Pragmatic Transactive Energy A Green Field Campus Design

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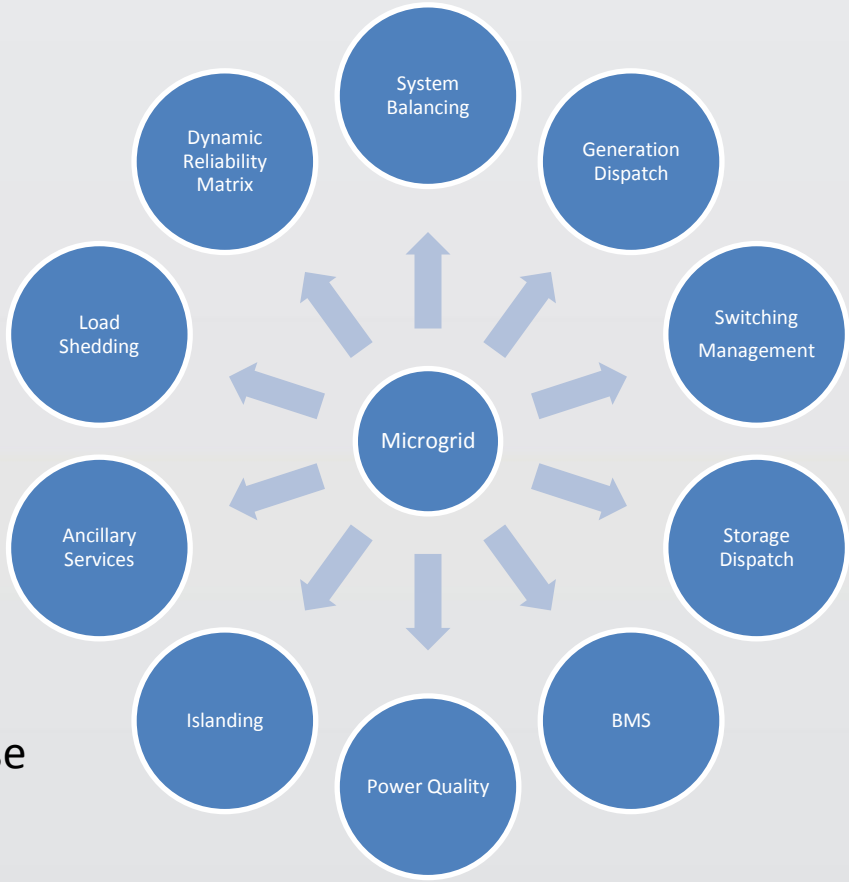
Corporate Campus Microgrid: Business Values

- Summary Objective:
  "Achieve business continuity with a **system that pays for itself** and supports environmental stewardship"

- Order of energy use / load order is:
  1. Energy efficiency/energy conservation
  2. Onsite Renewable energy
  3. Direct access energy

- Campus will be Net Zero Energy (NZE) facility
  - California AB900 Net Zero Facility
  - Efficiency and conservation top priority
  - Minimum 30% reduction in energy use
  - Minimum 30%-35% reduction in water use
  - Reduce employee automobile trips

    Electric charging stations for 300 vehicles



Corporate Campus Microgrid: Business Values

- Extremely high energy supply reliability required
  - High hourly employee productivity/revenue generation
  - Self generation needed in event of utility outage

- High power quality required – including during islanded operation
  - Computer equipment sensitive to momentary conditions
  - Critical labs & loads have specific concerns

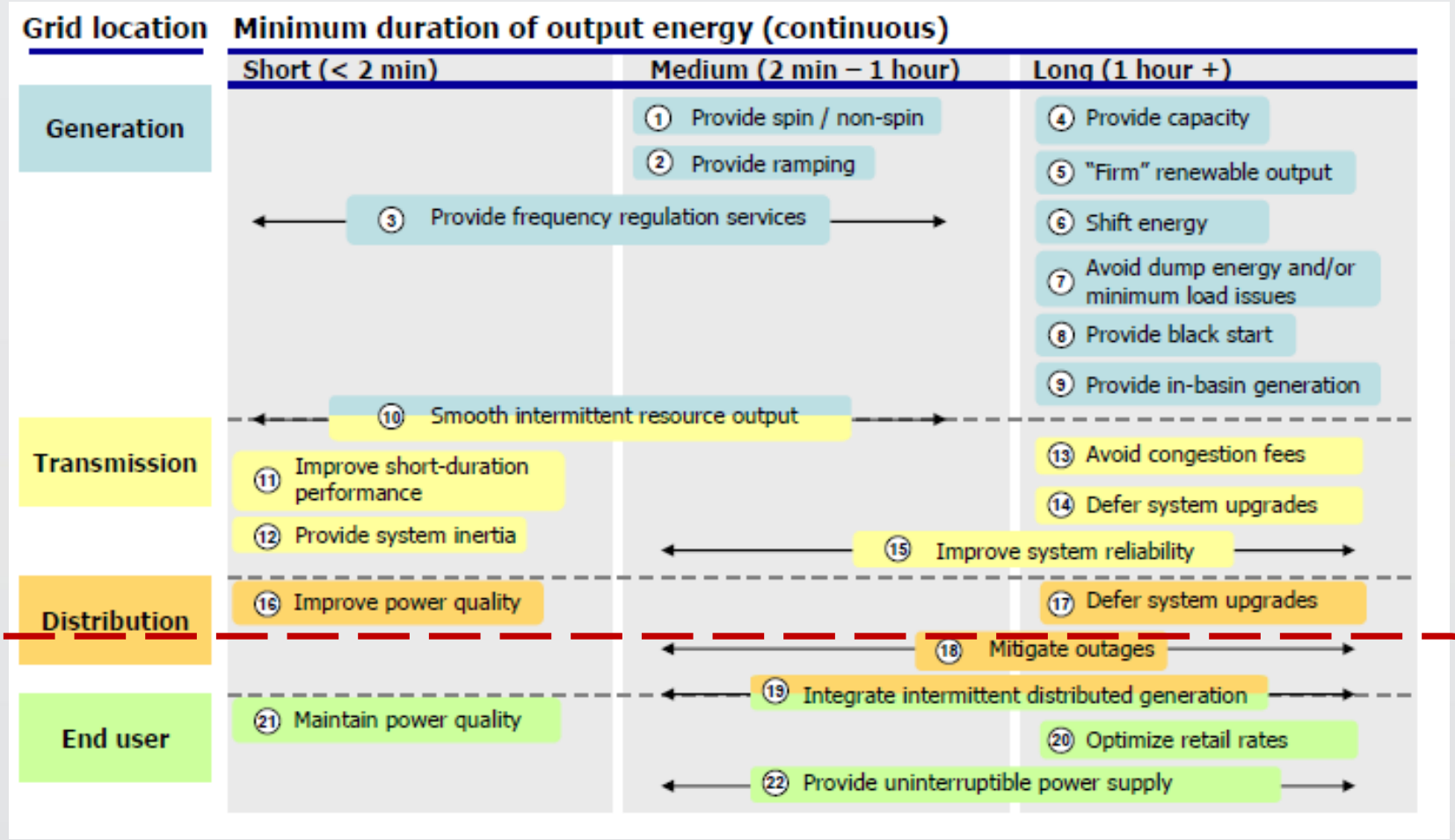
- 100% renewable energy from on-site generation preferred
  - On-site solar and on-site biogas fed fuel cells
  - Remaining power supplied by off-site renewable energy

- Microgrid load balancing achieved using storage, transactive energy based load control

- **Design for all revenue opportunities** (e.g. peak shaving, ancillary services, demand charge management, renewable energy supply back to utility on weekends, ramping services)

Differentiated Service Options

22 Services that DER can provide with proper structuring and pricing



Source: SCE

Core Components – Transacting Parties

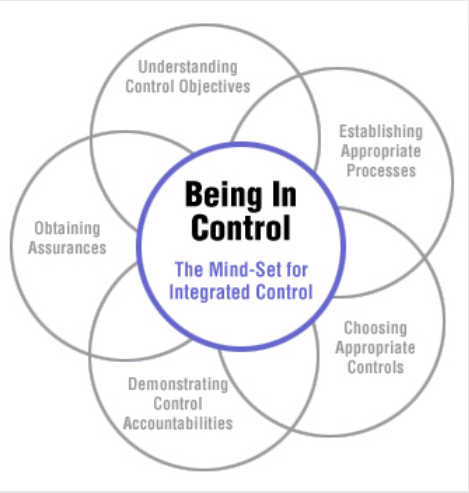
- PV Panels and associated inverters and controls
- Fuel Cells, associated controls, fuel source, metering
- Large Energy Storage System, associated inverter and controls
- Small UPS systems and associated controls and metering
- Fast-start diesel generators
- Building and utility switchgear
- Utility interface metering
- Building Automation System(s)
  - Lighting Control System
  - Presence Detection System
  - HVAC Control

Transactive Energy Information Streams

- Cost of fuel cell fuel
- Cost of diesel fuel
- Cost of utility retail energy
- Cost of direct access energy
- Cost of internally sourced energy equipment operation (battery, DVR)
- Offer prices for various ancillary services (e.g. volt/var/freq)
- Per hour / cycle equipment operating cost functions
- Cost of quality (power and product) transfer functions
- Cost of employee productivity transfer functions

Microgrid Controller Functions

- Actually a Transactive Energy Controller
- Interacts with multiple devices and control nodes capable of knowing their own operational constraints and cost/value functions
- "Negotiates" with multiple devices and control nodes on instantaneous, medium and long term costs and value associated with meeting instantaneous, medium, and long term energy, quality, and business requirements for real time processes while at the same time being ready to react to and mitigate one or more contingencies



- Operational priorities depend on whether operating in connected mode or islanded mode

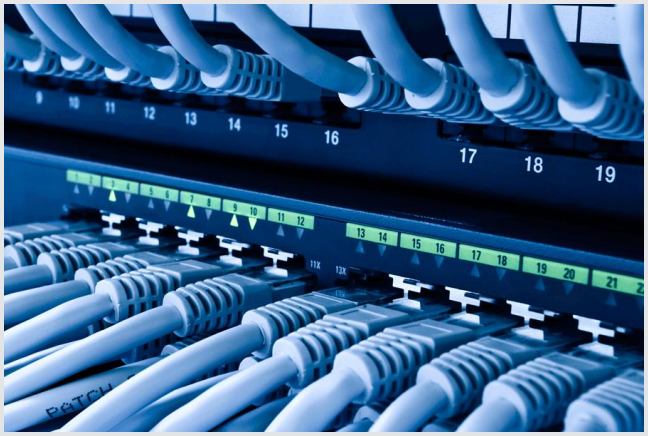
Internal Device Negotiation Scenario

- Bright but puffy cloud day
- Local PV generation providing bulk of instantaneous energy demand
- Cloud transients causing or predicted to cause increasingly deep voltage sags
- Controller asks connected devices in pilot manufacturing area cost of sags to current processes running and those expected to run for the day
- Response is $12k in QC rejected widgets per sag. Also responds with alternate offer that there is no impact if sags kept to no lower than 80% of nominal
- Controller queries Battery / Dynamic Voltage Restorer (B-DVR) on operational cost to support voltage during sags to ensure never <80% for predicted number (20) of cloud transients expected today
- B-DVR responds $1,000 per sag
- Controller evaluates cost of do nothing or operating B-DVR and commands it to operate at 80% level rest of day

- Controller also considered cost of reducing PV utilization and buying more renewable via direct access, or dispatching storage, or using fuel cells, ….
- B-DVR operates autonomously using local sensor data
- Logger captures actual operations and costs for controller to use in future decision making

Infrastructure Concerns

- Many managed devices
- Many physical networks – proprietary, boutique, and TCP/IP
- Many logical networks – operations/control, measurement, building automation, corporate
- Many protocols – DNP3, MODBUS, BACNet, OpenADR, etc.
- Many gateways
- Many interoperability points
- Many points of security vulnerability
- Multiple, simultaneous incompatible optimization functions across a broad stakeholder group



- Further simulation needed to verify control stability

Observations and Conclusions

- Negotiation and transactions occurred using monetary values but with no external market
- If current production schedule was such that it was not sensitive to sags, cost savings can be achieved by not running the B-DVR at all

- Transactive energy based control and optimization **does not** have to involve extensive regulatory change or a market
- Transactive energy based control and optimization **does** require good information and process cost/value knowledge
- Local transactive energy applications such as this can be a stepping stone and living laboratory to discover how to operate on a larger scale

Questions

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Video Presentations and Podcasts

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- **E.W. Gunther,** "Modernizing the North American Grid" - http://gridinsights.energycentral.com/detail.cfm/blog/New-Podcast-Modernizing-the-North-American-Grid?id=100, EnergyCentral Grid Insights podcast, February 6, 2013
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- **E.W. Gunther,** "GridWeek 2010 Leadership Award", November 18, 2010 at GridWeek in Washington DC, http://www.youtube.com/watch?v=RNTzlLmhmiU
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- **E.W. Gunther,** "Gunther on Smart Grid", Energy Priorities Podcast, April 23, 2007 at GridWeek - http://energypriorities.com/entries/2007/04/gw07_day1.php

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- **E.W. Gunther,** “Smart Grid Security Loopholes Hit the Enterprise”, CIO Insight, December, 2013 - http://www.cioinsight.com/security/smart-grid-security-loopholes-hit-the-enterprise./
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- **E.W. Gunther**, “The Convergence of High-Tech and So-Called Low-Tech”, IEEE Smart Grid Newsletter, Inaugural Issue, January 2011 - http://smartgrid.ieee.org/january-2011/81-the-convergence-of-high-tech-and-so-called-low-tech