Microgrids for Climate Action

IDEA Campus Energy 2020
Microgrid Workshop
Denver Colorado
February 11, 2020

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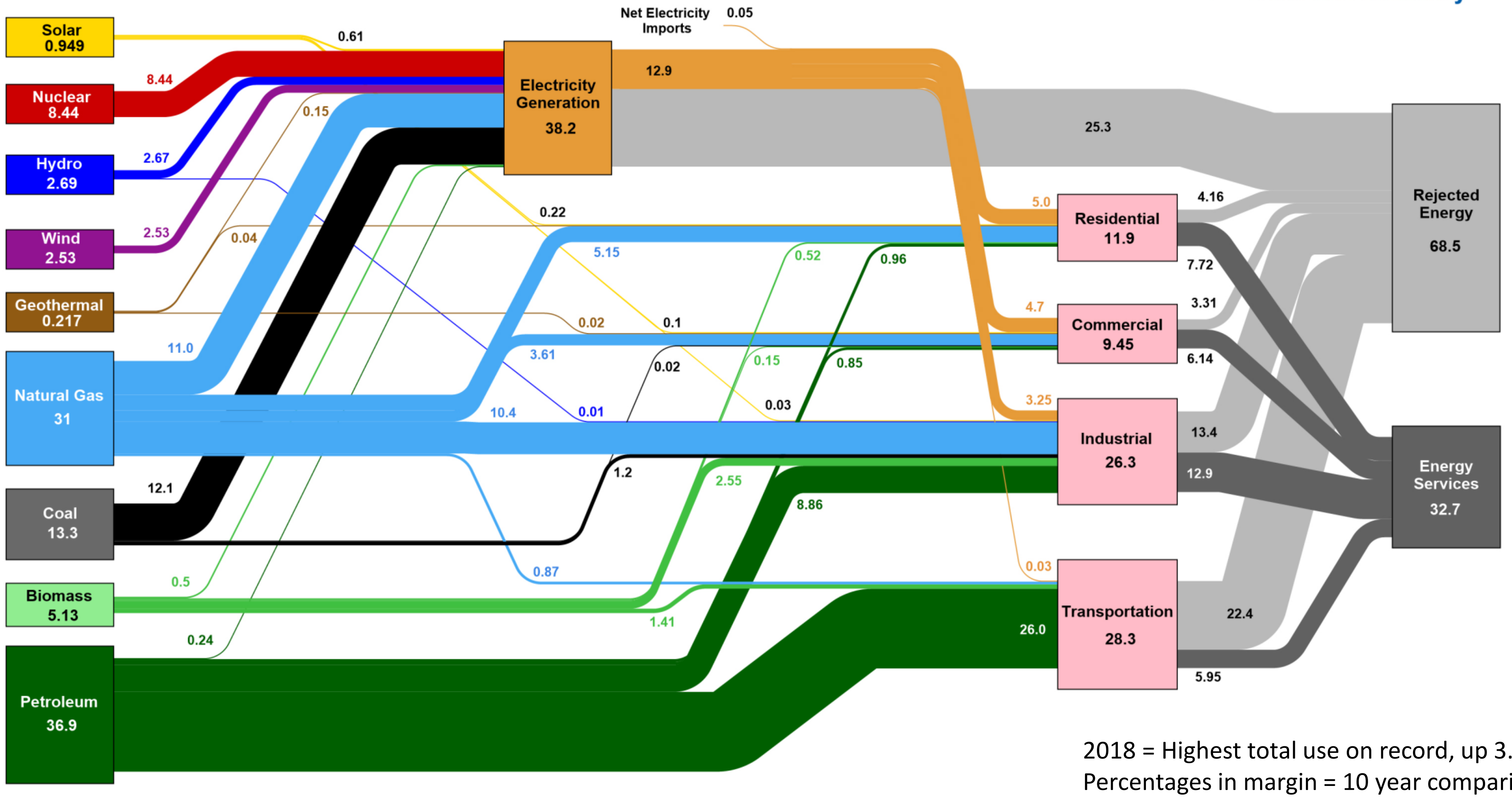
Energy Obesity

Estimated U.S. Energy Consumption in 2018: 101.2 Quads

Lawrence Livermore National Laboratory



+1%

+2%

+8%

-6%

+2%

+14%

2018 = Highest total use on record, up 3.6% from 2017

Percentages in margin = 10 year comparisons (rounded)

A Low Carbon Energy System

- Use less energy
  - Building and industrial energy efficiency
  - Smart cities
- Use cleaner electricity
  - But don’t pick technology winners
- Convert majority of transportation to electricity
- Generate more energy at the grid edge
  - Resilience
  - Reduce line losses, transmission expansion costs

A Resilient Energy System

Resilience must be measured by the ability to sustain the health, security and economic activity of local communities. It arises from:

- A networked system, smart metering and communication
- Utility scale battery storage.
- Visible controllable distributed energy resources in strategic locations
- System architecture that reduces the criticality of individual components
- Intelligent load shedding customer by customer [and internally for a microgrid] rather than radial by radial
- Adaptive islanding that permits individual microgrids and grid sub-regions to operate independently to reduce the impact of outages.
- National Academy of Science, Engineering and Medicine: Enhancing the Resilience of the Nation's Electricity System, 2017, available at https://www.nap.edu/catalog/24836/enhancing-the-resilience-of-the-nations-electricitysystem.

The Microgrid

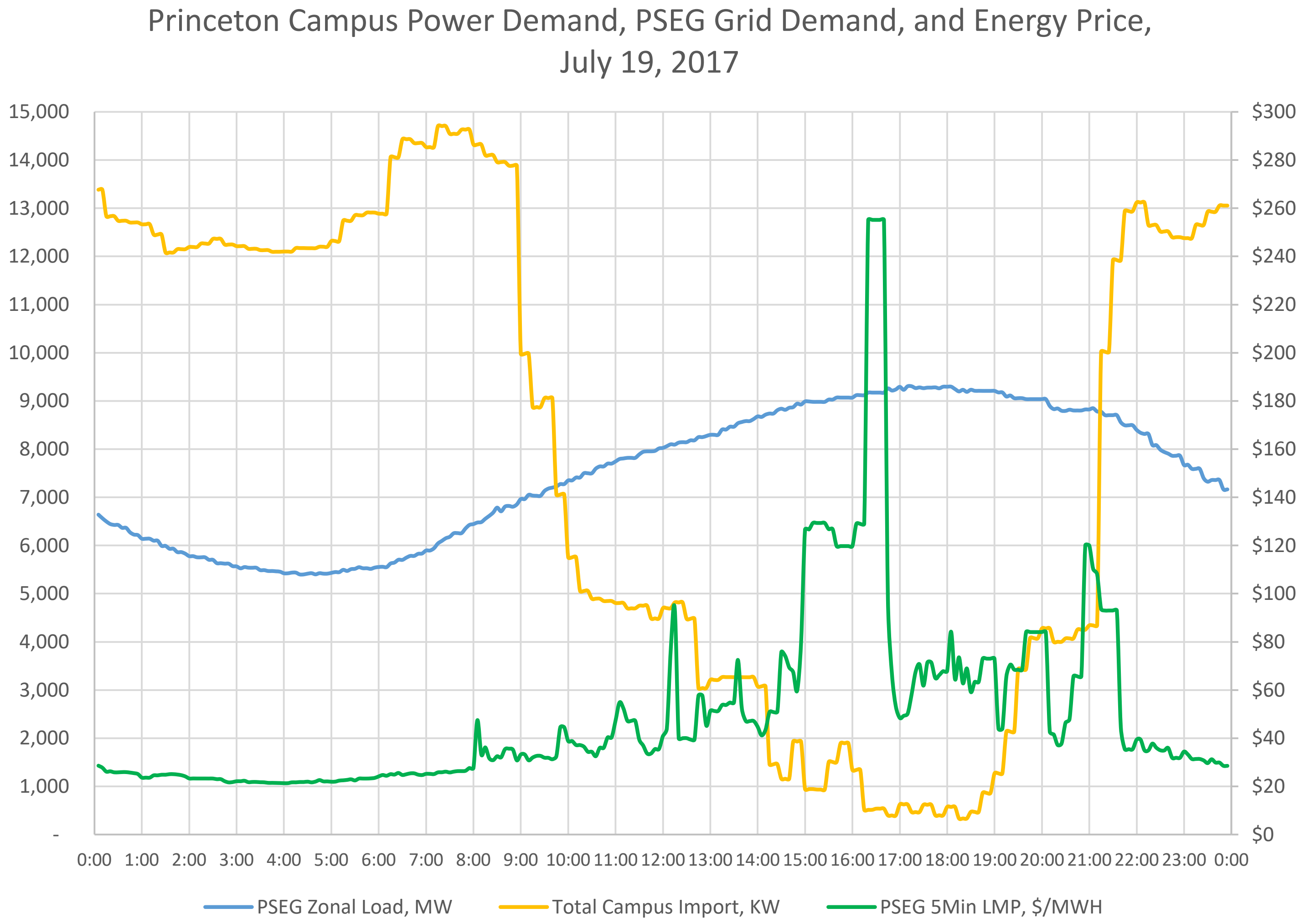
- A microgrid is a local electric system (**a local control area**) or combined electric and thermal system:
- that includes retail load and the ability to provide energy and energy management services needed to meet a significant proportion of the included load on a non-emergency basis
- that is capable of operating either in parallel or in isolation from the electrical grid
- that, when operating in parallel, is capable of providing energy, capacity or related services to the grid

Microgrid Resources Coalition

The Microgrid Solution

- Decarbonization
  - Microgrids integrate variable renewable energy resources with hybrid generation, storage
  - Cogeneration efficiency beats the grid 80 to 35%
  - Smart management of thermal loads begins with energy efficiency, uses buildings as thermal storage
- Resilience
  - Smart load shedding and Islanding
  - Serve critical facilities
  - Provide emergency grid services

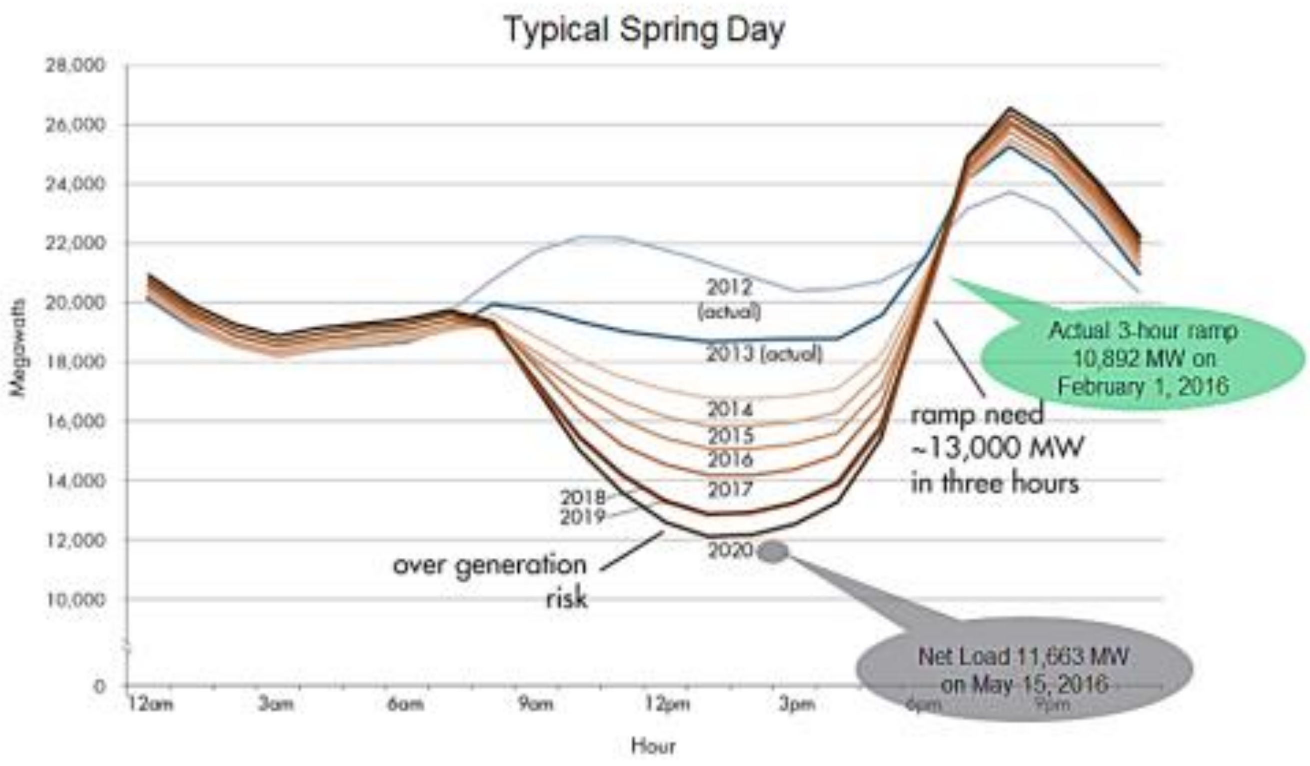
Princeton Microgrid Performance



Note that system load and campus imports use the same left margin scale, but system load is in MW and campus imports are in kW.

Princeton purchased a substantial amount of electric energy in the early morning to charge its thermal storage – chilled water in an insulated tank. It then purchased almost no electric power at the time of peak usage and peak pricing on the PJM system. This result at peak was achieved by 15 MW of cogeneration and 3.75 MW of solar. Normal campus load of around 26 MW was reduced to around 19 MW through use of steam chillers supplied by heat from the cogeneration plant and discharge of chilled water from the thermal storage tank. Princeton avoided purchasing high priced power (the prices reached $255.00), and reduced its obligation to pay transmission charges, which are allocated according to customer usage at system peak. Princeton paid a weighted average of $34.06 per MWh for power that day compared to a system average price of $50.17 per MWh.

The Duck Curve



- Solar generation peaks at midday and causes the California "duck curve"
- **Overgeneration** puts base-load nuclear plants at risk of having to shut down
- The grid has a steep **ramp requirement** for flexible sources such as gas turbines and battery storage to rapidly meet the the drop in solar production
- Solar and wind are also **Intermittent**

How Much Investment is Required?

- Deep Decarbonization Pathways Project estimates of needed investment:
  - $400 billion annually on building efficiency
  - $600 billion annually on clean electric generation
- 2017 annual U.S. investment (and level or falling)
  - $41 billion for energy efficiency
  - $40.5 billion for renewable electric generation
- Private investment needed

Role of Utility Regulation

- Federal Power Act (1935): consumer protection regulation
- Federal Energy Regulatory Commission (FERC) regulates
  - Wholesale sales of power (in interstate commerce)
  - Transmission (in interstate commerce)
  - Replaced utility transmission operation with Regional Transmission Organizations (RTOs) in many regions
  - RTOs set up markets for energy and ancillary services
- States regulate
  - Retail sales of power
  - Generation of power
  - Integrated resource planning

The Carbon Conflict

- State deregulation separates generation from distribution
  - Undermines resource planning
- RTO markets for capacity not really markets
  - Administratively set demand
  - Minimum offer price rule (MOPR) for some resources
- State support for low carbon capacity
  - Renewable Energy Credits - 27 states
  - Zero Emissions Credits – 4 states – 2 in PJM
- FERC and PJM require all subsidized resources to use MOPR
  - Basically a subsidy for gas and coal (the Rick Perry solution)
- Need a carbon price and a replacement for capacity market

Current State Actions

- Regional Greenhouse Gas Initiative
  - Cap and trade on electricity sector
  - 10 states plus
- Puerto Rico
  - Free rein to one and two party microgrids
  - Treating larger microgrids as mini-utilities
- Hawaii
  - Microgrid Tariff
- California
  - Economy-wide cap and trade – reciprocity with Quebec
  - Microgrid tariff

A Microgrid Tariff

- Interconnection
  - Microgrid control capabilities make them safer
  - Look at intended range of operation
- Clear away barriers to ownership and operation
- Microgrid Operator is a single point of responsibility
- Open all markets to microgrids
- Procure “distribution support services”
  - Map grid needs
  - Procure services or accept unsolicited proposals
  - Long term contracts help finance distributed resources such as microgrids
- Provide tariff support for resilience

The Grid of the Future

- A self-healing grid in emergencies
  - The grid can separate into self-supporting microgrid and minigrid islands
  - Each island is its own semiautonomous control area
  - Each supplied by Distributed Energy Resources (DER)
  - The islands can support one another (DERMS)
- Microgrids provide grid support services when not in emergency mode
- Microgrids are increasingly clean energy resources
  - Flexible co-generation is more efficient than the grid
- The grid operators conduct the concert

A Program for Action

- Fair and open markets
- A single price on carbon
  - Eliminate fuel and technology subsidies
- Pricing for resilience
- Customers and communities balance between local and grid scale services evaluating all dimensions:
  - Electricity, thermal energy, resilience, carbon emissions
  - Customer information belongs to customers
  - Grid information is available to all
- Utility investment in the grid of the future

Questions?

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'The economy is a subset of the ecology."