the Availability Digest

Google's Extreme-Green Data Centers

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Google has recently filed for a patent describing an all-green data center.[1] No man-made energy is used for powering the data center nor for cooling it. Rather, power is generated from the wave motion of the ocean; and cooling is accomplished using seawater. Essentially, Google's proposed green data centers are barges that house cargo container-sized server farms

The Explosion in Data Center Growth

Hundreds of millions of people now access the Internet daily. As a result, many information providers are building massive data centers, each comprising thousands of servers and their communication and other ancillary equipment.

Each of these data centers can impose an extraordinary load on the local power utilities. Not only is power needed to drive the thousands of servers, but additional power is needed to provide the cooling required. The impact of this power load was felt in California a few years ago when brown-outs became a frequent occurrence.

Most of this energy is derived from fossil fuels and so contributes to our carbon footprint and probably to global warming. Therefore, there are many reasons to try to be more energy efficient in our data centers, ranging from our limited power sources and high cost of energy to global warming and pollution.

A long-range solution is to build power networks from renewable energy such as wind, solar, hydro, and even nuclear power. However, as important as these solutions are, they are massively expensive and require sometimes decades to implement. Furthermore, they are effective only to the extent that they can integrate with existing power grids, which themselves must be significantly expanded. The result is that the location of new green energy and new data centers may have no relation to each other.

Google's proposed solution is to collocate new data centers with cheap sources of energy – mainly the oceans of the world.

How Do We Tap the Oceans for Energy

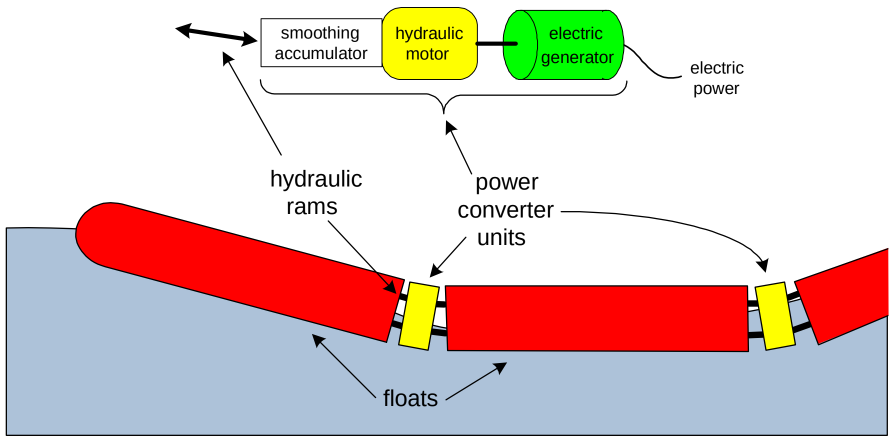
There is a tremendous amount of free renewable energy that can be derived from the wave motion of the oceans, and several techniques have been proposed and developed to harvest this energy. Predominant among these is the Pelamis Wave Energy Converter developed by Pelamis Wave Power[2] of Scotland.

[1] J. Clidaras, D. Stiver, W. Hamburgen, Water-Based Data Center, *U.S. Patent Application US 2008/0209234*; August 28, 2008.
[2] www.pelamiswave.com

The Pelamis Wave Energy Converter

Currently, Pelamis Wave Energy Converters are in operation off the coasts of Scotland and Portugal. The Portuguese installation is to be expanded to provide 21 megawatts of power, enough to power about 15,000 Portuguese homes (see an explanatory video at http://uk.youtube.com/watch?v=7k5r89IseEM.

The Pelamis Wave Energy Converter uses the motion of ocean surface waves to generate electrical power. The Converter comprises connected cylindrical floats that flex and bend with respect to each other as waves pass. It uses this motion to generate electricity.



Pelamis Wave Energy Converter

Each float is massive. It is 35 meters in length and 3.5 meters in diameter. Successive floats are connected together via articulated hydraulic rams that drive high-pressure oil through hydraulic motors as the rams are forced into and out of each float by the wave action. A float string is typically anchored in 50 to 100 meters of water five to ten kilometers from shore.

The oil pressure to the hydraulic motors is controlled by the use of smoothing hydraulic accumulators, which are essentially pressure storage reservoirs.[3] They store high oil pressure and release consistent oil pressure to the hydraulic motors. This allows the hydraulic motors to operate at constant speeds. The hydraulic motors drive electrical generators that can provide power to the Google data centers.

This power is used not only to power the servers in the data center but is also used to power pumps that drive cool seawater through heat exchangers to cool the servers. The use of heat exchangers allows the caustic seawater to be isolated from the coolant circulating in the closed loop system that is used to cool the data center servers.

Pelamis machines off the coast of Scotland

A connection between a single pair of floats (a Pelamis "machine") can generate 750 kilowatts of power. Pelamis floats are typically arranged as a set of four floats. The three articulated joints connecting the four floats can generate up to 2.25 megawatts of power. Forty Pelamis machines occupying about one square kilometer of ocean can generate about 30 megawatts of power.

[3] Hydraulic Accumulator, *Wikipedia*.

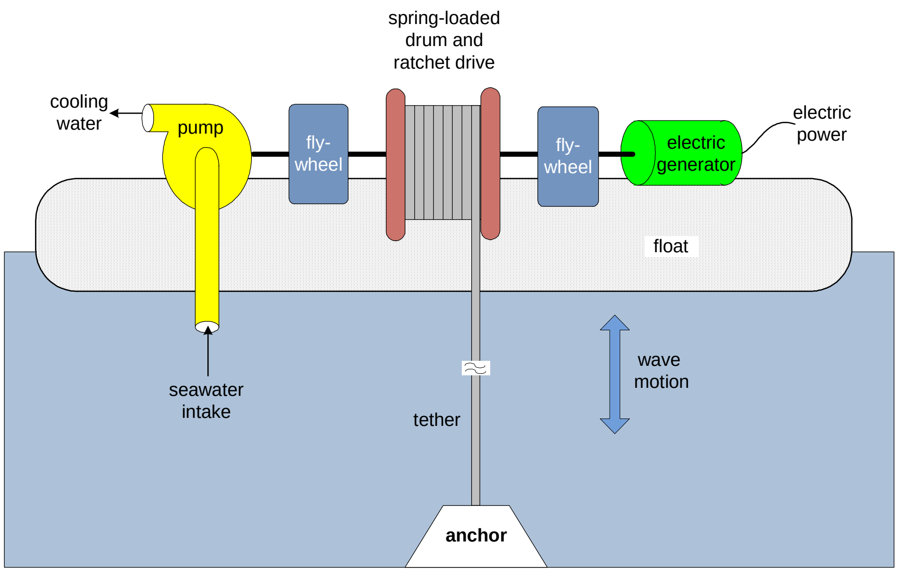
Diesel backup generators are provided to provide power should the ocean turn glassy enough so that sufficient power is not being generated by the Pelamis machines. Experience has shown that recourse to backup diesel power is seldom needed.

An alternative configuration is for some of the hydraulic motors to drive seawater pumps directly rather than having the pumps be electrically powered.

An excellent video describing the Pelamis Wave Energy Converter can be found at http://www.youtube.com/watch?v=mcTNkoyvLFs&feature=related. Many other impressive videos may be found on www.youtube.com by searching on Pelamis.

Tethered Wave Energy Converter

An alternative method for generating electricity from wave motion uses a tethered floating platform that rises and falls with wave action. A long tether is anchored to the ocean bottom on one end and wraps around a spring-loaded drum on the other. As the platform rises, the tether rotates the drum in one direction. As the platform falls, the spring-loaded drum rotates in the opposite direction, winding up the slack tether.



Tethered Wave Energy Converter

The tether drum is connected to a shaft via a ratcheting mechanism so that the shaft is turned in only one direction. Fly wheels on the shaft and a speed governor help keep the shaft rotating at a constant speed. The shaft can be used to drive an electrical generator to power the servers and/or a pump to supply seawater for cooling.

Other Techniques

There are many other techniques that have been proposed and implemented in at least prototype form to convert wave energy to electrical energy. One example is the Wave Runner,[4] developed by the now defunct U.S. Myriad Technologies in the early 1990s. It is similar to the tethered wave machine described above except that it uses a gas or fluid-driven piston to drive electrical generators.

[4] K. Welch, C. Rothi, H. Rothi, Buoyancy Pump Power System, *U.S. Patent 7059123*; July 13, 2006.

Containerized Servers

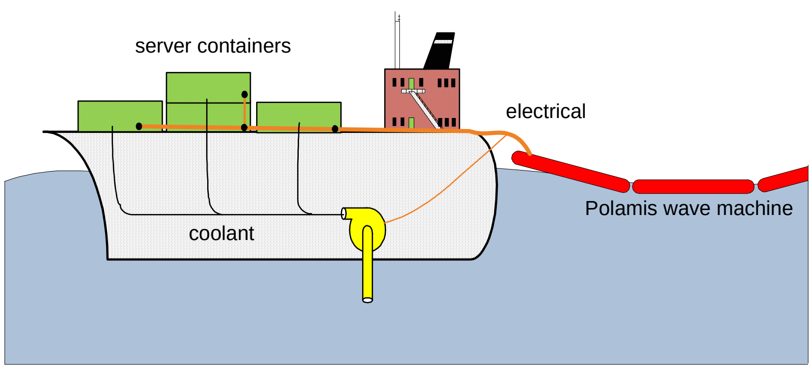
One way to package the large server farms required by the data center is in large rooms that are actually standard crane-moveable intermodal shipping containers used by ocean-going freighters. These containers can be 40 feet in length and are 8 feet in width and 9 ½ feet high, plenty of room for a sizeable server farm. All ports and connecting road and rail transportation facilities are built to handle these containers.

In this way, standard rail or trucking facilities can be used to move the server containers from their point of manufacture to an ocean port. There they can be loaded onto a floating server platform that will become the data center. The server platform can, in fact, be an ocean freighter configured to handle standard shipping containers.

The platform contains the backup batteries and/or diesel generators required to ensure continued power to the data center. Hydrogen fuel cells can be used for backup and can be recharged with hydrogen by the electrolysis of seawater when wave energy is available.

Once loaded, the freighter moves under its own power to the desired position in the open ocean and anchors there. The freighter then connects to the wave-powered electrical grid. The containerized servers are connected to the electrical power and the cooling facilities.

All that is left is communication to the data center's users. This can be done by connecting the floating data center to the Internet backbone via microwave links or underwater fiber. Satellite links can also be used for those applications that can tolerate the communication latency that is imposed by satellite communications.



A floating extreme-green data center

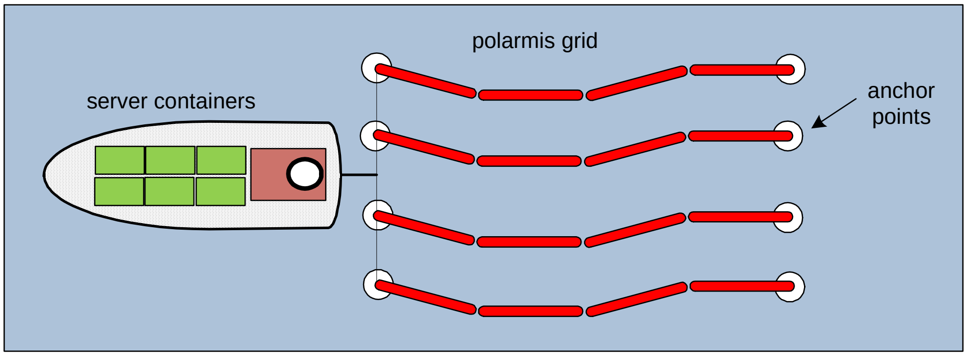
Of course, the floating data centers must be kept out of shipping lanes to avoid collisions. They must also be suitably marked for visibility and be shown on navigation charts.

Powering the Data Center

In Google's preferred embodiment, the floating data center will be powered by Pelamis machines. Multiple such machines will be anchored in the vicinity of the data center. Their generated power will be connected together in an electrical grid in such a way that the loss of a machine will have no affect on the power grid except that the machine's power-generating capacity will be lost.

Pelamis machines typically comprise four floats connected together and anchored at their ends. At float lengths of 35 meters each in length, this results in float configurations about 140 meters long weighing over 300 tons. The resulting three machines (one per each float-pair interface) can generate over two megawatts of power.

Sufficient machines are provided to generate the power required by the data center. For instance, if six to eight megawatts of power are required, four sets of four floats will suffice.



Connecting to the wave-powered electrical grid

Maintenance

The floating data centers are designed with maintenance in mind. If servers are to be upgraded, a maintenance ship with container-handling capabilities can be sent to the floating data center with upgraded containerized servers. Old server containers can be offloaded at sea and the new server containers put in place. Likewise, the data center can be expanded by adding additional server containers and, if needed, additional power-generating capacity.

If a Pelamis machine malfunctions, it can be disconnected from the electrical grid and towed to port. There it can be repaired, towed back, and returned to service. In the same way, Pelamis machines can be upgraded. If additional capacity is needed, more Pelamis machines can be towed to the data-center site, anchored, and connected to the electrical grid.

Except for diesel power backup facilities, there is no ongoing energy expense. Perhaps equally important is that additional power can be provided as the data center grows without having to build expensive generating and distribution infrastructure.

In fact, there may not even be a need to get governmental approval for any of this construction. If the data centers are far enough at sea, they will be in international waters and are subject to no governmental regulations. There is even precedence for this. In the 1990s, an abandoned floating 6,000 square-foot gunnery base in the North Sea became the tiny sovereign nation of Sealand. Sealand provided a data haven for people who wanted to avoid governmental snooping or regulation.[5]

Summary

The floating data centers envisioned by Google use free, non-polluting renewable energy – the tremendous energy of oceanic wave action. The only time that this is not true is when backup power is needed during those times in which there is not enough wave action to completely power the data center.

[5] Welcome to Sealand, *Wired*; July, 2000.

Google points out that the use of these floating data centers has other advantages. For instance, during times of emergency following a hurricane, earthquake, or terrorist attack, such a data center can be moved quickly to the vicinity of the disaster and can provide data-processing services to replace those destroyed or disabled by the disaster.

A major focus of data-center design today is the minimization of energy footprints. Google's floating green data centers may be a major step in this direction.