



EPSTM

A Voltyx Company

Everything Solar

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What They Are

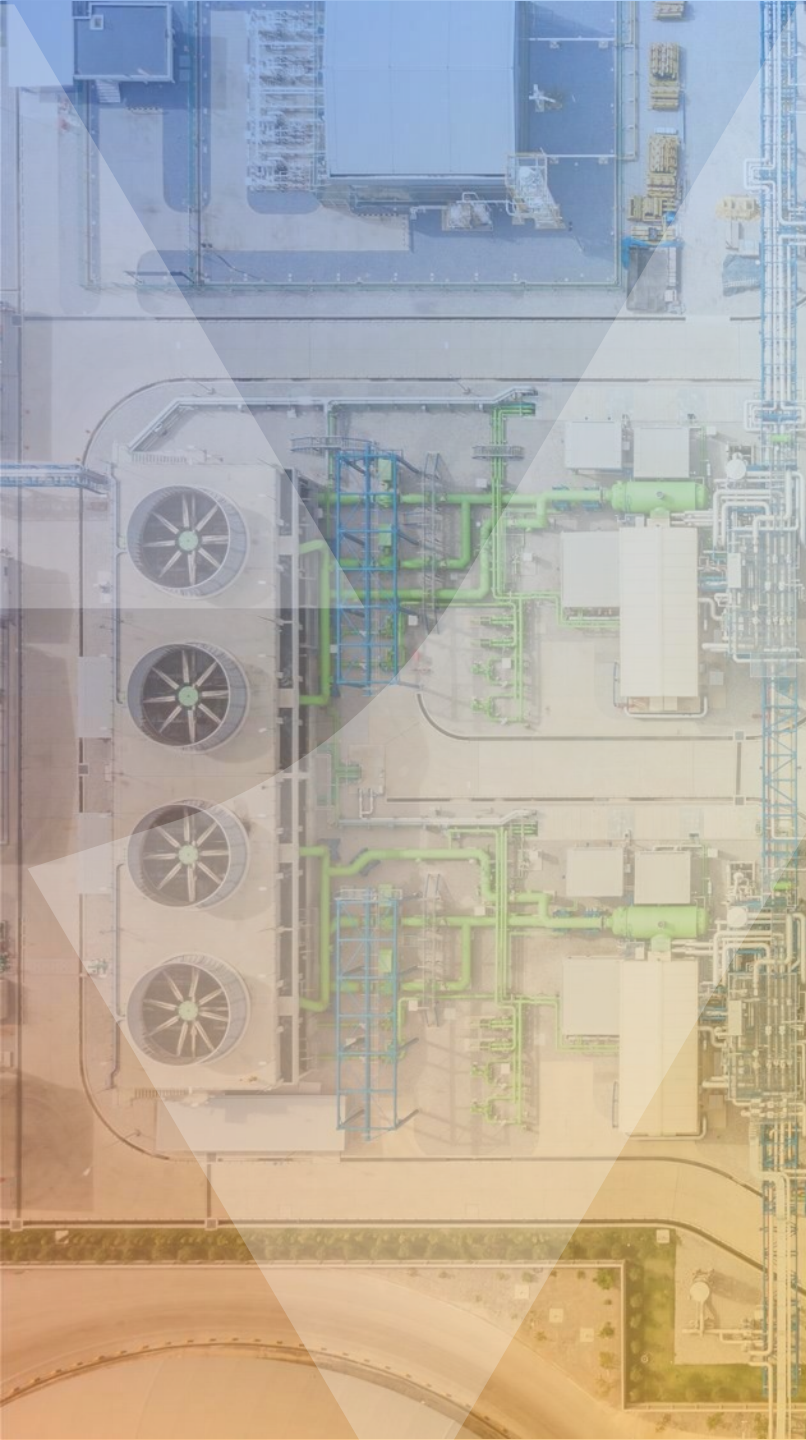
Systems, Standards
and Rules

Implementation

Studies,
Review/Inspection,
Rates, Testing

Impacts

Protection, regulation,
revenue, operations.

An aerial photograph of an industrial facility, likely a power plant or refinery. The image shows a complex network of pipes, tanks, and structural steel. On the left side, there are four large, circular cooling towers with visible fans. The facility is surrounded by a paved area and some greenery at the bottom. The image is partially obscured by a semi-transparent orange and white geometric overlay.

We operate an instantaneous, variable energy transport and delivery system in public and private rights of way which is subject to regulated safety and performance standards intended to protect employees and the general public.

A background image of a transmission tower structure, viewed from a low angle looking up, with a blue sky and clouds. The tower is made of metal lattice and has a yellowish tint at the bottom.

Define what these systems are, how they work and how they interconnect to the existing AC grid.

Implementation of these systems includes studies, design, review, inspection and testing as well as rates.

These projects have the opportunity to impact our system protection and voltage regulation, operations and revenues.

Descriptions

Distributed Energy Resources (DER) – Generating resources connected to the distribution system which may be inverter-based or not.

Inverter Based Resources (IBR) – Systems converting energy into DC electricity, then AC electricity via inverters which are in turn interconnected to the Bulk Electric System via step-up transformation.

Battery Energy Storage Systems (BESS) – Systems using batteries to store large amounts of energy for controlled discharge into an electric system.

Components

- Energy source from forms such as mechanical, gravitational, radiant, chemical, etc.
- Energy converter such as wind turbine/generator, solar panel, hydro turbine/generator, battery, etc. producing DC current/electrical energy.
- Inverter converting DC electricity into AC electricity for utilization in conventional grid applications.
- Typical PV panels are 12-48V DC, you stack (series) connect them getting up to 1000V DC for connection to an inverter.
- NREL website can help calculate energy production based on location

Inverters and Rectifiers

- Rectifier converts AC electricity into DC electricity.
 - Vehicle – Alternator
 - Battery Chargers (cell phone, laptop plug in power supply, 6-24 volt “charger”)
- Inverter converts DC electricity into AC electricity.
 - Grid following inverters require grid to function. Off within 2 seconds of outage.
 - Grid forming inverters have the components to control and regulate frequency and voltage (islanded operation). Required for micro-grid or islanded operations.
- Let’s look at how they work.....

Rate Components

- Energy - \$/kWhr “how much you used”
- Demand (when applicable) - \$/kW over some time interval.
“maximum rate you used it at” includes transmission system, delivery system.
- Customer Charge - \$/month – fixed cost recovery
- Power Cost Adjustment Clause (PCAC) – budget to actual deviation
- Public Benefits Charges
- Taxes
- Power Factor

Purchase Power Components

- Energy - \$/kWhr “how much you used” On and off peak
- Demand (when applicable) - \$/kW over some time interval.
“maximum rate you used it at” includes transmission system, delivery system (maybe transformation) asset charges.
- Customer Charge - \$/month – fixed cost recovery
- Taxes
- Power Factor
- Generation Capacity – having what you need when you need it.

Power Factor-ratio of real to apparent (total) power

- Power Factor = $\cos(\text{Real Power} / \text{Apparent Power})$
- 1000kW real power
- 500kVAr reactive power
- 1118kVA total power
- ~90% (89.44%) power factor

What happens if the customer installs 500kW of DER?

Exercise

In your group calculate the new power factor for the scenario of having 500kW of DER added to a 1000kW/500kVAr load.

System configuration

- It's important to understand the overall electric system is a ground-referenced system (this includes transmission, distribution and utilization level systems). These new generation sources must protect the electric system against un-grounded operation.
- The current school of thought for DER is 30% penetration is usually acceptable. We're seeing systems above that level which can lead to significant power swings.
- What can(will) you do when the next DER request you get drives your system beyond its penetration limit (can you say "no")?
- Will a utility-scale DER project mean your customers can't have their project(s)?

Standards and Rules-DER

- Institute of Electrical and Electronics Engineers (IEEE)
 - 519 - Harmonics
 - 1547 – Baseline requirements for interconnection of DER to utility grid
- Underwriters Laboratories (UL)
 - 1741 – Inverter safety and compliance with IEEE 1547
- National Electrical Code (NEC)
 - 690 – Solar Photovoltaic (PV) Systems
- State of Wisconsin
 - SPS 316 – State Electrical Code
 - PSC 119 – Distributed Generation Standards (and 112, 113, 114, rate tariffs, extension rules also.....).

Standards and Rules – Rates

- <20kW – PGS-1 net metering
- >20kW – PGS-2 negotiate, avoided costs

Avoided costs includes power supply costs (energy and demand) and system losses. Does not include base rate components such as customer costs, metering/billing costs, delivery system costs, most demand costs, public benefits costs.....

You need a calculation of your avoided cost rate before you get one of these requests.....

Premise of the “Pitch” – Retail DER

- Energy source is “free” and available to all.
- All the owner needs to do is purchase the conversion system (standardized/off the shelf equipment) and pay for it to be interconnected.
- Tax incentives pay part of the cost lessening the initial investment and promoting project penetration.
- Given cost offset vs. retail rates “payback” is less than 10 years, then everything is free (no power bills).
- This reduces your carbon footprint saving the environment.
- You can get access to “really cool” apps so you can see what you’re using/producing and your calculated savings.

Premise of the “Pitch”–continued

- Residential projects are often sized for “off-the-grid” – meaning if the real estate (surface area) is adequate the annual energy production of the system will meet or exceed the annual usage of the customer.
- The economics of commercial projects are often calculated with savings in both energy and demand charges.

Exercise

In your group identify three (3) potential conflicts between the Premise of the Pitch and either:

- the physical realities of the systems
- or the rate components.

Implementation



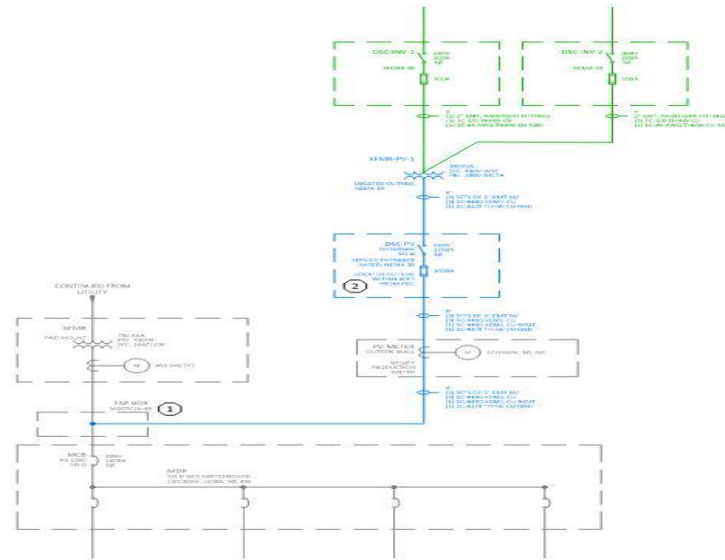
Application

- Do you have a DER application form/process?
- Does your new/modified service application ask about generation/DER?
- Do you have a system model that can be used to assess DER impacts within the timeframes of PSC 119?

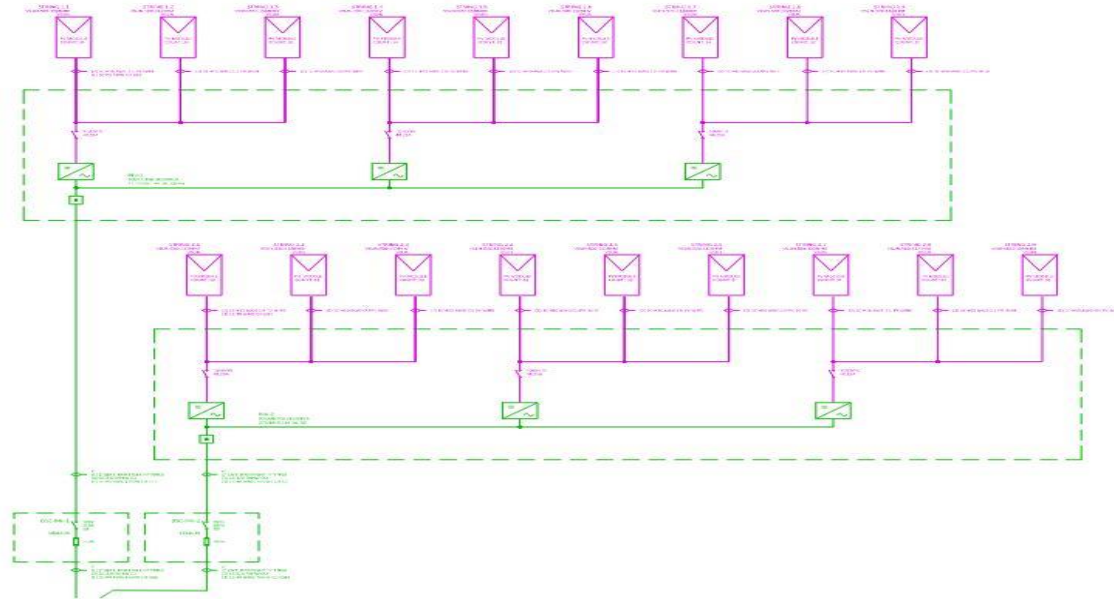
Exercise

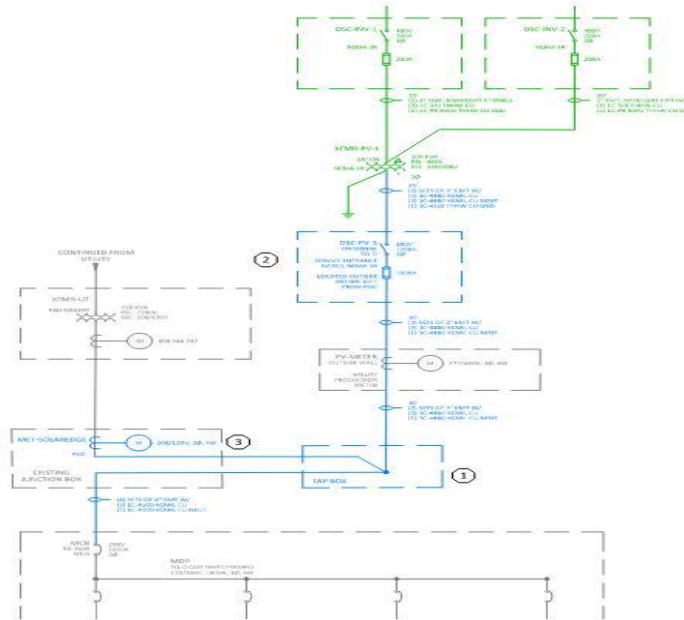
In your group discuss what issues you've found for the DER application reviews you've conducted and be prepared to outline one issue of interest to the group.

Standards and Rules-example submittal



Standards and Rules-Panels





Standards and Rules-continued

- PSC 119.20 (5) – “All DG transformations shall be multi-grounded. The DG facility may not be designed or implemented such that the earth becomes the sole fault current path.”

Standards and Rules-continued

- Accessible, lockable, visible isolating disconnect/switch.
- Protective Device (overcurrent, over/under frequency, phase reversal, anti-islanding, over/under voltage, etc.).
- Metering (bi-directional, extended-range/high-accuracy).
- Generation curtailment function (anti-backfeed) – could be stipulated in an existing T-L Interconnection Agreement.

DER Review

- Does the proposed system overload (>nameplate) your transformer(s)?
- Are you provided the infrastructure you need?
- Will the system negatively impact other interconnected entities on the grid?
- Is the documentation adequate?
- Do you need to model the performance aspects (voltage drop/rise, power factor, fault current)?
- Do you review your reclosing timing on distribution feeders (inverters have up to two (2) seconds to drop off-line)?

DER Review – continued

- Relay settings wouldn't protect system.
- Reclosing intervals too fast (won't allow DER to isolate before reclose)
- Unacceptable voltage levels/missing voltage control components
- Missing system components (no disconnect, no overcurrent protection).
- Overloaded transformer
- Incorrect grounding
- No curtailment equipment (but it's needed)

Utility-Scale (DER) Projects

- <5MW – sized for the normal load (no backfeed) or protection is added.
- Behind the Meter (not normally subject to network system impact studies).
- No G-T Interconnection Agreement
- Direct (or very closely) interconnected to a substation bus.
- Curtailed when the substation is OOS.

Studies

- >5MW – 1200MW
- System Impact Studies – transmission operator
 - Ground grid duty impacts (do you know the design?)
 - Equipment interrupting capacity
- G-T Interconnection Agreements (not T-L like most are).
- Energy only or BESS too?

Testing < 20kW

- Witness anti-islanding testing
 - Three phase loss of power
 - Single phasing condition
- Metering verification/validation (PSC113)
- Review Protection System tests
 - Verify protective elements are programmed

Testing > 20kW

- Cable withstand testing
- PV curves/output verification vs. illumination
- Total system loss verification
- Full protection system functional testing
- Power factor compensation system testing
- Transformer(s) testing

Utility-Scale (IBR) Projects

- >5MW – 1200MW
- Compliant with IEEE 2800-2022
- System Impact Studies – transmission operator
- G-T Interconnection Agreements (not T-L like most are).
- Energy only or BESS too?
- Bulk Electric System Interconnections >100kV

Utility-Scale (IBR) Projects

- Metering – some suppliers require generation input metering (for chargeback) even though your DER/IBR is “behind the meter”.
- Due to the dynamic nature of the generation your voltage regulation equipment will see more operations (and will need more maintenance).
- Power Factor compensation can be an issue depending on the energy conversion model.

Utility-Scale (IBR) Projects

- Seeing more hybrid systems (IBR w/BESS, IBR w/combustion generation, wind w/solar, IBR w/hydrogen production/storage) improving capacity performance of the combined system.

Impacts

The background of the slide is a photograph of a large-scale renewable energy facility. In the foreground and middle ground, there are numerous rows of solar panels mounted on racks, stretching towards the horizon. Two large wind turbines are visible, one on the left and one on the right, standing tall against the sky. The sky is filled with soft, colorful clouds in shades of orange, yellow, and blue, suggesting a sunset or sunrise. The overall scene conveys a sense of clean, sustainable energy production.

Exercise

In your group discuss what impacts you anticipate for a utility-scale DER project interconnected to your utility's delivery system and be prepared to outline one impact of interest to the group.

Impacts

- These systems create a small (110% of nameplate) increase in system short circuit/fault levels (vs. 400%-600% of nameplate) increase for rotating machines.
- Voltage regulation will swing more frequently and to a greater degree (beyond bandwidth) such that LTC's and voltage regulators will operate more (requiring more maintenance activities/on shorter intervals).

Impacts

- Billing is more time intensive when you add more metered sources to your network (including annual reporting requirements, MISO settlement activities, network planning activities).
- On a purchase (normally 20-year term) contract the initial purchase price will flow to your customers by increasing your PCAC.

Impacts

- Capacity accreditation (if you pursue it) gets you roughly 25-30% of the nameplate capacity (without BESS) as an offset to your demand charges.
- How do you monitor transformer loading with net metered DER?
- SCADA integration?
- Who has remote control to isolate the DER if you need switching in a hurry/emergency? How often will you test these systems?
- Power Factor compensation at your POI?

Conclusions

- DER/IBR is here to stay-Rules/Standards are intended to simplify the process and improve penetration
- Project review should be easy (but somebody has to do it).
- Buyback rate should be based on avoided costs.
- System impacts are far-reaching



Questions or Comments?

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