NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Hydrogen Carriers in Carbon Free Data Center

Genevieve Saur
National Renewable Energy Laboratory

Department of Energy Hydrogen Carriers Workshop:
Novel Pathways for Optimized Hydrogen Transport & Stationary Storage
Golden, Colorado
November 14, 2019

Topics of Discussion

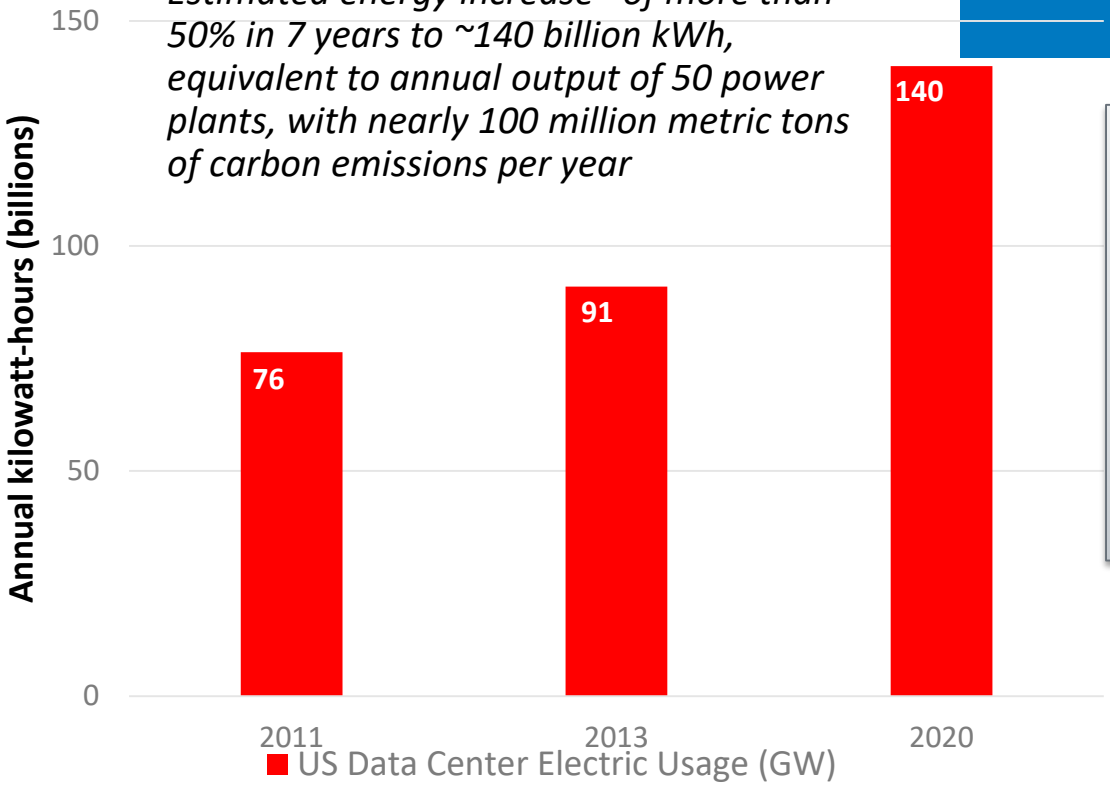
Data Center Application

System Specification

Challenges & Opportunities

Estimated Electricity Use

Estimated energy increase of more than 50% in 7 years to ~140 billion kWh, equivalent to annual output of 50 power plants, with nearly 100 million metric tons of carbon emissions per year*

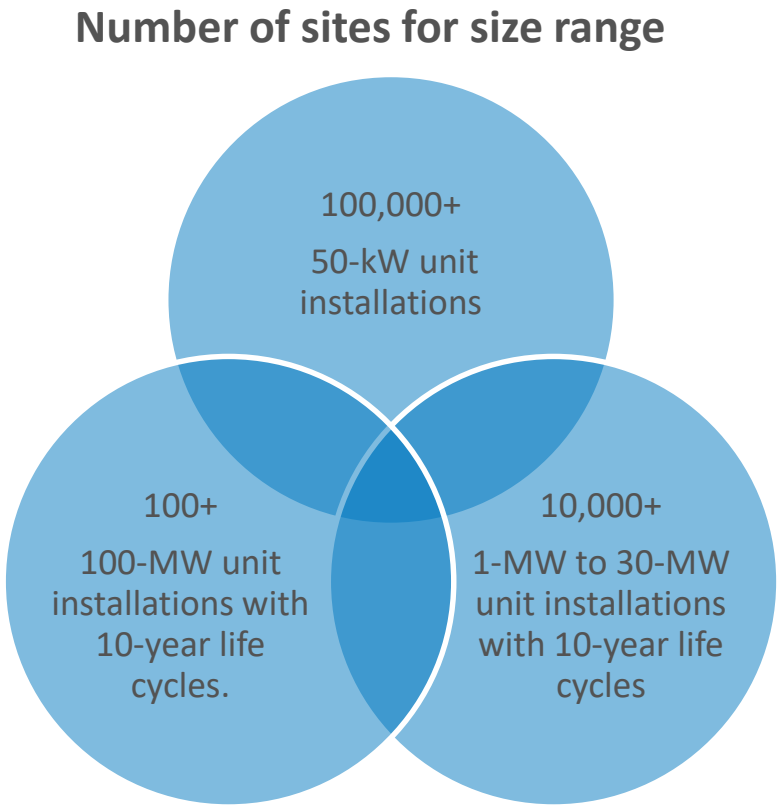


Data center electricity use would be 3.5% of total U.S. electricity use in 2020 according to projections.

Annual Energy Outlook 2019
Table: Electricity Supply, Disposition, Prices, and Emissions
Case: Reference case

Types of Data Centers

- **High performance computing**—High-speed computing-intensive application
- **Hyperscale, single customer**—Single company's business needs. Hyperscale, single customer data centers are modularly designed to allow for the seamless increase of computing capacity. Sizes range from 100 kW to 100 MW.
- **Hyperscale, co-location**—Scaled appropriately based on the individual needs of multiple customers that contract from a third-party data center company.
- **Point of presence servers/mini data centers/micro data centers**—This design is smaller (50 kW to 2 MW).



Power Scenarios

	Thermal Integration	Frequency of Use	Incumbent Technology
Prime	Y	24/7/365	Grid + Diesel/battery backup
Backup	N	~ 100 hrs/yr	Diesel/battery backup
Backup/Prime + Grid	N	6 weeks of services + 100 hrs/yr	Grid + Diesel/battery backup

- **Prime**—A large capacity fuel cell outside or smaller fuel cells integrated at the rack/row level inside the data center to meet the critical loads with optional thermal integration.
- **Backup**—Either a larger capacity fuel cell or distributed fuel cells used as backup and sized to meet the critical loads of the center.
- **Backup/Prime + Grid Services** - Services could include peak shaving, frequency regulation, and increased demand response.

Topics of Discussion

Data Center Application

System Specification

Challenges & Opportunities

Onsite Storage and Flow Rates

	Power Range	Module Size	For Specified Module Size			
			Onsite Storage 48-72 hrs (H_2)	**Annual H2 - Prime (50% LF)**	**Annual H2 - Backup (50% LF)**	**H2 Flow Rate at module peak power**
Hyperscale Computing	100 kW - 100 MW	20 MW	**60-90 tonne H_2**	**5,500 tonne H_2/y**	**100 tonne H_2/y**	**15000 nm3 H_2/h**
Micro datacenter	50 kW - 2 MW	100 kW	**300-450 kg H_2**	**27 tonne H_2/y**	**0.3 tonne H_2 /y**	**38 nm3 H_2/h**

Estimated to demonstrate the scales required for onsite storage and flow rates.

Key Considerations

- Implicit assumption in previous estimates that hydrogen is the key end-product
  - Dependent on fuel cell type used
- H2 Carrier
  - Onsite space requirements (energy density) and vessel cost
  - Onsite weight not likely an issue for this application
- Delivery requirements and considerations
  - Frequency of deliveries
  - Time for on/off loading of carrier
- Process for onsite hydrogen release
  - Response time of system start-up important for backup scenarios
  - Redundancy to reduce compressed hydrogen storage
  - Thermal integration a possibility in prime power applications

Incumbent Technologies

- Prime power competes against grid electricity
  - Delivered power at 3¢/kWh (5¢/kWh for green)
  - Durability, efficiency, and cost important over data center lifetime
- Backup power competes primarily against diesel generator/battery UPS
  - $1,000/kW delivered power
  - Cost main driver, durability and efficiency not as important
- Backup power can also be provided by 2nd utility interconnect and redundant equipment
  - Incurs significant demand charges depending on peak loads
- *For on-site fuel storage, diesel is favored by the industry due to its high energy density, low cost, and low space requirements.*

Topics of Discussion

Data Center Application

System Specification

Challenges & Opportunities

Key Challenges/Opportunities for Alternate H_2 Carriers

- Compressed hydrogen
  - Large space requirement for quantities needed
- Liquid Hydrogen
  - Not suitable for purely backup application
- Alternate H_2 Carriers
  - Competes against traditional H_2 storage *and* incumbent technologies
  - Application requires reliable supply and large quantities
  - *Green/renewably-sourced H_2 an industry priority, but fossils fuels can be part of the transition*

Information for this presentation taken in part from:
G. Saur, V. Arjona, A. Clutterbuck, E. Parker. 2019. *Hydrogen and Fuel Cells for Data Center Applications Project Meeting: Workshop Report*. NREL/TP-5400-75355. (Soon to be published)

Thank You

www.nrel.gov

NREL/PR-5400-75423

This work was authored by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by U.S. Department of Energy Office of Energy Efficiency and Renewable Energy Fuel Cell Technologies Office. The views expressed in the article do not necessarily represent the views of the DOE or the U.S. Government. The U.S. Government retains and the publisher, by accepting the article for publication, acknowledges that the U.S. Government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for U.S. Government purposes.