Sustainable Data Centres

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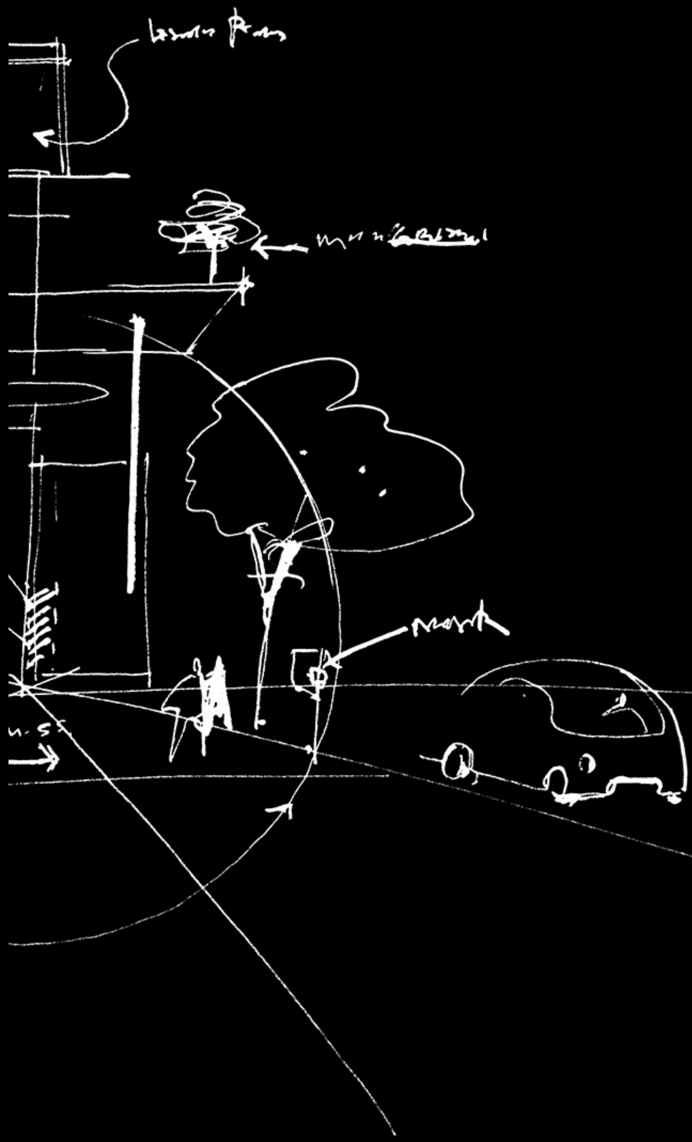
Jacobs Challenging today. Reinventing tomorrow.

Contents



Sustainable DCs start with Corporate Commitments (ESG)

Example Climate Action – Tech Sector Leadership

Google

"This generation owes it to the next generation to address climate change . . . The time to act is very narrow, and shrinking as we go."
- *Sundar Pichai, CEO of Google and Alphabet*

- Since 2007, carbon neutral for company operations
- Since 2017, 100% renewable energy for global operations
- By 2030, enable 5 GW of carbon-free energy for manufacturing
- **By 2030, 24/7 carbon-free energy for data centres**

"Climate change is real and we all share a responsibility to fight it. We will never waver, because we know that future generations depend on us."
- *Tim Cook, CEO of Apple*

- Since 2014, 100% renewable energy for data centres
- Since 2017, 100% renewable energy for global operations
- **By 2030, carbon neutral — from supply chain to the power you use in every device we make.**

Microsoft

"The world's climate experts agree that the world must take urgent action to bring down emissions. Ultimately, we must reach "net zero" emissions, meaning that humanity must remove as much carbon as it emits each year."
- *Satya Nadella, CEO of Microsoft*

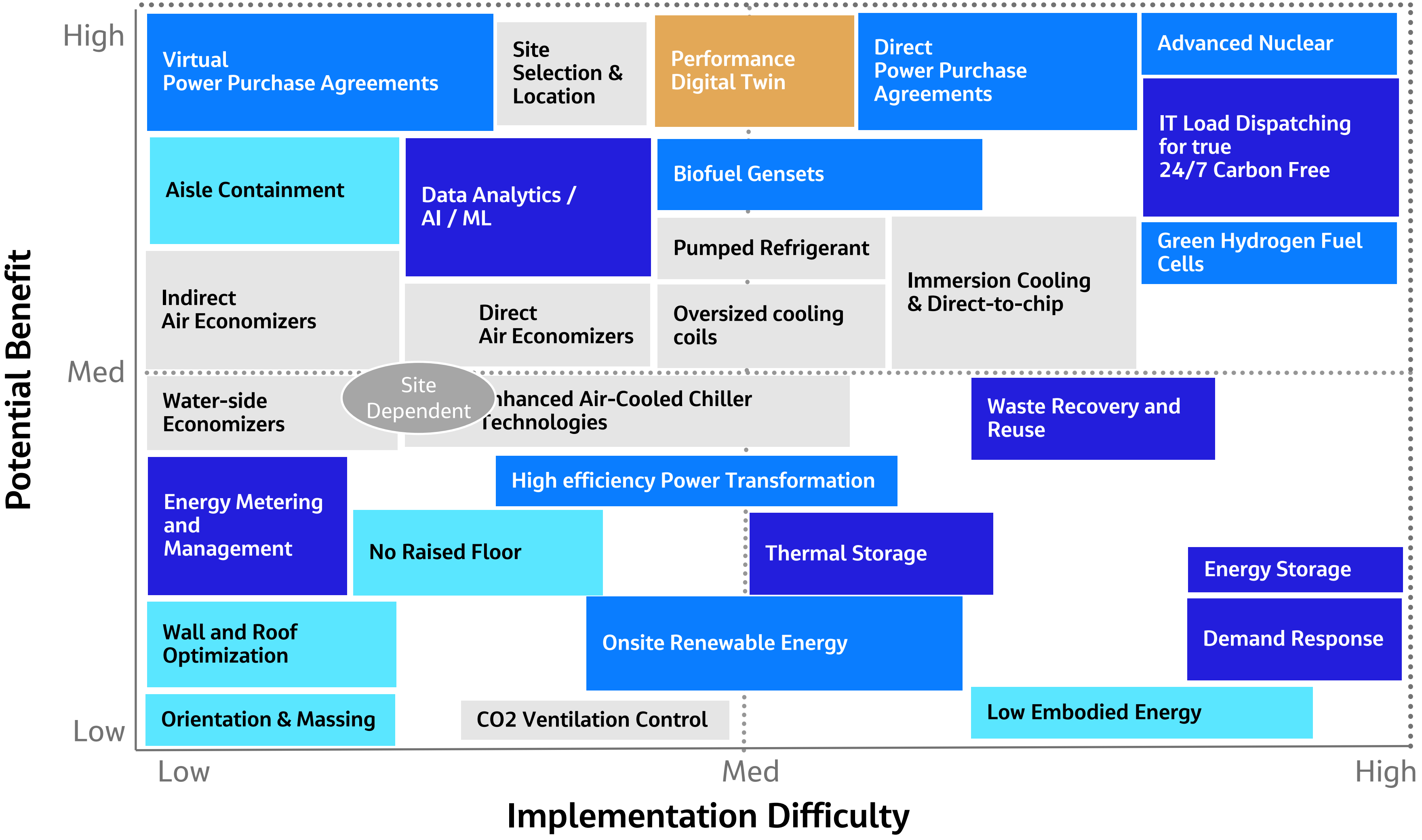
- By 2025, 100% Renewable Energy
- **By 2030, carbon negative for company's value chain**
- **By 2050, removal of historical carbon footprint**

"Climate change is a crisis we will only be able to address if we all work together on a global scale and Facebook is committed to playing its part and helping to inspire real action in our community."
- *Mark Zuckerberg, CEO of Facebook*

- By 2020, net zero GHG emissions for global operations
- **By 2030, net zero emissions for company's value chain**

Multinational corporations are currently the main driver of change.

Data Centre Sustainability Best Practices



Operations

- Energy Management and Metering
- Data Analytics
- Artificial Intelligence & Machine-Learning
- Demand Response
- Thermal Storage
- Energy Storage
- IT Load Dispatching (24/7 Carbon Free)
- Heat Recovery
- Performance Digital Twin

Power

- Onsite Renewable Energy
- Direct Power Purchase Agreements
- Virtual Power Purchase Agreements
- Green Hydrogen Fuel Cells
- Biofuel Gensets
- High Efficiency UPS/Transformation
- Advanced Nuclear

Architectural

- Low embodied energy/water
- Orientation and massing
- Wall and Roof optimization
- No Raised Floor
- Air Containment

Cooling

- Site Selection & Location
- Indirect Air Economizers
- Direct Air Economizers
- Water-side Economizers
- Enhanced Air-Cooled Chiller Technologies
- Pumped Refrigerant
- Immersion Cooling & Direct-to-chip
- CO_2 Ventilation Control
- Oversized cooling coils

Performance Digital Twin

- Value “waterfall” of system efficiencies
- Plan renewables operation strategies
- Deploy innovation virtually, limiting risk

PUE (Power Usage Effectiveness)
WUE (Water Usage Effectiveness)

Environmental Priorities of Industry and Peers

Bold shows commonalities across table

ESG Standards and Ratings | Selected Industry Peers

Client	SASB	MSCI	GRESB	UN SDGs	Competitor 1	Competitor 2	Client
Energy Management	**Energy** Management [Software]		**Energy** [M]	Goal 7: Affordable and Clean Energy Goal 12: Responsible Consumption and Production Goal 13: Climate Action	**Energy** efficiency	**Energy** Use/ Efficiency	Energy efficiency
100% Renewable Energy		Opportunities in Clean Tech			100% clean and renewable **energy**	Renewable **Energy**	**Renewable energy**
Carbon Management		**Carbon** Emissions	**GHG** Emissions [M]	Goal 11: Sustainable Cities and Communities Goal 12: Responsible Consumption and Production Goal 13: Climate Action	**GHG** emission	**Carbon** Emissions	Carbon Emissions
Water Management		**Water** Stress	**Water** inflow/withdrawals [M]	Goal 12: Responsible Consumption and Production		**Water** Use	**Water** stewardship
Waste Management		Toxic Emissions & **Waste**		Goal 12: Responsible Consumption and Production Goal 13: Climate Action		**Waste** Management	**Waste** reduction/ diversion
Green Buildings					**Green building** and material (healthy and sustainable offices)	**Green Building** Design	**Green Buildings**
						Climate Change **Resilience**	**Resilience**
			Biodiversity and Habitat [M]				Healthy ecosystems: **biodiversity**
							Circular economy

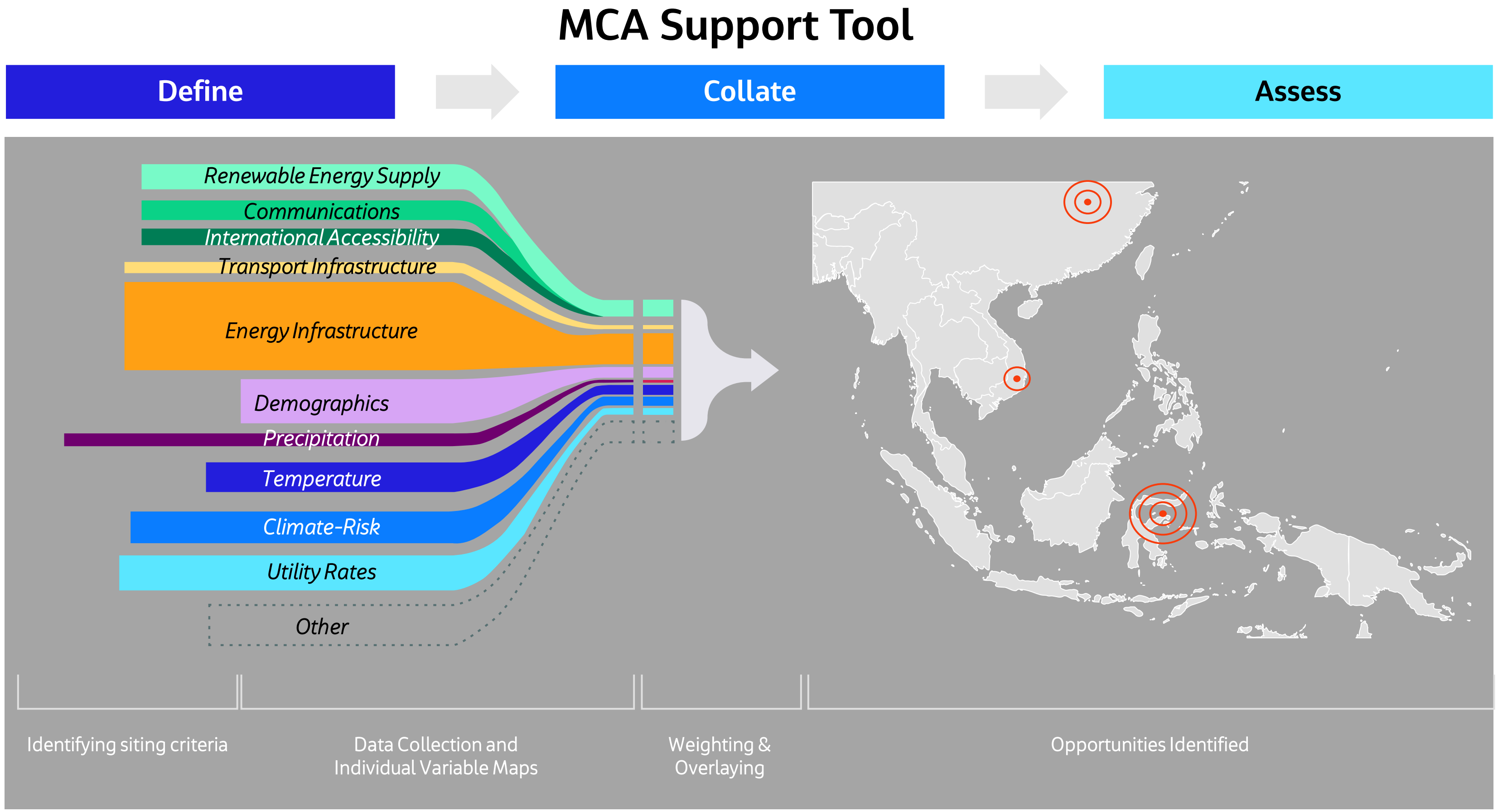
SASB= Sustainability Accounting Standards Board
MSCI=MSCI Inc. Global ESG Standard Index

GRESB= (formerly the Global Real Estate Sustainability Benchmark) is the global standard for portfolio-level ESG reporting in the real estate sector

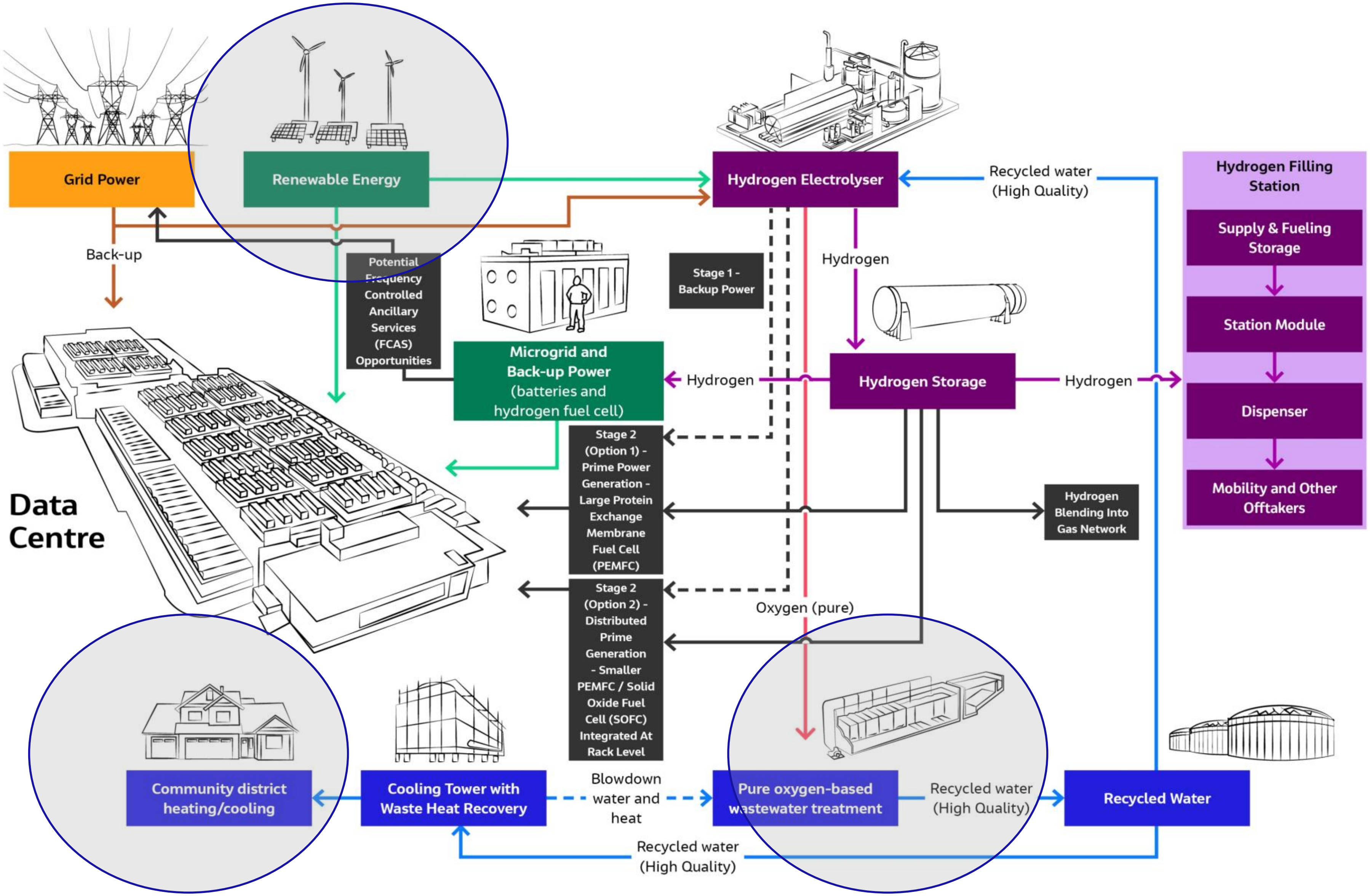
UN SDGs= United Nations Sustainable Development Goals

Sustainable Site Selection

Sustainable Site Selection with a Spatially driven Multi-Criteria Analysis Framework for Access to Renewable Energy & Low Climate Risk Locations

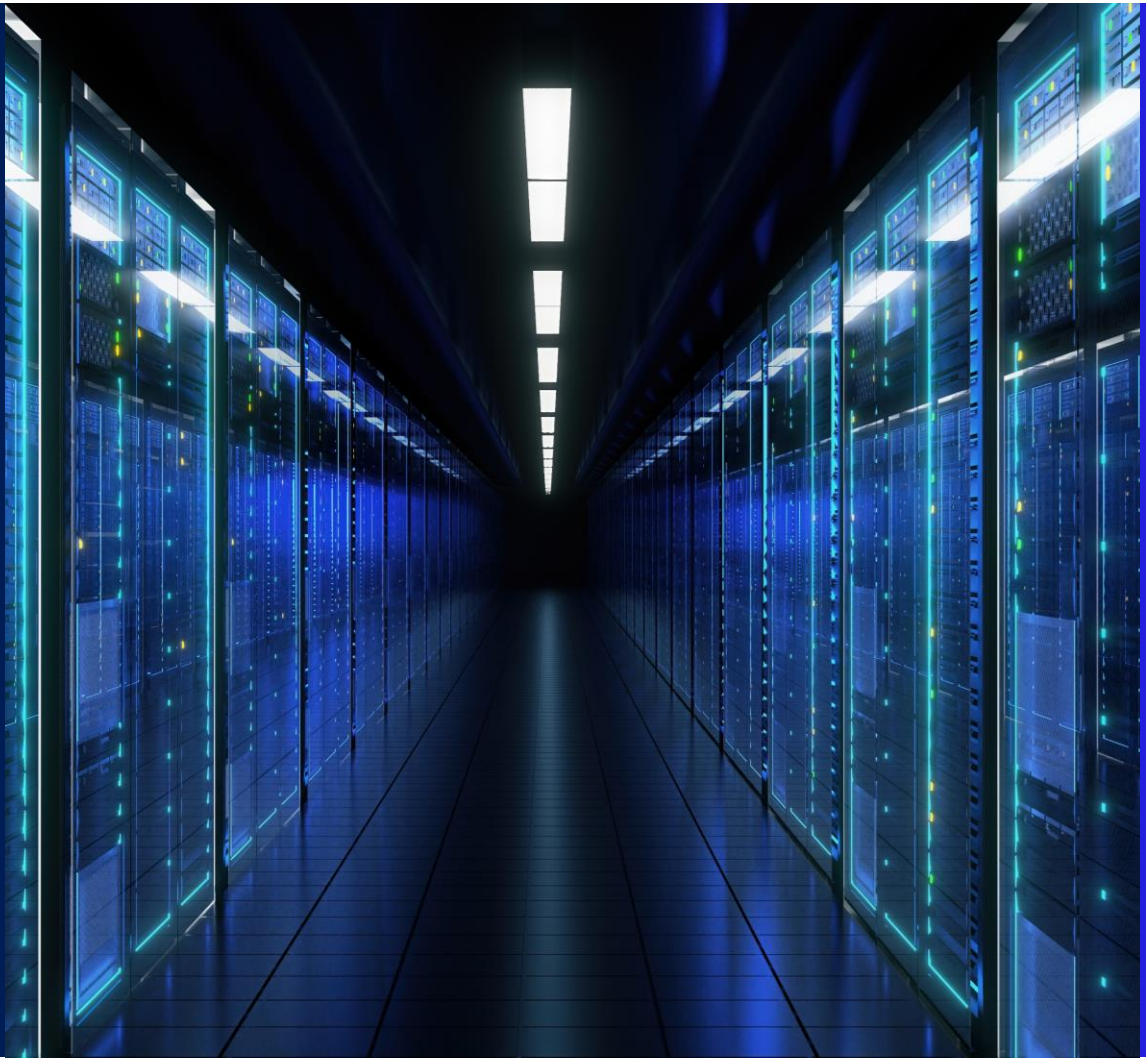


Hydrogen Data Centre Systems Map - Innovative colocation



Sustainable Design Elements

Data Centres Can be Large Water Consumers



- 1-MW data centre using traditional cooling methods uses about 6.75 million gallons of water per year (Uptime Inst. 2016)
- **Water Usage Effectiveness (WUE)** is a key measurement of water performance in data industry (The Green Grid, 2011)
  - Includes water used on-site (Source 1) and water needed to produce energy (Source 2)
  - Tradeoffs and accounting between:
    - **Different sources of water (i.e. reuse/reclaimed water has less embedded energy vs surface water)**
    - **Embedded energy/water in chemicals used for treatment (i.e. more treatment chemicals needed = more energy/water consumed)**

Social Value Creation

- District heating or cooling to local communities
- Free data
- Community rooftop solar for offsets
- Repurposing of buildings for future community use
- Disadvantage community employment
- Co-ownership
- Others?


Mobility


Physical & mental health


Work

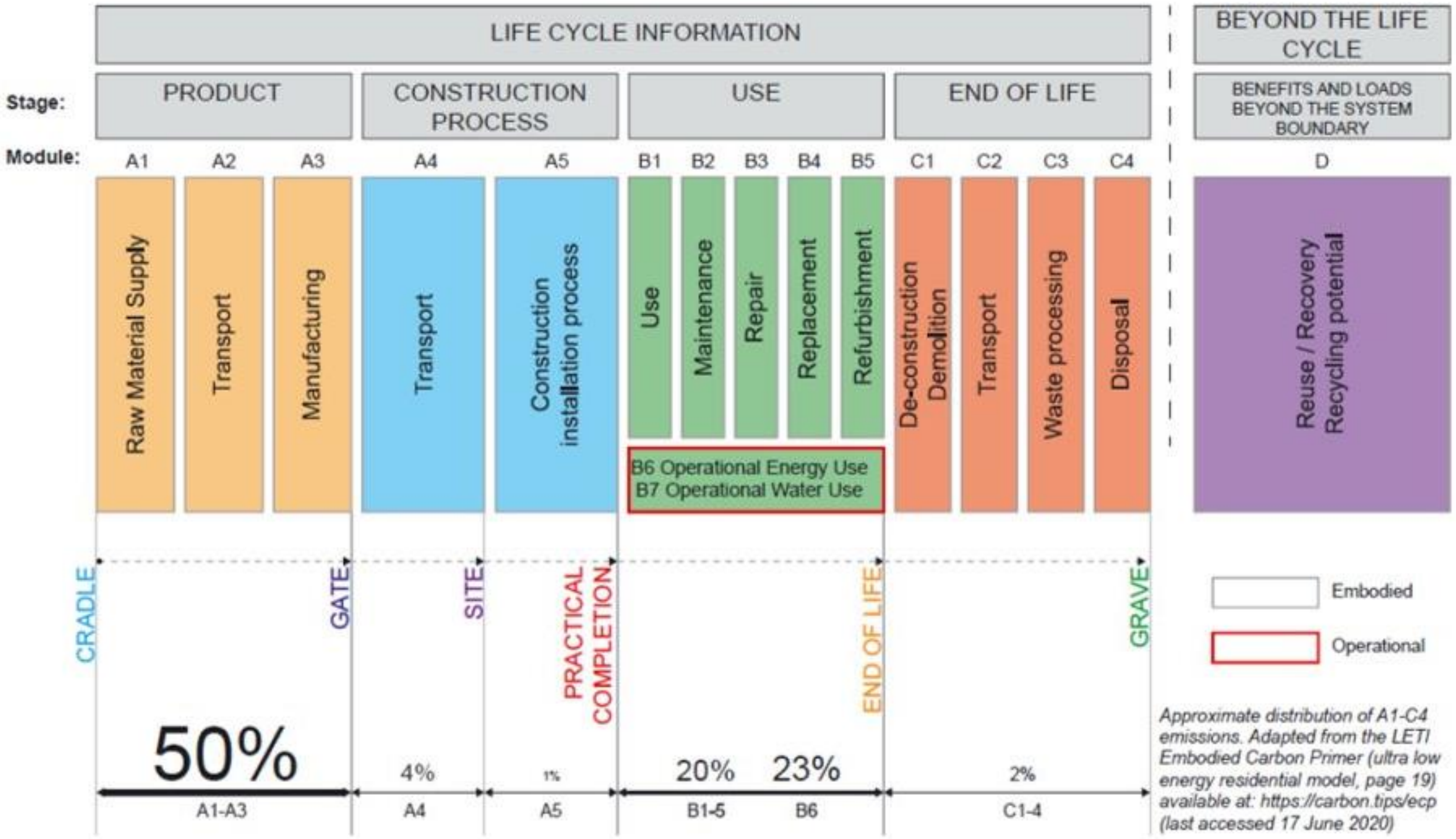

Equality & equity


Housing affordability


Access to vital services


Community wellbeing

Embodied Carbon



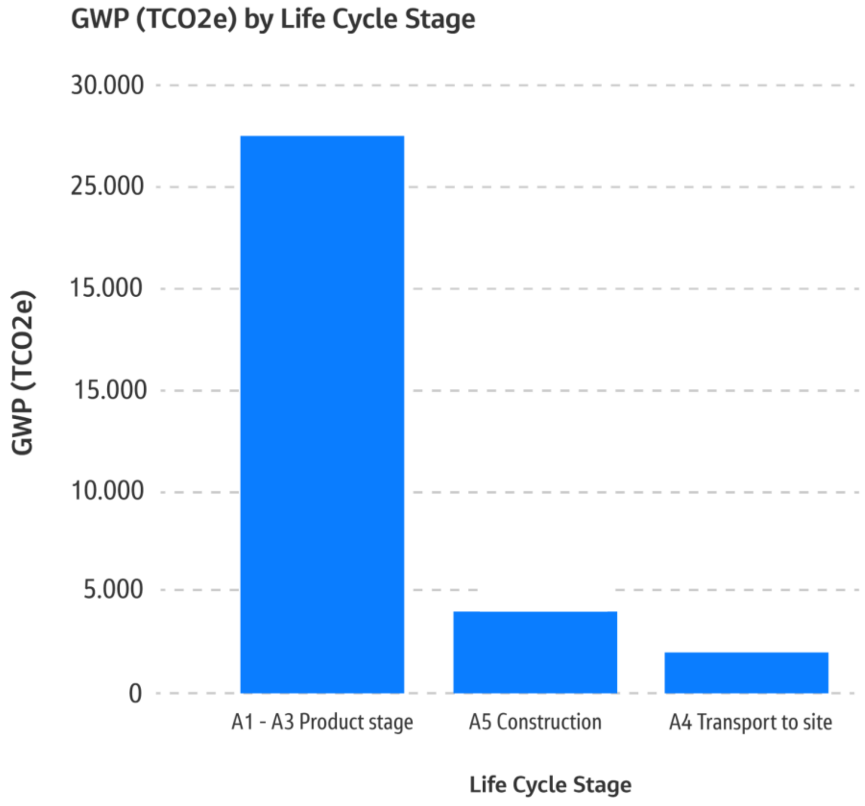
Source: A brief guide to calculating embodied carbon, July 2020 -John Orr, Orlando Gibbons and Will Arnold

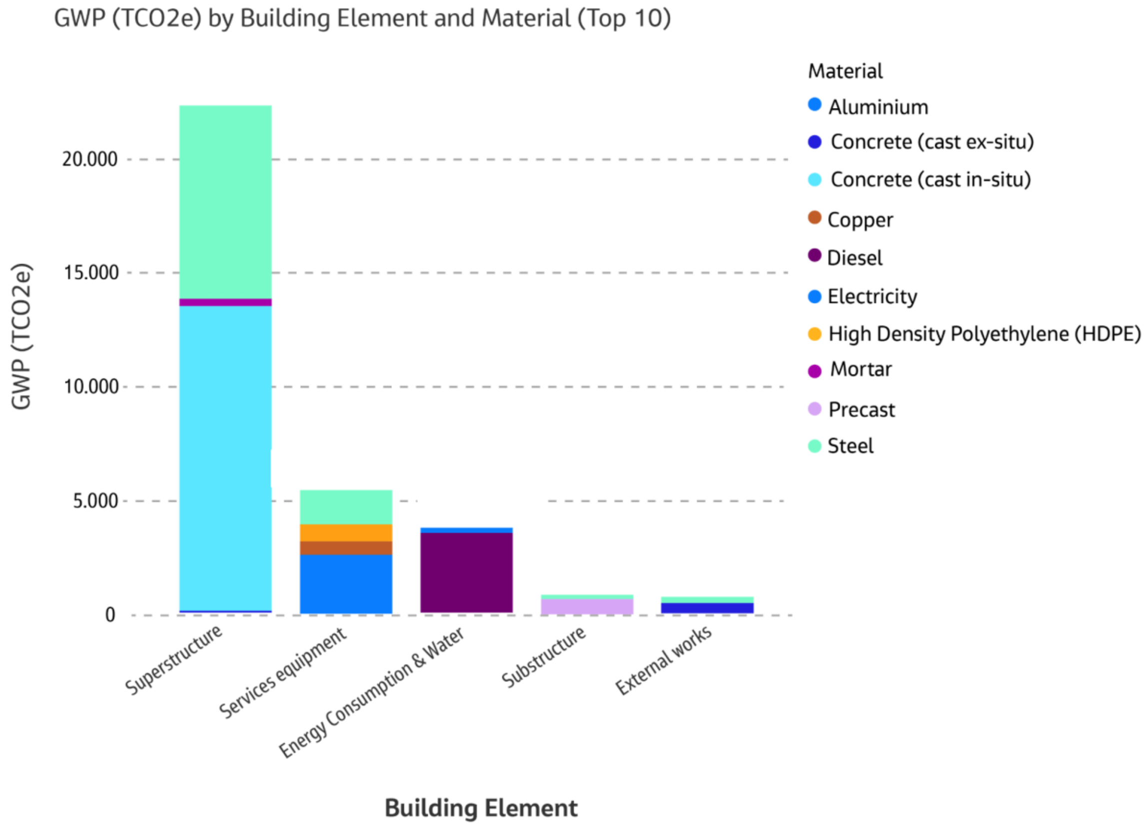
Embodied carbon

- **Includes** CO_2 emissions associated with materials, transportation, and construction processes throughout the lifetime of a building.
- Accounts for 11% of all carbon emissions globally

Steel from the Superstructure is the largest contributor

- Most of the CO_2e emissions are coming from the A1- A3 Product Stage
- Concrete and steel from superstructure building element are the major contributors



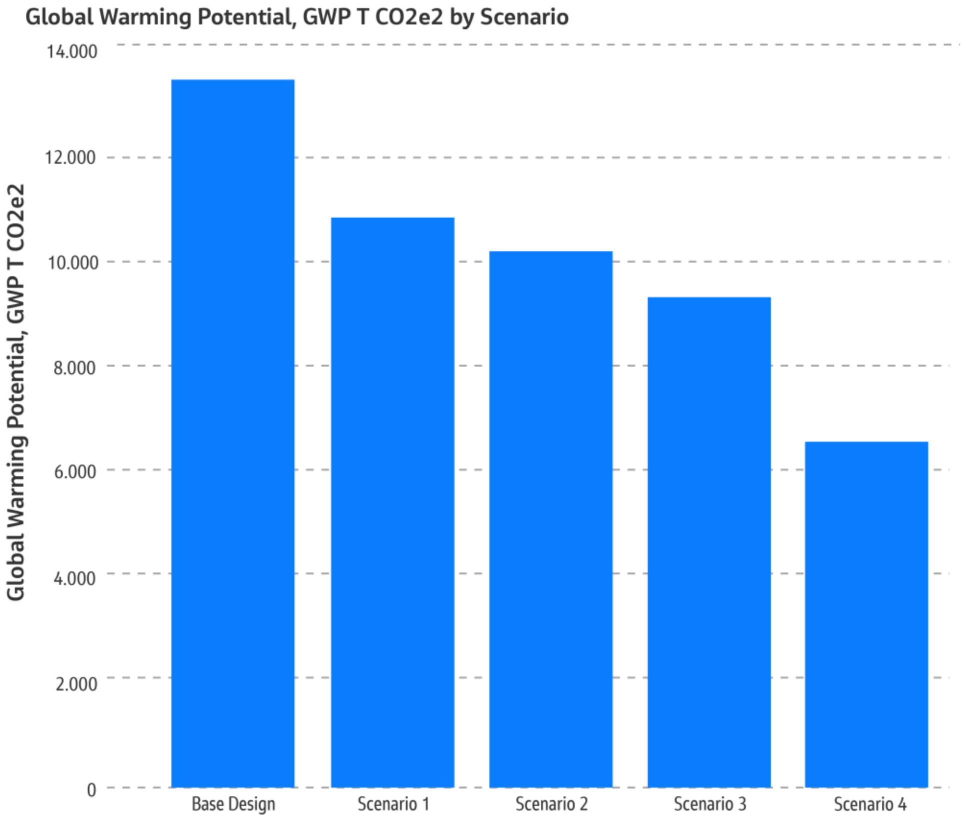


Potential CO_2e Reduction Scenarios for Concrete Analysis

- Using low carbon impact concrete could lead to 19% to 51% reduction in carbon emission from concrete

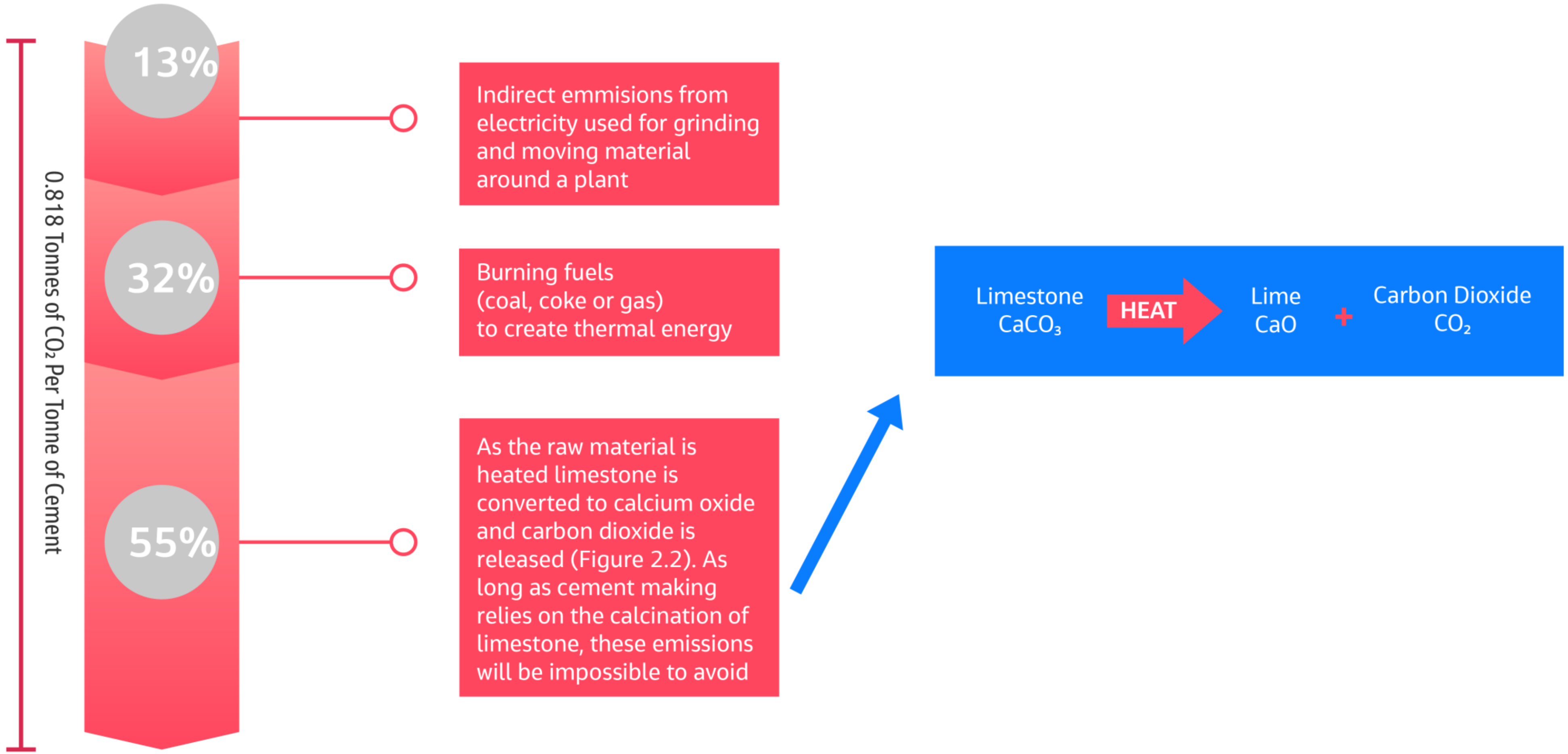
Scenario	Description	% Reduction as Compared to Base Design
Base Design	0% SCM – 3% Recycled	-
Scenario 1	20% SCM – 3% Recycled	≈19%
Scenario 2	**20% SCM – 10% Recycled**	**≈24%**
Scenario 3	**20% SCM – 30% Recycled**	**≈31%**
Scenario 4	**20% SCM – 50% Recycled**	**≈51%**

Good Practice in Concrete Usage in Singapore[1]
– Semi-green concrete: 20% SCM and 10% recycled aggregates
– Green concrete: 20% SCM and 30% recycled aggregates
– Eco-concrete: 20% SCM and 50% recycled aggregates



__Note__:
SCM = Supplementary Cementitious Materials. Mainly ground granulated blast furnace slag (GGBS) and fly ash in Singapore
[1]: Building and Construction Authority: A guide on Concrete Usage Index – BCA Sustainable Construction Series - 6

CO2e Release in Cement-Making

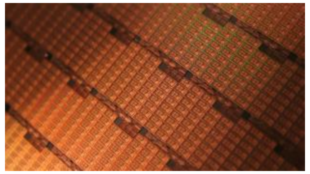


Beyond Zero Emissions (2017), *Zero Carbon Industry Plan: Rethinking Cement*, ISBN: 978-0-9923580-2-0

Supplementary Cementitious Materials

- Geopolymer concrete is concrete made from synthetic materials in the place of Ordinary Portland Cement (OPC), typically:

Fly ash
By-product of coal fired power plants



Slag / Ground Granulated Blast Furnace Slag (GGBFS)
By-product of iron/steel manufacturing process

Silica fume
By-product of the induction arc furnaces in the silicon metal and ferrosilicon alloy industries.

Metakaolin
Derived from clay soils or mining waste

Property Comparison: Geopolymer vs Conventional Concrete

Property	Geopolymer versus Conventional Concrete
Compressive Strength	Similar, heigher rate of early strengt gain
Tensile Strength	Indirect tensile strength typically higher for similar compressive strength
Flexural Strength	Similar to higher depending on alkali activator, higher rate of early strength gain
Modulus Elasticity	Typically lower
Density	Similar to lower
Poisson's Ratio	Typically lower or similar
Shrinkage	Lower to similar
Creep Coefficient	Lower
Bond Strength to Reinforcement	Similar for similar compressive strengths; higher compressive strengths
Carbonation Coefficient	Higher
Chloride Diffusion Coefficient	Lower (migration test); lower (core test)

Property	Geopolymer versus Conventional Concrete
Fire Resistance	More resistant
Freeze-Thaw Durability	More durable
Volume of Permeable Voids	Varies depending on mix proportions; higher
Water Absorbtion	Similar
Rapid Chloride Permeability	Lower to similar depending on mix proportions
Corrosion Rate of Embeded Steel	Limited research, particularly filed exposure, prevents conclusive comparison
Sorptivity	Higher
Sulphate Resistance	Somewhat higher, depends on cation
Acid Resisiance	More resistant to organic and inorganic acid attack
Alkali-Silica Reaction Susceptibility	Variable based on limited research

Cooperative Research Centre (CRC) for Low Carbon Living (2013), *Pathways for overcoming barriers to implementation of low CO2 concrete*, RP1004-I

Operational Carbon Management: Evaluating Low-Carbon Energy Options for Singapore

Singapore

Domestic Renewables:
Solar or geothermal

Domestic:
Energy Efficiency and use of Cold Energy

Interconnection and electron import to commercially lead renewable projects in Malaysia.

Pipeline - blue/green hydrogen from Malaysia

Domestic
Hydrogen production from gas & LNG via SMR/ATR/POx with CSS
- Development of Carbon Capture and Export Hub Facilities

Hydrogen from Methane pyrolysis in SG

International imports
- CSS at LNG facility = 'low carbon gas'
- CCS @ exporting country & ship hydrogen

Hydrogen form:
- Compressed
- Liquified
- LOHC
- Ammonia

Interconnection and electron import to commercially lead renewable projects in Indonesia.

Pipeline - blue/green hydrogen from Indonesia

Stakeholder Engagement for developing and managing commitments Example Stakeholders Involved in Low-Carbon Energy in Singapore

Replacing Diesel Generators with Fuel Cells

Example:
Microsoft pilots a hydrogen fuel cell system in New York.

https://news.microsoft.com/innovation-stories/hydrogen-fuel-cells-could-provide-emission-free-backup-power-at-datacenters-microsoft-says/

Key Takeaways

- Sustainable data centres start with strong Corporate ESG
- Sustainable Site Selection & Design are key to achieving KPIs
- Finding low-carbon energy can be a challenge but there is much progress being made

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Questions?