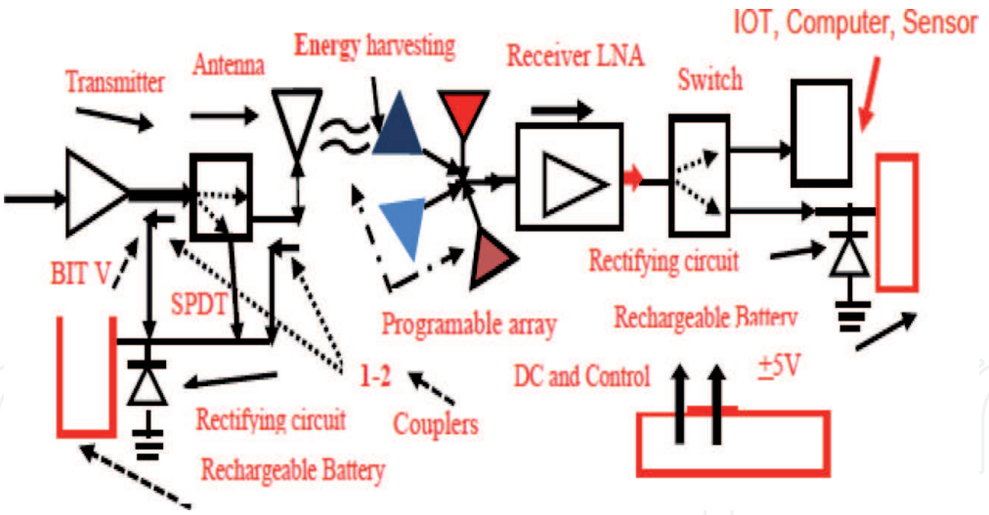


Figure 4.
Dual mode energy harvesting concept.

Amplifier, LNA, is part of the RF system. The LNA DC bias voltages are supplied by the DC unit of the RF system. The programmable array consists of 3 to 4 antennas that can harvest RF energy from around 140 MHz up to 18GHz. The total received electromagnetic energy is transformed to DC power. The harvesting system consists of antennas, matching and feed networks, rectifying circuit, and a rechargeable battery. The RF harvesting system function as a dual mode harvesting unit. The harvesting unit can be part of a computing network, server, communication system, medical, IOT, computer, and smartphone. The LNA bias voltages are supplied by the RF system. The energy coupled to the built in test port, -20 dB, may be used to recharge a battery.

5. Recycling

Recycling is the process of collecting and processing used materials that would otherwise be thrown away as trash. Recycling conserves raw materials and saves the additional energy that manufacturers would use producing new products from scratch. The continuous growth in development of cellular wireless communication systems over the last thirty years has resulted that most of the world population owning laptops, computers, smartphones, smart watches, I-pads, and other devices. As a result, the number of unwanted electronic devices is huge. With this huge number of devices being produced and discarded, a new environmental disaster strikes our planet. Electronic waste or discarded old electronics are filling up landfills and trash storage areas. These electronics waste contain hazardous materials and toxic materials that endanger the environment and the health of local communities. This electronics waste increase air and water pollution. Green electronics and computing technologies are used to decrease environmental pollution. Recycling of computers waste, electronic devices waste, old batteries, plastic waste, and bottles decrease environmental pollution. Recycling saves original raw materials. Recycling reduce waste and reduce pollution. Computers recycling waste is shown in **Figure** 5.

Benefits of Recycling

- Conserves natural resources such as cooper, steel. Water and other minerals
- Minimize energy consumption by using recycled devices and parts

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Figure 5.
Computers waste recycling cite.

- Increases economic security by tapping a domestic source of materials
- Prevents pollution by reducing the need to collect new raw materials
- Reduces the amount of waste sent to landfills
- Saves energy needed to produce new components and materials
- Supports manufacturing companies and conserves valuable resources
- Create jobs in the recycling and manufacturing industries in the United States
- Price of recycled devices is cheaper

6. Innovations and challenges in green computing technologies

In the last fifty years, the world has suffered from significantly rapid changes in the planet weather, water pollution, and air pollution. The private cars industry, electronic industry, high tech computing industry, and the communication industry in the last century depleted and ruined the world natural resources. The universe suffers from severe droughts, seawater acidification, rising seawater levels, increased depletion of groundwater reserves, air pollution, rivers pollution, and global rise of earth temperature. The rapid spread of diseases, viruses, and the extinction of animal species are the result of environmental changes. Most of these changes are irreversible. Computers waste, electronic waste, plastics, and food garbage contain dangerous chemicals that pollute air, soil, rivers water, sea water, and groundwater. These toxic materials cannot be removed from fishes, vegetables, fruits, and other food products. These toxic chemicals can be found in fruits, vegetables and other food crops, fishes, meat, and corps grown on polluted soil. Toxic waste, polluted water, polluted air, and climate changes affect severely first children health and grownup health. The universe oceans, rivers, seas, and lakes suffer from plastic and chemical waste. Chemical toxics and plastic waste kill the ocean and sea habitats in our planet. Hazard materials, chemical toxics, and plastic waste kill fishes, birds, and other creatures. We should encourage countries, governments, communities, and citizens to act rapidly to save the universe. We should encourage companies to use green materials, green energy, and green components in production of

communication, electronic devices, and computers. We should encourage global activities to re-use and recycle computers and electronic waste. In green computing and green electronic industries, the use of hazardous materials such as cooper, lead, plastic materials, and other toxic materials should be limited to decrease pollution.

Computers, communication devices, and electronics manufacturers should be encouraged to develop electronic devices that are green and environmentally friendly. Computing and electronics manufacturers should use green materials, renewable energy, efficient green devices, and energy harvesting systems.

Future Computing and Electronics Green Technologies Challenges and Innovations

- Using renewable and harvesting energy in computing and electronic devices
- Using recycled components and devices in manufacturing computers and electronic devices
- Design and development of green computers and electronic devices
- Producing cheap solar green energy
- Recycling most of the computers and electronics waste
- Development and production of green cars and airplanes
- We should encourage peoples, young people, and kids to lead around the world initiatives to decrease air pollution, water pollution and climate changes.

Author details

Albert Sabban[1,2]

1 Kinneret Academic College, Galilee, Israel

2 Ort Braude College, Karmiel, Israel

*Address all correspondence to: avi_111@netvision.net.il

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