Pragmatic Transactive Energy
A Green Field Campus Design

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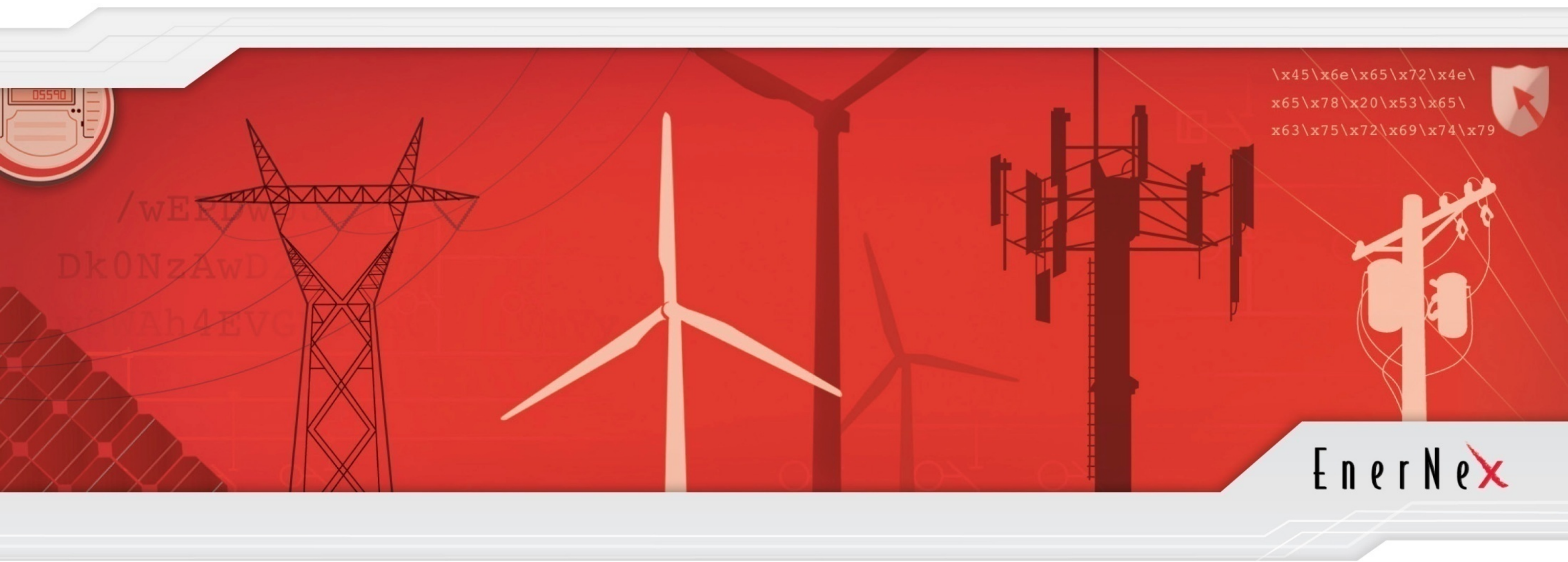

Corporate Campus Microgrid: Business Values

- 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

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Corporate Campus Microgrid: Business Values

- 100% renewable energy from on-site generation preferred
  - On-site solar and on-site fuel cells fueled with biogas
  - Remaining power supplied by off-site renewable energy
  - Microgrids/storage/responsive loads/off-site Renewables used to balance load
- Direct Access is preferred method of purchasing renewable
- **Design for all revenue opportunities** (e.g. peak shaving, ancillary services, storage based arbitrage, demand charge management, renewable energy to grid on weekends – participate in all potential markets wholesale, retail, **insale**)
- Extremely high energy supply reliability required – campus resiliency
  - High hourly employee productivity/revenue generation
  - Self generation needed in event of utility outage (3 weeks plus capable)
  - Increased operational flexibility – resiliency to regulatory uncertainty
- High power quality required – including during islanded operation
  - Computer and prototype manufacturing equipment sensitive to momentary conditions (sags, swells, transients, momentary interruptions)
  - Critical labs & loads have specific concerns

Core Components

- 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
- 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
- Barters with multiple these devices/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 Bartering Scenario

- Bright but puffy cloud day
- Local PV generation providing bulk of instantaneous energy demand
- Cloud transients causing increasingly deep voltage sags
- Controller asks connected devices in 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 Dynamic Voltage Restorer (DVR) on operational cost to support voltage during sags to ensure never <80% for predicted number (20) of cloud transients expected today
- DVR responds $1,000 per sag
- Controller evaluates cost of do noting or operating DVR and commands DVR 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, ….
- Logger captures actual operations and costs for controller to use in future decision making

Observations and Conclusions

- Bartering and transactions occurred using monetary values but with no market and energy cost was not a factor
- If current production schedule was such that it was not sensitive to sags, cost savings achieved by not running the DVR at all
- Transactive energy based control and optimization doesn't have to involve energy or a market
- Transactive energy based control and optimization does require good information and process cost/value knowledge

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