# Reactive Power Compensation: *Unlocking New Revenue Opportunities for Solar and Storage Projects*

**July 29, 2020**

A Webinar by the Solar Energy Industries Association and the American Wind Energy Association


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# Presenter Bios

# Regulatory and Markets Expert

- Michael Borgatti, Vice President of RTO Services, Gabel Associates
  - Deep expertise in operations, procedures, and markets of regional transmission organizations (“RTO”)
  - Authored responses to numerous FERC matters and serves as a lead participant in the successful development of reactive rates for several wholesale power assets
  - Active involvement in reactive service issues at PJM, including collaborating with industry executives, counsel, and FERC staff to facilitate the filing process, prepare testimony and filings, and assist litigation and settlement

# Financial Economics Expert

- Adrian Kimbrough, Vice President, Gabel Associates
  - Expert witness in litigated regulatory proceedings before the FERC, addressing economic damages analyses, cost-of-service and market-based ratemaking, market power studies, and **reactive revenue rate filings**
  - Advises renewable project developers and asset owners on developing bankable market forecasts, risk management strategies, and transaction structuring, pricing, and execution
  - Prior to joining Gabel Associates, Mr. Kimbrough also served as an expert witness FERC's Office of Administrative Litigation, leading multiple cases involving complex regulatory economic issues including reactive power ratemaking
  - MBA, Harvard Business School

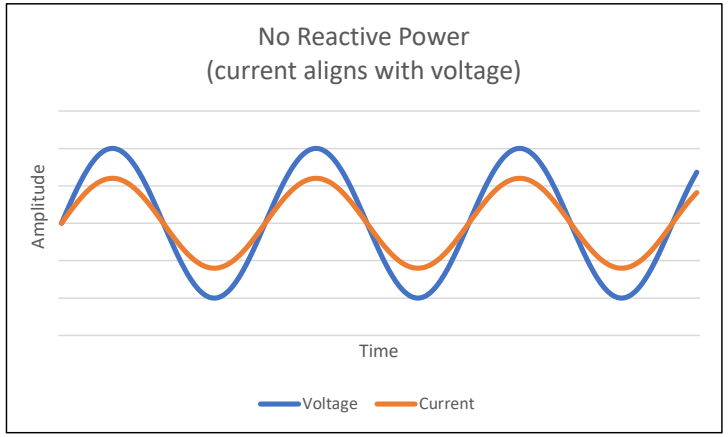
# Legal Services

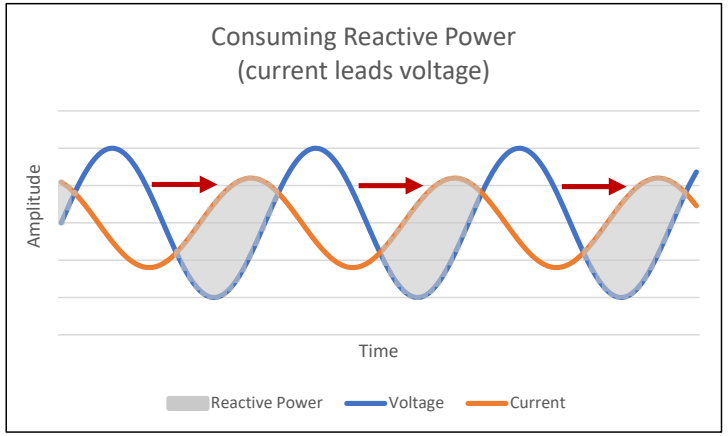
- Steven Shparber, Partner, Nelson Mullins Riley & Scarborough
  - Outside counsel to AWEA and SEIA on FERC and RTO-related issues impacting utility-scale renewables and storage
  - Former lead markets attorney at PJM; responsible for drafting tariff provisions related to reactive power compensation in PJM
  - In-depth experience negotiating settlement agreements related to a wide variety of matters under the Federal Power Act
  - Former Attorney-Advisor in Office of Administrative Law Judges at FERC (the office that oversees reactive compensation settlement proceedings)

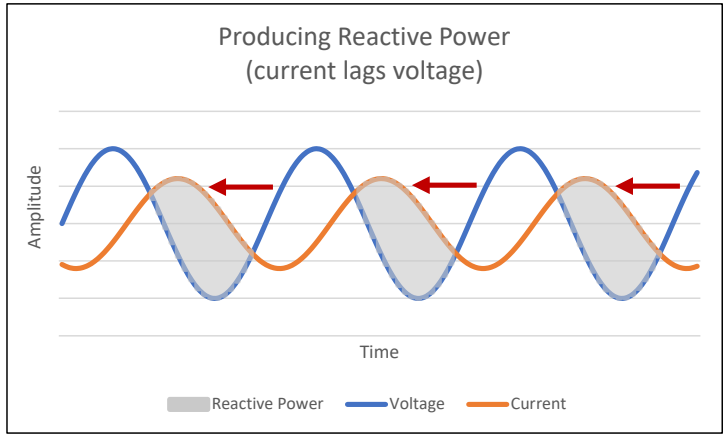
# Reactive Power Fundamentals

# What is Reactive Power?

- Moves energy around the grid between generators and load
  - Imagine transmission lines as water pipes: reactive power sources would be the pumps that “push” and “pull” energy across transmission system
  - Stabilizes voltage levels and improves power flow
  - 2003: 55 million lose power across Northeastern US due, in part, to insufficient reactive power support
- Necessary for Alternating Current (AC) electrical systems
  - All balancing authorities must procure enough sources of reactive power to safely manage the grid
  - Generator interconnection agreements require generators to operate within certain reactive power limits
  - ISO/RTOs and some non-market areas compensate generators for their ability to provide reactive power



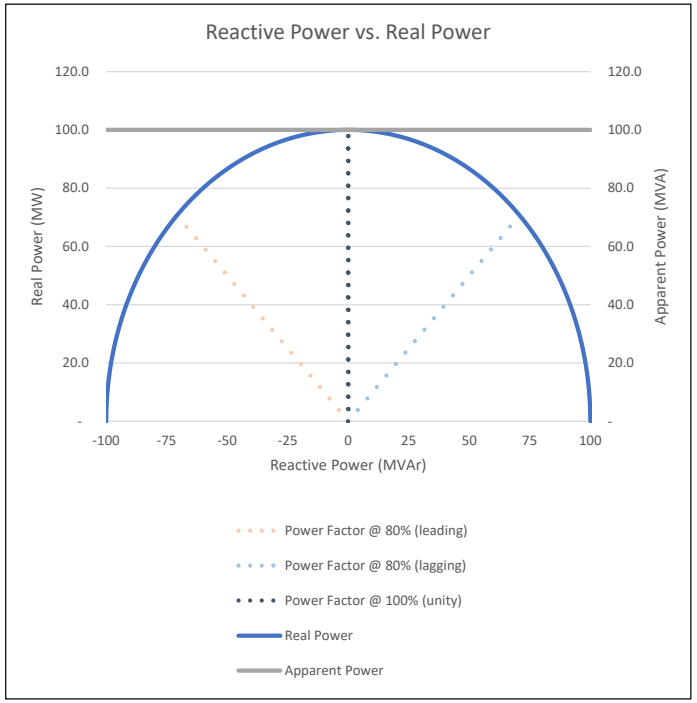



# Reactive Power vs. Real Power

- All generators can supply real and reactive power
  - Real power: active work to power load
  - Reactive power: voltage support that physically moves real power from generation sources to load
  - Leading: absorbing reactive power
  - Lagging: producing reactive power

- Generator's reactive capability measured by "Power Factor"
  - "Unity" Power Factor = 1.0 or 100% (implies no reactive power)
  - Lower Power Factor = greater reactive capability
  - Generators with 0.8 Power Factor can provide more reactive power than those with 0.9 Power Factor
  - Tradeoff between real and reactive power: generators generally less efficient at lower Power Factors




***Key Takeaways***

- Solar generators are required to be capable of providing real and reactive power
- Eligible for compensation for providing this necessary service

# FERC Reactive Power Compensation

- FERC-approved *AEP Methodology* is standard for calculating cost-of-service reactive service compensation
  - Based on 1999 FERC rate case for thermal based on thermal generators
  - Adapted for renewable resource
  - Follows FERC Uniform System of Accounts
- Used by PJM and MISO
  - Different approaches in other ISOs

***Key Takeaways***

- Generators are entitled to reactive payment by right in most markets
- Applying for compensation does not change plant operating profile

**Step 1**: Identify construction cost of real and reactive power equipment

- Inverters
  GSU Transformers
  Power Stations
- DC/AC Collectors
  SCADA
- Balance of Plant

**Step 2**: Use FERC-approved allocators to isolate reactive power equipment

- Reactive Costs *
  Power Factor Allocator
- All other costs *
  BOP Allocator

**Step 3**: Calculate annual reactive revenue requirement (**ARR**)

- Step 2 costs multiplied by carrying charge

# Reactive Compensation Overview

- Fixed Payments
  - Compensate for the capability to supply reactive power regardless of actual performance
  - To receive compensation, market participants must submit a tariff filing to FERC pursuant to FPA Section 205
  - Payments provided for life of the asset, subject to ongoing compliance obligations and performance standards
  - FERC can reconsider in future under new Section 206 proceeding

- Variable Payments
  - Compensates for lost energy market revenues when RTO dispatches generator to provide reactive power instead of energy
  - No tariff filing with FERC is required
  - Because resources typically provide less reactive power than their rated capability, these payments are typically less than the fixed capability payments and not as certain
  - RTOs can dispatch generators to provide reactive power regardless of whether or not they receive fixed payments

# Reactive Power Regulatory and Legal Considerations

# Regulatory Overview (Order No. 827)

- 2016 FERC order revising *pro forma* Large Generator Interconnection Agreement (LGIA) and the *pro forma* Small Generator Interconnection Agreement (SGIA) and requiring new non-synchronous generators to provide dynamic reactive power within power factor range of 0.95 leading to 0.95 lagging

- Applied to all non-synchronous generation, which includes solar and storage

- FERC made this change because it found that providing reactive power was no longer cost-prohibitive for non-synchronous generators at the high-side of the generator substation (compared with the Point of Interconnection)

# FERC Filing Process For Cost-Based Compensation

- Applicant's filing under Section 205 of the FPA will contain: 1) a filing letter; 2) tariff with a proposed rate, 3) supporting testimony, affidavits and exhibits

- Within 60 days, FERC almost always:
  - 1) Issues order accepting filing on requested effective date "subject to refund"
  - 2) Establishes a new proceeding under Section 206 of the FPA
  - 3) Establishes a refund effective date (typically the date that notice of the Section 206 proceeding is published in the Federal Register)
  - 4) Institutes hearing and settlement judge proceedings

- During settlement process applicant and FERC staff negotiate reasonableness of inputs and assumptions used to justify proposed rate
  - Almost always includes some confidential discovery process to determine reasonableness of assumptions used to calculate rate
  - Vast majority of cases settle at some discount to filed rate
  - FERC accepts rate subject to compliance filing implementing changes and refund for delta between filed and settled rate
  - Payments made to generator at as-filed rate during settlement and approval process

# Factors Impacting Negotiations With FERC Staff

- Reasonableness of assumptions being used
- Complexity of project (i.e. solar or solar-plus-storage)
- Maturity of project
- Are assumptions in line with industry values?
- Are different proxy inputs being used by Applicant?
  - Question of what reasonable proxy is for determining the capital structure and cost of capital for a merchant generator in PJM has been set for hearing (Docket No. EL19-70)
- Quality of data
- Level of preparedness when answering FERC's questions
- FERC staff assigned to case

# Reactive Power Markets

# Revenue Potential by Market

- **<u>MISO and PJM are most lucrative markets</u>**
- Fixed Payments are most bankable (higher value and certainty)
- Variable Payments are least bankable (lower value and certainty)

| RTO | Fixed Payment | Variable Payment | Revenue Potential |
|---|---|---|---|
| PJM | ✓ | ✓ | High |
| MISO | ✓ | ✓ | High |
| NYISO | ✓ | ✓ | Moderate |
| ISO-NE | ✓ | ✓ | Low |
| SPP | ✗ | ✓ | Low |
| CAISO | ✗ | ✓ | Low |
| ERCOT | ✗ | ✓ | Low |

# Revenue Potential by Technology

- Revenue potential
  - Measured in $/MW-yr
  - Driven by higher costs & capability

- **Highest revenue potential: Solar & Battery Storage**
  - Solar and battery storage capex ($/kW) historically higher than fossil fuel-fired capex
  - Inverters tend to have a higher reactive capability than fossil fuel-fired generator/exciters
  - Solar settled reactive rates range from $2K/MW-yr to $12K/MW-yr
  - Wide range of outcomes due to small sample size (very few solar reactive settlements on file)

| RTO | Costs | Capability | Revenue Potential |
|---|---|---|---|
| Solar | High | High | High |
| Battery Storage | High | High | High |
| Waste-to-Energy | High | Moderate | Moderate |
| Natural Gas | Low | Moderate | Low |
| Wind | Moderate | Low | Low |

# Solar Reactive Rates

| Settled Solar Reactive Rates (PJM and MISO) | | | |
|---|---|---|---|
| Project | FERC Docket No. | Filed ARR $/MW-yr | Settled ARR $/MW-yr |
| Galt Power, Inc. (Baker Point Solar) | ER19-62 | 16,410 | 12,556 |
| Pilesgrove Solar | ER17-2415 | 20,161 | 11,806 |
| Frenchtown 1 Solar, LLC | ER18-89 | 16,655 | 9,739 |
| Frenchtown 2 Solar, LLC | ER18-90 | 16,232 | 9,739 |
| ConEdison Energy, Inc (PA Solar Park) | ER18-1226 | 24,149 | 9,500 |
| Algonquin Energy Services, Inc (Great Bay Solar) | ER17-2386 | 34,037 | 7,008 |
| Frenchtown 3 Solar, LLC | ER18-734 | 11,852 | 4,688 |
| Stuttgart Solar | ER18-1704 | 3,590 | 2,519 |

# Reactive Power Revenue Estimation

# Revenue Drivers

- Investment in Reactive Equipment
  - Higher investment = higher revenues
  - Example equipment: inverters, transformers, dynamic synchronous condensers, mechanically switch capacitors, etc.

- Reactive Capability
  - Lower power factor = higher reactive capability = higher revenues
  - Based primarily on power factor

- Counterparty Settlement Positions
  - Can vary significantly from case to case
  - **Uncertainty creates wide range of revenue outcomes**

# Revenue Drivers: Solar Example

| Reactive Revenue Driver Comparison (Solar) | | | | | |
|---|---|---|---|---|---|
| **Settlement Outcome** | **Avg Settled ARR** | **Avg Capex** | **Avg Power Factor** | **Avg Capacity** | **Avg Settlement Discount** |
| | *$/MW-yr* | *$/kW* | *%* | *MW* | *% Filed* |
| Highest Settlement Outcomes | 11,367 | 2,981 | 80.0% | 10 | -35.5% |
| Lowest Settlement Outcomes | 5,928 | 2,371 | 84.9% | 44 | -57.6% |

***Key Takeaways***

- Higher costs = higher reactive revenues
- Lower power factor = higher reactive revenues
- Lower capacity = lower risk of settlement discount

# Simplified Calculation Overview

- Solve for revenue required to breakeven with the cost of constructing and operating a generation resource's reactive investment each year over its estimated useful life

- Referred to as the "Annual Revenue Requirement" or "ARR"

- ARR = Reactive Capex * Reactive Power Allocation Factor * Fixed Carrying Charge
  - Reactive Capex = Inverters + Transformers + Reactive Support Equipment
  - Reactive Power Allocation Factor = reactive capability weighting
  - Fixed Carrying Charge = reactive costs attributable to O&M, depreciation, working capital, cost of capital, taxes

- Additional considerations:
  - Reactive costs should be allocated consistent with the Electronic Code of Federal Regulations, Uniform System of Accounts (USoA)
  - Include balance of plant costs
  - Additional allocation factors may need to be applied to portions of the reactive investment (e.g., accessory electric equipment, balance of plant, etc.)
  - Heating losses can also be included in the fixed ARR

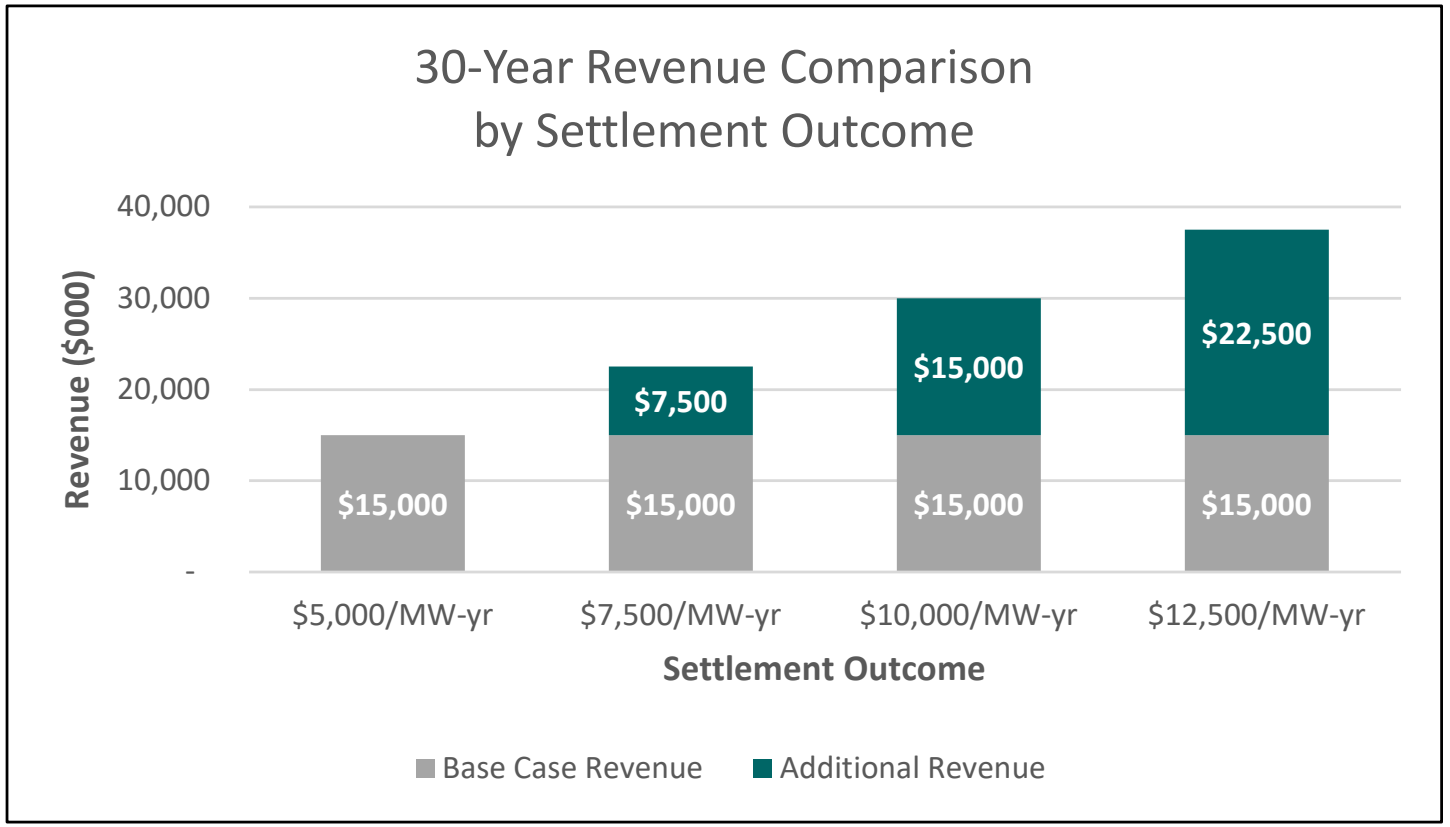
# Example High-Level Revenue Estimate

| Assumptions | | | | |
|---|---|---|---|---|
| **Input** | **Units** | **Total** | **Row** | **Source** |
| Total Capacity (nameplate) | MWac | 100 | a | *Assumption* |
| Total Capex (unitized) | $/kWac | 1,250 | *b* | *Assumption* |
| Reactive Share of Total Capex | % | 20.0% | *c* | *Market Avg* |
| Power Factor | % | 80.0% | *d* | *Assumption* |
| Fixed Charge Rate | %/yr | 11.0% | *e* | *Market Avg* |
| Settlement Discount | % ARR | 50.0% | *f* | *Market Avg* |

| Example Gross Annual Revenue Requirement (ARR) | | | | |
|---|---|---|---|---|
| **Output** | **Units** | **Total** | **Row** | **Formula** |
| Reactive Fixed Cost Basis | $ | 25,000,000 | *g* | *g = a * b * c * 1000* |
| Reactive Fixed Cost Allocation Factor | % | 4.0% | *h* | *h = (1 - d ^ 2) * e* |
| Estimated Filed ARR | $/yr | 990,000 | *i* | *i = h * g* |
| Estimated Settled ARR | $/yr | 495,000 | *j* | *j = i * (1 - f)* |
| Estimated Settled ARR (unitized) | $/MW-yr | 4,950 | *k* | *k = j / a* |

# Lifetime Revenue Example

- Assumptions
  - Base Case Settlement: $5,000/MW-yr
  - Useful Life: 30 years
  - Portfolio Size: 100 MW
- Implications
  - Each additional $2,500/MW-yr received through settlement translates to an **additional $7.5MM** received over 30 years



# Thank You and Q&A

# Contact Us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