Committee on Water
* IT includes servers, storage, and networking equipment (grey shades, bottom-to-top)
\[ PUE = \frac{\text{Total Energy}}{\text{IT Energy}} \]

* IT includes servers, storage, and networking equipment (grey shades, bottom-to-top)
ENERGY EFFICIENCY OPPORTUNITIES

- IT innovation
- Virtualization
- High-efficiency power supplies
- Load management

- Better air management
- Move to liquid cooling
- Optimized chilled-water plants
- Use of free cooling
- Heat recovery

Power Conversion & Distribution
- High-voltage distribution
- High-efficiency UPS
- Efficient redundancy strategies
- Use of DC power

IT Load/Computing Operations

Alternative Power Generation
- On-site generation
  Including fuel cells and renewable sources
- CHP applications
  (waste heat for cooling)

Graphic courtesy of Dale Sartor, LBNL
DEMAND RESPONSE OPPORTUNITIES

- Load shifting or queuing jobs
- Load migration
- Shutdown of storage clusters
- Server shutdown

- CRAC unit shutdown
- Temperature set point adjustment
- Pre-cooling

Power Conversion & Distribution

IT Load/Computing Operations

Cooling Equipment

Alternative Power Generation

- Back-up generators (for emergencies)
Thank you!
sjsmith@lbl.gov
Committee on Water
Reducing Water Waste In Data Centers

7.17.2018
Water Use in Data Centers

438 Million Gallons Per Year
20 MW Data Center

- Electricity
- Cooling
Water Stress by Country: 2040

Ratio of withdrawals to supply:
- Low (<10%)
- Low to medium (10-20%)
- Medium to high (20-40%)
- High (40-80%)
- Extremely high (>80%)

NOTE: Projections are based on a business-as-usual scenario using SSP2 and RCP8.5.

For more: ow.ly/RiWop
Aligned Energy
Componentized & Pre-Manufactured Infrastructure

By engineering and constructing our solutions around standardized, pre-manufactured infrastructure components we reduce on-site construction time, increasing both capacity delivery velocity and overall systems reliability.
Cactus Platform Delivers Flexible Density

Designed To Adjust to Any Environmental Condition
Efficient Optimization of Water and Power
Flexible Density

- Deploy Any Density On Demand
- Adjust Density From 30 Watts/Sqft to 2,000 Watts/Sqft
Water Use and **Hours per Year** versus Outdoor DB
Phoenix, AZ
1 MW of Load
Aligned Platform
Phoenix, AZ Total PUE Load Curve

PUE

Utilization

1.15 at 30%
Next Generation CACTUS Waterless Operation

1.2 MW CACTUS Delivered as Integrated Unit
Committee on Water
Powering Big Data with the Sun
Lisa Moerner, Director of Corporate Public Policy
Dominion Energy Profile
Primary Operating Segments

**Power Delivery**

- Electric Transmission
  - 6,600 miles of transmission lines
  - Favorable regulatory environment

- Electric Distribution
  - 57,900 miles of distribution lines
  - 2.6 million franchise retail customer accounts in VA and NC

**Power Generation**

- Utility Generation
  - 22,327 MW of capacity
  - Balanced, diverse fuel mix
  - Favorable regulatory environment

- Merchant Generation
  - 3,710 MW of capacity, including nuclear, gas and renewable power
  - Active hedging program for energy revenue/margins

**Gas Infrastructure**

- Gas Transmission
  - Together with Gas Distribution, operates one of the largest natural gas storage systems in the U.S.
  - 14,800 miles of pipeline in 11 states
  - Cove Point LNG facility (bi-directional)
  - Well positioned in Marcellus and Utica Shale regions

- Gas Distribution
  - 51,800 miles of distribution pipeline and 2.3 million natural gas customer accounts in five states

**Dominion Energy Solutions**
Dominion Energy Nationwide Renewables Portfolio

- 6th in the nation for solar ownership among utility holding companies.
- 2,700 MW+ of solar capacity in operation or under development across 9 states.
- 580 MW of solar in Virginia in partnership with data centers.

Notes:
- Includes capacity under long term contract.
- Fuel cell powered by natural gas; qualifies as a renewable energy facility in Connecticut.

*Capacity (MW) includes projects under development, under construction, and operational and reflects Dominion Energy ownership in whole or in part.
Dominion Energy’s Solar Portfolio – 2015 vs. 2018

SOLAR IN VIRGINIA AS OF 2015
- Solar capacity 1 MW
- 4 solar installations
- No projects developed for data centers

SOLAR IN VIRGINIA AS OF 2018
- Solar capacity* 744 MW
- 27+ solar installations
- Vast majority supported by data centers
  - More than 77% (580 MW)
  - 7+ installations

* Operational or under development
# Dominion Energy Virginia: Renewable Options for Large Customers

<table>
<thead>
<tr>
<th>File Year</th>
<th>2018</th>
<th>2017</th>
<th>Current Offerings</th>
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<tbody>
<tr>
<td><strong>Offering:</strong></td>
<td>Community Solar</td>
<td>Schedule CRG</td>
<td>Schedule RG</td>
</tr>
<tr>
<td><strong>Description:</strong></td>
<td>Purchase Subscriptions from solar facility</td>
<td>Purchase renewable energy 24x7; load following</td>
<td>Contract for Differences</td>
</tr>
<tr>
<td><strong>Summary:</strong></td>
<td>Anchor for Residential</td>
<td>Greenest Solution</td>
<td>Choose up to 100% of load</td>
</tr>
<tr>
<td><strong>Customers:</strong></td>
<td>Anchor Tenant</td>
<td>N/A</td>
<td>Walmart</td>
</tr>
</tbody>
</table>

Size of Transaction
Timeline of Dominion Energy Solar Partnerships with Data Centers in Virginia

- Announced acquisition of Amazon Solar Farm (80 MW) on Virginia’s Eastern Shore: Nov 2015
- Amazon Solar Farm on Virginia’s Eastern Shore enters operation: Oct 2016
- Partnership for up to 300 MW of solar with Facebook announced: Oct 2017
- Remington Solar Project enters operation: Dec 2017
- Announcement of 180 MW expansion of solar alliance with Amazon: Nov 2016
- Amazon solar expansion projects (5 projects at 180 MW) enter operation: Oct 2017

Timeline:
- Nov 2015
- Mar 2016
- Oct 2016
- Nov 2016
- Oct 2017
- Dec 2017
Data Centers in Dominion Energy Virginia Territory

- Largest data center market in the world as of 2015*
- Both Co-location and Enterprise Facilities
- Contribute 100 MW+ growth in demand per year
- Comprise 1 GW of actual electric load
- Data center efficiencies in electricity consumption being masked by aggregate data center growth
- Chip technology allowing operation at higher temperatures, leading to higher density of servers per facility
- New technologies advancing efficiencies in cooling, e.g. KyotoWheel, ambient air cooling

*Northern Virginia Technology Council, *The Economic and Fiscal Contribution that Data Centers Make to Virginia*, February 2018

Photo credit: Tqn.com
Solar Alliance with Amazon Web Services

• Supports AWS’s 100% renewable energy goal

• Project Details:
  • 260 MW of ground-mounted solar facilities
  • 6 projects
  • ~2,500 acres

• Dominion Energy crafted and received state regulatory approval for a Special Rate Contract (SCR):
  • Provides correlating retail bill with wholesale pricing for their renewable projects
  • Also available to other customers who want to achieve similar effort

Amazon Solar Farm U.S. East II – Buckingham County, Virginia
Public-Private Partnership with Microsoft and Commonwealth of Virginia

- Supports Microsoft’s sustainability goals
- Project Details:
  - 20 MW ground-mounted solar facility
  - ~125 acres
- Public-Private Partnership:
  - Dominion Energy constructs and owns facility
  - Commonwealth of Virginia purchases energy
  - Microsoft purchases RECs
Partnership with Facebook to Support More Solar on the Grid for Virginia Electric Utility Customers

• Supports Facebook’s 100% renewable energy goal

• Data Center Project Details:
  • 970,000 Sq Ft on 328 acre site
  • Early 2019 operations date
  • $750 million investment

• Solar Project Details:
  • Multiple projects, up to 300 MW
  • Facilitated by Schedule RF
    • Facebook pays premium in exchange for renewable attributes
    • Supports true additionality
    • Lowers cost of solar for all customers
Dominion Energy’s Commitment to Reducing Water Usage in Power Generation

- Modern cooling systems that require no water for new fossil-fueled facilities
  - Advanced coal facility in Southwest VA uses air-cooled condenser instead of cooling water
  - Similar modern cooling systems installed at new natural gas facilities in Virginia

- Increasing water reuse, recycling, and conservation at generation facilities requiring water for cooling
  - Reuse of water from wastewater treatment plant in air emissions control equipment at fossil-fueled facility in Virginia
  - Variable speed drives to regulate water usage at nuclear facility in Connecticut

- Increasing use of solar to generate electricity which requires no water

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**Dominion Energy Generation Water Reuse and Recycling**

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July 17, 2018
Emerging Issues

• Rise of cryptocurrency mining companies
  o Operate like data centers
  o Pose unique challenges for utilities

• Land-use challenges with large-scale solar
  o 1 MW of solar could require as much as 10 acres of land
  o Competition with agricultural uses for arable land
  o Concerns about viewshed and historic sites
Key Takeaways

- Data Centers are economic engines in the Commonwealth
- Aggregate data center electricity load continues to grow while individual data centers become increasingly efficient
  - Advanced cooling technologies reducing water usage
  - Advanced chip technologies allow operations at higher temperatures
- Data center renewable energy commitments have supported more than 77% of large-scale solar capacity either under development or in operation in Dominion Energy’s Virginia service territory
- Dominion Energy continues to track and reduce water usage in power generation and other aspects of our business
Thank you!
Committee on Water