Exponent®

Engineering Management Consulting
Energy and Utilities

Value Proposition of Hybrid On-Site Power Systems – Current and Future Markets

NYSERDA On-Site Power & Expo

December 7, 2016

About us

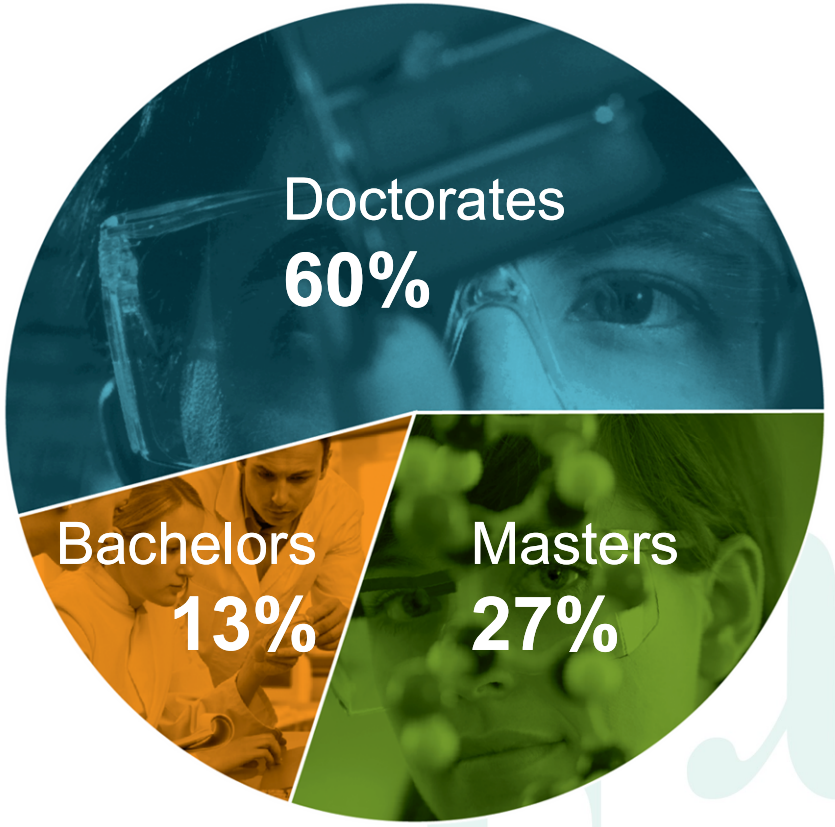
History:

- Founded in 1967 as “Failure Analysis Associates”
- Premium engineering & scientific consulting
- Long history with EPRI, industry, and others
- More than 900 employees

Business and Staff:

- ISO 9001 certified QMS
- Authorized by GSA for Federal services
- Consulting staff background (see chart)

Staff: Experienced, industry-active, top-shelf practitioners



Exponent®
Engineering Management Consulting
Energy and Utilities

What is the Basis for the Interest in "Hybrid" Applications

- *Our focus for today is to examine the benefits of combining solar, storage, and CHP to drive to better economics and to attempt to expand roles of the assets*

- *Summary of the Hybrid Concept we will review today*
  - ***Individual technologies and their benefits***
    - *Individual technologies are utilized at facilities to provide "retail" savings by reducing energy cost for a facility owner thru self generating or providing offsets to the current retail rate structures*
  - ***Combining technologies to increase retail benefits***
    - *Using the combined performance characteristics to expand the benefits and savings at the individual facility*
  - ***Utilizing the combined assets to provide "Grid Services" or System Benefits***
    - *Leveraging technology characteristics to perform grid services such as reducing overall demand, injecting renewable energy, and assisting with renewable integration and grid operations*
- Goal
  - To help all three categories but try to create mechanisms to deploy systems that can help customers on the retail side while simultaneously improving grid operations

Agenda for Today's Discussion

- **Discussion of Technologies**
- Benefits of Hybrid Applications
- Examples of Hybrid Applications
- Challenges to Hybrid Deployment

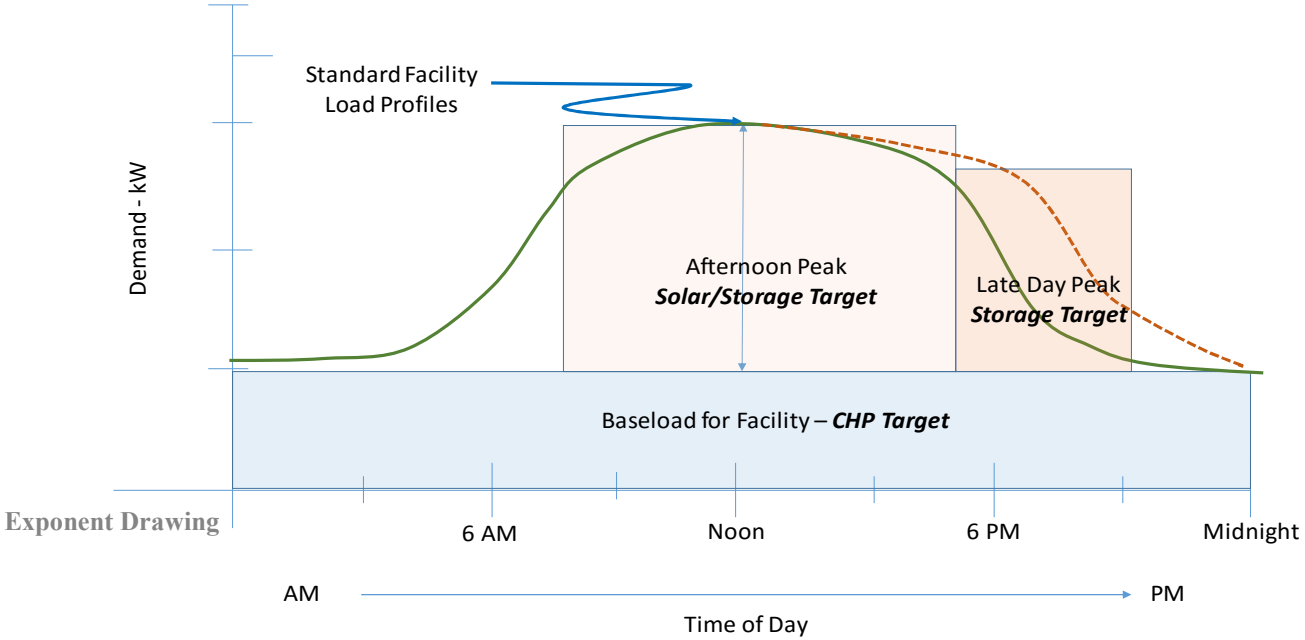
Summary of DER Technologies & Applications

- ***CHP – "Base loaded" application***
  - Typically Natural Gas based but CHP is an "application" that is utilized across all technologies
    - Combustion Turbines
    - Microturbines, Fuel Cells
    - Reciprocating Engines

- ***Solar – "Variable" Renewable Technology***
  - Zero fuel cost and rapidly decreasing capital cost
  - "Passive system" that requires little physical or complex maintenance by system owner

- ***Energy Storage – "Flexible" Technology***
  - Provides ability to store electricity for later use
  - Capable of providing multiple discharges from 30 minutes to 6 hours

Key Drivers to Deployment of Individual DER Technologies and Retail Benefits

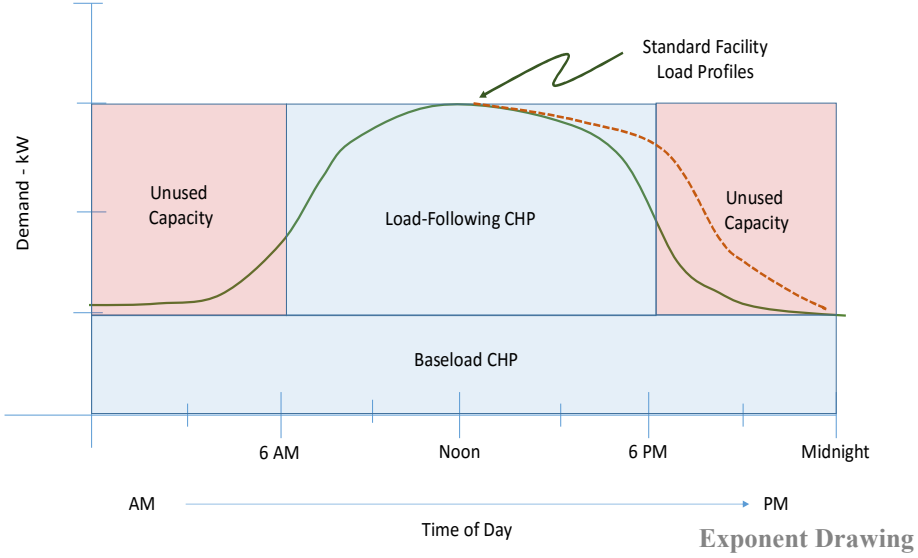


- DER Applications today tend to be targeted at behind-the-meter, facility based benefits
  - Efforts are made to expand the capabilities of the technologies and applications to "maximize" the potential savings or offsets that a technology can provide to a facility
  - Expansion of benefits often includes unique tariff plays, unique capital purchase needs, expanding the "facility roles" of applications in order to increase the benefit streams

Limitations with Individual Technologies: Combined Heat and Power Applicactions

- Combined head and Power – application simultaneously produces heat and electricity

- For electricity "following" systems, CHP is typically optimized when designed to the facilities "baseload" consumption level – thus considered a **"baseload" application**



Exponent Drawing

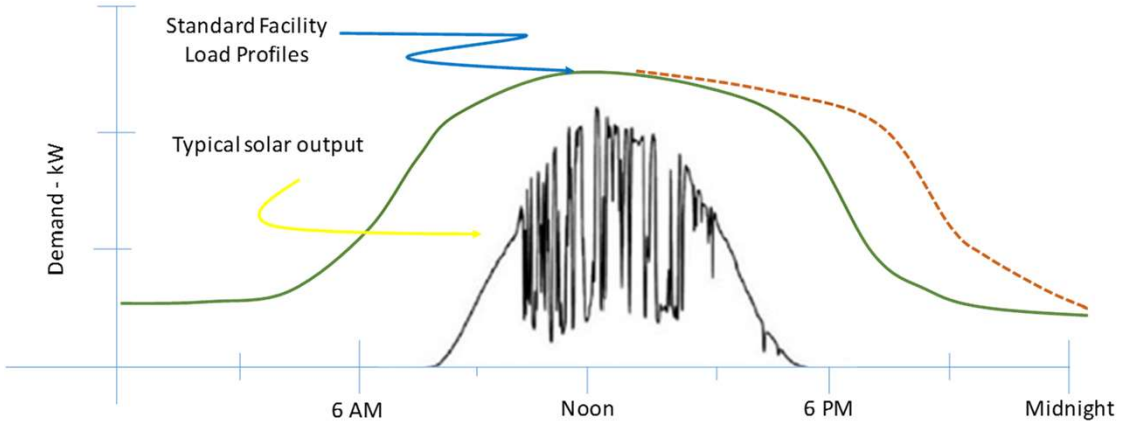
- However, a "baseloaded" application provides little flexibility for the application to participate in additional revenue streams outside is operating profile

- Systems tend to be baseloaded due to economics. If sized to facility peak, often, the unused capacity and capital for that capacity sinks economics. (shown in red in diagram

  Spoiler alert: Better off using another technology for peak shaving

Limitations with Individual Technologies: Solar – PV Technologies

- As solar systems are dependent on the sun shinning, it is defined as a **variable technology** because output can be unpredictable

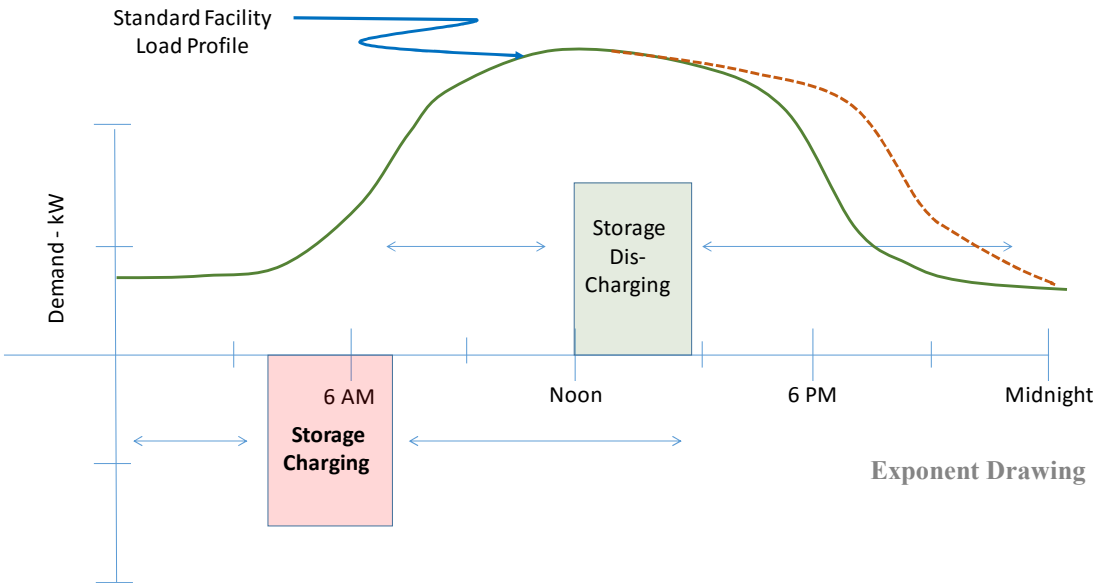


Exponent Drawing

- Payback is driven by the energy cost savings from the solar system production
- Drawback is that system output is not "firm-guaranteed" or highly predictable. Chart shows even during the day, system can fluctuate due to cloud cover or passing weather events
- Variable nature of the technology application prevents the device from participating in demand response programs…Additional technology (Transfer switch) required for the device to play in a back-up power role

Limitations with Individual Technologies: Storage Technologies

- Considered a **"flexible"** device as storage systems are devices that can charge during off-peak and discharge at a more appropriate time



- For facility retail applications, payback is driven mainly by energy shifting, demand reduction, and an alternative to short duration back-up power
- Drawback is that system output tends to be a shorter duration and needs to be recharged after discharge (longer duration storage systems are commercializing)
- Additional drawback in the early stage technology tends to be cost prohibited and has difficulty making the business case work

Agenda for Today's Discussion

- Discussion of Technologies
- **Benefits of Hybrid Applications**
- Examples of Hybrid Applications
- Challenges to Hybrid Deployment

Exponent®
Engineering Management Consulting
Energy and Utilities

Benefits Stacking for Improved Economics: Basis for "Hybrid" Applications

- In order to improve economics, projects look to expand value stacks and revenue streams by maximizing **individual** capabilities
  - First occurs behind the meter, focusing on additional opportunities within the facility
    - Can solar reduce demand as well as energy?
    - Can storage, serving as a peak shaving unit, also replace short term back-up capabilities?
    - Can CHP also serve as a back-up, avoid a boiler replacement?
  - Process tends not to be scalable and leads to customized solutions for facilities

- Are there additional benefit streams to capture?

- Even greater benefits streams available by potentially tapping outside retail benefits into system and societal benefits if they can be monetized
  - Injecting energy into the system
  - Installed Capacity Value – differences based on firming or intermittent
  - Demand reduction and locational system relief
  - Environmental value
    - Carbon, reduced SOX and NOX

Exponent®
Engineering Management Consulting
Energy and Utilities

Challenges to Tapping into System Benefits: Individual Technologies "Find" Their Limits

- As the technologies look to tap into larger system benefits, performance gaps can limit the ability for technologies to fully capture such benefits
  - Solar variability is problematic for demand reduction or capacity benefits
  - CHP is base-loaded, not a flexible load reduction tool and initially has to be optimized for the facility economics, limiting export potential
  - Storage may not have the duration to accommodate system benefit requirements

- Hybrid approaches can offer the opportunity for one technology to complement another, filling the performance gaps of single technology deployments
  - Combining characteristics of individual technologies leads to more robust applications and ability to tap into additional benefit streams
    - Storage – adding flexibility to solution
    - Solar – variable nature of technology can now be "firmed"
  - Hybrid combinations pull applications away from simply being an end-user solution to an asset that can support grid needs as well

Exponent®
Engineering Management Consulting
Energy and Utilities

Hybrid Applications or Combination of Technologies

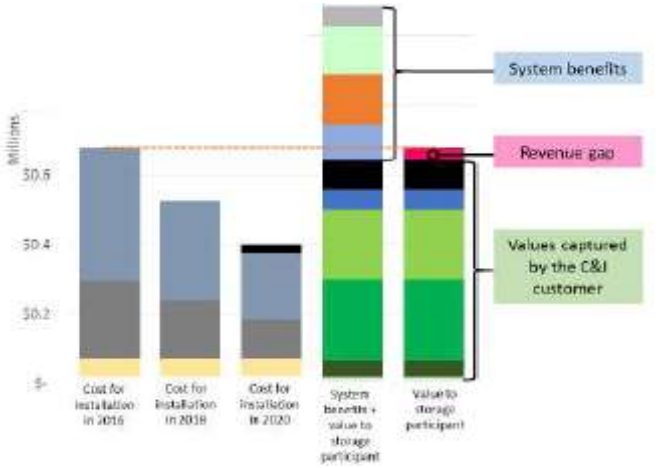
- Hybrid applications are simply technologies combining to extend the potential benefits streams that can be accessed by the systems
  - Solar + Storage
  - CHP + Solar
  - CHP + Storage
  - Solar + Storage + CHP
  - Solar/Storage + Energy Efficiency

- How is this different from past approaches, microgrids?
  - In Hybrid case, the system is combined to access the larger set of grid benefits that are potentially available to the applications
  - Can be thought of as a “simple microgrid” but where the combination of technologies acts as a shared resource rather than an “islanding” system
  - Effort is targeted to work in concert with REV, tariff / policy changes as well as to allow a pathway for technologies to access wider range of benefits
  - ***Even though concepts are exciting, the economics will still need to make sense and customers still need to want them installed at their facilities***

Exponent®
Engineering Management Consulting
Energy and Utilities

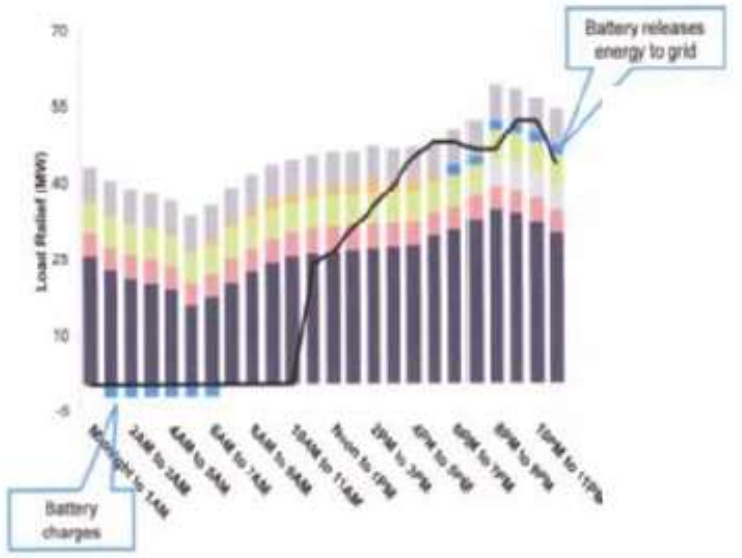
Hybrid Applications of Technologies: Value Stacks in Pursuit of System Benefits

- Value Stacks – Customer + System
  - Chart provides insight into why pursuit of system benefits is important to device deployment
  - Simple case showing how the DER asset captures retail benefits (energy savings, demand reduction), but just breaks even.
  - Adding system level benefits (wholesale, distribution services) provides opportunity for clear viability.



Courtesy MA "State of Charge Report – 2016"

- Aligning with Utility - Grid Needs
  - ConEd "DER" non-Wires alternative shows hybrid applications can naturally align into utility grid needs
  - Utilities look at DER as a portfolio of tools and assets



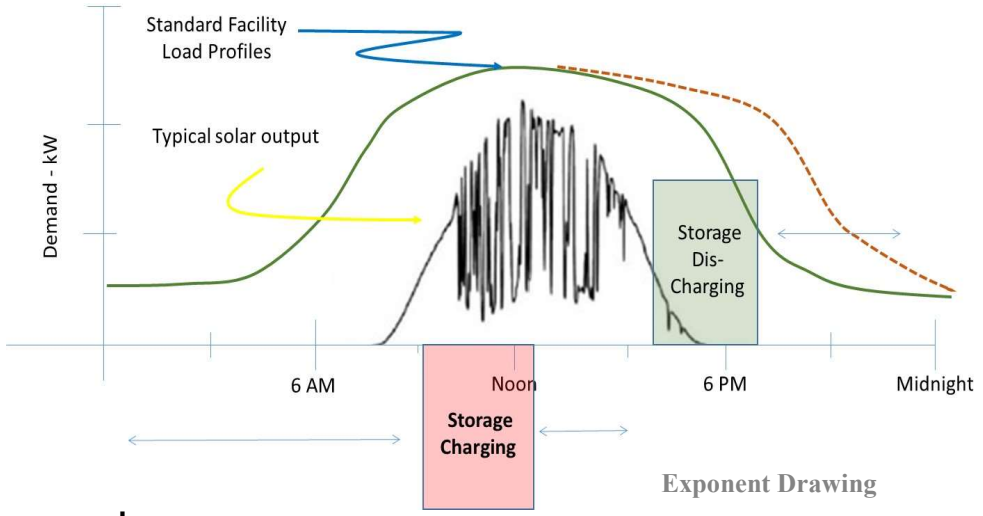
Courtesy ConED BQDM Summary– 2016"

Agenda for Today's Discussion

- Discussion of Technologies
- Benefits of Hybrid Applications
- **Examples of Hybrid Applications**
- Challenges to Hybrid Deployment

Examples of Hybrid Applications: Solar + Storage

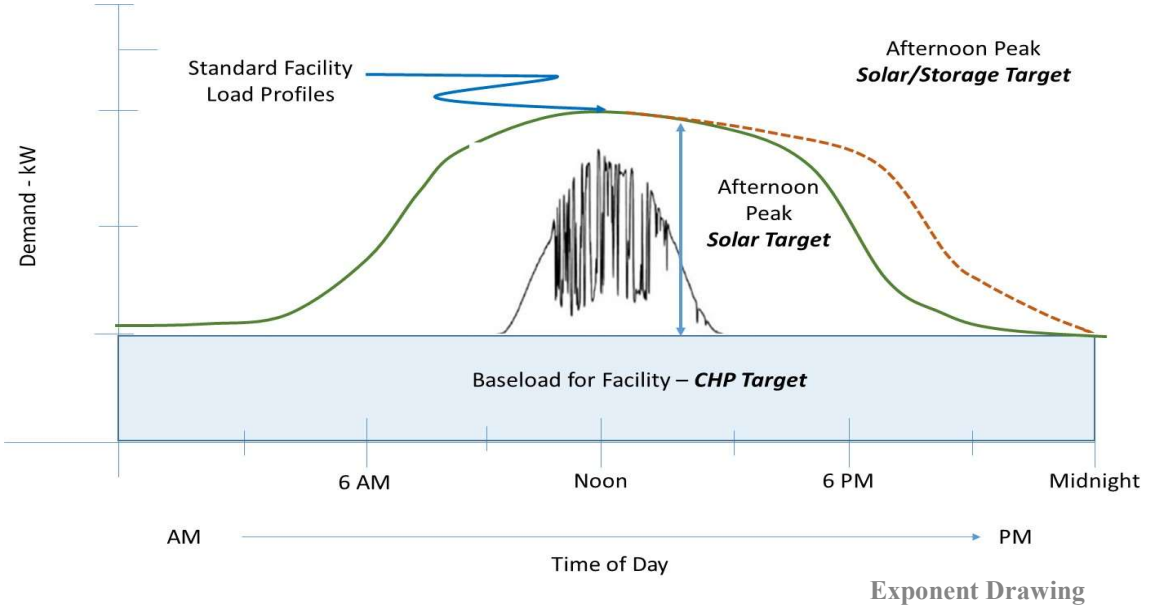
- Solar + Storage Aligning to Utility Needs
  - Battery becomes the battery instead of grid
  - Via storage, solar becomes a firm asset as storage can remove the "variability" from Solar



- Solar + Storage aligns with Customer needs
  - Resiliency
    - When installed correctly, ONLY combination of resources that can support critical loads continuously absent a gas or electricity infrastructure
  - Self –Optimizing Customer
    - Can choose whether to discharge against tariff or participate in grid support services
- Challenges
  - Cost of storage – getting the duration to map to application

Examples of Hybrid Applications: Solar + CHP

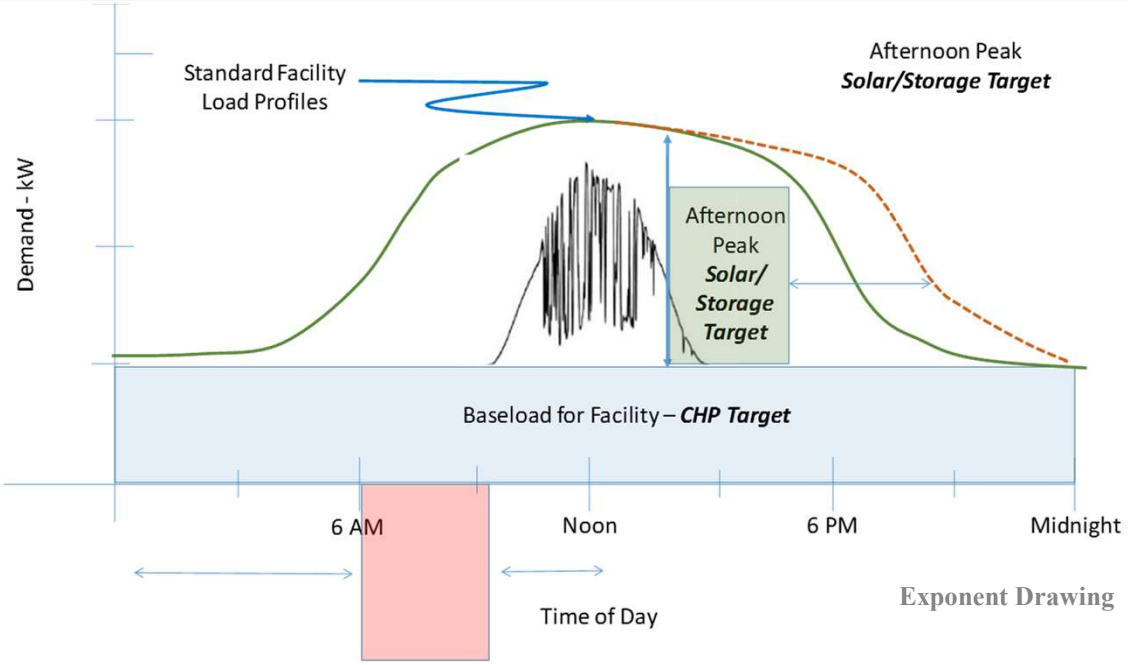
- Solar + CHP
  - Solar covers the peak for the facility allowing the CHP system to be optimized on the baseload of the facility
  - Provides the ability of renewable energy to be injected into grid



- Solar + CHP / Storage + CHP
  - Self –Optimizing Customer
    - Solar is used as a flexible asset for the facility but not firm asset
    - Similar approach can be taken with storage – or even a natural gas DG system – depending on various factors
- Challenges
  - Solar not a firm asset – will be able to contribute to some grid services but not all of them

Challenges to Hybrid Applications: Solar + Storage + CHP

- CHP + Solar + Storage
  - Creating a firm, disapatchable asset to address utility needs as well as customer needs
  - Application begins to really look like a microgrid at this stage



- Starting with CHP as the baseload technology, application allows for CHP to be optimized to facility – incrementally add assets (solar & storage) to address facility peak as well as adding flexibility to participate in grid services

- With cost of solar and storage, application will challenge the need to optimize size of devices and efficient use of tariffs to ensure that you don't have a zero sum game of adding capital for marginal returns

Hybrid Applications: Current & Future Examples

- Hybrid applications are not projections, the combinations have been common throughout the U.S.
- Only recently have applications looked to target additional grid services rather than simply enhancing the potential at a facility
- Examples we are seeing today
  - Solar + Storage applications where storage is targeting load reduction programs
  - Hitachi is showing how a combination of assets, when optimized, can result in lower overall cost of energy compared to stand-alone systems
    - However, it also notes issues that can arise when giving energy back to the grid

Agenda for Today's Discussion

- Discussion of Technologies
- Benefits of Hybrid Applications
- Examples of Hybrid Applications
- **Overcoming Challenges to Hybrid Deployment**

Exponent®
Engineering Management Consulting
Energy and Utilities

Regulatory Initiatives to Support Hybrid Applications

- When hybrid applications are focused on enhancing facility revenues by optimizing energy, the economics, not regulations, provide hurdles
- When tapping into grid services, the needs for regulatory and tariff initiatives become paramount to successful deployment of applications
  - Tariffs to allow DER to be compensated for the service
  - Regulations to allow end devices to provide services
  - Rules to allow end devices to participate in both Wholesale and Utility services
- Through the REV process, these issues are being addressed
  - NYISO is creating algorithms to optimize the assets it utilizes for daily operation, including DER systems
  - REV is focusing on tariffs to allow compensation for end users when they inject energy into the system
- Issues remain, depending on whether end users are simply providing capacity or generating a large percentage of kWhs

Customer Challenges and Economics of Applications

- Target Customers
  - Even with beneficial tariffs and the ability to tap into grid services, a customer will still need to want the system deployed on their premises
  - Though economics tends to be the main driver, ease of use, simplicity also play a significant role in customer adoption

- Industrial and Large Commercial (> 2 MW or greater facility size)
  - As combined asset complexity increases, the skill sets required to operate and maintain becomes greater. CHP adds a increased layer of complexity to that equation
  - CHP is not new to these facilities. Hence, adding solar and storage to existing facilities or introducing Hybrid - CHP will have less customer "adoption" hurdles

- Small Commercial (< 2 MW)
  - This segment is typically the largest "untapped" potential.
  - Simplicity is key in these applications because facilities often don't have the engineering staff to maintain complex systems and are less tolerant to pull away from primary focus
  - Differences between Industrial to Small Commercial
    - Load profiles becomes "peakier" and less hours of operation (7 days a week now 5)
    - Skills decrease as small facilities more focused on daily operations

Conclusions on Potential of Hybrid Applications

- Hybrid applications are already utilized today to enhance system paybacks for facilities…degree of difficulty rises when system try to tap into system-level benefits

- Hybrid applications can offer an elegant means to tap into additional revenue streams and offer characteristics that can support grid operations
  - → Though components such as solar and storage are on rapid price declines, cost and complexity needs to be taken into account when advancing solutions

- Tariffs and Regulatory Actions need to occur in parallel to not only make the potential benefits monetizable, but provide the proper signals to allow customers to optimize around tariffs

- Applications are here today! Assessing their potential involves understanding the economics but also realizing the assets are still evolving in both capabilities and cost reductions

Contact Us

For additional information, please contact….

Richard Fioravanti
Principal
Engineering Management Consulting Practice
Energy and Utilities
Exponent, Inc.

M: 703-216-7194
rfioravanti@exponent.com

www.exponent.com