Datacenters
Project Report

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Survey of best energy efficient practices in data centers around world

Many data centers have stood up against the maximum electric power available to them from their utility. Others are facing the management challenges: the amount of time to deploy new capacity, and to manage existing capacity and systems. And gains made by virtualizing and consolidating servers are often lost again as more gear is added in.

The demand for more CPU cycles and petabytes of storage won't go away. Nor will budget concerns, or the cost of power, cooling and space.

8 radical ways to cut data center power costs and Facebook's 'green' data center design to have ripple effect.

Here's a look at how vendors, industry groups, and savvy IT and Facilities planners are meeting those challenges -- plus a few ideas that may still be a little blue-sky.

Location

Data centers need power. Lots of it, and at a favorable price less than 2cents per unit.

Data centers also need cooling, since all that electricity going to and through IT gear eventually turns into heat. Typically, this cooling requires yet more electrical power. One measure of a data center's power efficiency is its PUE -- Power Usage Effectiveness -- which is the ratio of total power consumed by the facility for IT, cooling, lighting, etc., divided by the power consumed by IT gear. The best PUE is as close as possible to 1.0; PUE ratings of 2.0 are, sadly, all too typical.

You want to be in a cool dry geography with cheap power, like parts of the Pacific North-West. For example, Facebook's data center in Prineville, Oregon. Or in a very dry place, where you can get very efficient evaporative cooling, Companies like Apple, Google and Microsoft, along with data center hosting companies, have been sussing out sites that meet affordable power and cooling criteria (along with not being prone to earthquakes or dangerous weather extremes, available and affordable real estate, good network connectivity, and good places to eat lunch).

Google, with an estimated 900,000 servers, dedicates considerable attention to data center efficiency and other best practices, like, where and when possible, using evaporative cooling to minimize how often energy-hogging "chillers" run (When in use, chillers "can consume many times more power than the rest of the cooling system combined"). Evaporative cooling still requires power -- but much less. And Google's new facility in Hamina, Finland, "utilizes sea water to provide chiller-less cooling."

According to the company, "Google-designed data centers use about half the energy of a typical data center."

The Renewable, carbon-neutral power

In addition to looking for affordability, many data center planners are looking at power sources that don't consume fuel, or otherwise have a low carbon footprint.

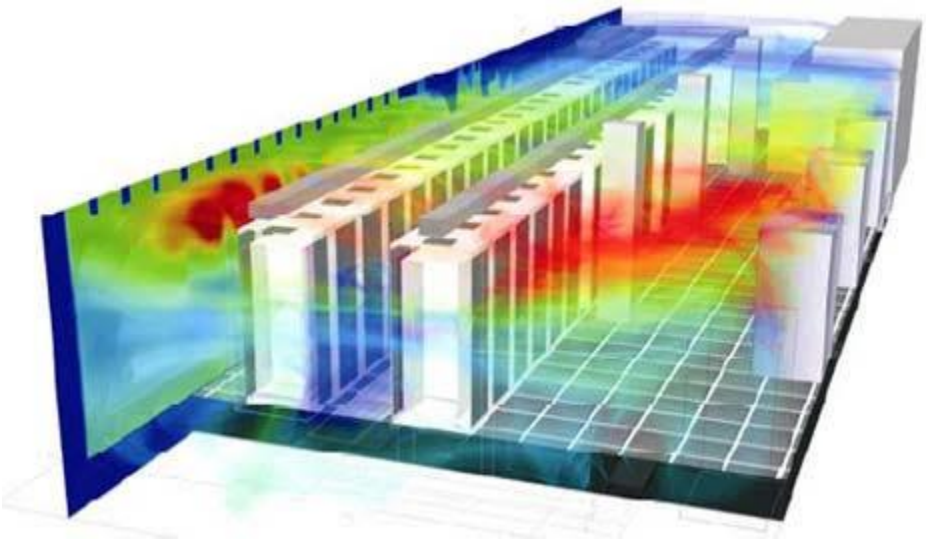
For example, Verne Global has set up a “carbon-neutral data center" in Iceland -- powered entirely by a combination of hydro-electric sources and geothermal sources. (About 80% of the power comes from hydro-electric generators.

Power in Iceland is also abundant, the current power grid in Iceland offers approximately 2900 Megawatts (MW) of power capacity and the population of Iceland is roughly 320,000 people. Their utilization of the total available power is thought to be in the range of 300MWatts. Aluminum smelters are currently the most power-intensive industry in Iceland, leaving more than sufficient capacity for the data center industry.

Iceland's year-around low ambient temperatures permit free cooling. Chiller plants are not required, resulting in a significant reduction in power cost. If a wholesale client should decide they want cooling at the server, there is a natural cold-water aquifer on the campus that can be used to accommodate their needs.

Depending on where the customer is, the trade-off for locating data centers based on power, cooling or other factors, can, of course, be incrementally more network latency -- the delay caused by signals travelling through one or several thousands of miles of fiber, plus, possibly, another network device or two. For example, one-way transit from the data center to London adds 18 milliseconds, to the United States, about 40 milliseconds.

It's not just the heat, it's also about the humidity



"Dry places" aren't necessarily in cool locations. I/O Data Centers' Phoenix facility, which according to the company is one of the world's largest data centers, is located, as the facility's name suggests, in Phoenix, Arizona.

One of the benefits of the desert is its very dry," says Anthony Wanger, I/O President. "It's easier to remove heat in a dry environment, which makes Arizona an ideal location."

According to the company, the Phoenix data center employs a number of techniques and technologies to reduce energy consumption and improve energy efficiency.

"We are doing everything possible to be energy efficient at all of our data centers, says Wanger.

"We separate cold air supply and warm air return. To get the heat away", says Wanger.

"There is still no more-efficient means of moving energy than through water. Air as a liquid is much less dense and less efficient. Once we get that hot air, we dump it into a closed loop system and exchange it into an open-loop system, where we can remove the heat. We also use thermal storage. We can consume energy at night when it's sitting in the utility's inventory."

Also, he says, "We have to put humidity into the air. The old way was to have a big metal halide lamp baking water. The humidification solution was to fire up a heat lamp and phase-transition it to humidity. Now we use a process called ultrasonic humidification, which uses high-frequency electronic signals to break water surface tension and dissipate cool water vapor into the air -- this takes about 1/50th the amount of energy."

The modding

For several years now, a growing number of vendors, like HP and Microsoft have been offering ready-to-compute data center modules that not only include compute, storage, but also cooling gear -- just plop (well, put gently) into place, and connect up power, connectivity, and whatever cooling is needed.

Some don't even need a proper data center to house them in.

And it's not just vendors, either; hosting providers like i/o Data Center not only use their own modules, but also offer them directly to customers who might not be availing themselves of i/o's facilities.

For example, HP offers its Performance Optimized Datacenter 240a, a.k.a. "the HP EcoPOD." Amazon has its own Perdix container, and Microsoft offers its Data Center ITPAC (IT Pre-Assembled Components).

HP's EcoPOD uses free-air and DX (direct-expansion) cooling, without needing any chilled water. "Just add power and networking -- in any environment," says to John Gromala, director of product marketing, Modular Systems, Industry Standard Servers and Software, HP. According to Gromala, "the EcoPOD optimizes efficiency achieving near-perfect Power Usage Effectiveness (PUE) between 1.05 to 1.30 (depending on ambient conditions)." And, says Gromala, "because EcoPODs are freestanding, they can be deployed in as quickly as three months. Customers are putting EcoPODs behind their existing facilities, inside warehouses or on roofs."

Switching from AC to DC

IT gear runs on DC (direct current), but utilities provide electricity as AC (alternating current).

Normally, "A UPS converts the 3-phase 480vAC coming from the power utility to DC, to charge its batteries, and then reconverts back to 3-phase 480vAC to send it through the data center. The PDU (Power Distribution Unit) for each rack or row of racks converts the 3-phase 480vAC to 3-phase 208vAC, which is what normally goes into IT gear like servers and storage arrays. And the power supplies in the IT gear converts that 208vAC into 380vDC," says Dennis Symanski, Senior Project Manager, Electric Power Research Institute, and chairman of the EMerge Alliance's committee writing the 380vDC standard.

Various initiatives are underway exploring going, ahem, directly from utility power. "We've done a lot of demos worldwide about running data centers at 380vDC (volts of Direct Current) instead of 208vAC," says Symanski.

Moving to a direct current infrastructure says Symanski, "gets rid of three conversion steps in the electrical system, and also reduces the load on the air conditioning by the reduced amount of heat being created.

What's that mean in terms of dollar savings? "We've found in most of our demonstrations that we get about a 15% reduction in the power used to run IT equipment. Plus the savings from needing less air conditioning, which are probably comparable, but harder to measure.

Since a DC infrastructure means DC UPSs, DC circuit breakers, DC interconnect cables, ET etc., data centers are unlikely to convert existing AC set-ups, other than as testbeds, says Symanski. "This is for when you are expanding in your data center, like adding a new row of racks, or building a new data center."

Switch to power-saving components

There are many opportunities to reduce power consumption simply by replacing some of the components in existing power and cooling systems.

I/O Data Centers, for example, "uses variable frequency chillers, pumps, cooling towers and air handlers to reduce energy consumption. By using only the power necessary to keep equipment running at optimal levels, i/o is able to operate energy-efficient data centers."

"You don't change the fan or the motor; you put a VSD on the motor. What used to be a single speed fan you can now slow down," notes EPRI's Symanski. "And by reducing the speed of a fan by 50%, with a variable-speed drive (VSD), you use only one-eighth of the power," However, Symanski cautions, "You have to make sure you don't get condensation and that the refrigerant doesn't freeze by slowing down too much."

There's even one easy component upgrade that can be done with some existing IT gear, Symanski points out: Replacing older power supplies with one of the new energy-efficient ones with certifications like 80PLUS and Energy Star.

"New power supplies may come in different versions -- Bronze, Silver, Gold and Platinum -- with correspondingly better efficiencies," Symanski notes. "Replacing an older power supply with a Platinum-level one can yield ten to fifteen percent energy savings, -- and the power supply is an inexpensive part."

Innovative Ideas implemented around the world

1. Introduction

The modern data center, along with the IT infrastructure, is the nerve center of an enterprise. One of the most important characteristic of data center is its high reliability and peak performance in, 7 days a week, 365 days a year. In the next section we will examine top five innovative data center research project around the world.

2. Microsoft's Natick

Natick is a Microsoft research project to manufacture and operate an underwater datacenter. Started in 2013 when Microsoft employee, 'Sean James', who served on a US Navy submarine, co-authored a Think Week Paper. Norm Whitaker read the newspaper and made a team to explore the idea of placing entire datacenters in water. Natick started in 2014. The experimental prototype vessel, christened the Leona Philpot after a popular Xbox game character, it was operated on the seafloor approximately one kilometer off the Pacific coast of the United States for August to November of 2015. This Deep water deployment offers ready access to cooling, renewable power sources, and a controlled environment. Natick will be powered by renewable marine energy sources such as offshore wind, wave, tide, or current. Natick is made to provide cloud services in way to customers in areas which are near large bodies of water (where nearly 50% of society resides). The vision of operating containerized datacenters offshore near major population centers anticipates a highly interactive future requiring data resources located close to users. Project Natick is currently at the research stage.

Microsoft's experimental underwater data center, the Leona Philpott, is lowered into the ocean in August 2015. (Photo: Microsoft Corp.).

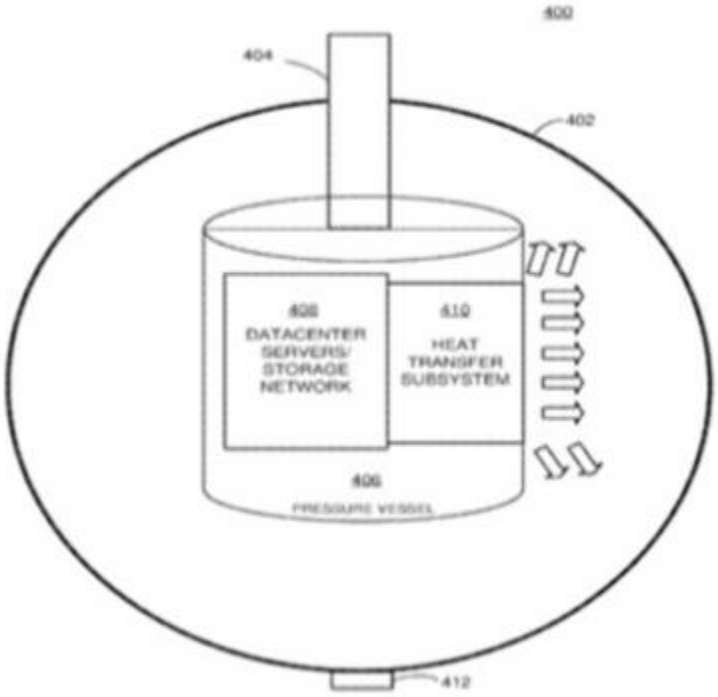
Cutler et al. (2016) patented their idea of 'Artificial Reef Data center 'in United states with Pub. No: US 2016/0381835 A10 on Dec 29, 2016. Artificial reef of datacenter contains

(i) a datacenter

(ii) Heat transfer subsystem including a first subset of heat exchangers and a second subset of heat exchangers, the first subset of heat exchangers and second subset of heat exchangers operates in a closed loop.

(iii) One Pressure vessel housing the data center and the heat transfer subsystem.

(iv) One Encasement association with pressure vessel, the encasement allowing access to datacenter as the artificial reef supported by encasement is maintained.



Block Diagram of Microsoft's Artificial Reef Data center.

In Figure above illustrates one example implementation of an artificial reef data center. Artificial reef data center 400 consists of a clamshell 402, an access point 404 and a pressure vessel 406. A Pressure vessel 406 may house data center 408 and heat transfer subsystem 410. Natick data center has following characteristics:

(a) Longevity of Natick Life span of Computers inside Natick data center is five year, after five year data center would be retrieved and reloaded with new computer & deployed again under water. The total life span of a Natick data center is twenty years, after this period the data center is retrieved & recycled.

(b) Need of Natick data center is made to be deployed near large bodies of water where nearly 50% of population resides. This will provides good interactive experience to users. Natick has ready access to cooling, Life span of Computers inside Natick data center is five years, after five-year data center would be retrieved and reloaded with new computer &

deployed again under water. The total life span of a Natick data center is twenty years, after this period the data center is retrieved & recycled.

(c) Effect on sea life Natick data center gets power from renewable energy resources so there is truly zero emission. Microsoft's Natick is built from recycled material. The facility like Natick shows end of Moore's law, because this as an opportunity to field long-lived, resilient datacenters that operate "lights out" – nobody on site – along with very high reliability for the entire life of the deployment, possibly as long as ten years.

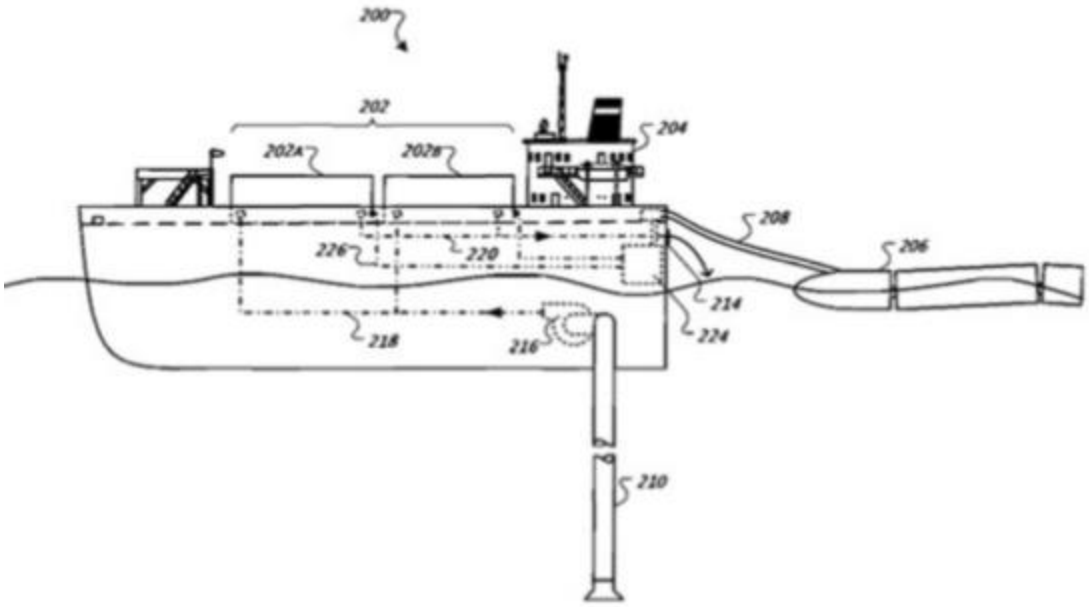
(d) Power to operate data center Natick gets its power need form renewable marine energy sources such as offshore wind, wave, tide, or current.

(e) Network connectivity to data center Use of subsea cables allows the Internet to span the oceans, making connection between devices and datacenters around the world. Natick was also connected via a cable to land and then to the Internet.

3. Google's Water Based Datacenter

On September 2008, Google entered a patent application for a "water-based data center" showing a floating data center. Data center gets it power from renewable marine energy sources such as offshore wind, wave, tide, or current. This system contains a floating platform-mounted computer data center comprising of large no of computing machines and one cooling unit that draws its power from wind & tide. This system is designed to provide computing, telecommunications, or other similar services support in a remote area quickly and easily.

The system consists of a "crane-removable modules" that contains racks of computing machines. Modules enable us to add, remove and move the computing power. The Computing units could be mounted in shipping containers that can be stored on floating platforms. As mentioned in the patient, that cites the use of Pelamis machines and other devices to give power to data center. A Pelamis machine consists of series of hydraulics that are powered by water motion to drive motors connected to electrical generators. Floating power-generation apparatus makes use of tethers and a spring-loaded hub to gather power from the rise and fall of water tides.



A side view of a Floating data center system.

It shows a side view of a Floating data center system. The system 200 consists of a modular data center 202 aboard a Floating platform 204, which is connected to one or more motion powered machines 206. This modular data center 202 can be made up of computer equipment in one or more modules. These motion-powered machines 206 may give power and cooling capacity to the modular data center 202. These modular data centers 202 can function without connecting to external utilities. A modular data center 202 of a Floating data center system 200 has modules 202A, 202B aboard a Floating platform 204. 202A, 202B modules may be in a standardized format, such as an intermodal freight container, such as those used in the transportation industry. 202A, 202B modules may have computing resources such as racks of servers, telecom-equipment, etc. Google’s floating data center is currently at research stage.

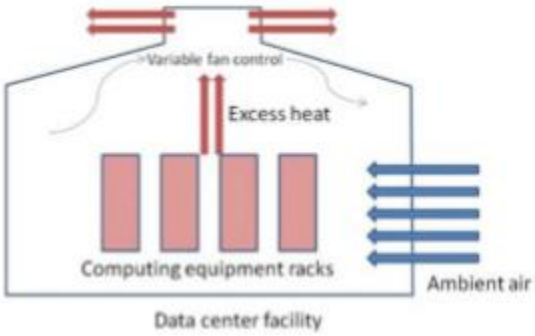
5. Oracle’s Utah Data Center Project

Oracle's Utah Data center project started in 2008 and became operational in 2011. Oracle makes use outside fresh air for cooling thus eliminates the need for energy intensive, mechanical refrigeration compressors. They make use of highly efficient coaxial fans and variable speed ECM motors. Hot and cold aisles with partition panels and doors allow maximum cool air flowing to the servers. Data center is equipped with temperature and pressure sensors that allow system to monitor and maximize efficiency.

It makes use of efficient magnetic bearing chillers instead of water refrigeration units. Power Usage Effectiveness (PUE) was measured to be less than 1.10 for the entire year.

5. Yahoo! Compute Coop Next Generation Passive Cooling Design for Data Centers

Yahoo's Compute Coop (YCC) building design uses outside air for cooling versus conventional HVAC (Heating, Ventilation, and Air Conditioning) equipment. Yahoo's Compute Coop design is first implemented at Lockport, New York computing facility in 2011. Data center makes use of fresh air for cooling the computers. PUE of data center is 1.1. The YCC design is similar to chicken-coop building where hot air rises through a cupola in the roof. Cool fresh air enters the building through side of the building that keeps the computer machines at ambient temperature. This system eliminates the need of expensive, energy-intensive chiller systems. YCC is designed in such a way that ensures the power is used for computing work rather than to supporting cooling infrastructure. YCC decreases energy consumption of a data center thus reductions in both capital and operating expenses. Figure below shows The YCC design.



The YCC design: Use of ambient air and variable fans for data center cooling.

(Illustration courtesy of U.S. Department of Energy Industrial Technologies Program.)

6. Google's Interplanetary Data Center "Ziggy Stardust"

Google Cloud Platform (GCP) is designed to meet their customer needs—no matter where they are. It supports some of the most demanding disaster recovery and data sovereignty needs of our Earth-based customers, we're looking to the future cloud infrastructure needed for the exploration and ultimate colonization of the Red Planet. Google is planning to build interplanetary data center on mars named "Ziggy Stardust. It starts its operation in 2018. It will be placed in Gale Crater, near the landing site of NASA's Curiosity rover. This data center allows us to perform astronomy research, exploration of Martian natural resources and interplanetary life sciences. This region will also serve as an important node in an extensive network throughout the solar system.

Figure 5 Google's interplanetary data center (courtesy Google)

To facilitate the transition for our Earthling customers, Google Cloud Storage (GCS) is launching a new Earth-Mars Multi-Regional location. The users will be able to store planet-redundant. This system allows us to store data across earth and mars, even if the earth experiences another asteroid strike like one that wiped out the dinosaurs, all public domain scientific, arts and history data along with your cat videos, selfies and other data will be in safe place. The only drawback with cloud computing is that it is a notorious power guzzlers and call for a stringent 'energy efficiency' regime. The average data center consumes as much energy as 25,000 households reported by Kaplan et al. Between 2000 and 2007, the total power consumption of datacenters worldwide went from 70 billion to 330 billion kWh; it's projected to grow to more than 1,000 billion kWh by 2020 . Martian data center will be the Google's greenest facility that takes full advantage of its new location. This Data center draws its power from Mars thin atmosphere and high wind. The cold weather of Mars provides natural cooling to rack of computer throughout the year. Cloud Computing is a relatively new technology and aims to offer "utility based IT services.

Designing a completely new data center using Zahid Technology

What is Zahid Technology?

Zahid Technology is green technology that focuses on maximum reuse of e-waste and minimum waste generation. It uses advanced techniques for electric power, cooling systems (chillers) and water management.

Reuse Techniques and equipment's Overview

According to the United Nations, 20 to 50 million metric tons of e-waste are discarded every year. Approximately 650,000 mobile phones are disposed of each day globally, according to survey of Zahid Servers. That equates to more than 234 million phones thrown away in one year.

There are a lot of thrown away items thrown by general public that are still useable but have become old like memory cards with and hard disks which have less space and old mobile phones, parts of PCs, laptops, etc that are still working fine but has become old and are slow.

Even big data centers like Google prefer to break and throw out the hard disks which are corrupted instead trying to repair and reuse them in proper way because they will have to do a lot of work like deleting data from hard disk and in order to protect that data they are polluting the planet.

Zahid Technology uses MLDTs and FOPCBs to reuse the thrown away SD card as hard disks and mobile phones as hard disks. It also uses this technology to make energy efficient and faster servers .You will learn about them in **1.What are MLDTs and FOPCBs?**

SD cards generally have slow read and write speed and they cannot be used in data centers for storing data so Zahid Technology makes them at par with the speed of a SSD. You will see this how exactly in deep in **2. Concept behind reusing thrown SD cards as hard disks in data centers**

This technology makes use of software called ZahidIntegrator to run the ARM devices as additional computing power in data centers. You will see it in Depth in **3.Concept behind reusing thrown mobile phones as additional computing power**

A lot of old graphics cards and rams which are old are only thrown away due to their slow speed by users. This can be optimized and used as additional computing power when there are server overloading this also reduces server down time and provides client with much better service. This technology uses MLDTs, FOPCBs developed by Zahid Servers and software a called RZSIntegrator developed by ZahidSoft. You will see it in Depth in **4.Concept behind reusing old computer parts like rams and graphic cards as additional computing power**

Zahid Technology makes use of rain water harvesting to store water for various purposes. It uses water disposed of from washrooms, chillers, water economizers, ACs, etc by using desalinization plants installed in the left side of datacenter building. You will learn it in depth in **6. Concept of reusing water from toilets using desalinization plants and rainwater harvesting**

This technology makes use of solar panels for 80% of energy requirements of the datacenter

1. **What are MLDTs and FOPCBs?**

FOPCB:

FOPCB stands for Fiber Optic PCB. They are a kind of printed circuit boards that uses small layers of fiber optic cable instead of gold/copper. This technology isn't currently available on a large scale but test are made by Zahid Servers (company that created this technology).This idea first came into existence when I aka Mohammed Zahid Wadiwale worked on GCC project to make a completely green datacenter in year 2018.Images of FOPCB's aren't included into this report for security reasons, but they are much a like normal PCBs. There are some limitations of using FOPCBs like they can't be redesigned once they are created doing modifications to it is extremely difficult. They normally don't get damaged or harmed under normal circumstances but if they are damaged they can only be repaired in highly sophisticated labs. The reason to use FOPCBs is they are extremely fast; they aren't made for normal day to day use but instead used in datacenters for reuse purpose. They require a technology called MLDT (Micro Laser Data Transferor) to convert data in electrical signal format into light format and then the data is passed from the component into fiber optic cable in the board and then the data is again converted back to electronic signals. This technology is used for reusing old thrown out devices as additional computing power. This technology increases efficiency in using them. Though one may say why to use such expensive technology just to increase a slight percent in computing power but Zahid Servers has their answer "This technology will make reuse of around 7%'s of e-waste thrown globally. Even if it did 1% its worth to invest in as this is an initiation towards a green future". So do you think that Zahid Servers initiative is worth it?

MLTD:

MLDT stands for Micro Laser Data Transferor. This technology was designed by Zahid Servers to work in FOPCBs alongside micro fiber optic cables. They are very tiny and size is not disclosed.

2. **Concept behind reusing thrown SD cards as hard disks in data centers**

SD cards are developing and improving rapidly. As new SD cards are coming into market that are 10 times faster and have more space people are throwing their old SD cards into Dustbins according to my survey. SD cards are so small that they can't be seen while processing waste and they normally go into wet waste and are buried into ground and even if they go in dry waste they are burned off. People take this SD cards lightly but they contain a numerous rare elements like gold and processed silicon. And it takes lot of time to extract gold from earth or to process silicon.

Reusing memory card is very basic initiative towards GCC.

Earlier people use to sell their old SD cards to mobile shopkeepers but now mobile shopkeepers have stop taking old SD cards since most people prefer to buy a new one.

Reusing SD cards as Storage Device in Datacenters:

SD cards can be used as in data centers as storage device after some modifications. There are various circuits designed till now that are used to make a Hard Disk out of SD cards. But problem here is that SD cards are very slow and inefficient to be used as storage device in data centers since they have very slow read and write space plus the circuitry makes it more slow. This was solved by me using a simple way that is using FOPCBs and MLDTs to recreate the circuit and using only $1/4^{th}$ space of SD cards. This made hard disk made from reused SD card 20% more faster than before. But still they didn't achieve the speed required for datacenter but they could be used now in household PCs. To overcome this problem the solution is to use it as additional storage device for managing the local servers that are used within the datacenters to share usually word documents and presentation, because in our data center even the local machines don't have own storage local cloud is used and files are shareable, so that employees don't waste their time on shiity work rather than of our company.

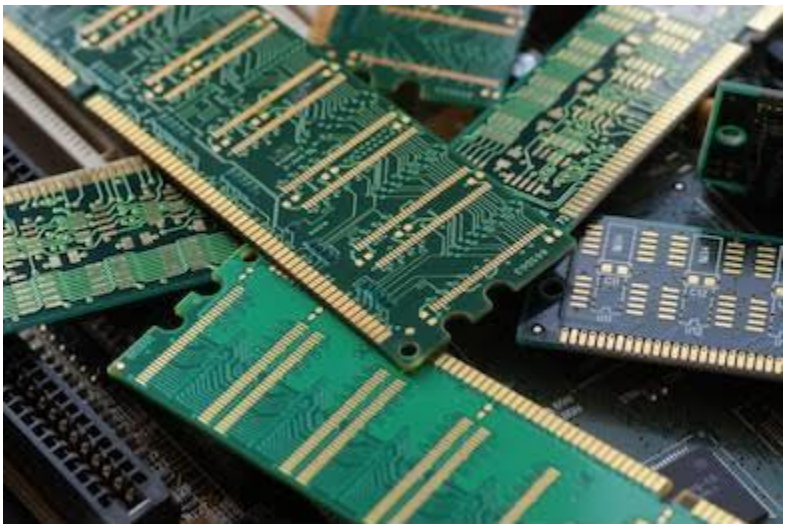
3. **Concept behind reusing thrown mobile phones as additional computing power**

3.78Billion People currently uses phone on planet that's 61.62% of total population. Approximately 150 million mobile phones are discarded each year in the USA alone. Approximately 650,000 mobile phones are disposed of each day globally, according to

survey of Zahid Servers. That equates to more than 234 million phones thrown away in one year. Today, there are over 7 billion devices to connect to cellular networks around the world. According to the International Card Manufacturers Association (ICMA), there were 5.4 billion SIM cards manufactured globally in 2016 creating over $6.5 billion in revenue for traditional SIM card vendors. Its estimated to grow till 2025 to 14 billion cellular networks that's double the population of whole world. This is a major threat to planet as now people are buying 3-4 smart phones each year. The Global E-Waste Monitor, 2017 published by the United Nations University estimated that India generates about 2 million metric tonnes of e-waste (2016) annually. Nearly 82 per cent of this is personal devices.

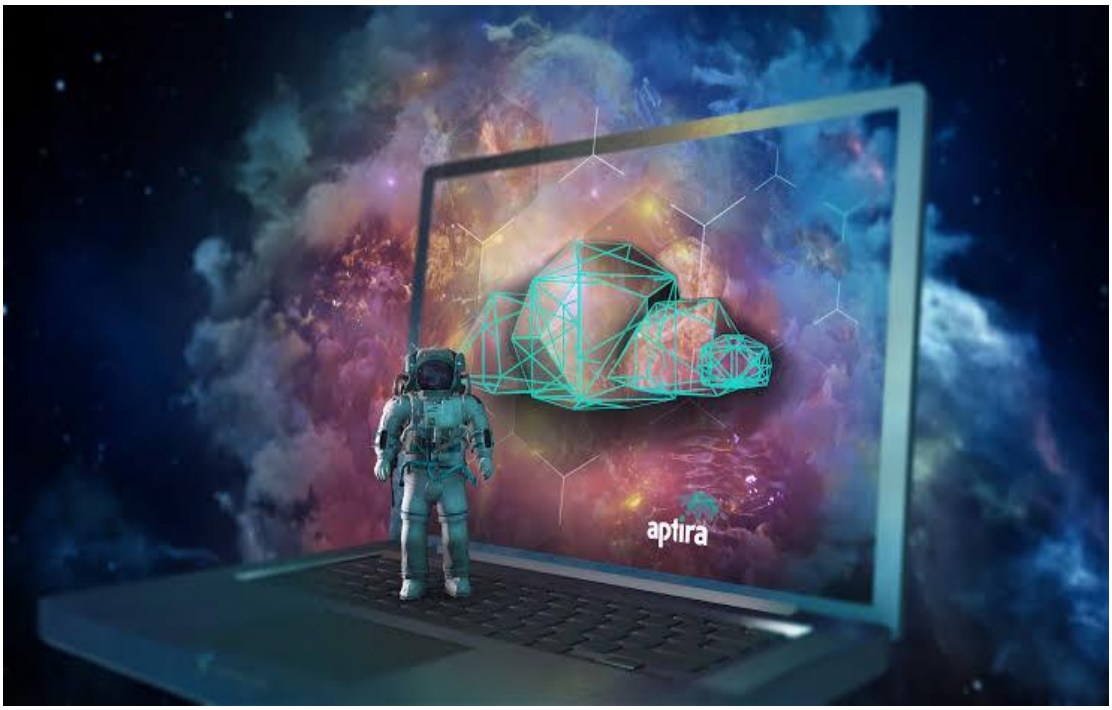

There is software called ZahidIntegrator to run the ARM devices as additional computing power in data centers designed by Zahid Servers and ZahidSoft. This software was created to integrate various kind of devices based on ARM architecture with various OS like Symbian, Linux, Windows, RIM, IOS, Tizen, Firefox OS, Minix, Palm OS, Zahid OS, etc. This software is used to integrate all different kinds of devices and run them as a cloud. This is inefficient therefore its currently only used for local cloud processing that is used for PowerPoint presentations and other documentation stuff of the organization on intranet.

4. **Concept behind reusing old computer parts like rams and graphic cards as additional computing power**

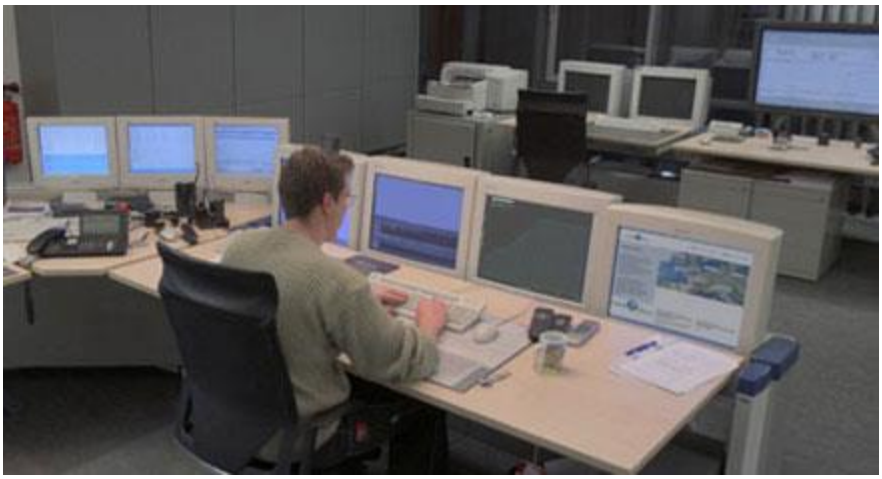


A lot of people throw their old pcs and old pc parts that are still usable but are extremely slow, like old graphic cards and RAM that can be still used. Data Centers can use this as it cost very less amount to buy such thing. This can increase the amount of computing power of well-designed server for free. The bigger the ram memory slower is Server and servers require very high speed, here this used parts come in picture. A server which has capacity to upgrade itself and add extra storage and ram can be attached with more rams of free of cost. Thus increasing Computing power and speed and decreasing the e-waste generated.

5. **Using local cloud server for internal work rather than laptops and PCs**



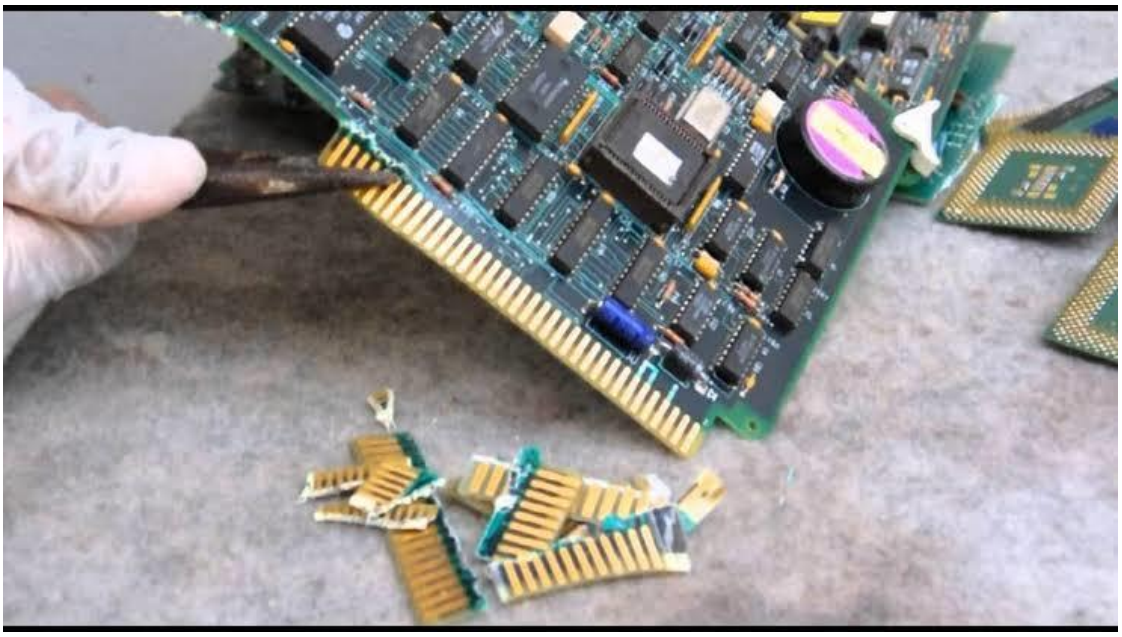
Data centers usually use PCs and Laptops for internal use like monitoring servers, making presentations, and all other stuff of marketing department. This increases power usage. This power usage is so much that it can light homes of 35 lower middle income group families living in Mumbai for a year. In any medium size datacenter there are about 80 computers and laptops just of monitoring purpose which can be easily done without use of so much computing power.



Our organization uses local cloud servers for storage. This reduces amount significant of heat generation and usage of storage.

6. **Disposing center for disposing of un-repairable stuff**

The rams graphic cards mouse circuits etc which are not working can be disposed of in following recycling maximum things and minimizing the waste.

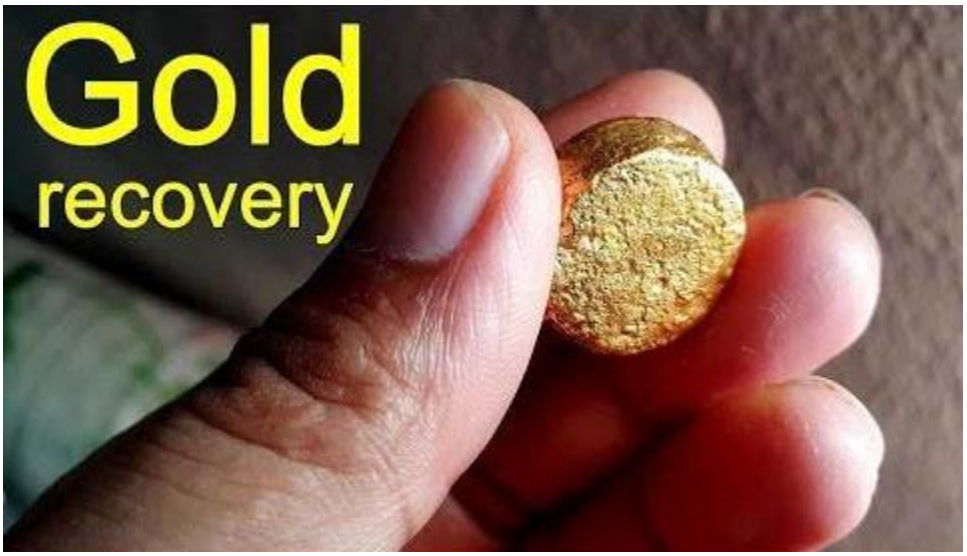


First off, PCB can be found in the majority of the electronic gadgets and devices popular today. Also, they serve as a conductive foundation where you fix other electronic components, such as capacitors, resistors, inductors, and much more.

With its vast use in today's electronics, printed circuit boards should be recycled when gadgets get spoiled or broken.

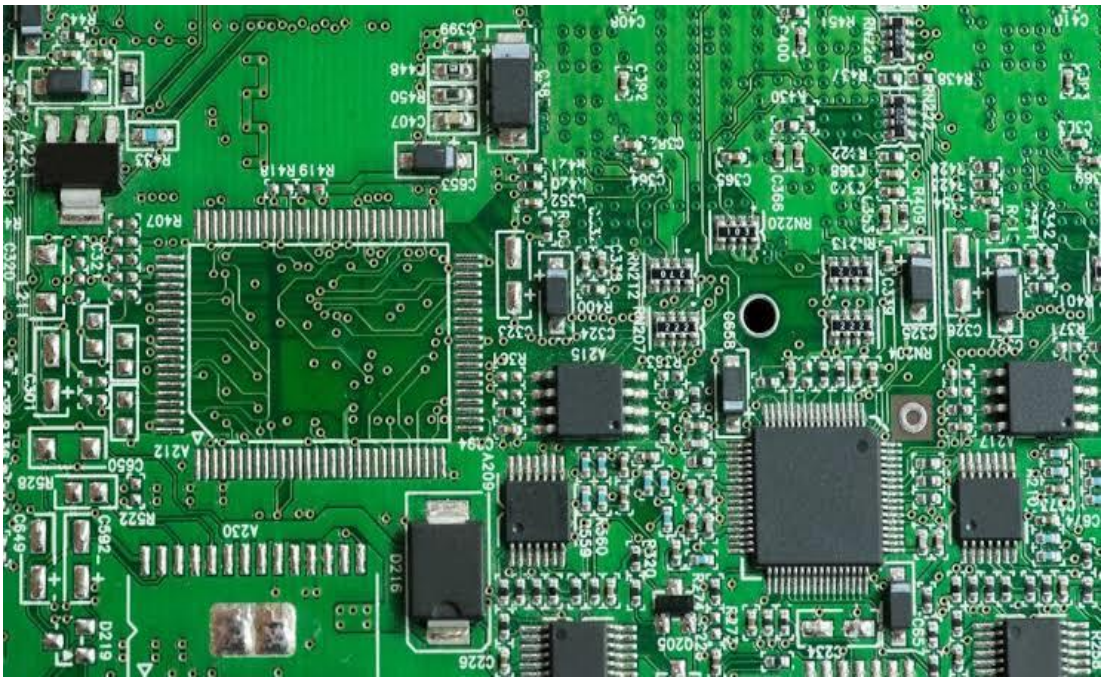
Why Recycle PCB?
Recycling printed circuit boards that are populated with many components could yield more valuable materials like:

Gold
Silver
Platinum
Palladium
How? The process extracts components affixed to the boards. Recycling PCB recovers approximately 99 percent of the precious and scarce metals from the recycling process.



Also, the copper part of the board is completely recyclable as a metallic material. Recycling PCB helps reduce depletion of natural resources such as copper, as processors often reuse these boards multiple times. Although, after recycling, they must test the boards as the recycling process might damage certain parts of the board.

Recycling Printed Circuit Boards PCB



Furthermore, because of the excessive use of this type of circuit board in the electronic manufacturing industries, recycling printed circuit boards reduces solid waste, landfill and land pollution.

How to Recycle PCB

Due to the nature of the intricacy of the boards themselves, recycling them poses difficulty because of the several chemicals, metals and glass fibers used in manufacturing them. Subsequently, in order to successfully recycle them, recyclers separate these components carefully to prevent total destruction of scarce materials.

Likewise, there are three main ways of recycling PCB:

Electrochemical process
Hydro-metallurgy, and
Smelting process

These methods assist in recovering valuable electronic components, connectors and metal scraps. Hence, Recycling Printed Circuit Boards PCB. The most popular way of recycling PCB is through dismantling. This involves loosening the board from its components. The steps are as follows:

First, the components are checked whether they can be repaired or not then they are sent to disposing center in datacenter. Next, the employees drills the boards and loosens them to remove components easily.

Finally, they meticulously remove the components, namely the following:
Capacitors
TV plugs
Motors
Screws
LED
Transistors
Switches
Dismantling the boards requires special tools and meticulous handling in order to avoid damaging the board as well as its components.
Each Component of the board is checked whether its working or not the working components are kept aside to be resell.
After this, the recyclable materials (copper, gold, platinum, and palladium) melt and refine into new products. Finally, all plastic is collected and sold to make plastic seeds and any waste left off is then only thrown off.

7. Concept of reusing water from toilets using desalinization plants

Across the globe, 2 out of 10 people do not have access to safe drinking water, and in India, many states face water shortages and droughts. Meanwhile, reports suggest that Mumbaikers uses 24 gallons of water each day to flush their toilets approximately 5.8

billion gallons. What a waste! As the global population continues to grow and climate change results in more water crises, where will we find enough water to meet our needs? We spend billions of dollars treating water to drinking water quality when we use only 10% of it for drinking and cooking, then flush most of the rest down the toilet or drain. So the growing use of recycled wastewater for irrigation, landscaping, industry and toilet flushing, is a good way to conserve our fresh water resources. Recycled water is also used to replenish sensitive ecosystems where wildlife, fish and plants are left vulnerable when water is diverted for urban or rural needs. In coastal areas, recycled water helps recharge groundwater aquifers to prevent the intrusion of saltwater, which occurs when groundwater has been over pumped. Therefore there is need to recycle water, you may think what the necessity of it in a datacenter is? The answer is simple there are hundreds of people working in a datacenter, imagine how many times the toilets in datacenter are used and how much water is waste. This is done in data centers using mini sewage plants.

8. **Rain Water Harvesting in Data Center**

Can Data Center Become Water Self-Sufficient?

To curtail data centers' huge cooling power consumption and water demand (for cooling), air-side economizer has been increasingly adopted to cool down servers. Recently, another sustainability practice, rainwater harvesting, has also seen a growing adoption in data centers, potentially leading to water self-sufficiency without connecting to water utilities to supply cooling water. Nonetheless, various factors, e.g., unpredictable rainfalls and limitations on water harvesting area, make water self-sufficiency challenging. In this research, I present a first-of-its-kind study to evaluate whether it is feasible to achieve water self-sufficiency in data centers. I find that although water self-sufficiency depends on non-controllable factors such as weather; improving power proportionality (via power management) and increasing water tank size will increase the feasibility, relieving the requirement on water harvesting area and making water self-sufficiency a reality in different locations

As critical assets for digital economy, data centers have collectively accounted for over 2% of global electricity usage. Meanwhile, data centers are also very "thirsty", consuming an enormous amount of water (e.g., through evaporation in cooling towers to exhaust server heat into the environment).

For example, U.S. National Security Agency (NSA) data center in Utah, when fully operational, would consume up to 1.7 million gallons of fresh water.

Amid the anticipation that water demand worldwide exceeds the supply by 40% in 2030 and also urged by prevalent severe droughts , reducing data centers' water consumption has become increasingly imperative, as attested by LBNL's recent guideline which places water and energy as two major considerations for U.S. federal data center consolidation.

While there have been numerous efforts to improve data center energy efficiency, attention has also been recently paid to reduce water consumption in data centers.

Hence rainwater harvesting should be done in data centers. Data centers should be designed such that rain water can be collected and store for data centers use.

9. Concept of generating electricity from solar , biogas and hydro power

CAN GREEN ENERGY BE USED TO POWER A DATA CENTER?

How practical is it?

100%. Data centers are usually huge cluster of buildings like a housing system.

They consume a lot of power and huge bill is generated. Data centers have to be always ready with backups plans like if plan A is failed plan B and sometimes even plan C.

Data centers cannot be depended only on one sources for energy they need alternate ways so in in case of emergency they can immediately shift the power source.

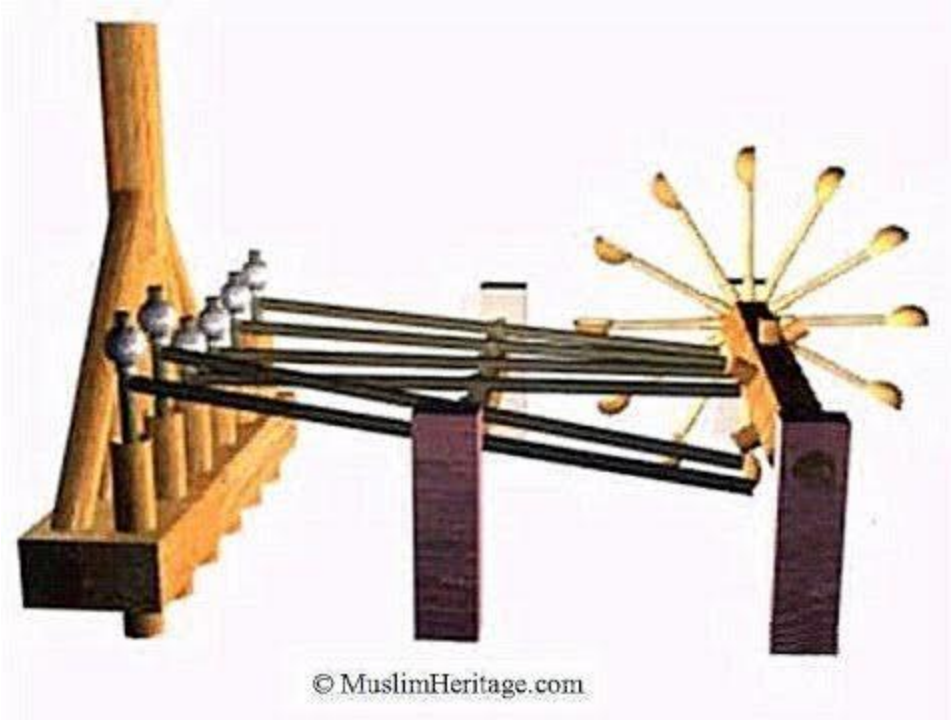
Solar Panels in Data Centers:

Solar is the best way to power a Data center Solar panel can be installed on the roof of buildings of Data Centers.
The slope of a roof plays a major role in determining the efficiency of solar panels. Furthermore, the slope is also necessary to facilitate the drainage of water during the rainy season. Ideally, a north facing roof is preferable as rooftop solar panels installed in such a roof will generate the maximum amount of electricity. Additionally, the inclination of the roof should be in the range of 10 to 30 degrees to allow proper drainage of rainwater and removal of debris.

Biogas Plant in Data Center

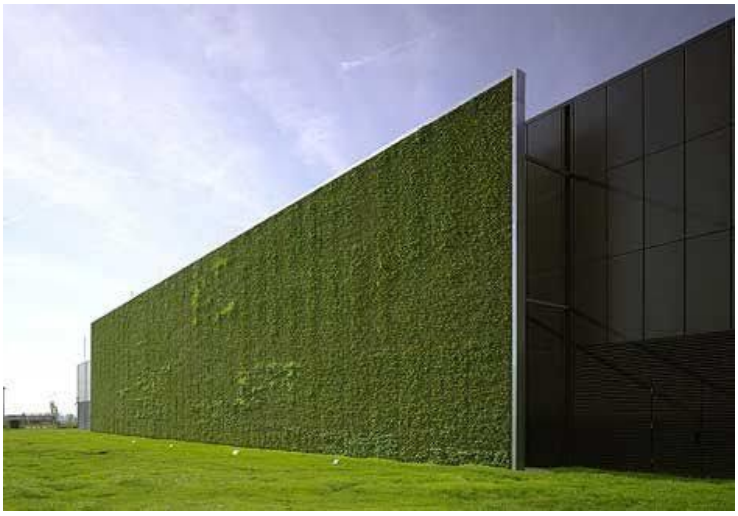
Many companies like Microsoft, Zahid Servers, and Attractasoft are already using this method to generate electricity. The sewage waste from the toilets of datacenter is collected and water is treated and reused and the sewage is transferred to mini biogas plants where electricity is generated. The decomposers in these plants are advanced and uses special kind of bacteria's to produce quality biogas. Then this biogas is used to generate electricity using biogas engines. The one of very advanced of them is made by me. This uses a special kind of engine which is very lite and made from special alloy and reuses gas even after burning it for turbofans (component of engine).

Using Hydro-power for electricity



We all know how ancient technique is hydro-power invented by Al-Jazzari. Still the concept is same just designed is a bit modified.
So as we so far know that data centers consumes a lot of water but what after? The same water can be used to generate electricity unlimited times using Jazzari's inventions. It's no knew concept even huge hydro-electric government plants uses same technique.

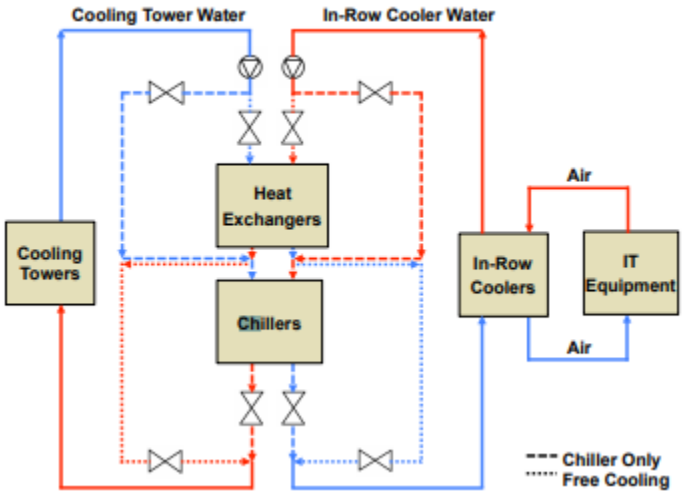
10. Concept of using plants to naturally keep cool the data center building

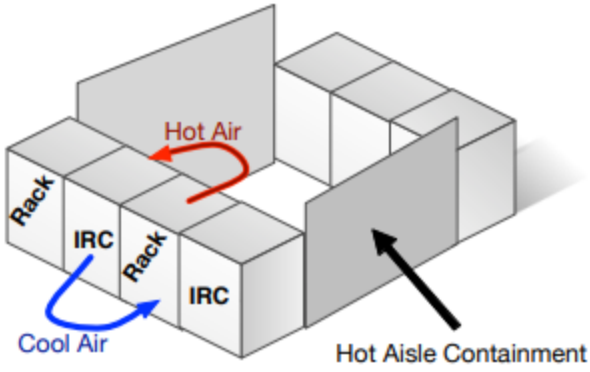


Data Centers generate a lot of heat this heat nearby the datacenter can be drastically reduced by planting grass alongside the walls of data centers and plating plants in its surrounding.

This significantly reduces the heat.

11. Concept of using green chillers





Traditionally, data centers have used chillers for cooling. Since chillers consume a significant amount of energy, they are a key contributor to high PUE. Data centers are therefore adopting alternative technologies to lower their PUEs, and continue to explore innovative options [5]. MGHPCC leverages “free cooling” (also known as “renewable cooling”) to reduce the amount of energy used by its chillers.

As shown in Figure 2a, there are two main water cooling loops.

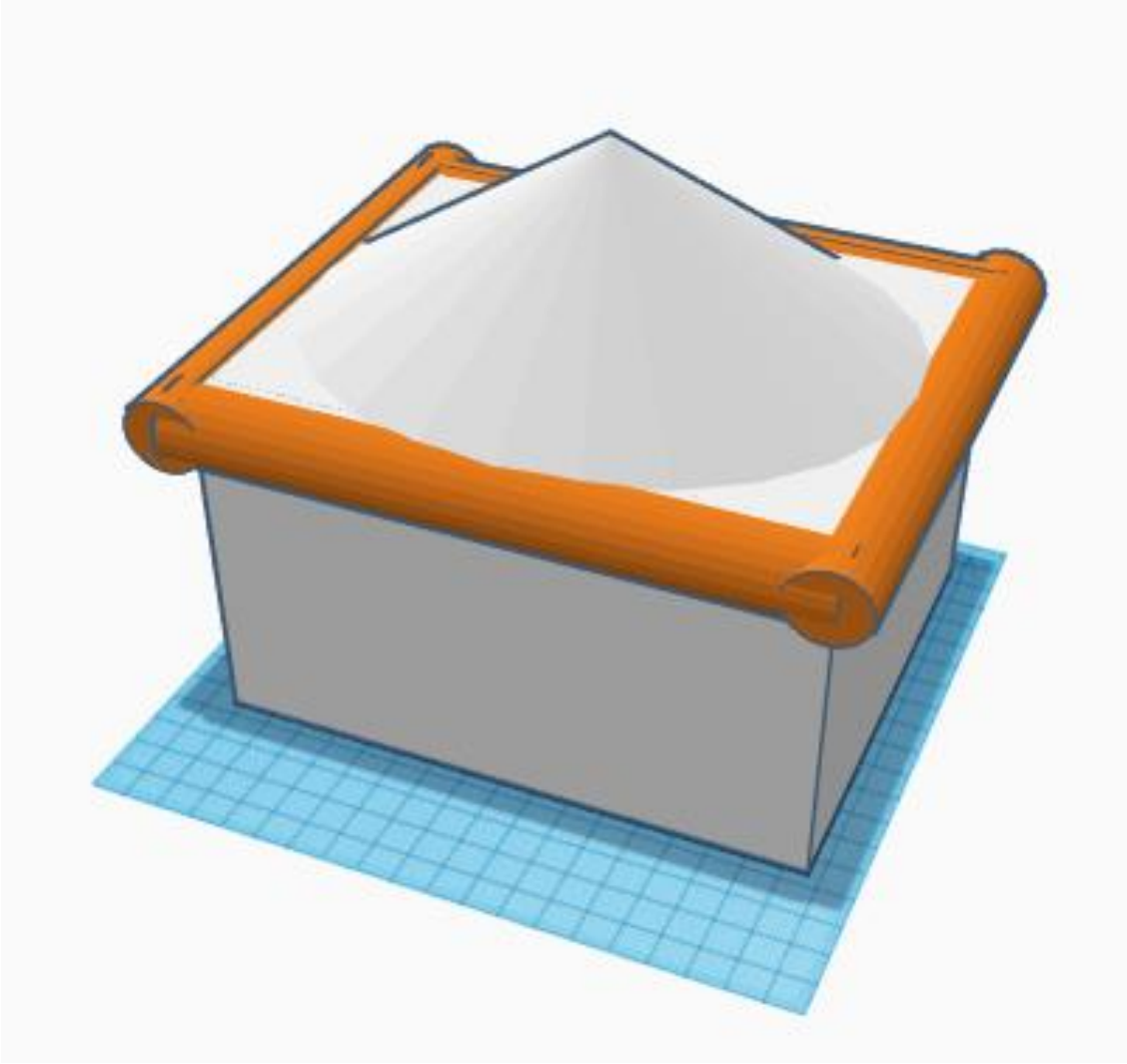
The water in the cooling tower loop is cooled using evaporative cooling. The chilled water loop circulates chilled water through IRCs that cool the computer room air as they remove it from the hot aisle shown in Figure. If the outside air temperature and humidity are low enough, then it is used by the heat-exchangers to cool the water in the chilled water loop.

To maximize the amount of time in free-cooling mode, the facility maintains the computer room temperature at 26.7◦C, which is compatible with modern servers but higher than the temperature settings for traditional data centers. Combined with the cooler climate of Massachusetts, this permits the use of free cooling for more than 70% of the year.

Each tenant’s rack is configured to use hot aisle containment to prevent hot and cold air from mixing together (Figure). The cold water in the chilled water loop is circulated through in-row coolers (IRCs), which are deployed adjacent to racks to cool the hot air extracted from the servers. The use of in-row coolers allows for a close coupling of the cooling with the computing heat load—the controls of the in-row coolers actively adjust fan speeds and chilled water flow to closely match the computing heat load on nearby racks, thereby enhancing efficiency

12. Figuring out everything together

So now let us figure out everything together how this futuristic datacenter will belike.
So first let us design the map and interior and exterior of datacenter for which I have used adobe thinkercad.



This is the basic design of datacenter building which is 5 floors high approximately 90ft above the ground without the top cone and a underground 3 story's which is usable area for datacenter severs. The top cone is where solar panels will be installed which will ensure maximum electricity generation; apart from it will also ensure that rainwater is maximum harvested and stored through the orange pipes which will send the water in storage area in the top cone. The orange pipes will also perform function of taking in water vapors and outside air for chillers.
Each floor in the building will be 18ft high only. Due to low ceiling height the chiller will cool the servers faster and will consume less energy.

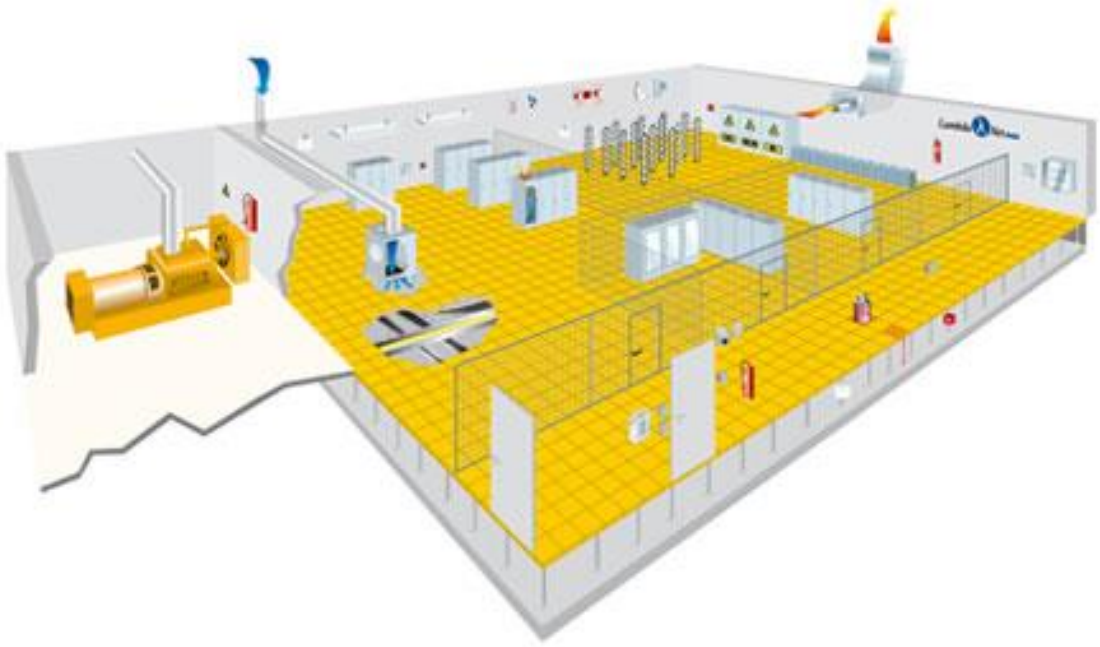
The mini biogas plant and mini desalinization plant with Zahid Generator will be installed in 3rd underground floor that means bottom most floor. The waste generated from toilets will be sent to separator in 3rd underground floor via pipes and there all waste will be separated from water the waster will enter in mini biogas plant where it will be used to generate biogas and the gas generated will be pumped into Zahid Generator B3-V8 which is powerful generator that reduces emission and generates maximum amount of power, it uses repetitive technology which is based on aljazzari principles of hydro power, basically the gas is used by engine for burning and generating torque which is connected to an alternator which generates electricity, the gas after being burned completely is used in turbofans to supply oxygen to the engine the gas is passed through five turbofans and then to 6 Zahid A8s which are device by Zahid Motors that generates electricity through compressed air and after that the gas is used it processed by various equipment's to reduce pollution and then is only realized through chimney installed 15 meters away from the building. The water sent desalinization plant after purification is used in chillers and various other needs of datacenter and waste remaining is again sent to biogas plant.

There will 400 trees planted near the datacenter building to reduce the heat and pollution generated by datacenter and keep the datacenter cool.

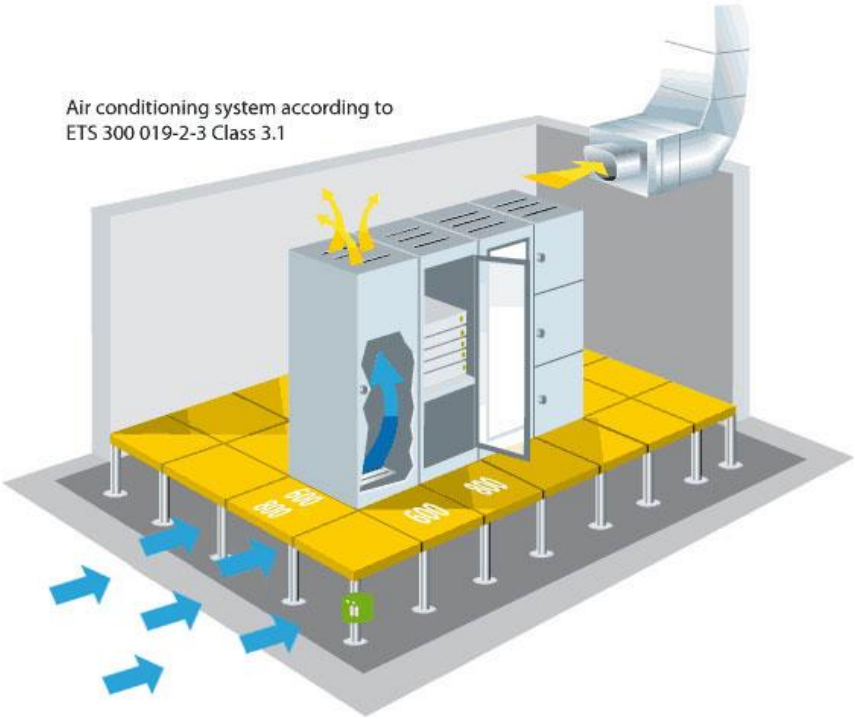
It's also proven by various studies that planting trees can make rain happen in an environment more regularly.

The server rooms in data center are raised for efficient cooling and caballing.

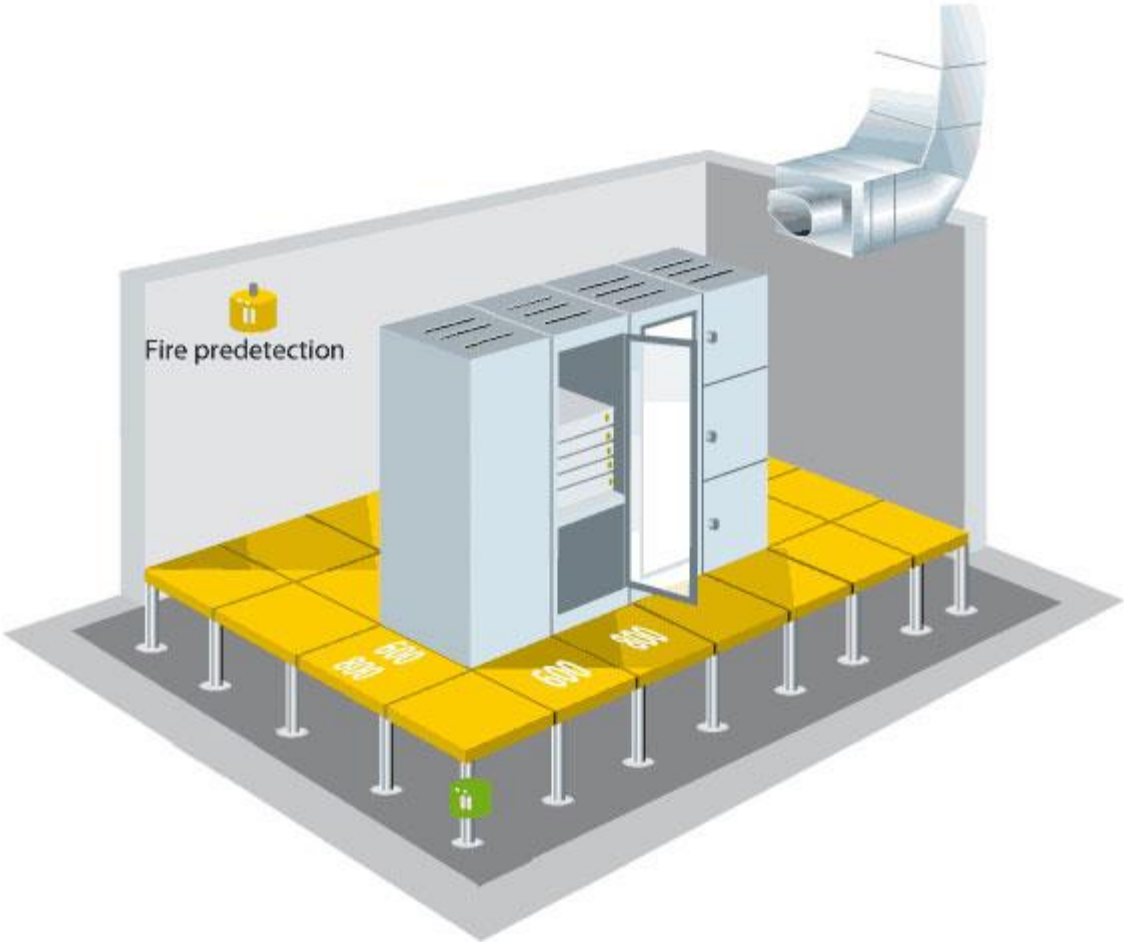
The floor height can be controlled hydraulically. It can be raised or decreased hydraulically so if there is work to be done that requires the casing of server to be removed from above it can be done by lowering the height of the floor. This is an 3d image to show exactly system works.



Here on the floor there is another floor made of special alloy is installed which is controlled hydraulically and the caballing is done under the hydraulic floor.
There are two chillers one is working on very low temperature other works on normal temperature.



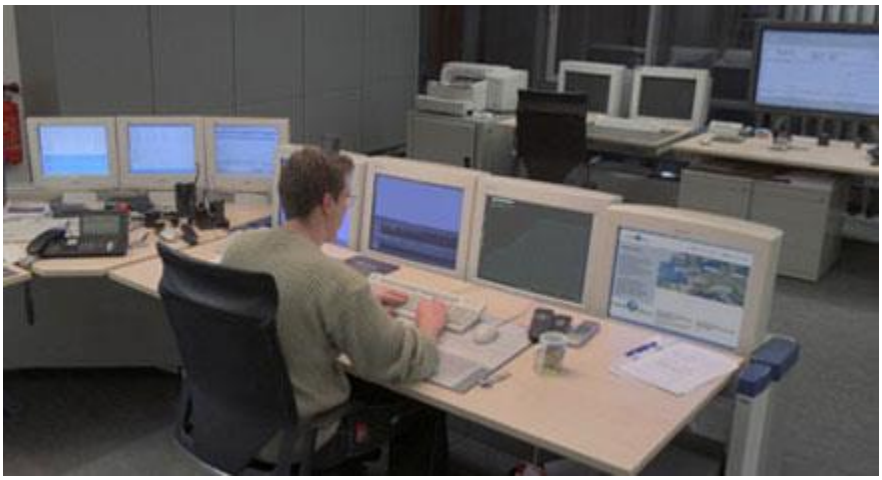
The one that works on normal temperature is for the wiring beneath the raised floor and other high power is for cooling down the servers.
The is fire protection unit in each corner of each room plus additional units are installed in places where there could be fire situation.



Smoke detectors and heat sensors are installed all across the building.
In the 2nd under ground floor there is repair, rebuild, recycle and disposal factory where all the operations takes place regarding e-waste management.
On the walls of data center building special plants will be grown to keep the building cool.
Using Aljazzari technique the water will be pumped across datacenter without using electricity for various purpose and using same technique electricity will be generated from the water.
The water storage is at the top the building in the cone.
Whenever water goes down from storage to any floor it goes through spiral pipelines enclosed in another pipes which have turbines fitted and generates electricity.
Water is pumped up back using modified Jazzari pumps.

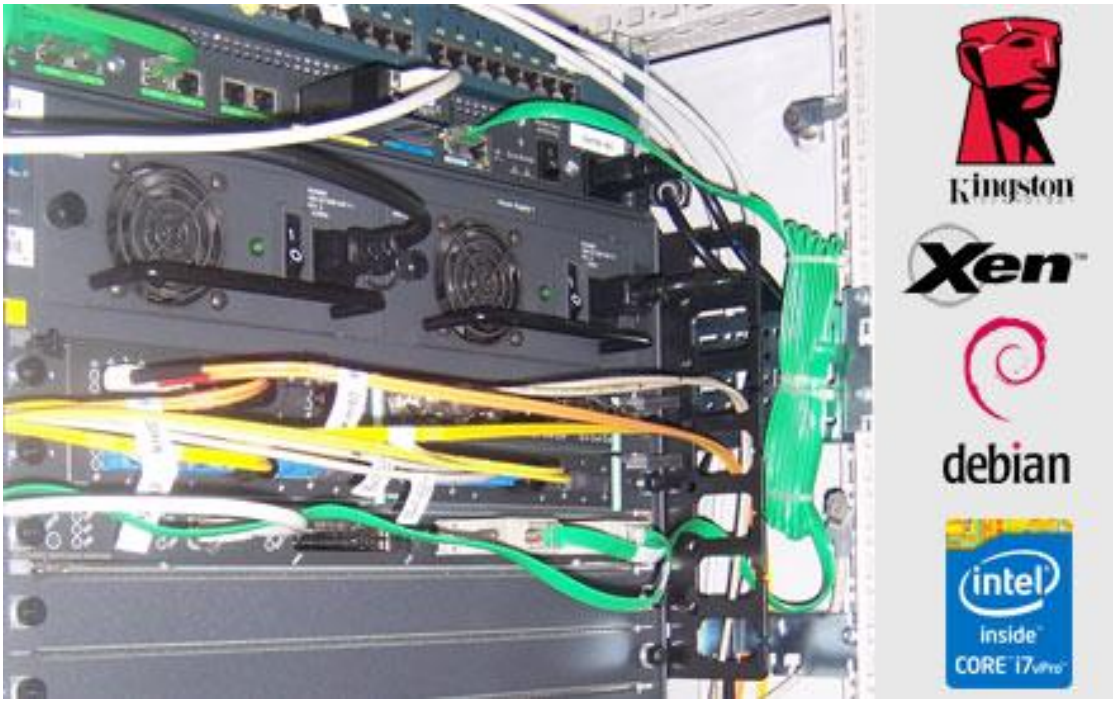
There are 15 additional solar panels outside the datacenter to meet the energy requirements.
On each floor there are 3 rooms and a lobby.
Two are smaller rooms of which one known as command and control room which as mini-severs made of reused/recycled phones, graphic cards rams, CPU's and laptops that uses MLDTs and FOPCBs

and other room is the Monitoring Center use to monitor the main servers the monitoring room only has monitors all connected to one mini-cloud situated in Command and Control Center this reduces the amount of heat generated and power consumption by individual pc.

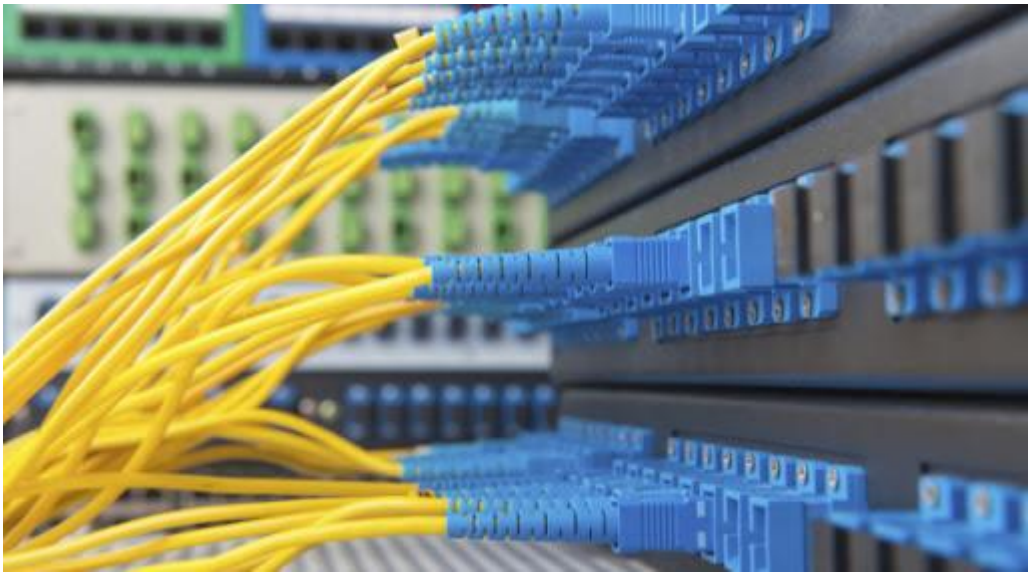


The picture above is of monitoring Center of Attractasoft Datacenter in Kiel, Germany.
The technical support team and marketing will also use mini cloud computing system made from e-waste situated at fifth floor.
In all the servers Linux operating system will be used as it's the most efficient Operating System which reduces the device power consumption upto 40% as compared to other operating systems.

The Debian distro of Linux will be used.



All the servers used will be ecofriendly based Intel's core i7 processors of latest generation.
Power consumption of each device will be monitored by Monitoring Center using Command and Control Center in case of any unusual activity in power consumption the power supply of that particular device will be cut down.
Fiber Optic cabals will be used for data transfer cloud internet and all other feasible thing.

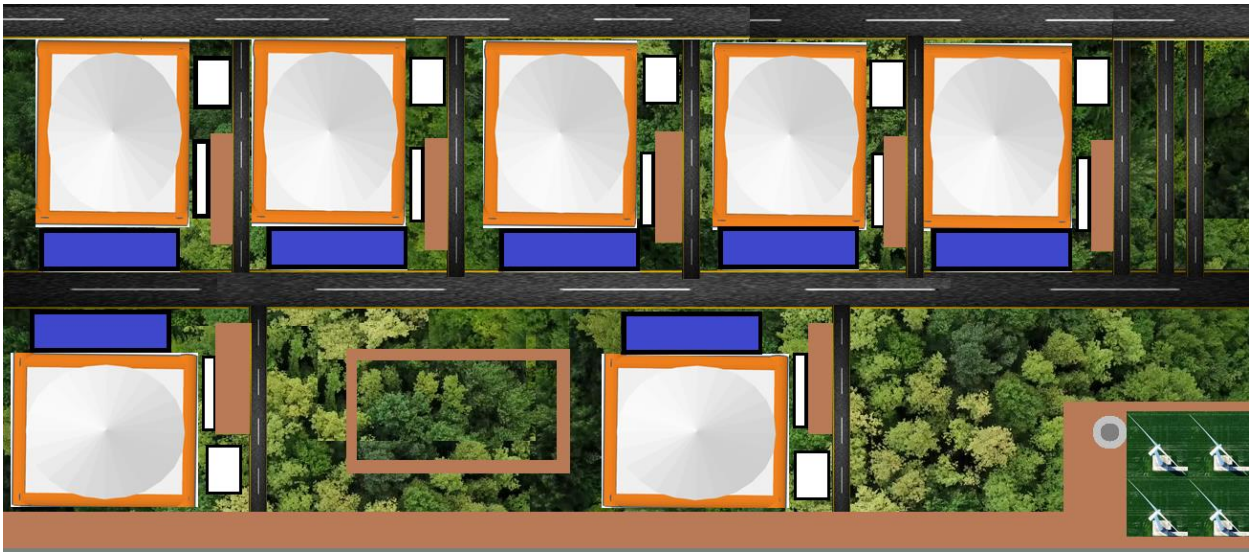


For datacenter employees the food won't be purchased from outside the rather the food would be grown organically in a garden near the entrance of datacenter this will keep datacenter naturally cool and will also reduce the food scarcity in the world to negligible extent but will be good steps for the employees and it would encourage them towards green and efficient computing.
For transportation of employees company will provide them free ride from home to datacenter in electric buses this will reduce the traffic and pollution of individual cars plus make employees more energetic and happier to work and they will work with their full efficiency and sincerity also this will improve company's rating and generate a brand name of the company providing it an competitive edge over the competitor.
There will be bus charging station outside the datacenter building.
In this way there will be total of 18 sets of datacenter build together connecting each other with fiber optic network and to travel between each block there will be electric cycles for the employs.

The above image is of Google Data Center

There will be also charging station for cycles near each datacenter building.
The marketing team could also do work from home just by logging into network present in deep web which would be fully secure and domain would be directly registered from icann.

This would not only provide safety and security for company's database but will also reduce employs pressure and company's cost by reducing power consumption by employs in the office.
Only the marketing team departments employ accessing from his home network will only be granted access to the marketing cloud site only and that to only his/her section which display him/her only data on which individual have to work thus preventing the loss or any kind of misuse of companies data.
Each block of datacenter will have its own systems for power and all other things.



The image above shows you how the block of this datacenter's will look from top down-view. Sorry my modeling isn't that good so it isn't the actual image like the cone of each datacenter will have solar panels installed on it.
Given in blue in the map are the solar panels that will be installed outside the datacenters.
Narrow box with black border and white color is the cycle parking where cycles will be parked.
Over there would also be cycle charging stations where cycles can be charged.
Cycles will be used by employees into go from one block into another.
The brown color represents mud.
The whit boxes with black borders are bus stands near datacenters building from where employees will be pick/drop to home/datacenters.
There will be charging stands for buses in this areas.
The orange border is the datacenter building with conical top on which there are solar panels. In right side there is chimney from where all the smoke realized by biogas plant and all other emissions will be realized.
The fans in right represent air turbines which are used as second back for the entire data plant.

Each datacenter is equipped with its own invertors

in case of power loss by solar water and biogas generators and then after power loss would use energy from wind turbine.

The datacenter have capacitors and power cutters in each second power is shut down several times and stored in capacitor which then sends current. This is done to reduce power consumption.

The brown border in data plant shows the area where vegetation will be grown.

That will be a garden where the company will grow organic plants for giving free food to employees. The garden will be 100% organic and no pesticides or any kind of artificial fertilizers will be used.

There will be lamps everywhere outside the datacenter building which will have their own solar panels mounted on top of them and own batteries inside the pole.

In evening the lights will automatically turn on and at day time they will automatically turn off.

There will total 418 trees planted of different kind of fruits that can be grown in that area along with neem and tulsi tress to keep away insects like mosquitos.
The trees will not only keep the datacenter buildings cool but also provide free organic fruits which company can use to serve their employees at lunch breaks this would not only make employees happy but would also make companies brand image and it would also help company to acquire employees and keep them on a low salary.

Next thing is to make theme black for the main website and control panels of the datacenter to reduce energy consumption it saves upto 750 watts per client in each year and that's total a lot of energy enough to power a tiny village.
Even if the website has 20000 daily hits it will save 15,000,000 watts per year.

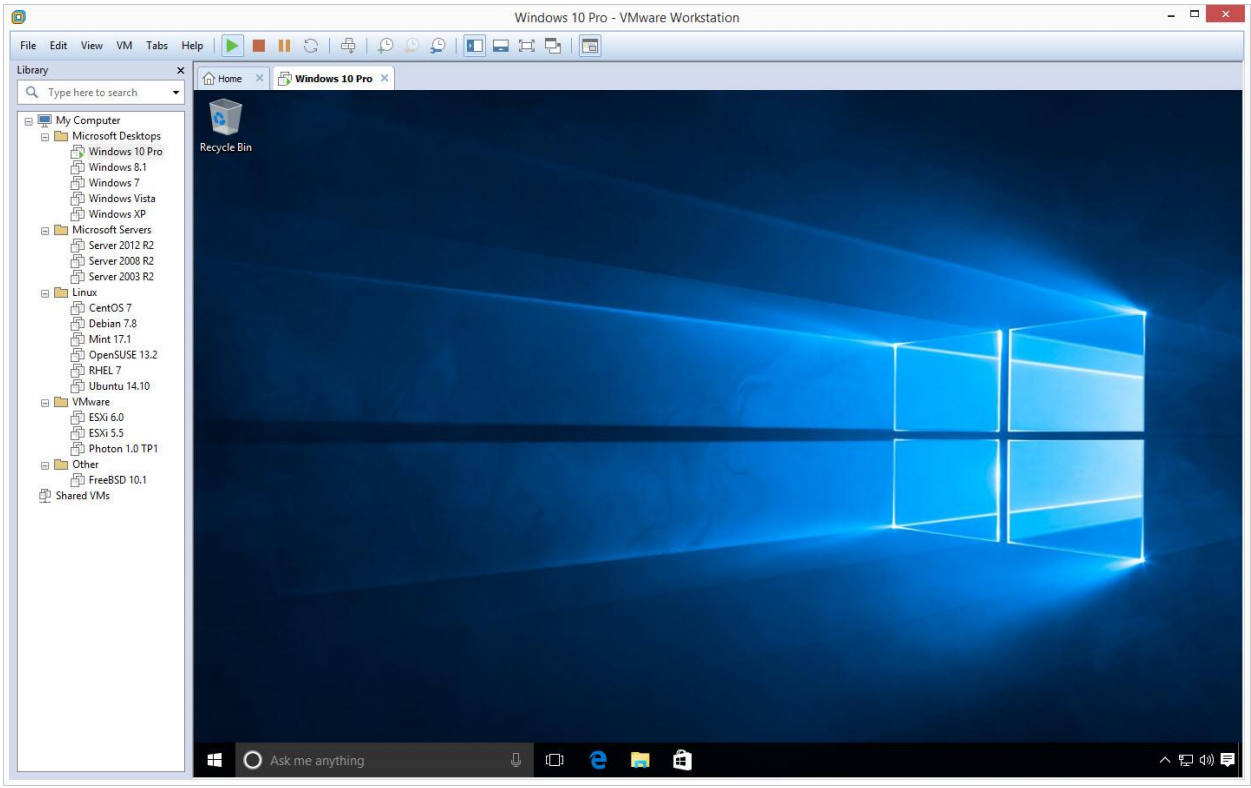
Next is to make mobile friendly apps for clients as most clients will prefer using mobiles but are currently forced to use pc or laptops to make or manage their websites.
An average pc for startup just cost 85 watts. Turning on and using them would cost a lot of power from client side when they can be even done on mobile but most web hosting sites even after being mobile friendly don't fully support mobile devices and many features doesn't work in mobile browsers thus the clients are forced using a desktop or a laptop.

The solution it is making websites more mobile friendly and making apps for different purposes like creating or managing websites this would save a lot of energy consumption and also create better and comfortable user experience due to which company will also increase its shares in the market and is beneficial for the company in the long run giving and edge over its competitors.

The datacenter will use id scanners instead of register files to note down the time of employee entry at work and exit this will reduce amount of paper waste and make datacenter greener.

The above image is of datacenter of CERN as you can see the racks above are empty this increases load on chillers and more energy is consumes cooling empty spaces the servers should be shifted upwards while the empty space should be block with carbon sheets to increase the cooling efficiency and reduce the power consumption.

So in our data centers the servers would be shifted automatically upwards hydraulically and then a carbon sheet shutter would block the empty spaces thus increasing the cooling and reducing power consumption hence saving cost.



To offer client windows hosting VPS will be allocated to the client a virtual private server that won't exist in reality but will be running in a simulator on Linux servers this will not only reduce the power consumption but will provide operation simplicity and efficiency.

The chillers in the Datacenter will use green technology for efficient cooling and power saving. Hybrid chiller will be installed in datacenter buildings. This technology will make use of both air side and water side economizers.

4. Impact of newly designed Data Center on Environment and Cost cutting

The datacenter won't be depended on government for electricity or water supply.
This datacenter will be self-sufficient and it will be eco-friendly towards nature.
By its eco-friendly power consumption policy it will reduce around worlds 2% carbon emission and will be also capable of selling out extra energy generated to the nearby residents.

The datacenter will drastically reduce around 0.5% e-waste generated in the world and will also be capable of outselling the remanufactured products at cheaper rates and thus generating a lot of profit.

The disposal factory in datacenter would help in removing harmful substance from the e-waste and converting the precious substance like gold, silver, mercury, aluminum, silicon back to original form which would then sold out to factories which would make company an annual profit of 1.6 million USD. This amount is so much that the company won't need any more investors for raising funds the company will be able to have its own funds by this cash cow.

This will increase company's assets and make the datacenter a very profitable business for the company. This eco-friendly datacenter will not be just reducing waste and pollutants but will also be a cash-cow for the organization.

This datacenter will make the organization in news headlines and will make it easier to acquire clients without a lot of marketing and will save a lot of money spend on marketing that could now be spend on R&D and making more greener datacenters.

These implementations will reduce the customer acquiring cost for the datacenter being all time in news. The organization would able to compete with tech giants and will give and edge over all other competitors.

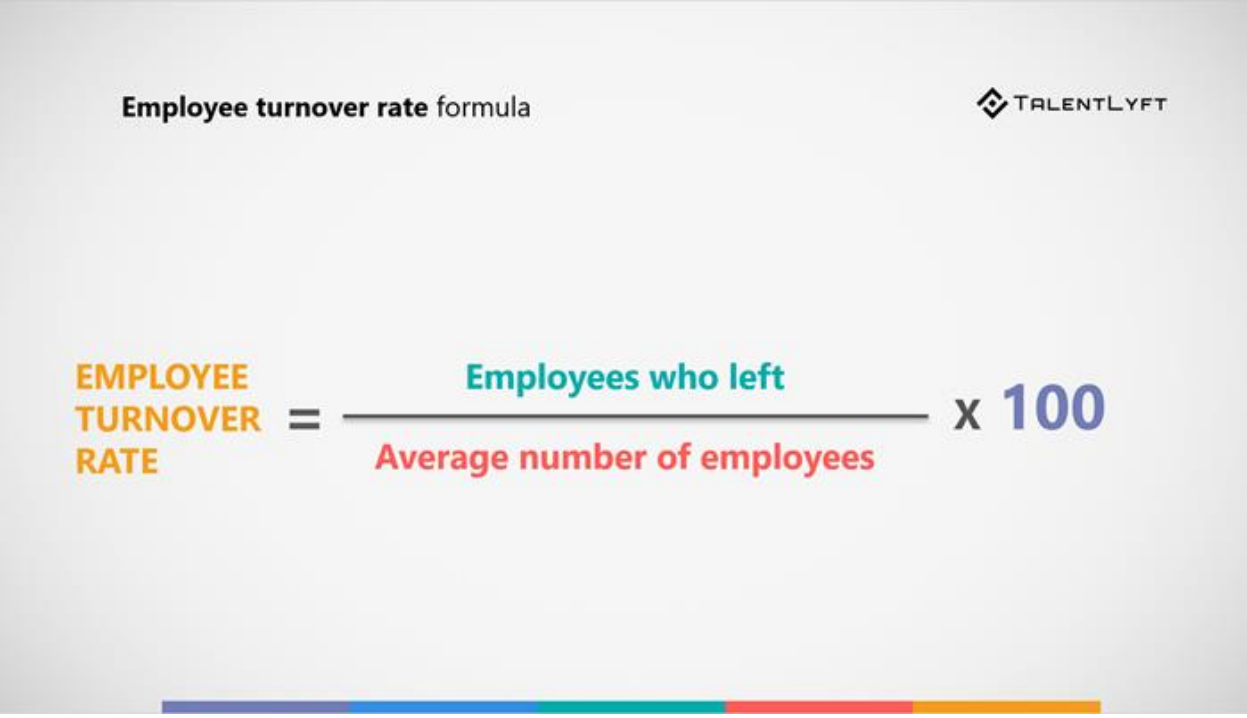
These implementations will help company to get better ratings on international forums and directives like WEEE and various other EU and UN directives.
This will make company's better image towards media houses and government and the company could easily get tax exemptions.

This datacenter will itself fulfill CSR that is Corporate Social Responsibility so it will save around 30% funding's go into CSR project that now can be used for the expansion of the company.

The experienced employee's would very easily get recruited at a very low package and company can very easily manage its employee turnover ratio as most employee's won't be leaving company for higher salaries due to better facilities provided that would save new employee's training cost and company won't need any recruitment agency for recruiting employee's as many people will come for placements themselves to company and thus saving the money that company gives to these agencies.

Being able to maintain a good employee's turnover ratio a lot of investors would be attracted towards the company and the share prices of the company would rapidly rise in the stock market indicating better performance.

The average employee turnover ratio in tech companies is 13.2% which will be for our datacenter around 65.9% according to estimates which will be very high percent and will help the company growth in future.



Here is the formula that I have used to calculate the ETR.
This formula I have taken from TalentLyft official website.

So after having the entire report you may think is it still worth I mean the amount that will be invested in this technology will it have the returns more than investment cost and how much time will it take these are some basic questions that may arise into your mind so now let me clear it for you.

This datacentre would cost from anywhere around $180 million to $400 million US dollars and that's a lot of money costing a fortune. So depending upon your business model is your revenue. Let us take an ideal situation of web hosting company where by this model you if you also provide easy to install automated scripts with drag and drop builders and mobile application it would generate you easily a revenue of 25-45 million USD per year. So it may take you 8 years to get the return of investment amount keeping inflation in mind. So in another 8 years you will make 4 times that money keeping that in mind if you invested same money in fixed deposit by 8% interest you getting and 2.5% inflation you are only making around 110% profit of invested money in 16 years but same for datacenter is 220% returns if everything goes right.
So I think it's worth risk plus it will also give an image and an identity.
So if you are interested in having own datacenter I suggest you to some million bucks more in start to get better results in the end. You may have heard that as you sow shall you reap. If you invested in inefficient technologies than initially it will be cheaper but will cost you in the long run. There are many datacenters that have failed due their inefficient practices in the past.

Even if you go for making normal datacenter without any green technology it will cost you around 80million to 250million USD and which will cost you in billions. The light bill will be so much high assuming rate of 8.5 rupees per unit that means your electricity bill will be 1,204,707,388,259.388 rupees that's 1.2 trillion rupees equivalent to 17,210,105,546.56269 USD that's 172 billion USD each month. Let me show you how 10000000 is total no of average servers place in a datacentre building. There will be 8 building in our park so it will be 80,000,000 servers each costing 1000 watts of power. For a minute pretend that the server will only cost 1 watt than to there are other devices like chilers and light bulbs. The average light bulb uses 100watts so now the total is 32,000,040,000 units. Then chilers consume 0.64 KWPH that's now total 10,240,012,800,204.8 watts. Now with 8.5 rupees average per unit it would cost 1,204,707,388,259.388 i divided it by 8.5 so got the answer so paying such big massive amount is terrible it's a night mare for any company almost impossible to pay causing a cash crunch or losing market share and then causing cash crunch.

So as you see green technology as so many benefits not only it helps and protects the environment but also reduces the cost of everything. Almost every big datacentre's like Google, Facebook, Attractasoft, Opera, Yahoo, Go daddy, etc all are trying to make more and more use of green technology.

As you might be aware that pollution is increasing day by day. Delhi and Shanghai the two cities known as the pollution capitals with title world's most polluted city faces many problems. People living there have respiratory problems and carbon emissions have a big role in it. And datacentre's are responsible for world's 0.3% carbon emission. This very serious problem that needs to be addressed and hence many companies are coming up with different innovative ideas.