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Driving sustainability in data centers.

Insights with Debbie Seibold Egeland, Jacobs Environmental Regional Solutions Director, Asia Pacific

As the world generates more data than ever, reducing the environmental footprint of power-hungry data centers is becoming increasingly important.

Jacobs environmental specialist, Debbie Seibold Egeland, sheds light on the challenge and identifies key factors to consider in reducing their impact.

We live in an era of the Internet of Things, cloud computing, virtual universes and AI-powered chatbots – all made possible through data centers. It's estimated that by 2025, every person will have at least one interaction with a data center every 18 seconds[1]. As applications for data and demand for bandwidth continue to grow, so does the demand for data center services. With this comes a huge expansion in physical infrastructure including large buildings with significant mechanical, electrical and piping (MEP) equipment, and in energy consumption.

According to the International Energy Agency, data centers consume approximately 220-320 terawatt-hours of electricity, accounting for about 0.9 – 1.3% of global electricity demand. Data centers and data transmission networks also account for nearly 1% of energy-related greenhouse gas emissions worldwide.[2] As the impacts of global warming become increasingly evident, many organizations are focusing on reducing data centers' energy consumption and moving toward a more sustainable future.

The sustainability movement for data centers is gaining momentum, largely driven by organizations' environmental, social and governance (ESG) commitments. Technology giants are turning their ESG goals into tangible actions and progress throughout their value chain. Their efforts, such as transitioning to carbon-negative operations and 100% renewable energy, set an important precedent for others to help shape a greener future for the data center industry.

Sustainability best practice for data centers

Sustainable data centers work to be as efficient as possible in the following areas:

Energy consumption

Data centers are major energy consumers – everything from the servers, storage equipment and cooling infrastructures requires a significant amount of electricity. Power Usage Effectiveness (PUE) measures how efficiently data centers use energy for primary IT equipment power. Incorporating thoughtful design choices to improve PUE and choosing renewable energy sources are essential components of a sustainable data center.

Emissions

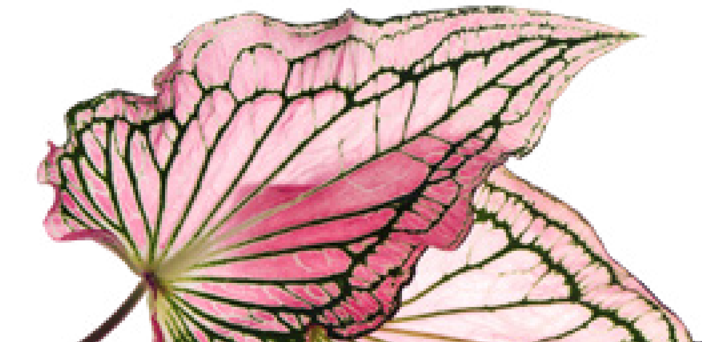
In addition to energy-related greenhouse gas emissions, data centers also contribute to air pollution by using backup diesel generators and refrigerants in cooling systems. Prioritizing low-carbon energy sources and exploring alternatives to diesel generators and ozone-damaging refrigerants that also have a high global warming potential are important to reduce emissions.

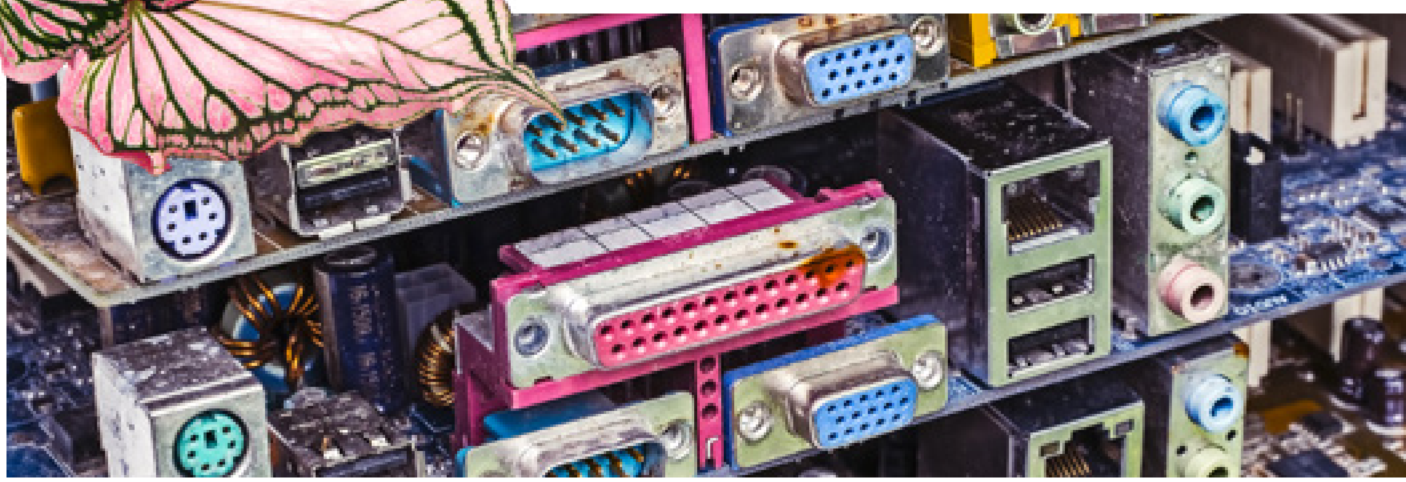
Resource use

Resources such as water, metals and land are used in the construction and operation of data centers. It is important to incorporate these resources thoughtfully to positively influence and limit their impact on local ecosystems and communities.

Waste generation

Waste generated at data centers, predominantly used electrical and electronic equipment, can be repurposed or recycled effectively. The concept of a circular economy is gaining much traction and selling outdated equipment to secondary markets is often cost-effective. Due to large volume and demand, data center owners can also exert pressure on suppliers of servers and computers, building materials such as steel and concrete, and mechanical and electrical equipment in their supply chain to influence sustainability outcomes.





Considering these factors and taking proactive steps to minimize their impact is essential to building and operating a sustainable data center.

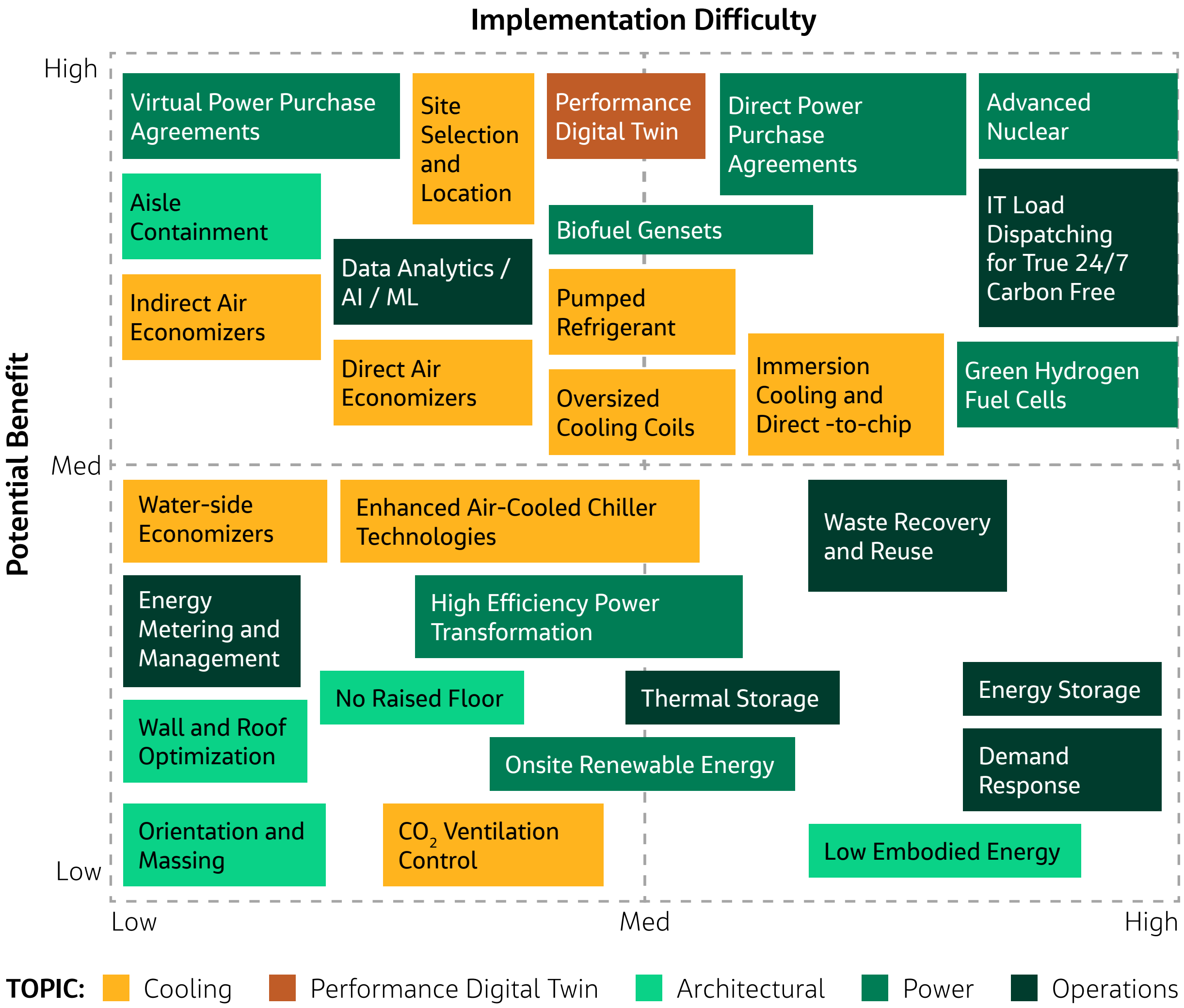
Identifying areas for improvement, potential solutions and technological advancements that can reduce waste and energy usage, maximize resources and increase efficiencies to drive long-term sustainability gains are important first steps.

However, each organization's sustainability journey is different. While some may invest in game-changing decarbonization solutions and technologies, others may focus on design optimizations and supply chain decarbonization.

The chart below demonstrates some examples of sustainability measures and how they measure against potential benefits and implementation difficulty.

For instance, some organizations are taking bold steps by investing in 24/7 carbon-free energy or green hydrogen fuel cells, which are currently challenging to implement but can yield significant benefits. Conversely, other organizations are focusing on more viable near-term solutions such as virtual power purchase agreements or design optimization measures such as immersion cooling or economizers.

Sustainability measures for data centers and how they measure against potential benefits and implementation difficulty.



For example, our team has supported and managed many different sustainable approaches referenced in the chart:

Green hydrogen fuel cells

We're evaluating the viability of green hydrogen fuel cells or hydrogen reciprocating engines as both backup and full-time power for a global technology company to reduce data center carbon footprint.

Immersion cooling

We're supporting a global data center client with designs incorporating immersion cooling – a method of cooling computer hardware, such as servers and other IT equipment by submerging it in a non-conductive liquid coolant to help reduce significant power consumption typically required to cool the entire building.

Data analytics / Artificial Intelligence (AI)/ Machine Learning (ML)

To support our client's sustainability efforts, we're working with a software partner to help our clients calculate Scope 3 emissions more accurately and effectively by using AI and ML technologies.

Onsite renewable energy

Although onsite renewable energy may not generate enough electricity to fully power a data center, it can still help with carbon offsets and other advantages. For instance, solar photovoltaic systems can be used as shade structures at carparks and are easy to implement. We help our clients assess potential emissions reduction by adopting onsite renewable energy solutions.

Energy storage (Battery Energy Storage System or BESS)

We're helping many of our clients evaluate BESS to store intermittent renewable energy and then use that energy when needed.

Performance digital twin

We can help our clients evaluate operational changes of the data center via performance digital twins to maximize efficiency and therefore sustainability outcomes.

Computational Fluid Dynamics (CFD)

CFD is used to validate novel energy efficiency design concepts, such as using natural draft/thermal buoyancy to reduce or eliminate fan cooling energy. CFD allows us to test virtual prototypes to help steer energy-efficient design, while prioritizing energy resilience and confirming operational consistency.

Sustainability certification

We help global data center clients certify their data centers according to the globally-recognized LEED framework. Our clients can achieve Platinum, Gold, Silver or Certified depending on the credits earned around water, energy, carbon, waste, transportation, materials, health, and indoor environmental quality. We also recently completed an evaluation of the potential for the Living Building Challenge. While this standard isn't widely used with data centers, it requires very thorough sustainability practices.

Key factors to consider for a sustainable data center

Sustainable site selection

Building a sustainable data center starts with site selection, with sustainability as one of the key criteria. Sustainable site selection prioritizes site characteristics and critical considerations such as access to renewables, existing transport, communications and energy infrastructure, resource reliability, environmental justice and equity considerations, air quality, climate risks, and current and projected precipitation and temperature. Geographic Information Systems (GIS) analysts use geospatial technology and data visualization tools to support tech and data center companies during this crucial step.

This helps operators better understand a site's opportunities and challenges and make informed decisions by comparing and analyzing multiple parameters.

Embodied carbon

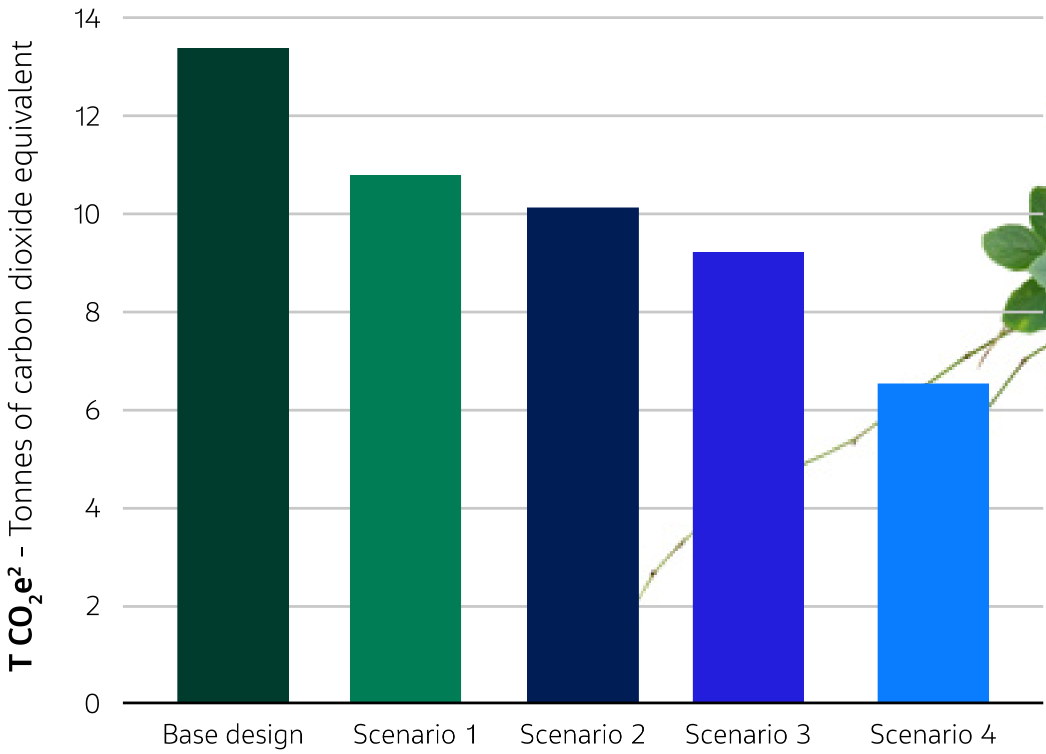
Embodied carbon refers to the greenhouse gases emitted in the data center's building mechanical, electrical and plumbing systems, as well as materials, equipment, transportation and construction processes. To minimize embodied carbon, it is critical to consider low-carbon options during the design phase.

Concrete and steel are the two most significant contributors to embodied carbon in the building envelope. By sourcing green concrete and steel from sustainable sources, sustainable design can maintain structural integrity and reduce embodied carbon emissions by more than 50%.

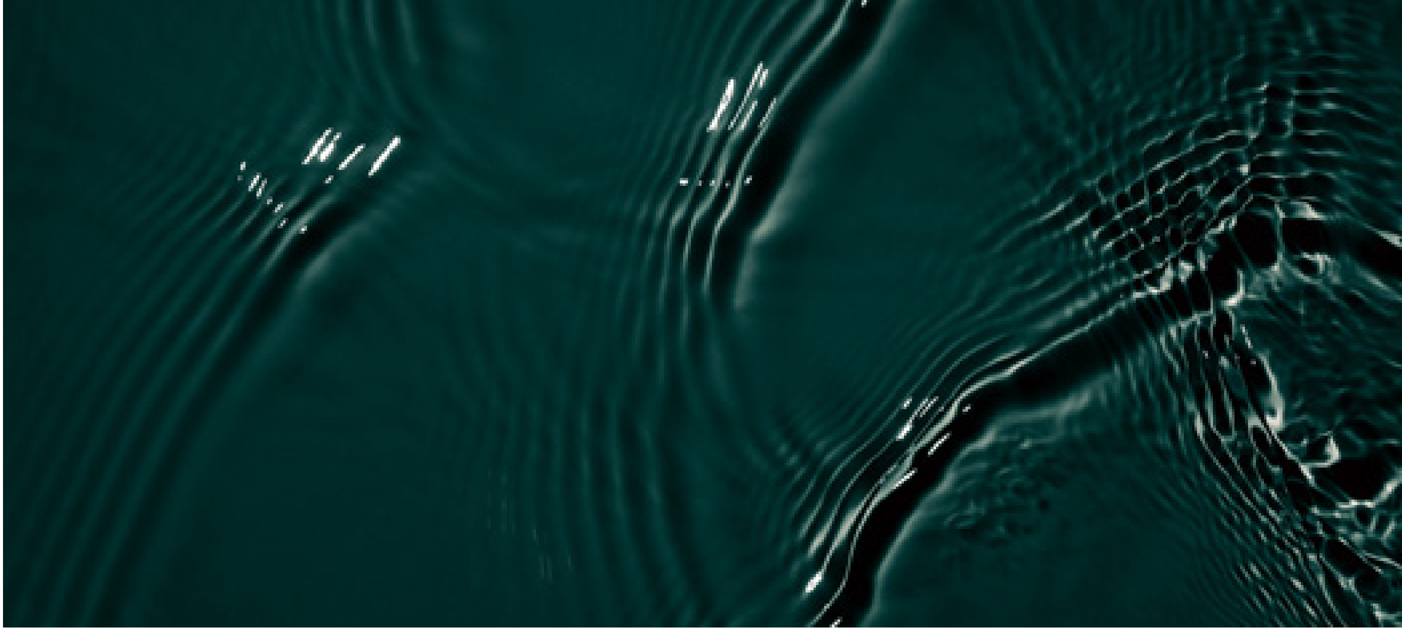
For instance, in various scenarios modeled on the chart below, introducing Supplementary Cementitious Materials (SCM) and recycled material as a low-carbon impact alternative could lead to greater than 50% carbon reduction from concrete. This highlights the potential substantial reduction of embodied carbon as a result of sourcing more sustainable materials and is a significant step towards a more environmentally friendly approach to data center construction.

Potential carbon emissions reductions from use of SCM

Global warming potential (GWP) T CO_2e^2 by scenario



Base design	0% SCM, 3% recycled	**0% reduction in emissions**
Scenario 1	20% SCM, 3% recycled	**≈20% reduction in emissions**
Scenario 2	20% SCM, 10% recycled	**≈25% reduction in emissions**
Scenario 3	20% SCM, 30% recycled	**≈30% reduction in emissions**
Scenario 4	20% SCM, 50% recycled	**≈50% reduction in emissions**



Water management

Data centers can be large consumers of water which is primarily needed for cooling systems. The amount of water a data center uses varies depending on its size, location and technology. A typical one-megawatt data center using traditional cooling methods consumes about 6.75 million gallons of water annually.[3] With increasing demand for data storage and processing power, the data center industry is growing at an unprecedented rate – making it an ideal platform for promoting water conservation and sustainability.

Data centers can improve their water usage effectiveness (WUE) by using advanced air-cooling technologies. Recycling cooling tower blowdown, re-using treated water within the facility using treated water from the municipality or sea water cooling methods (the process of pumping sea water through cooling modules) can all help reduce the amount of potable water a data center uses. Adiabatic cooling is another alternative. It employs outdoor air with a temperature of under 29.4 degrees Celsius, rather than water, to cool the equipment. Another technology, free air cooling, uses a sensor to detect when outdoor air meets the necessary temperature and humidity requirements to be used without conditioning, and then switches off the evaporative cooling system (which uses water.)

In addition, data centers can collaborate with local communities, water management organizations and other stakeholders to implement water conservation programs, promote water-saving technologies and raise awareness about the importance of water stewardship and watershed protection. By engaging in these initiatives, data centers can help to promote a culture of water conservation and demonstrate their leadership in promoting sustainable water management practices. By demonstrating their commitment to water stewardship, data centers may also inspire other organizations to follow suit and take similar actions to conserve water or go further to replenish or improve the watershed.

Social value creation

Building a data center can create significant social value for local communities.
By considering the social impact and opportunities of the project, organizations can help improve the overall quality of life for local communities, foster positive relationships with project stakeholders and contribute to the long-term prosperity of the local economy.

Examples of social value creation:

Addressing the digital divide

Offering complimentary data to the local communities can help bridge the digital divide and improve access to information and communication technologies. Organizations can support local utilities, infrastructure operators and suppliers to implement accessible broadband services for all.

Engaging the community

It is important to bring local communities on the journey by developing and engaging a support network of residents, community leaders and local companies. This provides a platform to help build trust and understanding about the project's benefits and opportunities, and address potential concerns they may have.

Creating jobs

Data centers can create exciting employment opportunities for local talent to support the construction, operations and maintenance of the facility. Additionally, promoting disadvantaged community employment can provide equal employment opportunities for all.

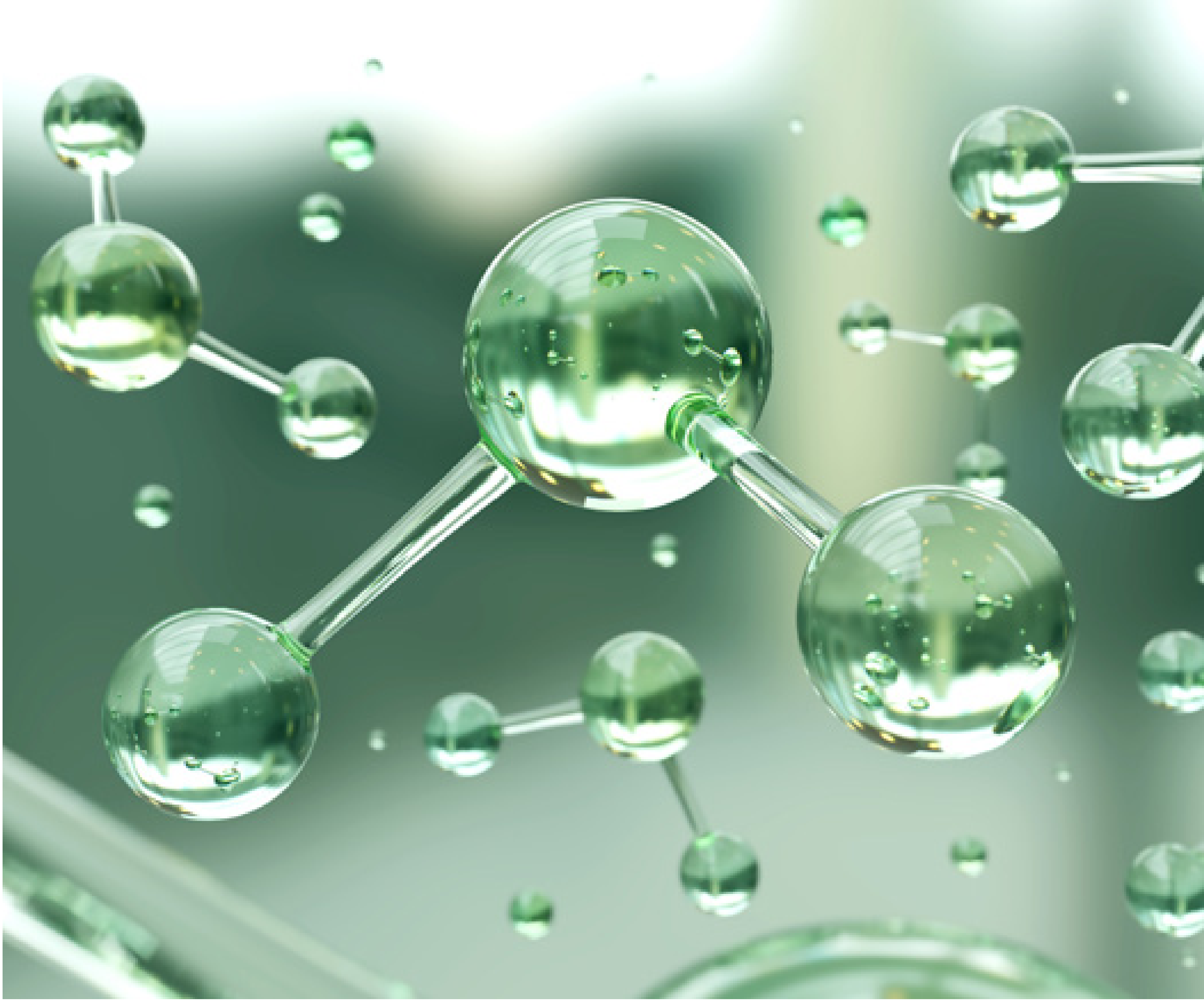
Protecting the environment

Building sustainable data centers can promote environmental benefits, such as preserving natural resources for future generations. Investing in community rooftop solar for carbon offsets and recovering data center waste heat for district heating for local communities can help reduce overall energy consumption and increase energy efficiency in the local area.

Supporting local businesses

Sourcing materials and services from local suppliers can contribute to the growth of the local economy and create a positive ripple effect. In addition to economic benefits, working with local suppliers to co-create solutions for the project offers a great opportunity for developers and owners to strengthen relationships with the local communities and help build advocacy for the project's development.

By prioritizing social value creation in the planning and construction of data centers, organizations can create positive, lasting impacts on the surrounding community, enhance their reputation and build strong relationships with local communities and organizations.



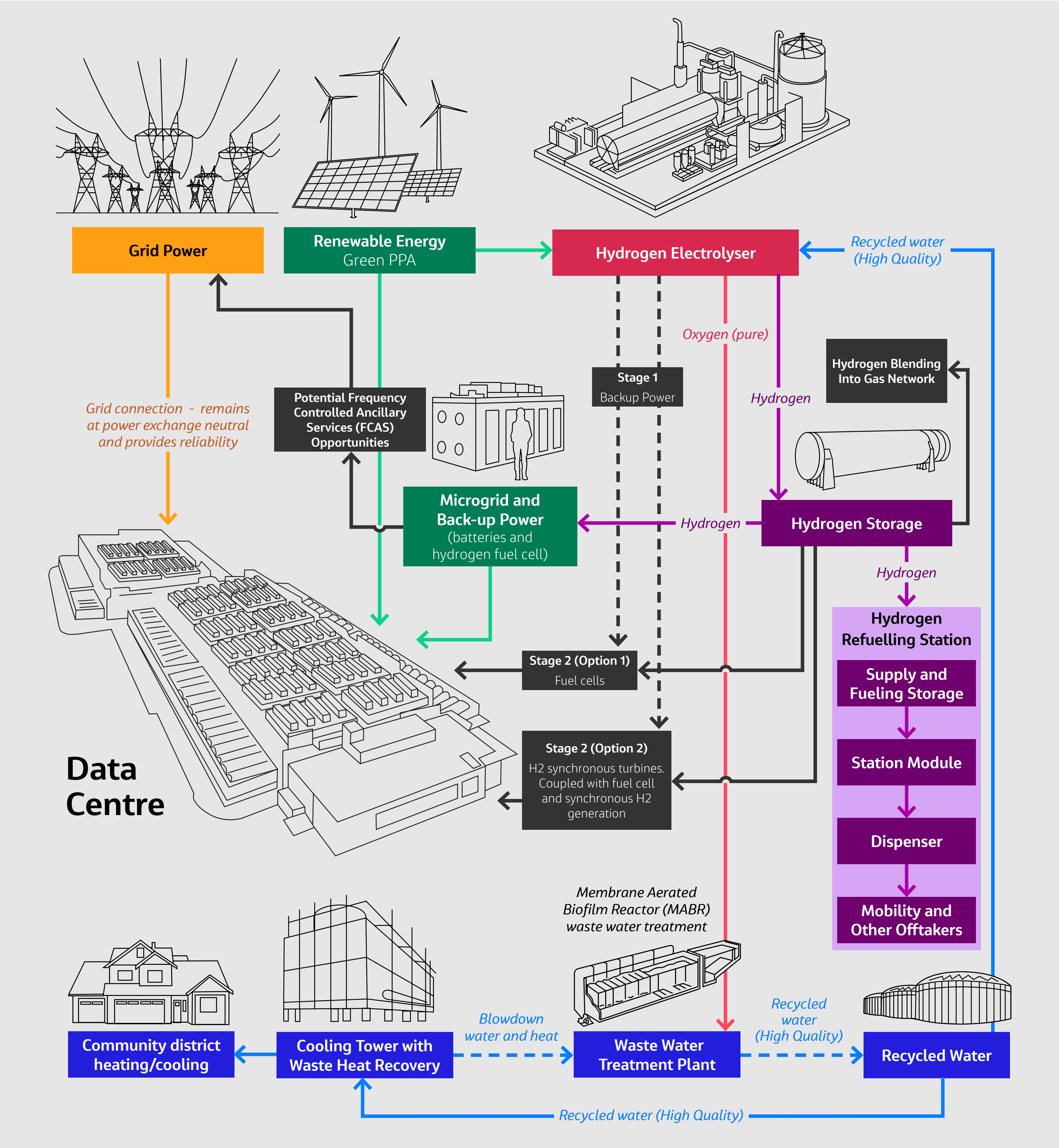
Driving sustainability across the supply chain

Data centers have the potential to significantly impact ESG goals by extending their focus beyond their own operations to achieve sustainability across their supply chains. Partnering with suppliers with established environmental standards to reduce Scope 3 emissions can help achieve sustainability goals across the value chain. To achieve this, data centers must work with partners to prioritize their decarbonization and sustainability plans.

Innovative co-location

An innovative concept worth exploring is the co-location of data centers with wastewater treatment plants and hydrogen electrolyzers. This approach involves creating green hydrogen from renewable energy sources to split water (H20) into hydrogen and oxygen. The hydrogen from the electrolyzer can be used in a fuel cell to power the data center, while the pure oxygen produced in the process can be utilized by the wastewater treatment plant for aerobic treatment. Additionally, the waste heat recovery from the data center's cooling tower can provide heating and cooling for surrounding communities, thus creating a circular economy. This innovative concept has the potential to be a game-changer for the energy-water nexus of data centers, offering an exciting possibility to simultaneously improve resource efficiency and contribute to a more sustainable future.

The processes and benefits of co-locating a data center with wastewater treatment plants and hydrogen electrolyzers.



Did you know data centers make up...

220 - 320 terawatt-hours

OF GLOBAL ELECTRICTY CONSUMPTION

0.9 - 1.3%

OF GLOBAL ELECTRICTY DEMAND

1%

OF GLOBAL GAS EMISSIONS WORLDWIDE

6.75 million gallons

OF WATER CONSUMPTION FOR ONE MEGAWATT DATA CENTER ANNUALLY

Every 18 seconds

EVERY PERSON WILL INTERACT WITH A DATA CENTER

Conclusion

While the environmental impact of data centers is an increasing concern, there are significant ways to reduce their environmental footprint, such as implementing energy-efficient technologies, using renewable energy sources and adopting eco-friendly practices in building construction and operation.

Working with a knowledgeable partner who understands the importance of sustainability in data center design can help organizations meet their objectives and significantly impact the environment in a positive way.

At Jacobs, we understand the importance of operational reliability and speed to market and work closely with our experienced data center design teams to ensure that it is at the forefront of any sustainability or energy efficiency measure. By implementing effective strategies and forming meaningful partnerships, we can protect the environment and create a more sustainable future for data centers.

References

1. IDC: Expect 175 zettabytes of data worldwide by 2025, NetworkWorld Asia: https://www.networkworld.com/article/3325397/idc-expect-175-zettabytes-of-data-worldwide-by-2025.html
2. Data Centres and Data Transmission Networks, International Energy Agency: https://www.iea.org/reports/data-centres-and-data-transmission-networks
3. Ignore Data Center Water Consumption at Your Own Peril, Uptime Institute: https://journal.uptimeinstitute.com/dont-ignore-water-consumption/

Disclaimer

About the author:

Debbie Seibold Egeland brings 20 years of environmental consulting experience to her role as Jacobs' APAC Environmental Regional Solutions Director. She is responsible for bringing a team of technical experts from around the world to solve some of the most complex environmental challenges in the region. Before moving to Singapore in 2019, Debbie worked in Seattle, Washington, Oakland, California, and Philadelphia, Pennsylvania, U.S.. Her current projects include embodied carbon, green hydrogen, Scope 3, ESG due diligence, energy efficiency, hydrogen and climate risk.

Debbie has a Bachelor of Science in civil & environmental engineering from Duke University, and a master's in civil and environmental engineering from Stanford University. She is a licensed Professional Engineer in the state of California.

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