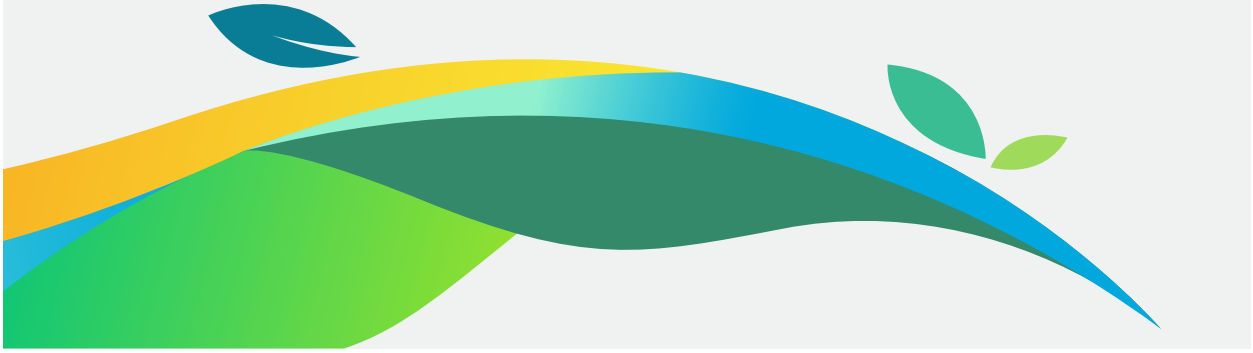
Striving for Net Zero Targets in Data Centers



by Robert Sty

I. Introduction

- Projections in the market highlight a 10% CAGR through 2030 by AI and cloud services. This growth requires an increasing amount of resources and energy to meet the global compute needs.
- Approximately 26 percent of all GHG emissions and 37 percent of combustion related emissions come from the construction and operation of the built environment.
- The challenge is to meet this demand while still reducing the operational and embodied carbon emissions to be on target with many of the goals set by various groups.
- A roadmap to the planning, design, and construction of data centers which leverages the latest technologies and considers specific regional energy and water resources is paramount to achieving net zero targets.

II. Efficient Data Center Design

- A major component of data center design and energy use is the choice of a cooling solution, which is defined by two aspects, the server/data hall requirements and the geographic environmental conditions.
- High density AI cabinet power densities have shifted the discussion from air cooled to liquid cooled systems, nonetheless, air cooling still remains popular for cloud-based platforms.
- The geographic site environmental conditions will drive the most energy and water efficient solutions. These are very site specific and recognize that strategies for the Southwestern region of the U.S. will vary to those of the Northern Plains. Direct and indirect evaporative cooling solutions are energy efficient, however, water intensive, and may not be appropriate or a desired strategy by the municipality.
- Economizer (free cooling) strategies are still important regardless of air or water cooled. Any opportunity to turn off the compressor will save energy and assist in reducing the operational carbon emissions.

III. Building Material Selection

- Data center campuses are now approaching the Gigawatt size, which inherently calls for larger buildings and more material resources. Building structural elements (steel and concrete) are the largest sources of embodied carbon, so improving the design and construction process helps to greatly reduce emissions.
- High-performance concrete mix designs using alternative replacement components such as fly ash or ground granulated blast-furnace slag (GGBS). These offset the typical limestone or clay mixture, injecting recycled CO2 into fresh concrete, using low carbon and/or recycled steel, or incorporating materials that sequester carbon.
- The use of mass timber structures in data centers are an interesting proposition, and HDR has already been working on live projects where this is being proactively developed as an option.

IV. Power Generation

- The demand for more data center space and capacity is far exceeding the existing grid capacities in many locations. This is driving a pressing need to find alternative power generation solutions that are both sustainable and reliable. The attention is also turning to how we can incorporate onsite electricity generation to avoid over-burdening local and national electricity grids while contributing to global decarbonization efforts.
- Natural gas is seen as an effective fuel However, it is carbon-based, and moving away from dependence

on fossil fuels is fundamental to the decarbonization of energy networks worldwide. The introduction of hydrogen as a fuel source has become a popular topic. The production quantities of green hydrogen must be increased exponentially to become a serious contender (there is no existing network that operates at scale) and production efficiency needs to be improved.

- Renewable energy sources, such as wind and solar, are very promising however, their intermittent nature requires substantial onsite energy storage. There is also the issue of space and site requirements. These technologies require far more land than traditional fossil fuel solutions.

V. Summary

- Another important consideration in seeking to achieve net zero targets is how the industry will embrace evolving technologies and the symbiotic relationship with data to help make informed decisions. For example, the application of a digital twin helps to understand detailed energy modeling and provides a thorough analysis of energy and water consumption, fuel availability, delivery, and energy storage options. Looking ahead to the future, it is essential that data center clients make decisions which are based upon information on how their buildings are performing. The ability to invest in such technology enables clients to assess and plan all aspects of data center design, construction and operations, while helping to meet regional sustainability goals.

STRIVING FOR NET ZERO TARGETS IN DATA CENTERS

Market projections indicate a substantial 10% CAGR through 2030 for data centers supporting AI and cloud services, driving a significant increase in resource and energy demands to support global computing needs. The construction and operation of the built environment contribute significantly to greenhouse gas emissions, accounting for approximately 26% of all GHG emissions and 37% of combustion-related emissions. Balancing this growing demand with ambitious carbon reduction goals presents a formidable challenge. To achieve net zero targets, a strategic roadmap is essential for data center planning, design, and construction, leveraging cutting-edge technologies and considering regional energy and water resources.

Cooling solutions are a critical factor in data center design and energy consumption, influenced by both server/data hall requirements and geographic location. While high-density AI cabinets have shifted the focus towards liquid cooling, air cooling remains prevalent in cloud-based platforms. Retrofitting legacy data centers from predominately air cooled to water cooled systems can be capital intensive, nonetheless, there is great potential for increased energy efficiency. Site-specific environmental conditions determine the most efficient approach in heat rejection, with strategies varying significantly between regions. Direct and indirect evaporative cooling offer energy efficiency, however, can be water-intensive, potentially limiting their applicability. Regardless of cooling method, economizer strategies are essential for maximizing energy savings and reducing operational carbon emissions by minimizing compressor use.

The increasing scale of data center campuses, often reaching gigawatt sizes, necessitates larger buildings and greater material consumption. Given the significant embodied carbon associated with structural elements for example, steel and concrete, optimizing design and construction processes is crucial for reducing emissions. Innovative approaches include high-performance concrete mixes utilizing recycled materials and carbon-sequestering components, as well as exploring the potential of mass timber structures. HDR has already been working on live projects where this is being proactively developed as an option. These strategies offer promising alternatives for minimizing the environmental impact of data center construction.

The surging demand for data center space is outpacing grid capacity in many regions, necessitating innovative and sustainable power generation solutions. To alleviate strain on local and national grids while advancing decarbonization goals, onsite electricity generation is increasingly being explored. While natural gas offers a viable option, the imperative to transition away from fossil fuels underscores the need for alternative energy sources. Hydrogen, though promising, requires significant advancements in production and infrastructure to become a practical solution. Renewable energy sources for example, wind and solar hold immense potential, yet their intermittent nature demands substantial energy storage and extensive land areas, presenting unique challenges.

Another important consideration in seeking to achieve net zero targets is how the industry will embrace evolving technologies and the symbiotic relationship with data to help make informed decisions. For example, the application of a digital twin helps to understand detailed energy modeling and provides a thorough analysis of energy and water consumption, fuel availability, delivery, and energy storage options. Looking ahead to the future, it is essential data center clients make decisions which are based upon information on how their buildings are performing. The ability to invest in such technology enables clients to assess and plan all aspects of data center design, construction and operations, while helping to meet regional sustainability goals.

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