Residential PV Generation: Impacts (Positive and Negative!) on Transmission & Distribution Networks and Operations

One element of the in-progress greatest change to the Grid in its 100 years of existence

Randy Boys
Manager, Strategy & Technology
Oncor
Randy.boys@oncor.com
Agenda

• Oncor in the Context of Electrical Utilities and ERCOT
  o Texas’ electrical utilities structure
  o Energy market

• Oncor’s SOSF Microgrid
  o What it is
  o Why we have it

• On-Line Interaction with Microgrid On-Grid and Off-Grid Controllers

• Industry Trends
  o DER / Renewables, DERMS, Microgrids
  o Storage, EVs
  o Transactional Grid 2.0

• Sample Projects:
  o West-facing PV wrt Oncor Energy Efficiency Program
  o CES South Dallas Pilot
ONCOR’s ROLE

- **REGULATED DELIVERY & METERING**
  - Privately held PUC-Texas regulated ERCOT TDSP (Transmission and Distribution Service Provider)
  - ERCOT is wholly contained in Texas, addressing 90% of state consumption
    - One of three US CONUS grids; Owned by IOU TDSPs, Munis. And CoOps
    - IOU TDSPs do not ... cannot ... interact in wholesale, retail, or ancillary markets
  - TDSP customers are wholesalers and REPs, also maintaining T&D assets to the Primary Point of Delivery (i.e., the ‘Utility side of the meter’)

Largest ERCOT IOU, in the lowest cost and highest quality quartiles
ELECTRICITY IS A COMMODITY MARKET

90% of Texas is managed as the ERCOT Grid (Energy Reliability Council of Texas), one of only three Grids in the Continental US

Consumer Participation is Defined by their Retailer Contract
Oncor’s Strategy & Technology Development Team

• Small group reporting to CTO/VP (Michael Quinn)
  o Intersection with: Metrics and Analytics; IT; Distribution Automation; Interconnect Planning; Energy Efficiency; Corporate Communications; capital planning

• Identified the need, with regard to DER and microgrids, for a Use Case analysis capability
  o The changing nature of our consumers is changing the nature of Distribution operations (and equipment, services, and the real-time IT infrastructure)
  o New product analysis/predeployment integration facility, as well as a way of separating the wheat from the chaff
  o Vectored the planned 2015 development of a new Environmental building, adding a microgrid overlay to that site
  o Located at the Service Operations Support Facility (SOSF), Oncor’s largest industrial/mixed use site
    • 100 acres in Lancaster, TX
    • Previously separate meters for the meter shop (AMI deployment, meter repair, fraud analysis), waste management, environmental labs (transformer oil analysis, remediation), transformer refurb center, tank farm, lineman/troubleman training (‘local’ substation and feeders), Telecommunications Operations Center, PPE staging yard, …
  o Included the public-facing Technology Demonstration & Education Center (TDEC)
SOSF MICROGRID
A microgrid is a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. If desired, a microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island-mode.

Microgrid Key Attributes (Defining Characteristics):

- Actively managed grouping of interconnected loads and distributed energy resources
- Has known execution plans (and costs) for off-grid operations
- Acts as a single, potentially controllable, entity on the grid
- When on the grid, typically manages behind the meter DER assets and site loads to lower energy costs
TECHNOLOGY DEVELOPMENT & EDUCATION CENTER

• Immersion Room
• Control Room
• Use Case Assets
Oncor’s SOSF Microgrid: Site Resiliency and Energy Efficiency, in a Testbed for DER Analysis on Both Sides of the Meter

- **Energy Sources**: South-facing 104kW carport (6xSMA inverters) and west-facing 2kW PV array (ABB) all as Kyocera cells; 4x diesel (210-45kW); 3x ESS (25-400kW, 815kWH, Tesla and S&C); microturbine (65kW, Capstone); temp Use Case assets
- **BMS** (Siemens) in LEED certified (Gold) TDEC building (only)
- **Our largest industrial/mixed use site** (1.3MW peak load)
- **Assets to emulate ‘Both sides of meter’**: 10 generators, 18 {mostly} smart switches, 18 meters, 4 >device controllers, 4 loggers, sitewide fiber ring & wifi network with ~40 uG-specific switches/converters, 14 UPS ‘stay alive’ islanding assets, 2 EV stations; 2 ATSs, …
- **On-Grid**: PV utilization typically consumed by ongoing ops: With microturbine/Grid/ESS economic dispatch via ‘EMA’ for demand response (tariff and also absolute source cost vs. market) and TOD shift (based on ERCOT day ahead pricing)
Demonstrations: SOSF Microgrid Direct Interaction

Microgrid Controller (GEMS), On-Grid Economic Dispatch (EMA)
Grid 2.0: Revolution or Evolution?

The Grid as we know it … as it has evolved with only efficiency changes in the first 100 years of its existence … is on the brink of a fundamental change

‘Waterfall’ carrier of electricity (Central gen > Trans > Dist)

… changing to a flow in all directions, of both information and energy

Due to:

- Energy efficiency; Local energy management
- DER & microgrids
- Solar, wind, and storage affordability
- Market deregulation / participation
- Intermittent production
- Carbon policy and/or desiresments
- Low energy costs, flat/declining markets

Basically: DER, renewables, storage, and changing market participation

… Calling for a More Transactional and Resilient Grid
A Perfect Storm …

Smart Grid 2.0
Utility Integration of DER: PV Impacts

• Whether PV power is placed on the Grid or consumed on site, there are impacts on Grid infrastructure and operations
  ➢ Differs between Utility-scale and residential or C/I generation
  ➢ Has the potential to more effectively optimize Grid loads, with ‘impacts’ becoming ‘resources’ … as can any controllable energy source or load

• Volt/Var Regulation
  ➢ Intermittent generation, particularly at generation (not consumption) peak
  ➢ Increased pressure on Distribution network maintaining ‘contract’ with Transmission
  ➢ Previously, water flowed downhill, and the hill was always a hill
  ➢ Volt/Var regulation more difficult, and, in aggregate, could impact transmission real time balance

• Interconnect & Metering
  ➢ Increasing DER interconnects, nature of interconnects
  ➢ Transparent metering, future market communications (transactive or conventional)

• Consumer desire for collectives/aggregation
TDSP Impacts from Feeder-Level PV (current/future)

• Volt/Var Regulation
  ➢ Intermittent generation, particularly at generation (not consumption) peak
  ➢ Increased pressure on Distribution network maintaining ‘contract’ with Transmission
    ➢ Previously, water flowed downhill, and the hill was always a hill
    ➢ Volt/Var regulation not only more difficult, but could impact ERCOT real time balance

• Interconnect & Metering
  ➢ Increasing DER interconnects, nature of interconnects
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• Consumer desire for collectives/aggregation

• Fault conditions
  ➢ With and without transactional element as resources on ‘islanded’ feeders

• Peak Load Curtailment
  ➢ The market is all about capital, driven by those few peak hours a year

• Rate Structure
  ➢ Balancing act, factoring overall infrastructure capital and operations costs between various consumer classes and volume-versus-peak driven cost collection mechanisms (per PUC-T tariff and rate approvals)
PV Impacts Peripheral to the TDSPs

• ERCOT PV Forecasting and Energy Market Pricing
  ➢ Per presence of non-dispatchable sources
    o Solar 90% P(o) 20% faceplate at 4PM peak; Wind even less
  ➢ Of both energy and ancillary services

• ERCOT Generation Build-Out
  ➢ Per solar and wind diurnal cycles
  ➢ Per potential Utility-scale storage
  ➢ Per NG price, carbon regulation, Texas economy, increasing DER, ...

• Content of Signalling, Across the Meter / Around the Meter (e.g., home WAN to LAN)
  ➢ Real-time control of loads, residential-scale storage, market participation

• Increasing Utility-Scale PV
  ➢ Most likely west Texas (favorable peak alignment to east)
  ➢ Congestion management
    o Longer term network changes are of direct concern, noting, however, that residential PV on feeders is projected to be >50% of production even as total PV production passes 20GW in <15 years
Oncor Residential PV Interconnections as of EOY 2016

Data is from 2009-fwd, the date of AMS data availability

- 9333 residential solar interconnects, with interconnect requests currently exceeding 500/month (almost all as modification to existing)
  - Overall new interconnects ~60K/year; Oncor’s $60M in EE incentives are the largest in Texas
- Averages: >15kW, south facing, 10-11 degree tilt
- Far fewer commercial installations (579)

As solar pairs with storage, the impact on T&D can change completely, as can the number of ways that owners use or release energy or otherwise parlay their assets

- Currently only 16 combined PV and storage interconnects (…of 3.4M)
As costs drop, will solar increase in Texas as did wind?

- Currently only 2% of production
- No Utility-scale production

Market participation by residential solar in Texas … as energy only … is constrained by market needs

- Low cost of alternative sources
- Mid-day overgeneration
- Dropoff at point of greatest value
- Many installations do not produce a surplus

… but,

- Certainty/Independence,
- Potential stacked value: Smart inverters, TOD participation, Coupled storage systems, EEA and market calls
What Change? Why the Change?

The Grid, a transactional collective of distributed parties/assets, is undergoing change to every convention short of the electrons

- **Large non-dispatchable generation**
  - Wind, solar, … Variable and not tied to consumption

- **Distributed energy resources (at arbitrary feeder locations)**
  - Individual, Campus, or Community/Municipality Resources
  - Renewables (Dominantly Solar)
  - Small, Efficient Petro/Natural Gas/Biofuel/Hydrogen Generators

- **Energy storage (stationary storage and electric vehicles) … and charging!**

- **Microgrids (campus energy co-management, resiliency)**

- **Increased and market-aware consumption management**
  - Home/Building/Campus Smart Energy, Smart Appliances

- **Consumer participation in markets**
  - Demand Response / Demand Curtailment
  - Aggregated Resource Sharing (local inverters/generation/storage, loads as resources), , ’

- **Outage Mitigation Technology, Including Possible Utility Dispatch of Stored Energy During Outages**

- **Social and regulatory carbon and other environmental pressures**

The only market model ever practiced since the Grid was formed … long term capital-driven consolidation in a growth market … is changing
With Regard to Storage, Oncor Would Like to See (ref: AEP Cases @ PUC)

* Based on PUC-approved plans, utilities would install energy storage throughout the grid, resulting in improved reliability. Customers' costs would be offset by an auction of this capacity to the competitive market, which could then provide power to customers when they need it the most.
VALUE STREAMS CREATED BY STORAGE & BEHIND-THE-METER MARKET PARTICIPATION

MARKET
Renewable generation smoothing and dispatch
Demand and time-of-use energy management
Electric supply reserve capacity
Peak shaving/load following
Fast response ancillary services

RELIABILITY
Support local grid during outages
Defer traditional transmission and distribution investment
Relieve transmission congestion
Integrate renewable sources to grid

CUSTOMER
Increased reliability
Increased grid efficiency and flexibility
Technologically advanced grid infrastructure
Lower customer bills
Possible Oncor Roles in Achieving Grid 2.0

• Support for High Speed Metering and Settlements
  ➢ Transparent metering, market communications

• Power Quality Management
  ➢ Response to DER and intermittent renewables

• Energy Resiliency and Security
  ➢ Storage (e.g., Community Energy Storage), Fault isolation/response, DSO functions

• Support for Renewables
  ➢ Energy to consumers (e.g., CREZ panhandle wind to city markets); Cookie-cutter interconnects (e.g., residential solar)

• Leverage Market Changes to Limit Infrastructure Investments
  ➢ e.g., Storage as deferral; Aggregation
Sample SOSF Microgrid Use Cases:

Capacity-Focused PV Incentives, Community Energy Storage
For Our West-Facing PV:

- ‘Crossover’ is at 2:45
- The value relative to south-facing per faceplate kW increases to over 2x during peak Grid demand, but only after 6:30
- Production is less than nameplate due to less irradiance, but the relative value to peak need is significant throughout the peak hours
• **Describe data set**
  
  • 2\textsuperscript{nd} year of operation
  
  • Data as sampled at 5 minute intervals
  
  • South-facing @ 10deg, west at 25 deg
  
  • ERCOT peak 3-7PM (only <4\% higher at typical 4-5 PM actual peak in this interval)
  
  • In the 8 future models, PV increases 2017-31 range from 14,500 MW to 28,100 MW (including ~60\% as residential)
  
  • Preponderance will be stationary, south facing
  
  • Somewhere in the 3-7PM period on the summer peak day, the last 6 GW (7\%) of system capacity will be required
  
  • That’s directly driving 7\% of the TDSP capacity … capital costs
  
  • This doesn’t even account for the impact of peak stress on the system components (i.e., disproportionate impact on component failures, volt/var regulation demands, etc.)
  
  • Relevance to TDSP build-out: % PV production at system peak
SOSF 2016 Comparative PV Production: Seasons and Orientation

- Seasons: Spring (3/20-5/20), Summer (6/20-8/20), and Winter (11/20-1/20)
- Orientation: South vs. West
  - $W_Z$ indicates normalization of small PV production to large PV norm, per season
Legend and Data Prep

• Although 61 days of data were selected as each ‘season’, days with PV failures (full or partial) were removed
  ➢ 6 days were removed from the Spring data and 10 from Summer

• 15 minute data
  ➢ Spring South is the only one plotted from 5 minute data
    o I have all the 5 minute data, but it was burdensome

• I started looking for peak summer impacts, omitting the <10:00 data
  ➢ I wish I had not done so, and can correct this later

• Times are respectively in DST or ST, correlating with usage patterns, not celestial events

• The Y axis is kW, accurate for the south facing PV only; West PV is adjusted to each season’s south-facing norm

• Even with 60 day baselines and 5 or 15 minute data, there is more variability than I expected
  ➢ Summer appears to vary as much as does Spring

• It would be interesting to go back to the efficiency data for S vs. W by comparatively correlating ‘facing-performance’ with the kW ratings
Seasons (Combined/Normalized PV Panels)

Spring
South vs. West (Combined Seasons)
South vs. West by Season

Spring

Winter

Summer
Net-Peak Load 2031 (Current Trends Model)
ERCOT 2016 Long Term System Assessment, 12/26/16
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ERCOT 2016 Long Term System Assessment, 12/26/16
CES Deployment – A Few Lessons for Feeder BES

The initial CES unit (of 6) was prototyped at the SOSF site

- Modified (additional metering / logging)
- Configured (end-feeder transformer one-line and transfer logic)
- Integrated & tested (with local/controllable assets)
- Transition to Ops
  - Siting prelims (underground units), addressed O&M and community concerns, interconnect
  - DOT training: safety, service, unique fire and first aid topics

Not intended as a testbed for feeder-level but some insights …

- Transfer trip and restoration in 2 cycles or less, with programmable ‘event’ detection
  - Not coordinated with DA assets (e.g., autoclosers)
- Provided SCADA-level visibility and control (not exercised) of additional line events
  - (Intelliteam data collection and SW pushes)
- Assessments of energy bleed, performance, and O&M impacts
  - Integration with DA and dynamics of performance are incremental to Distribution Ops
CONTACT

Randy Boys
Manager, Strategy & Technology
Oncor
randy.boys@oncor.com
214-486-4934