ServerDomes

White Paper

# Because the future is inevitable.

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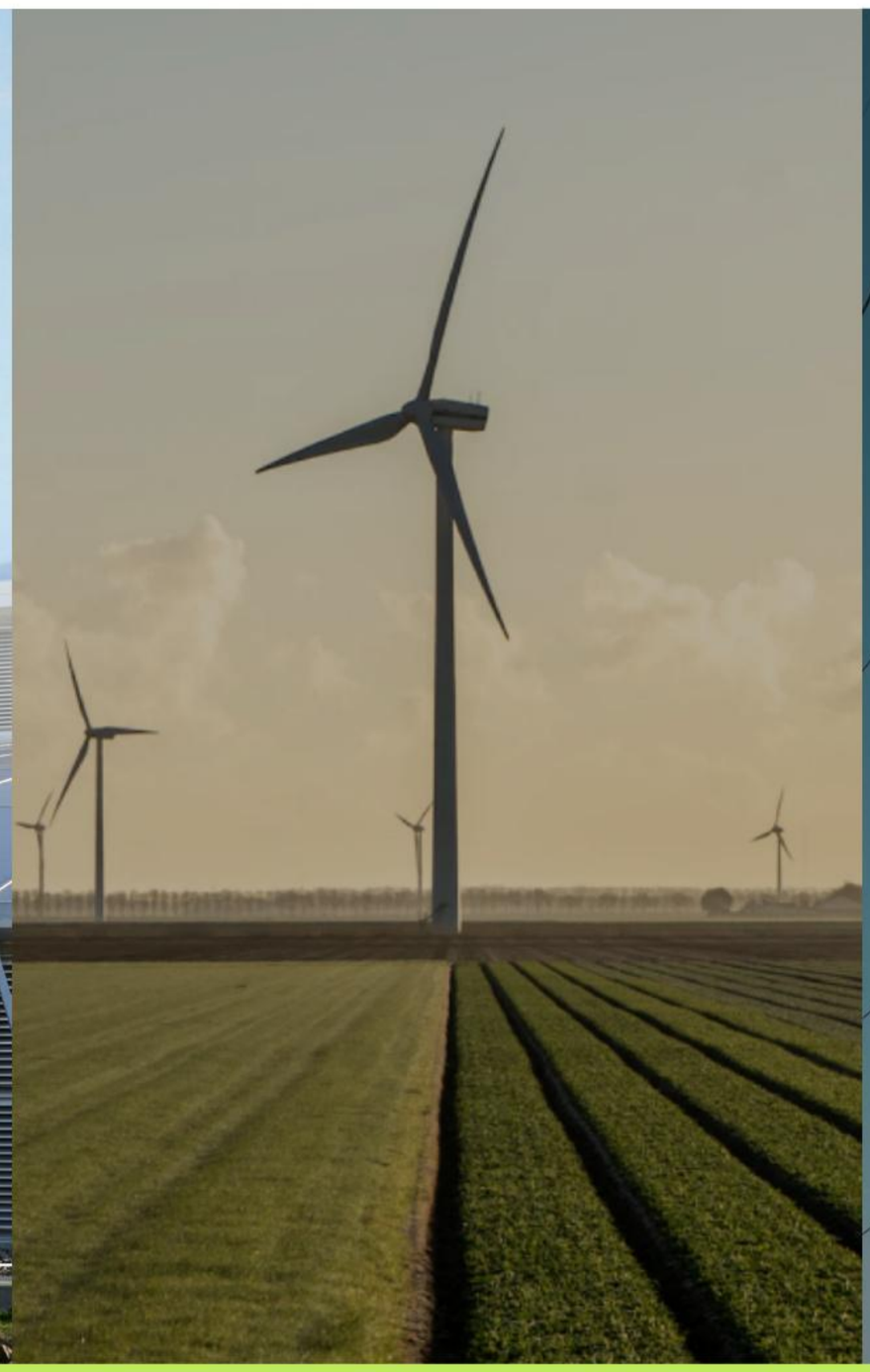

# Future - The Growing Impact of Data Centers

Information storage and retrieval is the backbone on which modern technological fields are built. It does not matter whether the application involves cloud solutions, hand-held mobile devices, social media, media streaming, cryptocurrency, self-driving vehicles, medical and financial records, or micro satellites. There is a total reliance on data center infrastructure. To underscore the pervasiveness, it is projected that through 2020, the colocation data center market, not including self-hosting and managed solutions, will be worth $54.8 billion with a compounded annual growth rate (CAGR) of approximately 12% domestically and 15.4% worldwide. The worldwide cloud market is projected to surpass $200 billion.

In 2017, the information and communication technology sector accounted for approximately 2% of the world's CO2 emissions and is projected to generate up to 3.5% of global emissions by the end of 2020. That level surpasses the aviation and shipping sectors. Unlike aviation, the tech sector is growing exponentially. Computer systems design and related services is the fastest growing industry with an 18% growth rate in the USA. That's more than double the average growth rate for all other industries. In a 2017 peer-reviewed study, Dr. Anders S.G. Andrae (Huawei) found that without dramatic increases in efficiency, the Information and Communications Technology (ICT) industry could use 20% of all electricity and emit up to 5.5% of the world's carbon emissions by 2025.

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# Power Hungry and Inefficient

Data centers in the US used approximately 90 terawatt-hours (TWh) of electrical energy in 2018. Globally, data centers used approximately 416.2 TWh, and this amount is expected to triple within the next 10 years. For comparison, California used 259.5 TWh to meet all of its electrical needs, not just for its data centers.

Unfortunately, most data centers use energy inefficiently. While servers in data centers require energy, they also create a lot of heat that needs to be removed for the servers to continue to function properly. Traditionally, this is where inefficient air conditioning units are utilized. That is the most obvious example of the dynamic between power used for IT and power used to maintain a conducive environment. For environmental and economic reasons, a metric was created to measure how much energy is wasted. It is called Power Usage Effectiveness (PUE). A PUE of 1.0 indicates 100% efficiency and means that no energy was used to run mechanical or other support systems such as AC units, lights, security cameras, environmental controls, or anything else. A PUE of 2.0 indicates that an equal amount of energy was used to run the machines as was used to run the other systems.

Uptime Institute has tracked industry average PUE numbers at intervals over 12 years. In 2019, for the first time, there was no recorded improvement. In fact, energy efficiency deteriorated slightly from an average PUE of 1.58 in 2018 to 1.67. When that value is applied to the total energy used by data centers globally, we can extrapolate that 162.4 TWh of energy is being wasted. At an average of 12 cents per kWh, the excess is costing nearly $19.5 B.

Large companies have been creating hyper-scale structures, sometimes referred to as mega data centers. Often utilizing customized equipment, these 100+ megawatt data centers are able to achieve an average PUE between 1.1 and 1.3. In contrast, conventional data centers typically have a PUE of about 2.0. Google, for example, boasts a PUE of 1.12 on average for all its centers. However, hyper-scale is not a singular solution. These facilities cost hundreds of millions to construct, require a vast area of real estate, have legacy instrumentation issues, typically consume large amounts of water, and lack the increasingly important agility or flexibility.

There are many organizations, such as those involved in edge computing, government agencies and universities, that wish to control their own data but are better suited with an enterprise-sized data center with a 1 to 5 megawatt capability. Traditionally, these enterprise-sized data centers devour energy as they have an average PUE of around 2.0, making them expensive while adversely impacting the environment.

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# Unmatched Performance and Versatility

Companies managing their own conventional data centers face intractable difficulties in reducing energy and maintenance costs. Mired with poor power usage effectiveness (PUE), inefficient operations, and lack of agility, many companies would like to migrate their systems into high-efficiency data centers. However, many current green data center designs have power constraints, lack adequate scalability, and may not accommodate older legacy equipment. Others involve a large footprint, high maintenance costs, and/or poor versatility to accommodate newly developed computer hardware and cooling technologies. Enter ServerDome.

The ServerDome combines world-class power efficiency with unmatched operational cost savings. The high-efficiency, Tier 3+ data center, nets an annualized PUE of 1.13. The "lights out," low-maintenance facility does not require chillers, computer room a/c units, ductwork, heaters, humidifiers or exhaust fans. Instead, the geodesic dome provides a massive surface area for air intake around the lower perimeter of the dome and exhaust around the circumference of the cupola. It allows up to 726,000 cubic feet per minute of airflow at the velocity of a light breeze. Due to high-volume air flow, the ServerDome can accommodate densely packed equipment with an average of 25kW/rack of available power for all racks, and a peak power availability of 40 kW/rack. When compared with industry average power efficiencies, the ServerDome running at full capacity generates a substantial ROI due to energy savings alone. This will continue to deliver significant annual cost savings by eliminating unnecessary infrastructure and simplifying operations and maintenance. Of course, this design can also accommodate any customer’s requirements for reduced power density and tier- defined redundancy without adversely impacting inherent design integrity or performance.

First-rate versatility empowers data center operators to scale and equip appropriately over time. Ten modular data pods distribute radially around a network distribution hub. Data center operators may initially choose to build out only a few of the data rooms, thereby deferring construction costs until additional equipment is needed. In addition to scalability, the ServerDome also offers far greater flexibility.

Unlike many other “green” data centers that require primarily homogeneous equipment to obtain low PUE ratios, ServerDome’s data center is able to achieve a very low PUE while accommodating a wide range of heterogeneous equipment throughout the facility. Consequently, low-power legacy systems can be housed alongside high-power or experimental systems in any location without the need for physical segregation and loss of efficiency. In addition, future data pods may be served by air handlers, water cooling technology, or a heterogeneous mix between data pods within the same data center.

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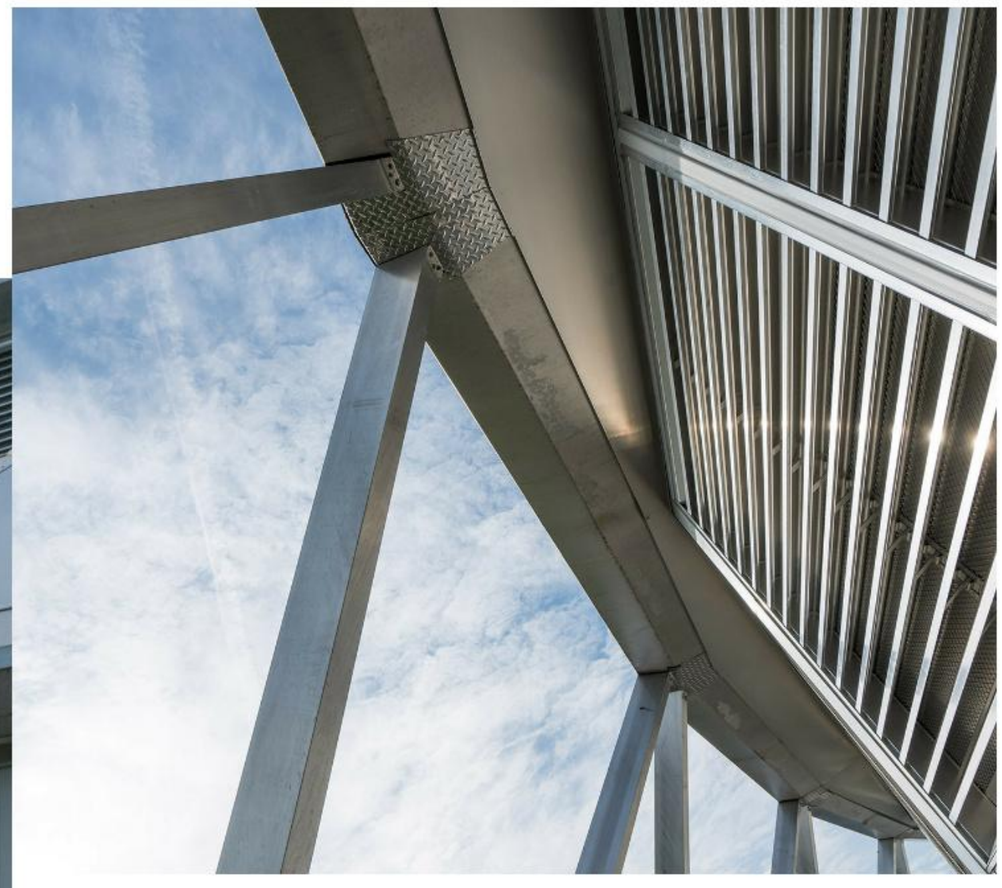

The ServerDome is a "lights-out," enterprise-sized facility that is topped with a unique, proprietary geodesic dome that eliminates the need for air conditioning through its design. The shape capitalizes on the physics of thermal buoyancy and air flow to naturally cool the building and keep the machines running at optimum temperatures. Supply fans comprise the singular mechanical system in the design and are connected to sensors that detect pressure differences and react to environmental changes. The sensors are so accurate that they can sense the pressure difference due to a single person entering or leaving the building, and initiate air flow adjustments. Every design decision in the construction of a ServerDome, down to the paint color is chosen to increase efficiency. The result is a unique, highly integrated data ecosystem where each component independently may not have a huge energy saving impact. However, when integrated as a whole system, the aggregate effect produces a PUE as lows as 1.06 and when annualized is between 1.13- 1.17. If all data centers could collectively achieve a PUE as low as ServerDomes, the worldwide savings would be well over 13.5 billion dollars as well as 79.5 million metric tons of carbon dioxide.

The ServerDome does not need air conditioning units, raised floors, ductwork, exhaust fans, heaters, dehumidifiers, UPS batteries

The ServerDome has a PUE annualized at 1.13-1.17

4MW/25-50 kWh available per equipment rack

# Water

Water is a scarce resource and many data centers, depending upon their cooling methods, are taking their toll on municipal water systems. In a conventional data center, standard air conditioning can soak up 40% of the energy bill while also using a high volume of water. US data centers are estimated to have used approximately 100 billion liters of water in 2014. Knowing the environmental impact that this growing demand is having on our waterways, “The Green Grid” created a metric called Water Usage Effectiveness metric (WUE), measured in Liters per kWh. They found that the average data center has a WUE of 1.8 L/kWh. It must be noted that these figures only include the on-sight consumption of water. Depending on the source, 1 kWh of electricity can require anywhere from 0-95 Liters of water to produce. In the US, the average is 7.6 L/kWh.

The ServerDome requires very little on-site water. Other than the sanitary systems, the only components that use water are the supplemental evaporative coolers. These adiabatic coolers are designed to activate when outside temperatures exceed a designated “cold aisle” setpoint. The hyper-efficient airflow design significantly reduces the runtime of this supplemental cooling system. Despite the initial ServerDome installation being in a location that has experienced record temperatures for the past several years, the evaporative coolers are only required for a few weeks each year. The water utilization effectiveness for a ServerDome is among the best in the industry at 0.1 L/kWh.

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# True Green

The need for data storage has brought some interesting conversations to the table about what it is to be green. In current data center vernacular, “green” is measured by the proportion of alternative energy used for power. That is a vastly oversimplified view of sustainability or “green.” For example, there has been a push for small and mid-sized companies to acquire dilapidated buildings and repurpose them to use as enterprise-sized data centers.

Although repurposing buildings is often a good idea that can lower carbon emissions, in the case of data centers it is a lot more complicated. Older buildings often have a higher maintenance cost. Also, they can pose some interesting design challenges in obtaining positive air flow, which means they are more susceptible to having a higher PUE than a building specifically designed to accommodate the required equipment. Within a relatively short time, the building intended to lower carbon emissions can quickly become a carbon liability.

The low maintenance costs, high power density, and modular design of the ServerDome all combine to give it its "green" credentials. With no HVAC system and no expensive AC units, the yearly maintenance costs for the building are substantially less than other equivalent data centers. Over many years of full operation, the initial installation has eliminated the maintenance costs associated with chillers, crac units, exhaust fans, humidifiers/ dehumidifiers, excess electrical systems, and other systems. In addition, a 4-megawatt ServerDome requires only 40,000 sq ft of space for the entire site footprint, whereas a more conventional 4-megawatt data center would require an area three times as large. This decrease in required square footage will reduce the environmental impact of placing a dome in a rural area, or make it perfect for fitting into a dense urban setting where space is limited.

Furthermore, a key part of the ServerDome’s sustainability is the use of recycled aluminum to construct the dome. The dome and its aluminum components also provide significant structural advantages.

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A dome is also the most structurally and seismically stable design for resisting earthquakes. It's open and modular design saves both time in construction and future expansion. Due to the concurrent scalability of the data center, mechanical, physical, or electrical systems can be scaled up or down at any time without disrupting any on-going operations, saving money, time, and material.

A 4 MW structure has a total site footprint of 40,000 sq ft (18,500 sq ft under the dome cover)

A dome is the most structurally and seismically stable design for resisting earthquakes

# The Dome is the Future

The world’s dependence on data storage is increasing and now is the time to prepare by making responsible choices, both economically and environmentally. Using less power not only puts less stress on the grid, but requires less capital. Water is going to be an even larger problem than it is now, especially as the rest of the world grows in both number and spending power. Shortages and sanitation issues have already had an economic impact in the US, and the cost of clean water is going to increase with demand. The ServerDome is a revolution in data center design, is green, minimizes water use, is highly energy efficient, and is poised to meet the ever growing needs of the future.

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