# Distributed Green Data Center + Energy Storage
## *Leveraging Investments for Energy Time Shifting Services and Grid Support*

Clarkson University

defy convention

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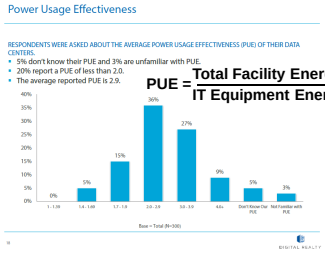
## Distributed Green Data Center (DGDC)

### Traditional Data Centers

- Large MW+ centralized facilities.
- Data centers in the US consume approximately 2% of all electricity (78 Billion kWh 2010).
- Servers are active less than 12% of the time, but consume approx. 40% of active power when in idle state; = *75% (or 58B kWh) wasted power!* Entire electricity usage for Greece was 56B kWh in 2010.

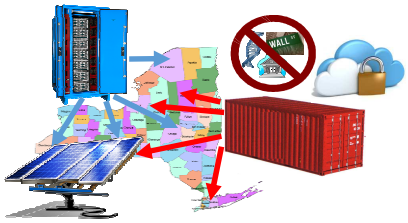
- Power Usage Effectiveness (PUE) is used to measure efficiency.
- Cooling is generally greatest use.
- 2013 Survey shows average PUE of 2.9, *nearly 3x* amount used for computing.




$$PUE = \frac{\text{Total Facility Energy}}{\text{IT Equipment Energy}}$$

### Distributed Data Centers

- Mini (<5kw), Rack (10-20kw) or Container (500kw+) sized, scalable, unmanned, self-contained units in distributed network.
- Co-located with Solar, Wind or other Renewable Power source.

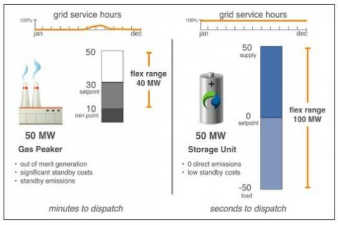


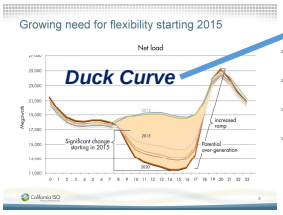

- Not for intensive data processing or highly sensitive data (research, financial). Focus on growing cloud sector (e.g. streaming media, photos, documents, etc.)
- Populated with primarily low power Network Attached Storage (NAS).
- Data duplicated on several DGDC units providing redundancy & backup.
- Master Controllers route client requests to combination of lowest latency & most efficient energy use.
- Generally installed outdoors to maximize free-cooling potential (PUE of < 1.2).
- Can be on-grid or off-grid co-located with renewable (Solar, Wind, Hydro).
- Master Controller can minimize power & shutdown units based to optimize efficiency.

## Leveraging Energy Storage Investments

- Grid Energy Storage is a small but growing market that provides an alternative to transmission and distribution upgrades, enables the adoption of distributed generation and provides support for a smarter-grid.
- Battery Energy Storage can react to Grid needs faster and cheaper than peaking power plants and with a much lower environmental impact.
- Adding a DGDC unit to the Energy Storage investment extends its capacity with a predictable and dispatchable load.
- The DGDC unit provides a platform for the hardware. software, and sensor control devices used for the energy storage smart-grid interaction and can host future innovations.
- Energy Storage with a DGDC unit can be deployed on either side of the meter at any size.

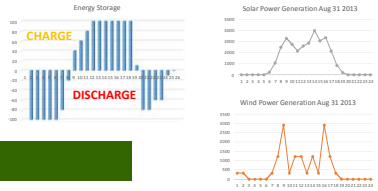
***"...the energy storage business could grow from $200 million in 2012 to a $19 billion industry" by 2017.*** -Information Handling Services, Cambridge Energy Research Associates (IHS CERA) report,



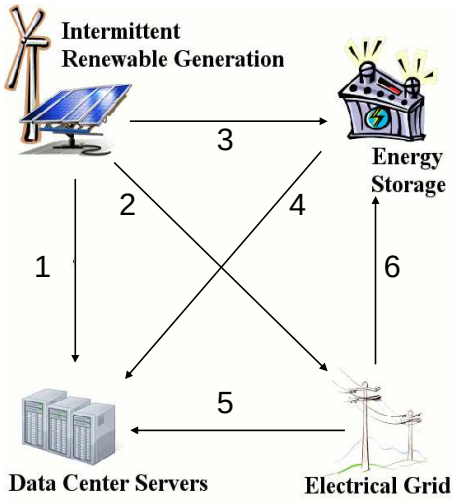

- Example of how on a single day with hypothetical Renewable Energy increases, how DGDC and Energy Storage can work together to change load profile.
- Brings closer to original load profile, but can also shift in other desired ways for demand response or other desired outcome.

- Expanding solar PV in California is changing the utility net load profiles; energy storage and dispatchable loads can help shift power use.
- Master Controllers and deployed DGDC units can host technology that coordinates with ISO and Grid distribution information systems to provide instantaneous & optimized grid support services.




## Options for Energy Inputs

| | Energy Flow | Revenue Flow |
|---|---|---|
| 1 | **Generated energy used for DGDC unit or facility load** | The least expensive source of electricity but there is an opportunity cost if the electricity can be sold |
| 2 | **Generated energy sold** | Revenue is generated according to the electricity purchasing agreement with the tenants or electric utility |
| 3 | **Generated energy used to charge the battery** | Electricity is stored in the battery when generating more than required to operate the data center |
| 4 | **Stored energy used for DGDC or facility load** | The electricity is used from the energy storage when the energy stored is cheaper than electricity from all other sources |
| 5 | **Grid energy used for DGDC** | Generally least optimal solution and DGDC unit can be powered down, but may at times be necessary |
| 6 | **Grid energy stored in the battery** | When cost effective electricity is purchased from the grid to charge the energy storage |



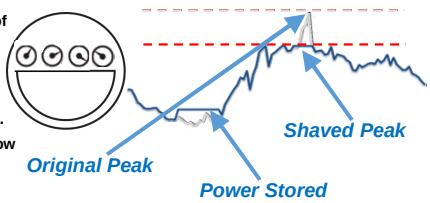

- Use to shave peak demand.
- Short-term emergency back-up power that can be extended with larger power and storage system setup.
- High speed internet access and opportunity to use cloud services with lowest latency possible.

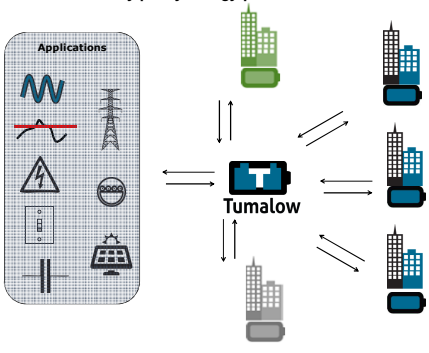
- Provides frequency stabilization
- Distributed Demand Response resource.
- Can be installed by utility directly in locations where dispatchable load and demand response needed most.
- Can be offered as guaranteed and instant, rather than voluntary unpredictable service.

- Enables residential or small business users to qualify for larger renewable energy incentives and provides time of use or peak demand power curtailment.
- Can be optimized with car charging and provide emergency back-up services.
- Can be used as base load and hub for community micro-grid applications.

## Applications for Building Energy Efficiency

- Commercial, Industrial and larger users of electricity often have both a kWh and a demand charge based on peak kW use.
- Demand charges vary by location and in some cases the time of use; and can represent up to 50% of the total utility bill.
- Storing energy when the energy load is low and then using it to reduce the peak is called peak shaving and can result in significant savings especially in facilities that have very peaky energy profiles.



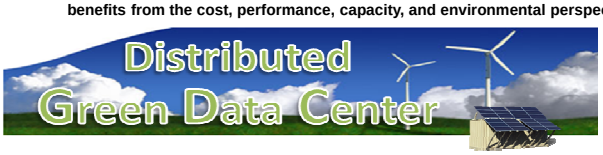

- Service providers like Tumalow Energy can provide peak shaving for several clients using energy storage.
- Building energy use information is reported back to a managing software solution that can also provide services to the grid using the stored energy at the several locations in the managed network.
- The Tumalow solution can therefore provide savings for building locations as well as offer a portfolio of grid services to the local distribution utility and the regional ISO for Demand Response and Frequency Regulation services.
- The DGDC unit could provide both a platform for Tumalow's technology as well an additional dispatchable load.

## Support for Grid, Policy, & Environment

- From ISO transmission and Utility distribution perspectives a large distributed network of small to mid-sized energy storage units is more useful for grid stability than larger units.
- Each combo DGDC+Energy Storage unit installed represents a location that is scalable, internet connected, fully managed distributed generation with emergency backup potential.
- This concept is in concordance with the goals stated in the Reforming Energy Vision REV initiative currently under consideration in New York State and can extend value of incentives.
- Combination of DGDC units with Grid or Customer sighted Energy Storage can lower the overall cost to speed up deployment of grid energy storage and desired energy policy goals.

## Conclusions

- Convergence of investments for smart-grid, datacenters, and renewables in a distributed network can share investment costs and operate together in a way that is more optimal than each operating individually.
- The overall investment is still much higher and the core focus of each is different enough that a combined investment will not occur often because it's not operationally optimal.
- Solutions can come from collaborations, partnerships and leasing agreements where each member calculates the value of the co-location and appropriately discounted leasing arrangements or cooperative agreements can be developed to reflect the entirety of benefits from the cost, performance, capacity, and environmental perspectives.

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