
IDEA2021
Powering the Future: District Energy/CHP/Microgrids
Sept. 27-29 | Austin Convention Center | Austin, Texas

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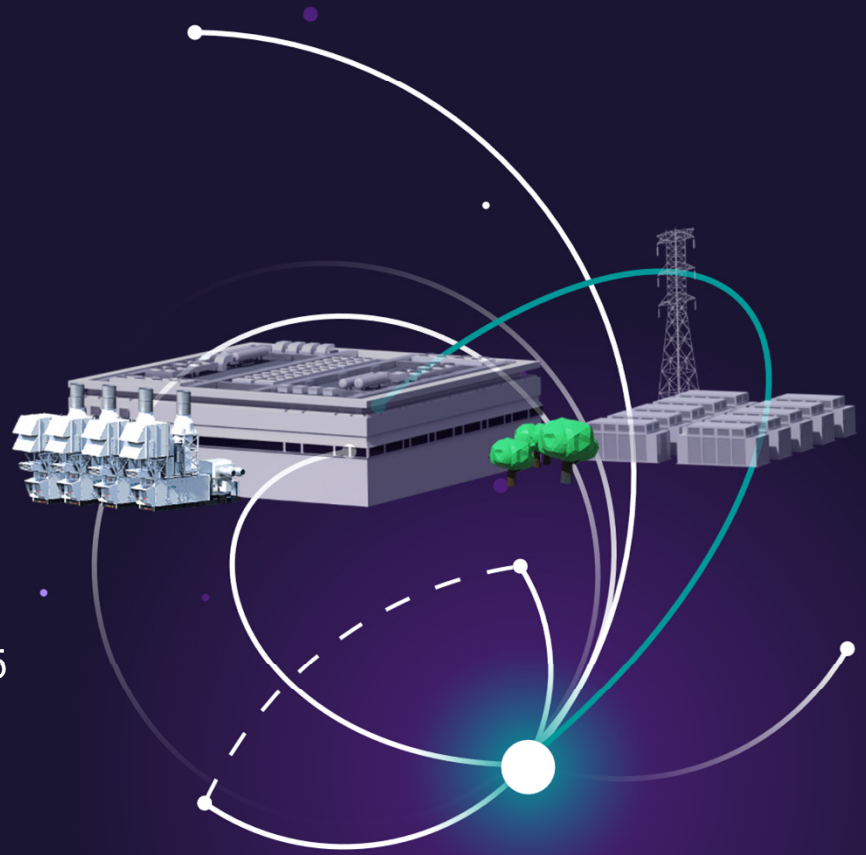
SIEMENS energy

Decarbonized and Reliable Power for Data Centers



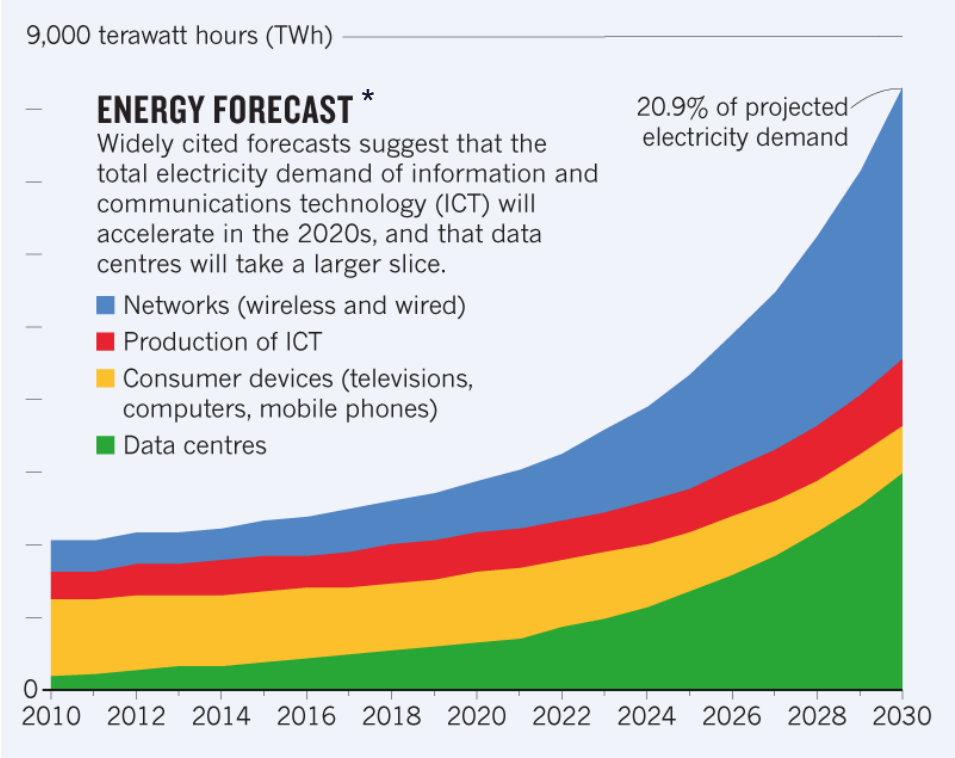
Robert Bouwens, Head of Sales and Aftermarket, SGT-A05

September 2021

The entire energy value chain
Our portfolio

Siemens Energy will take a **leading role** in the **energy industry.**

Data Centers – Growing requirements



Key Players:

- Google, Amazon, Facebook, Apple, Microsoft
- They all have a target to become carbon neutral by 2025/2030
- Each growing by about 200 data centers within next 5 years

Market:**

- The global data center market is expected to grow at a CAGR of over 2% during the period 2019-2025.
- Major growth in Europe and USA
- Asia Pacific is future growth region

* Source: https://www.nature.com/articles/d41586-018-06610-y

** Source: https://www.globenewswire.com/news-release/2020/02/13/1984742/0/en/Comprehensive-Data-Center-Market-Outlook-and-Forecast-2020-2025.html

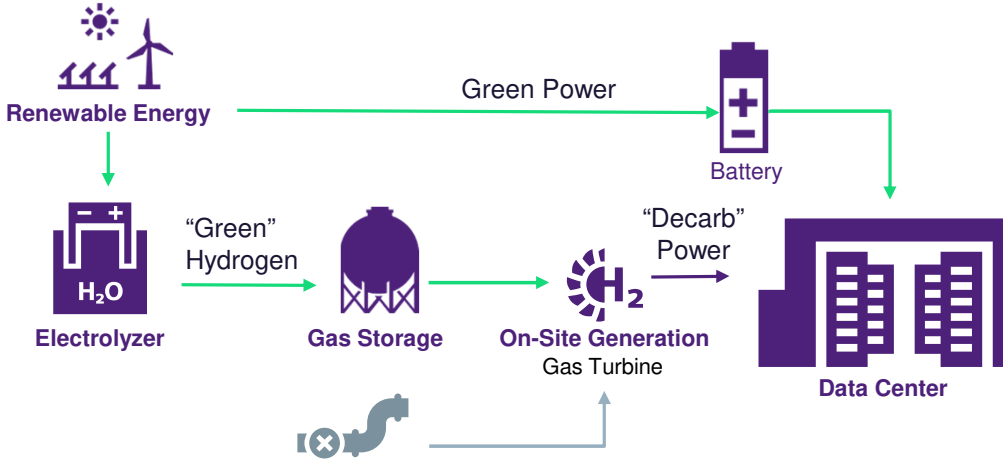
Customer Key Challenges

Fuel Flexibility	• Multi-fuel Capability • Hydrogen Capability
Start-Up Time	• Fast Start-Up
Cycle Efficiency	• Thermal and Electrical Output
Power Density	• Compact layout • Footprint challenges in densely populated areas
Emissions	• Local Emission Compliance • Future-proof Investments

H_2-ready Onsite Power Generation for Data Centers

Challenge: Short in capacity from grid

- Availability > 99.995%
- Very high fuel efficiency
- Additional revenues, savings



Hybrid Power Generation for Data Center

Challenge: Intermittent renewable energy

- Availability > 99.995%
- Up to "Zero" CO_2 footprint
- Renewable Energy enabler

Technology Agnostic Solutions

Enabled by our technologies

MISSION

Supporting our customers in transitioning to a more **sustainable world**, based on our **innovative technologies** and our ability to turn ideas into reality.

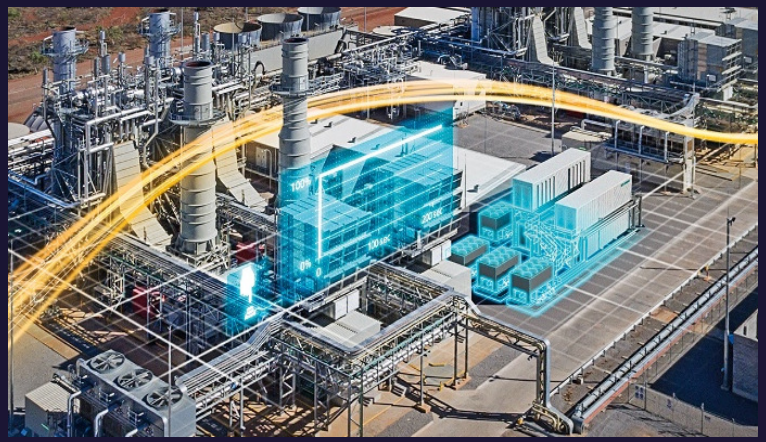
BACK-UP

- Gas Turbines
- Gas Engines
- Batteries
- Fuel Cells

BASELOAD

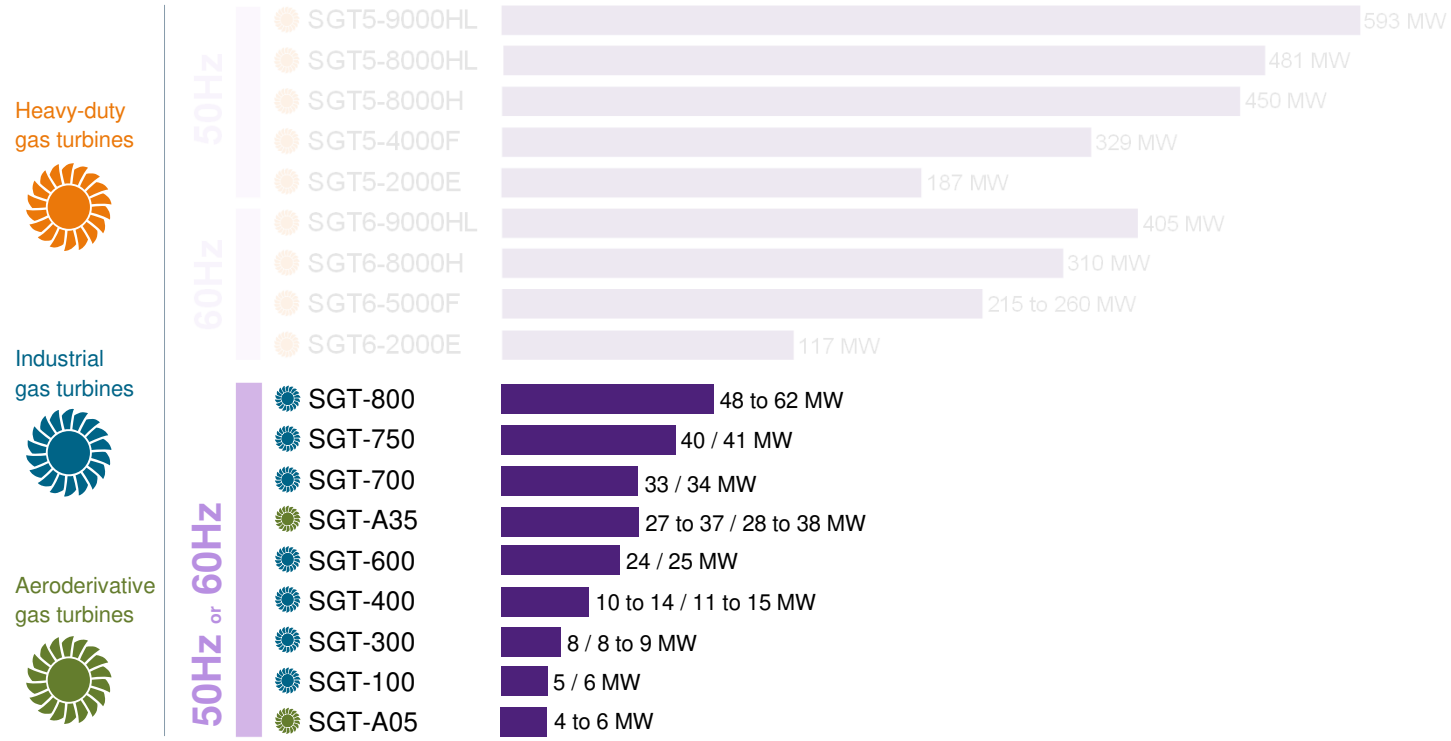
- Gas Turbines
- Gas Engines

Generation Solutions for Data Centers

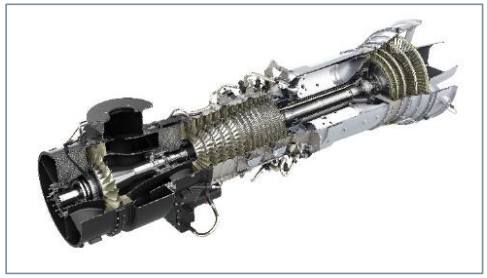


The Siemens Energy gas turbines portfolio: The right engine for every requirement

SIEMENS
Ingenuity for life



Power Generation / Mechanical Drive, Performance at ISO conditions



Siemens Hydrogen Gas Turbines for our sustainable future

The mission is to burn 100% hydrogen

	Gas turbine model	Power Output[1]	H_2 capabilities in vol. %	CO_2 reduction$_{2)}$ [%]
50Hz	SGT5-9000HL	595 MW	50	23%
	SGT5-8000H	450 MW	30	11%
	SGT5-4000F	329 MW	30	11%
	SGT5-2000E	187 MW	30	11%
60Hz	SGT6-9000HL	440 MW	50	23%
	SGT6-8000H	310 MW	30	11%
	SGT6-5000F	215 to 260 MW	30	11%
	SGT6-2000E	117 MW	30	11%
50Hz or 60Hz	SGT-800	48 to 62 MW	75	47%
	SGT-750	40/34 to 41 MW	40	17%
	SGT-700	33/34 MW	75	47%
	SGT-A35	27 to 37/28 to 38 MW	15 / 100	5 / 100%
	SGT-600	24/25 MW	75	47%
	SGT-400	10 to 14/11 to 15 MW	10 / 65	3 / 36%
	SGT-300	8/8 to 9 MW	30	11%
	SGT-100	5/6 MW	30 / 65	11 / 36%
	SGT-A05	4 to 6 MW	30	11%

DLE burner WLE burner Diffusion burner with unabated NOx emissions

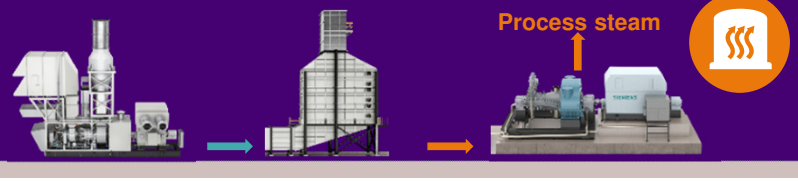
Heavy-duty gas turbines Industrial gas turbines Aeroderivative gas turbines

1 ISO, Base Load, Natural Gas 2) Compared with 100% natural gas operation

Values shown are indicative for new unit applications and depend on local conditions and requirements. Capability to operate on 100% natural gas is maintained (full fuel flexibility). Some operating restrictions/special hardware and package modifications may apply.

Higher H_2 contents to be discussed on a project specific basis

Power Generation Solutions For Data Centers

Simple cycle	Gas turbine 	33–44% electricity	Max. power density Modularity & redundancy	33–44% typical overall efficiency	Back-up
Combined cycle (CC)	Gas turbine with boiler and steam turbine 	48–60% electricity	Max. el efficiency OPEX	48–60% typical overall efficiency	On-site
Combined heat and power (CHP)	Gas turbine with boiler 	33–44% electricity	Max. fuel utilization OPEX & less emissions	75–90% typical overall efficiency	Back-up & cooling
Combined cycle (CC-CHP)	Gas turbine with boiler and steam turbine 	48–60% electricity	Max. el efficiency OPEX & performance	75–90% typical overall efficiency	On-site & cooling

Key Technical Features for Data Center Projects

100MW Gas Plant

Parameter	20x SGT-A05 Gas turbine simple cycle "High modular & redundant"	2x SGT-800 Gas turbine simple cycle "Low complexity & low CAPEX"	2x SGT-400 3x1 ORC[1] (CCGT) Organic Rankine Cycle "High efficient & modular"
Power / unit [MW]	5.8	50 - 62	52 - 58 (per ORC), 14 (per GT)
Power total [MW]	116	100 -124	104 - 116
Electrical efficiency [%]	33.2	39	47-50
Fuel capabilities	Tri-Fuel with online switch over (Natural Gas, Diesel incl. HVO, H2)		
Start Up Time [min.]	<1-1,5	8-10[2]	10 – 12[2] for GT 90 for ORC
Space required [m²]	5.700 (95x60)	6.768 (72x94)	15.300 (85x180)
Additional Benefit	Omit Diesel GenSet for Backup	Omit Diesel GenSet for Backup[2]	Omit Diesel GenSet for Backup[2]

Back-up power for Datacenter in Europe

Scope

- 9 x SGT-A05 Dual fuel WLE

Contribution to decarbonization of the back-up power for datacenters

This project is the first project decarbonizing the back-up power for datacenters with a switch from diesel as back-up fuel towards natural gas and later to green hydrogen when available

Project

- Component supply to packager
- 40MW of back-up power to datacenter with (N+1) configuration
  → 9 x SGT-A05 KB7 DF WLE

Customer

Data Center

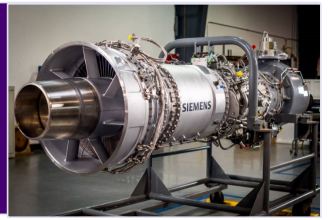
- World leading datacenter co-locator
- Whole datacenter with 40MW power demand build for big US data company

Winning Factors

- Fast track: < 3 months from first contact to selected product)
- Fuel flexibility (dual fuel + H2-capability)
- Fast start-up of <90s paired with 40% less stand-by costs

"This project represents an important milestone in how state-of-the-art gas turbine technology can secure the energy supply for data centers. Our customer will have reliable, low emissions, efficient, and high-power density solution for on-site back-up power generation."

Robert Bouwens



SGT-A05

Combines a reliable aero-derivative design with high efficiency, flexibility and fast start-up

Proven reliability

- Start **Reliability** 99.8%
- Over 1720 units installed around the world

Excellent performance

- 33.2% simply cycle **efficiency**
- Full engine power within **60 seconds**

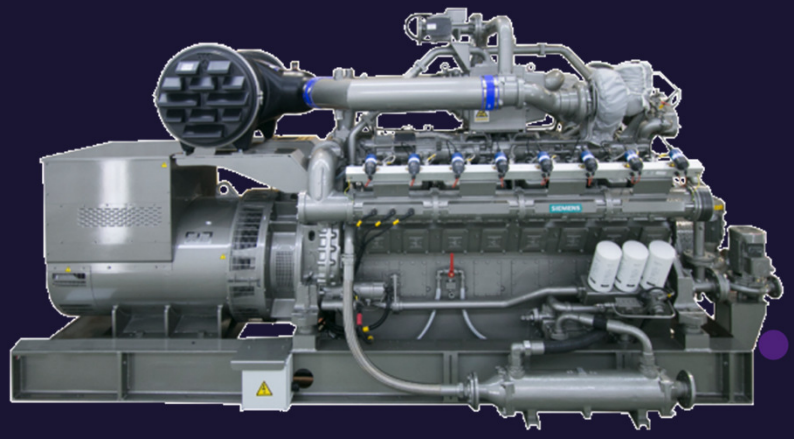
Flexible solutions

- **Fuel Flexibility** which can accommodate a wide variety of possible application scenarios and requirements

Sustainable & future proof

- **DLE or WLE system**
- **50% turn-down** capability is available as an option on the DLE system
- SGT-A05 capable of operating on **30% vol. hydrogen**
- Moving towards **100% hydrogen target by 2028**

Solutions for Back-up Power



Siemens Gas Engines
Fuel flexibility

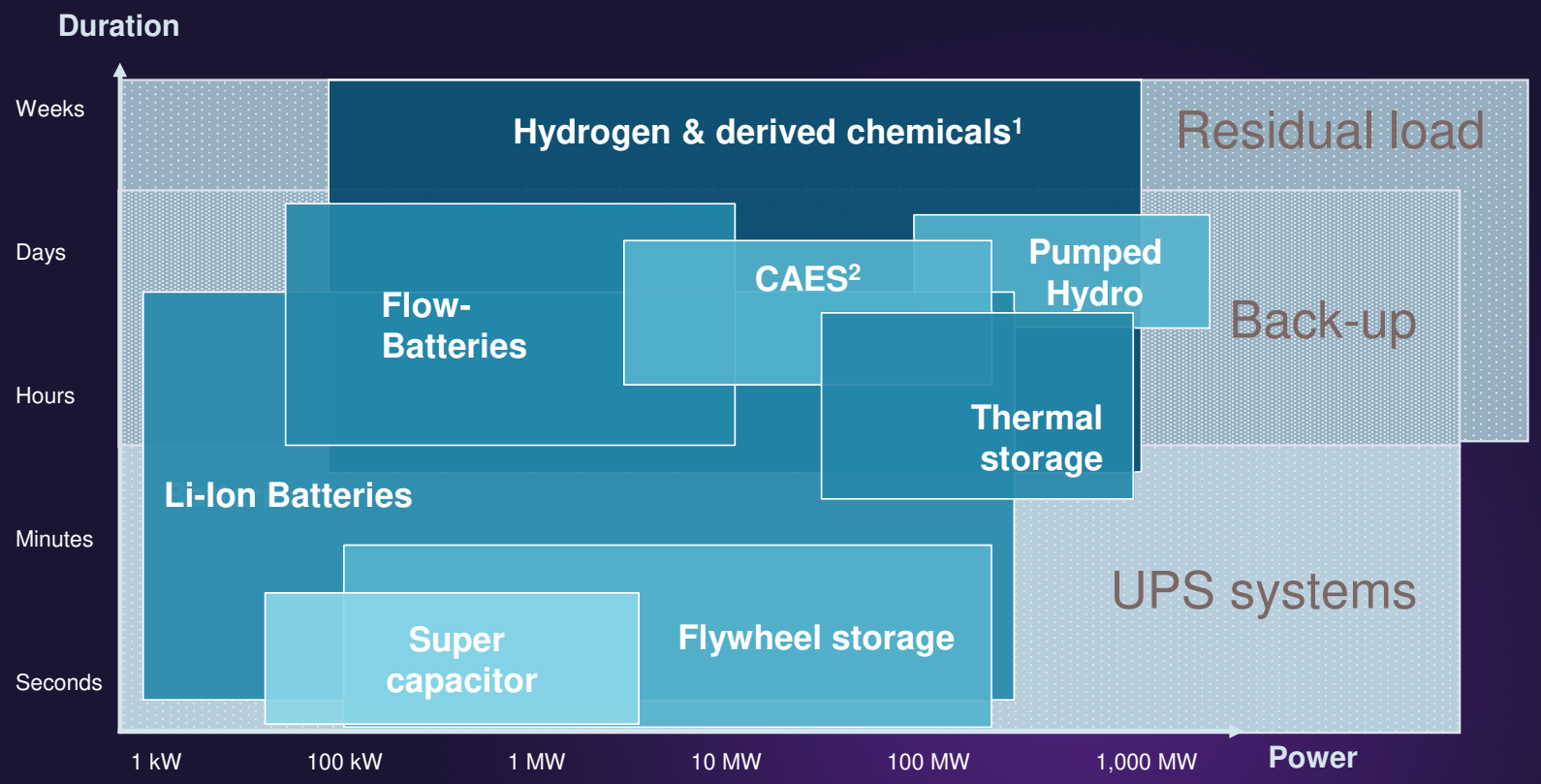
Large range of fuels of Siemens Gas Engines

Syngas | Landfill | Digester | Natural Gas | Well Gas | Propane

LHV	**120 – 375 Btu/ft³**	**375 – 620**	**590 – 805**	**805 – 1155**	**1155 – 2495**	**2495 – 2690**
	4.5 - 14 MJ/Nm³	**14 - 23**	**22 - 30**	**30 - 43**	**40 - 93**	**93-100**

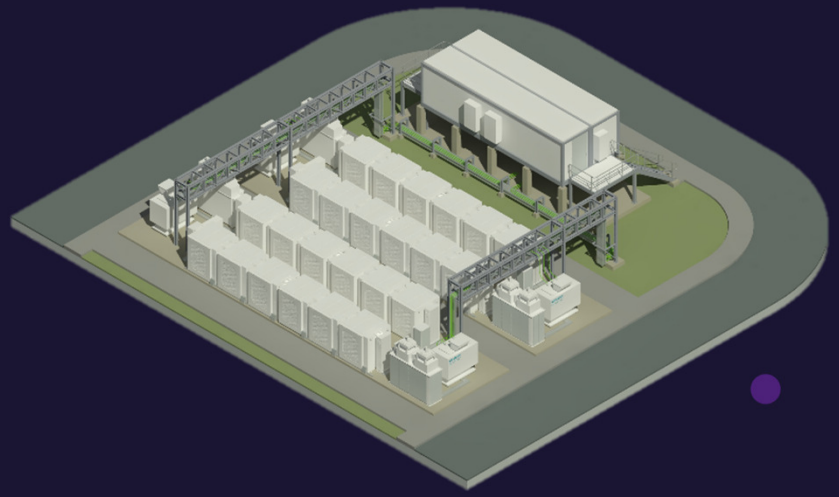
Storage Solutions for Data Centers

Different storage technologies for different applications in energy systems of datacenters



[1] Source: https://www.dvgw.de/medien/dvgw/leistungen/forschung/berichte/1510nitschke.pdf p. 24, [2] Liquid Organic Hydrogen Carrier

Battery Energy Storage Systems (BESS)

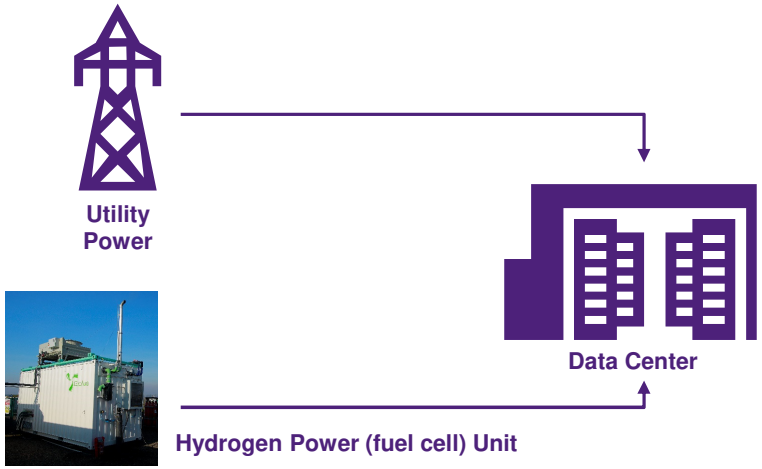


BESS Modularization – High Level Arrangement

Standardized approach to reduce BESS footprint

- Reduction of up to 2/3 of BESS footprint
- Modular steelwork and civil design to allow quick erection & commissioning and reduce manpower on site
- Available for Modul 2, 3 and 4 and any kind of project size

GeoPura Hydrogen Power Unit (Fuel Cell) for Critical Power and Backup Power



- 20 ft shipping container
- 250 kW peak (20 minutes)
- 100 kW/200 kW constant power.
- 216 kWh battery storage included in each module.

Instantaneous power

Carbon Neutral

Small Footprint

Summary

Path to Sustainable, Carbon-neutral Datacenter Backup Power

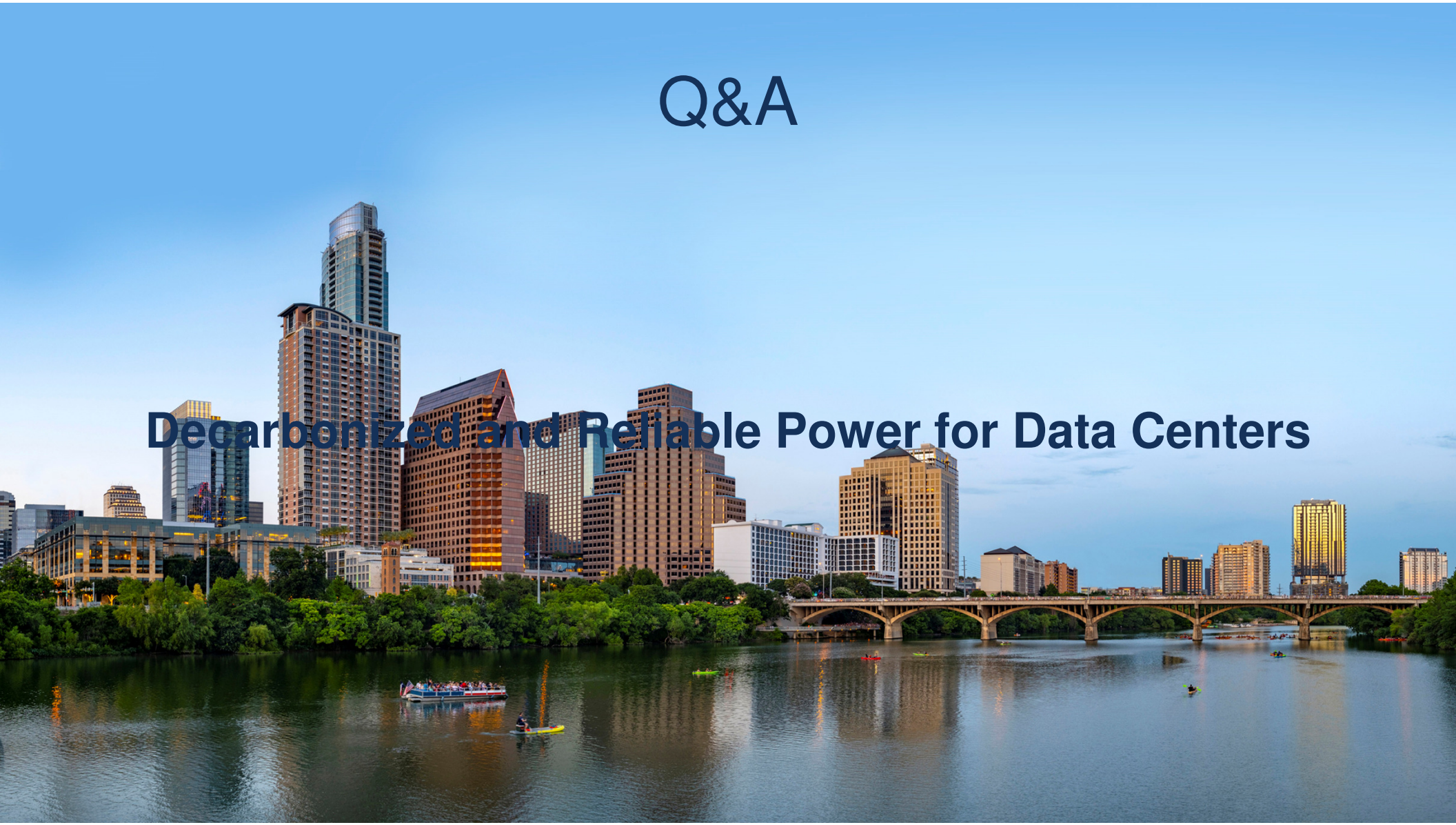
	Fuels	Start-up time	Cycle efficiency	Modularity	Power density	CO_2e emission*	Local emission	H_2 capable
Back-up	Diesel Natural Gas Hydrogen**	< 90 s	33.0 % 31.8 % 21.6 %	3.0 MW 3.0 MW 3.1 MW	54 kW/m²	800 g/kWh 650 g/kWh 0 g/kWh	0.79 g/kWh 0.58 g/kWh g/kWh	yes
Back-up	Diesel	< 60 s	43 %	2 – 4 MW	22 kW/m²	750 g/kWh	5.14 g/kWh	Once converted to H_2, limited natural gas / diesel capability
Back-up	Natural Gas	120 s	38 - 44 %	3 – 9 MW	~ 7 kW/m²	750 g/kWh	2 g/kWh	
Back-up	Hydrogen**						> -20% power	
Back-up	Power	< 1 s	> 85 %	2 – 4 MW / MWh	72 - 125 kW/m²	0 g/kWh	0 g/kWh	
Back-up	Hydrogen**	< 1 s	45 - 55 %	0.25 - 1 MW	16 - 63 kW/m²	0 g/kWh	0 g/kWh	yes
Baseload	Diesel (as back-up fuel) Natural Gas Hydrogen**	N/A 660 s 660 s	N/A 35 - 59 % 36.1 %	3.0 - 50 MW	15 - 54 kW/m²	460 g/kWh 350 g/kWh 0 g/kWh	0.42 g/kWh 0.31 g/kWh ??? g/kWh	yes
Baseload	Diesel (DF)	600 s	41 – 45 %	2 – 4 MW	~ 22 kW/m²	680 g/kWh	??? g/kWh	Once converted to H_2, limited natural gas / diesel capability
Baseload	Natural Gas (SI)	600 s	40 - 44 %	3 – 9 MW	~ 7 kW/m²	610 g/kWh	3.6 g/kWh	
Baseload	Hydrogen** (SI)						> -20% power	

* methane slip included
** 100% green hydrogen assumed

Key Takeaways

1. The global data center market is expected to grow at a CAGR of over 2% during the period 2019-2025.
2. Intelligent technology solutions for data centers are critical
3. Fuel flexibility including low carbon fuels is a major goal
4. Modularity and power density are key factors

Q&A



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