

Interconnection of Distributed Generation & Net Metering Seminar

March 22, 2012

Providence, RI

Hosted by: **nationalgrid**

Technical Sales and Engineering Support Department



Logistics & Introductions

- **Facilities**

- Emergency exits
- Restrooms
- Designated smoking area

- **Guests**

- RI Public Utilities Commission(RI PUC)
- RI Office of Energy Resources(RI OER)
- RI Governor's Office

Safety Moment

Avoid the Danger Zone

- Overhead power lines are not insulated, and carry enough energy to cause serious injury or even death. Regard all wires as live.
- Keep yourself, your co-workers, tools, and vehicles at least 10 feet away from electric lines and equipment.
- Stay alert. Keep ladders at least 10 feet away from power lines when carrying, moving, and raising them.
- Make sure the area is clear of wires before working near trees or shrubs.
- Never attach or tie anything off to power lines or electrical equipment.
- If you need to dig, first call Dig Safe at 1-888-dig-safe (1-888-344-7233) to get underground utilities marked.



**Interconnection of Distributed Generation &
Net Metering in Rhode Island Seminar**

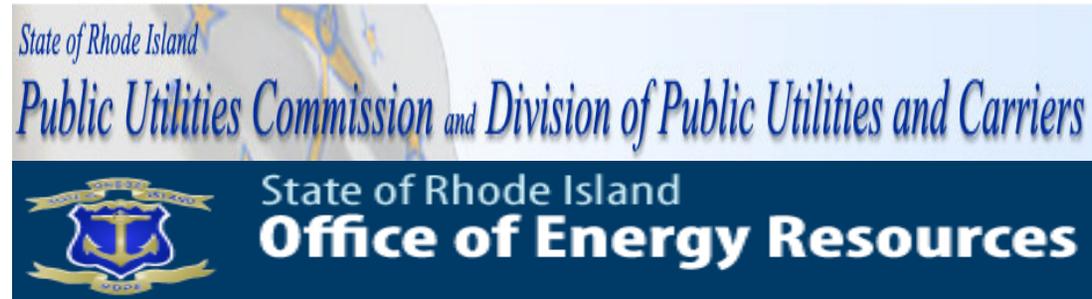
Date: March 1, 2012

Location: 280 Melrose Street, Providence, RI 02907

Agenda

- 8:30 a.m. Registration**
- 9:00 a.m. Welcome Message, Introductions, Presentation Overview**
- 9:10 a.m. Interconnection Process**
- 9:30 a.m. ISO-New England and Net Metering**
- 10:00 a.m. Break**
- 10:05 a.m. Interconnection of Distributed Generation: Electric Power System Impacts and Issues Created**
- 10:45 a.m. Interconnection of Distributed Generation: Technical Session**
- 11:45 a.m. Questions and Answer Session - National Grid Panel**
- 12:00 p.m. Adjourn**

RI Agency Welcome Slide



RI PUC and OER:

- Assisting with incentives for clean energy
 - Portfolio Standards
 - Net Metering
- Increasing awareness about policies
 - Interconnection
 - Rates
 - System Planning / Service Quality
- Advising on new policies
 - Streamlining Interconnection
 - Hands-on assistance with challenging projects

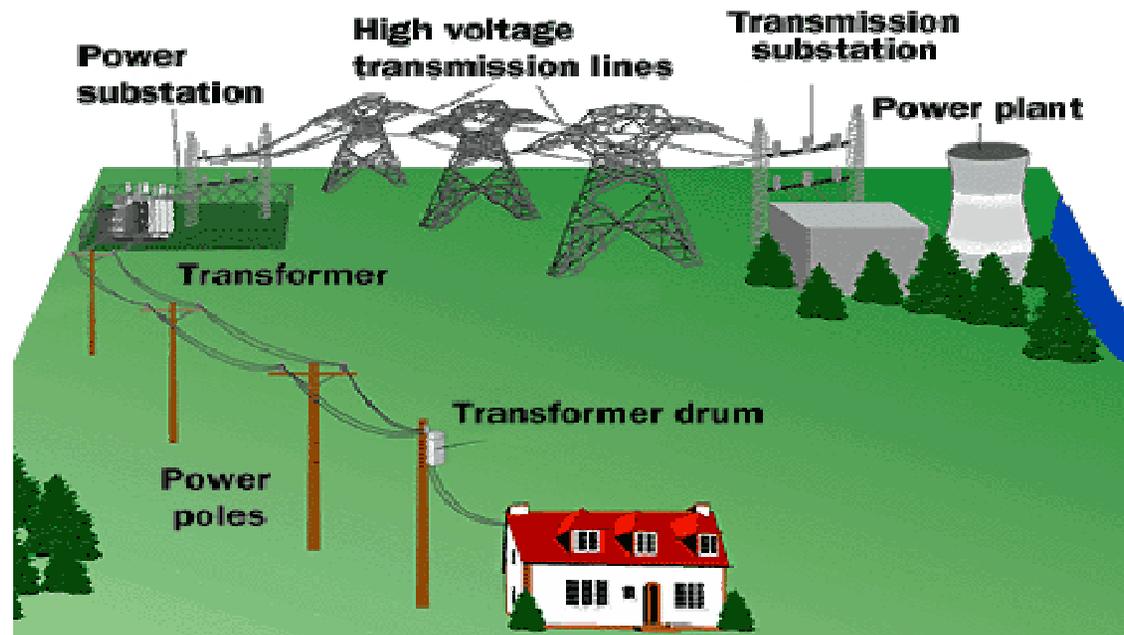
Presentation Overview

- **The Interconnection Process Basics**
 - Terms, Explaining the Grid, Defining Distributed Generation (DG)
 - The Interconnection Process
 - *Who, What, When, Where and How? – A General overview*
 - Determining the Interconnection Review Process
 - *Simplified, Expedited or Standard*
- **Advanced Interconnection for Installers and Developers**
 - Detailed Interconnection Review Process with timelines
 - Technical Issues
- **Net Metering**
- **Technical Session**
 - Aspects of Integrating DG with Utility System
- **Q & A**

Interconnection of Distributed Generation: The Process

How Does the Electric Grid Work?

- **Generators (Power Plants):** Produce electricity (usually large and centralized – nuclear, coal, natural gas)
- **Transmission System:** Transmits electricity at high voltage from generators to distribution systems (where the power is needed)
- **Distribution System:** Distributes electricity to customers via lower voltage wires
- **Substations and Transformers:** Used to “step-down” voltage to the appropriate task



Distributed Generation and the Electric Grid

Distributed Generation (DG) Systems are becoming more popular due to more aggressive incentives for clean energy such as net metering, RPS/APS, etc.

DG Systems are generally:

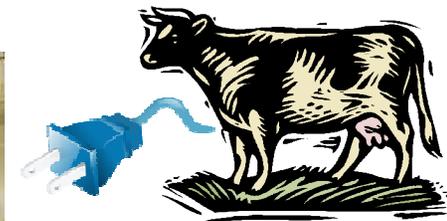
- much smaller in MW rating than centralized power generation
- tied to the distribution system of the grid (rather than the *transmission* side)

Two Types of grid-connected DG

- **Behind Meter:** DG system is used to partially or fully supply an on-site load. Any unused electricity is exported to the distribution system (most projects follow the state interconnection process; *there are exceptions that follow the ISO process*).
- **Direct Connect:** DG system does not supply an on-site load, and is connected directly to the distribution system (*all* such “wholesale energy projects” follow the ISO-NE Interconnection process)

RI PUC Interconnection Tariffs

- The RI PUC adopted a revised tariff titled, “RIPUC #2078, Standards for Connecting Distributed Generation”, on November 30, 2011.
 - Includes interconnection standards and renewable energy interconnection process.
 - Current version of “Standards for Interconnecting Distributed Generation” is can be found at:
https://www.nationalgridus.com/narragansett/home/energyeff/4_interconnect.asp
- The RI PUC adopted a revised tariff titled “RIPUC #2075, Net Metering Provision.”
 - Includes Eligible Net Metering Rate Classes and Technologies
 - Current version of “Net Metering Provision “ can be found at:
https://www.nationalgridus.com/narragansett/home/energyeff/4_net-mtr.asp



Importance of the Interconnection Process

- Following the interconnection process is important because a DG system changes the one-way power flow from the utility to customer, which can present dangers to utility workers if proper equipment is not installed
- While robust and capable of handling minor disturbances, the quality of grid power is extremely important. The interconnection process ensures the DG meets safety, reliability, & power quality requirements with regard to:
 - Islanding
 - Transient Voltage Conditions
 - Noise and Harmonics
 - Frequency
 - Voltage Level
 - Machine Reactive Capability
- It is essential that each interconnection get an interconnection agreement with the utility before installing and energizing any generation – *Installing an interconnected system without utility approval poses a potential for severe liability risk.*

Interconnection 101: The Basics

1. The customer starts the review process by requesting, filling out and submitting an application package to the local utility
2. The utility begins review to determine appropriate application path
3. If approved, the applicant will be required to sign an interconnection agreement with the utility. The system must be installed within 12 months of the agreement, or else a new application is required.
4. If there is a dispute over an application, the interconnection standards released by the RI Public Utilities Commission (PUC) include a dispute resolution process.
5. At first glance, the interconnection process seems simple, but there is a significant amount of information needed by the utility to successfully process the application. **Delays are common due to missing information, so it is important that the system design engineer help with the application process.**
6. Contact National Grid, RI PUC or RI OER assistance or with queries even **before** the system design process. **Everything Starts with the Application!**

Everything starts with the Application

- A complete complex application package includes:
 - All appropriate sections of 4-page application completely filled out. Customer will likely need assistance from vendor/engineer.
 - **Application fee** : This fee covers the initial review. If Feasibility Study requested, the Application Fee is waived in lieu of Feasibility Study Fee. See Table 2 of RI PUC 2078 tariff for fee amounts.
 - **Stamped electric one-line diagram**, preferably showing relay controls (one copy) (Stamped by Rhode Island Electrical PE)
 - **Site diagram** (one copy)
 - One copy of any **supplemental information** (if electronic – single copy acceptable)
 - Identify electric customer and owner of proposed generation
 - **Schedule B** if planning to Net Meter
- Errors or problems with application will slow down the process and *“stop the clock”*
- Send **Electronic copy** of all documents **preferred** if possible – Easier to distribute, saves paper, and is faster. However, submit first page of application with application fee.

Interconnection Review Paths

- There are three different interconnection review paths a project can follow based on generation type, size, customer load and the characteristics of the grid where the system is to be located.

Simplified	Expedited	Standard
For PV and other inverter based technologies served by radial systems, 10k W or less 1-Phase or up to 25k W 3-Phase [Note: Simplified Spot Network path is 30-90 days]	For inverter-based systems greater than 10 kW 1-Phase or greater than 25 kW 3-Phase and other systems of all sizes that are served by radial systems and meet other requirements.	All projects not eligible for simplified or expedited review, including all systems on networks
Typical Projects: small PV, demonstrations or homeowner wind	Typical Projects: certified large renewables, cogeneration, and other turbine or engines of any size	Typical Projects: uncertified large projects, unusually complex projects or projects of any size located on networks
Total Maximum Days: 15*	Total Maximum Days: 40 – 60*	Total Maximum Days: 125-150*

* Without delays

- Days listed apply to Company business days under normal business days.

Review Paths Side-by-Side

Review Process	Simplified	Expedited	Standard		Simplified Spot Network
Eligible Facilities	Listed Small Inverter	Listed DG	Any DG	Renewable DG	Listed Inverter ≤ 15 kW single-phase
Acknowledge receipt of Application	(3 days)	(3 days)	(3 days)	(3 days)	(3 days)
Review Application for completeness	10 days	10 days	10 days	10 days	10 days
Complete Review of all screens	10 days	25 days	n/a	n/a	Site review 30/90 days (Note 2)
Complete Supplemental Review (if needed)	n/a	20 days	n/a	n/a	n/a
Complete Standard Process Initial Review	n/a	n/a	20 days	20 days if Feasibility Study not requested	n/a
Send Follow-on Studies Cost/Agreement	n/a	n/a	5 days	5 days	n/a
Feasibility Study (if requested)	n/a	n/a	n/a	30 calendar days	n/a
Complete Impact Study or ISR DG (if requested)	n/a	n/a	55 days	The shorter of 55 days or 90 calendar days	n/a
Complete Detailed Study (if requested)	n/a	n/a	30 days	30 days	n/a
Send Executable Agreement (Note 3)	Done	10 days	15 days	15 days	Done (comparable to Simplified for radial)
Total Maximum Days (Note 4)	15 days	40/ 60 days (Note 5)	125/150 days (Note 6)	Varies depending on which studies are done (Note 6)	40/ 100 days
Notice/ Witness Test	< 1 day with 10 day notice or by mutual agreement	1-2 days with 10 day notice or by mutual agreement	By mutual agreement	By mutual agreement	1 day with 10- day notice or by mutual agreement

Simplified Review Path

- **Applies to:**
 - Single phase customers with listed single-phase inverter based systems 10kW or less on a radial feed
 - Three phase customers with listed three-phase inverter based systems 25kW or less on a radial feed.
 - *Listed* inverters:
 - Comply with current IEEE 1547 Standards
 - Have nationally recognized test lab results
- **Does not Apply to:**
 - Non-listed inverters or other generators (induction / synchronous / asynchronous)
 - Aggregate generation capacity of listed inverters that exceed the above-mentioned limits

Simplified Review Path

- **Typical process**
 - Submit complete application (use fax, scan/email, snail mail) – must be signed
 - Approval to install given within 10 business days in most cases
 - Install system and get certificate of completion (CoC) signed by local wiring inspector – submit to utility with electrical permit
 - Utility will change meter for net metering
 - Utility inspects within 10 days of receipt of CoC – utility can waive inspection

- **Advantages of Simplified**
 - No cost to customer (98% of cases)
 - Waived Application and Witness Test Fees
 - Rapid approvals

- The application has information the utility needs to update records and required reports to regulators

Table 1 of Section 3 in the Interconnection Tariff

Review Process	Simplified
Eligible Facilities	Listed Small Inverter
Acknowledge receipt of Application	(3 days)
Review Application for completeness	10 days
Complete Review of all screens	10 days
Complete Supplemental Review (if needed)	n/a
Complete Standard Process Initial Review	n/a
Send Follow-on Studies Cost/Agreement Feasibility Study (if requested)	n/a
Complete Impact Study or ISRDG (if requested)	n/a
Complete Detailed Study (if requested)	n/a
Send Executable Agreement (Note 3)	Done
Total Maximum Days (Note 4)	15 days
Notice/ Witness Test	< 1 day with 10 day notice or by mutual agreement

Expedited Review Path

- **Applies to:**
 - Single phase customers with listed single-phase inverter based systems >10kW on a radial feed
 - Three phase customers with listed three-phase inverter based systems >25kW on a radial feed.
- **Does not Apply to:**
 - Non-listed inverters or other generators (induction / synchronous / asynchronous)

Expedited Review Path

- Typically little or no (utility) system modifications required. If meter only – usually no charges passed to customer
- Application fee plus any Supplemental Review charges up to \$1,250 (if needed)
- Relay control system must be well defined to make supplemental review easier.
- Witness test fee of up to \$300 plus travel is required.

Table 1 of Section 3 in the Interconnection Tariff

Review Process	Expedited
Eligible Facilities	Listed DG
Acknowledge receipt of application	(3 days)
Review Application for Completeness	10 days
Complete Review of all Screens	25 days
Complete supplemental Review if needed	20 days
Complete Standard Process initial review	
Send Follow-on Studies Cost/Agreement	
Complete Impact Study (if needed)	
Complete Detailed Study (if needed)	
Send Executable Agreement	10 days
Total Maximum Days	40/60 days
Notice / Witness Test	1-2 days with 10 day notice or by mutual agreement

Supplemental Review

- If one or more Screens are not passed, the Company will provide a Supplemental Review Agreement.
- Customer signs agreement and pays fee for additional engineering time (max fee is \$1,250).
- The Supplemental Review may be able to determine what impacts the generation system will have and what (if any) modifications are required. If so - an interconnection agreement will be sent to customer detailing:
 - System modification requirements, reasoning, and costs for these modifications
 - Specifics on protection requirements as necessary
- If Supplemental Review cannot determine requirements, an Impact Study Agreement (or equal) will be sent to the customer. (You shift to the Standard Process.)

Standard Review Path

- **Applies to:**
 - Non-listed inverters or other generators:
 - Induction
 - Synchronous
 - Asynchronous
 - **Other large MW and Multi MW Projects**
 - **Renewable DG Customers / Developers**

Standard Review Path

- After initial review and/or supplemental review, customer may need to enter Standard Process
- Customer can request Standard Process
- Appropriate study agreement sent for signature and payment
- Studies could include:
 - Impact Study: Determine the impact of the new generator on potentially affected systems, including EPS, other customers and other generators
 - Detailed Facility Study: Determine utility system modifications required and cost
- ISO notification and possibly Transmission Study if over 1 MW
- After studies – interconnection agreement sent for signature
- Witness test fee is actual cost.

Table 1 of Section 3 in the Interconnection Tariff

Review Process	Standard	
	Any DG	Renewable DG
Eligible Facilities	Any DG	Renewable DG
Acknowledge receipt of Application	(3 days)	(3 days)
Review Application for completeness	10 days	10 days
Complete Review of all screens	n/a	n/a
Complete Supplemental Review (if needed)	n/a	n/a
Complete Standard Process Initial Review	20 days	20 days if Feasibility Study not requested
Send Follow-on Studies Cost/Agreement	5 days	5 days
Feasibility Study (if requested)	n/a	30 calendar days
Complete Impact Study or ISRDG (if requested)	55 days	The shorter of 55 days or 90 calendar days
Complete Detailed Study (if requested)	30 days	30 days
Send Executable Agreement (Note 3)	15 days	15 days
Total Maximum Days (Note 4)	125/150 days (Note 6)	Varies depending on which studies are done (Note 6)
Notice/ Witness Test	By mutual agreement	By mutual agreement

Responsibility of Costs

- **Interconnecting customer responsible for:**
 - Application Fee
 - Simplified Process: Fee Waived (except for Simplified spot network)
 - Expedited and Standard: \$3/kW (\$300 min and \$2,500 max)
 - Renewable DG: Feasibility Study Fee is required in lieu of Application Fee
 - Costs of impact and detailed studies if required
 - Grid modification requirements – can include ongoing charges
 - Witness Test Fee
 - Costs associated with design, construction and installation of the facility and all associated interconnection equipment on the customer's side of the meter
 - Many projects will not require impact or detailed studies or EPS upgrades
 - **See Fee Schedule for details**

Interconnection Process Fee Schedule

	Simplified	Expedited	Standard		Simplified Spot Network
	Listed Small Inverter	Listed DG	Any DG including Renewable DG not requesting a Feasibility Study or ISRDG	Renewable DG requesting a Feasibility Study or ISRDG	Listed Inverter ≤ 15 kW
Application Fee (covers Screens)	0 (Note 1)	\$3/kW, minimum \$300, maximum \$2,500	\$3/kW, minimum \$300, maximum \$2,500	N/A	≤\$3/kW \$100, >3 kW \$300
Supplemental Review or Additional Review (if applicable)	N/A	Up to 10 engineering hours at \$125/hr (\$1,250 maximum) (Note2)	N/A	N/A	N/A
Standard Interconnection Initial Review	N/A	N/A	Included in application fee (if applicable)	N/A	N/A
Feasibility Study	N/A	N/A	N/A	Residential : ≤25kW: \$0 >25kW: \$50 Non-residential: ≤100kW: \$100 ≤250kW: \$300 250kW–1MW: \$1,000 >1MW: \$2,500	N/A
Impact Study or ISRDG	N/A	N/A	Actual cost (Note 3)	Residential : ≤25kW: \$0 >25kW: \$100 Non-residential: ≤100kW: \$500 ≤250kW: \$1,000 250kW–1MW: \$5,000 >1MW: \$10,000 (Note 4)	N/A
Detailed Study (if required)	N/A	N/A	Actual cost (Note 3)	Actual cost (Note 3)	N/A
Facility Upgrades	N/A (Note 5)	Actual cost	Actual cost	Actual cost	N/A
O&M (Note 6)	N/A	TBD	TBD	TBD	N/A
Witness Test	0	Actual cost, up to \$300 + travel time (Note 7)	Actual Cost	Actual Cost	0 (Note 8)

Third Party Ownership

- Application must include information for both generation owner (interconnecting Customer) and electric or retail customer (Customer)
- Utility will correspond with owner, customer and installer
 - Listing email addresses for all parties on application makes communication easier and faster
- Utility will enter into agreement with our electric customer (Exhibit H of RIPUC #2078 tariff)
- ***Note:** Any Ownership change would require updated documentation submitted to the Utility Company

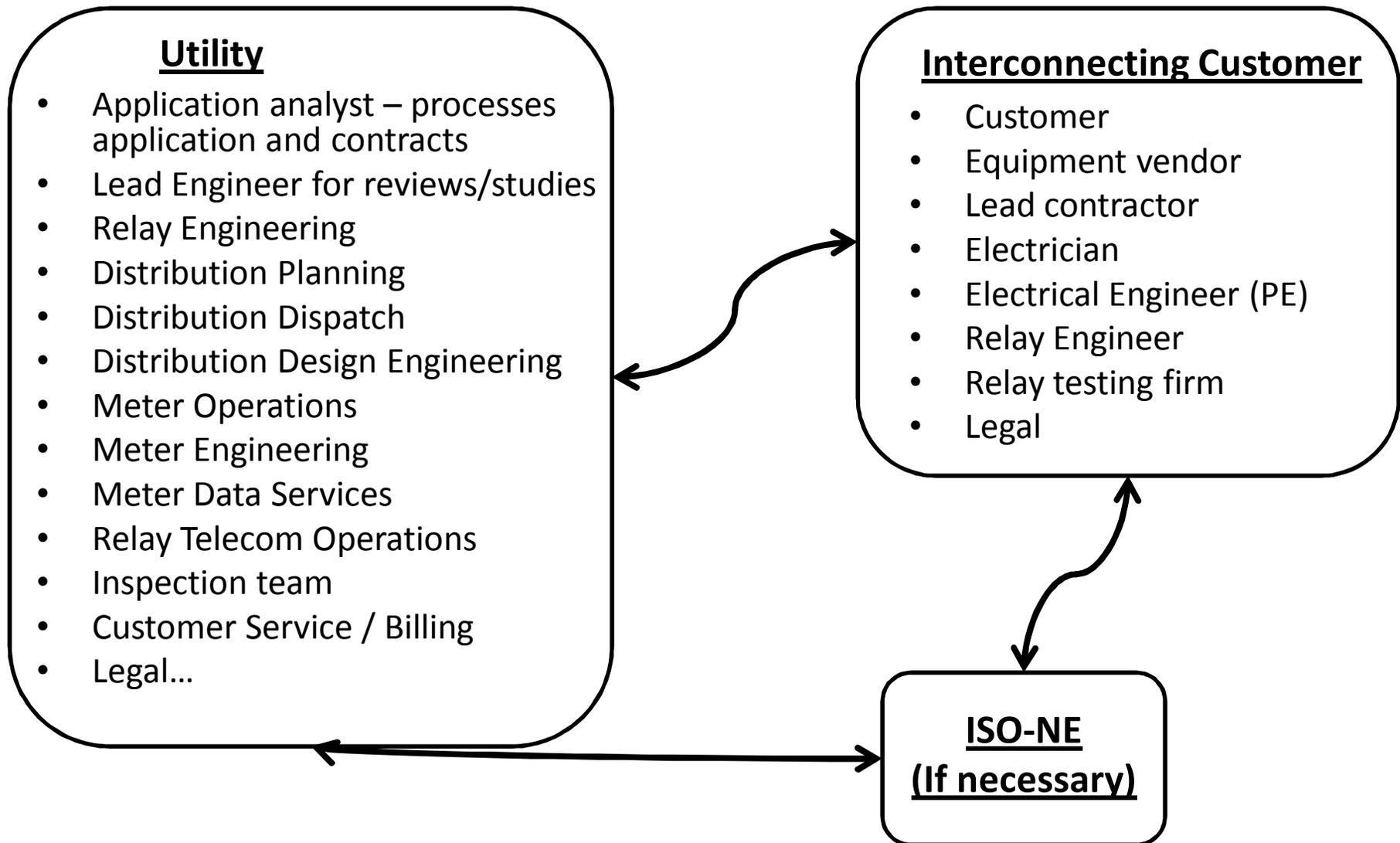
Common Application Mistakes

- Number of inverters being used not indicated
- Utility account or meter number not included or incorrect
- Address of facility not correct
- Name on application differs from name on utility account
- Application not signed
- Ownership of property not identified
- Not identifying third party ownership of generator

Common process delays

- New construction or service upgrade
- Host/Owner misidentification
- Changing inverter or other equipment
- Not supplying electrical permit
- Certificate of Completion (CoC) signed and dated before date given approval to install

Many Stakeholders Involved



Behind the scenes at utility...

- Review and replacement of metering, modifications to billing
- Modifications to protection systems as required (e.g. replace or install fusing, install switch, modify breaker/recloser set-points, transfer trip, etc.)
- Larger generators require review by NEPOOL reliability committee and registration with ISO-NE
- Adding generation asset to geographic information systems, maps, system one-lines, dispatch systems, etc.
- Publish internal special operating guidelines for utility field personnel on larger generators.
- Set up future testing for relay protection, meter calibration, insurance tracking, etc.

Interconnection Summary and Recommendations

- *Submit your interconnection application with National Grid early*, during conception phase before committing to buy no matter how simple or small the DG might be.
- You can always request general utility information about a specific location from your utility
- Large interconnection application take longer to study
- Stand alone (no load behind the meter) interconnection application take longer to study
- Interconnection timeframes do not apply to Electric Power System construction if required.

Summary and Recommendations

continued

- The Interconnection Standard is a wealth of information – get to know it
- Time frames are standard working days and do not include delays due to missing information
- Interconnection expenses such as application fees, required studies, potential system modifications and witness tests should be budgeted into each project
- Hire an engineer to help with application process
- ISO-NE notification not included in time frame
- Interconnection applications have increased significantly in the past few years – **APPLY EARLY!!!**

Interconnection Contacts & Tariff Links

Contacting National Grid in RI about DG:

- Tariff Link:

https://www.nationalgridus.com/narragansett/home/energyeff/4_interconnect.asp

- Net Metering Link:

https://www.nationalgridus.com/narragansett/home/energyeff/4_net-mtr.asp

- Simplified Process, All Applications

- Email: Distributed.Generation@nationalgrid.com

- Expedited/Standard Process: John Kennedy

- Office: 401-784-7221.

- E-mail: john.kennedy@nationalgrid.com

- Address: 280 Melrose Street, Providence, RI 02907

Customer Call Center: 1-800-322-3223

- This begins a customer inquiry for information by the Company in accordance with the Standards for Interconnecting Distributed Generation.

✓ Requirements need to be met prior to connection!

Other Information Resources

- RI OER Website:
<http://www.energy.ri.gov/index.php>

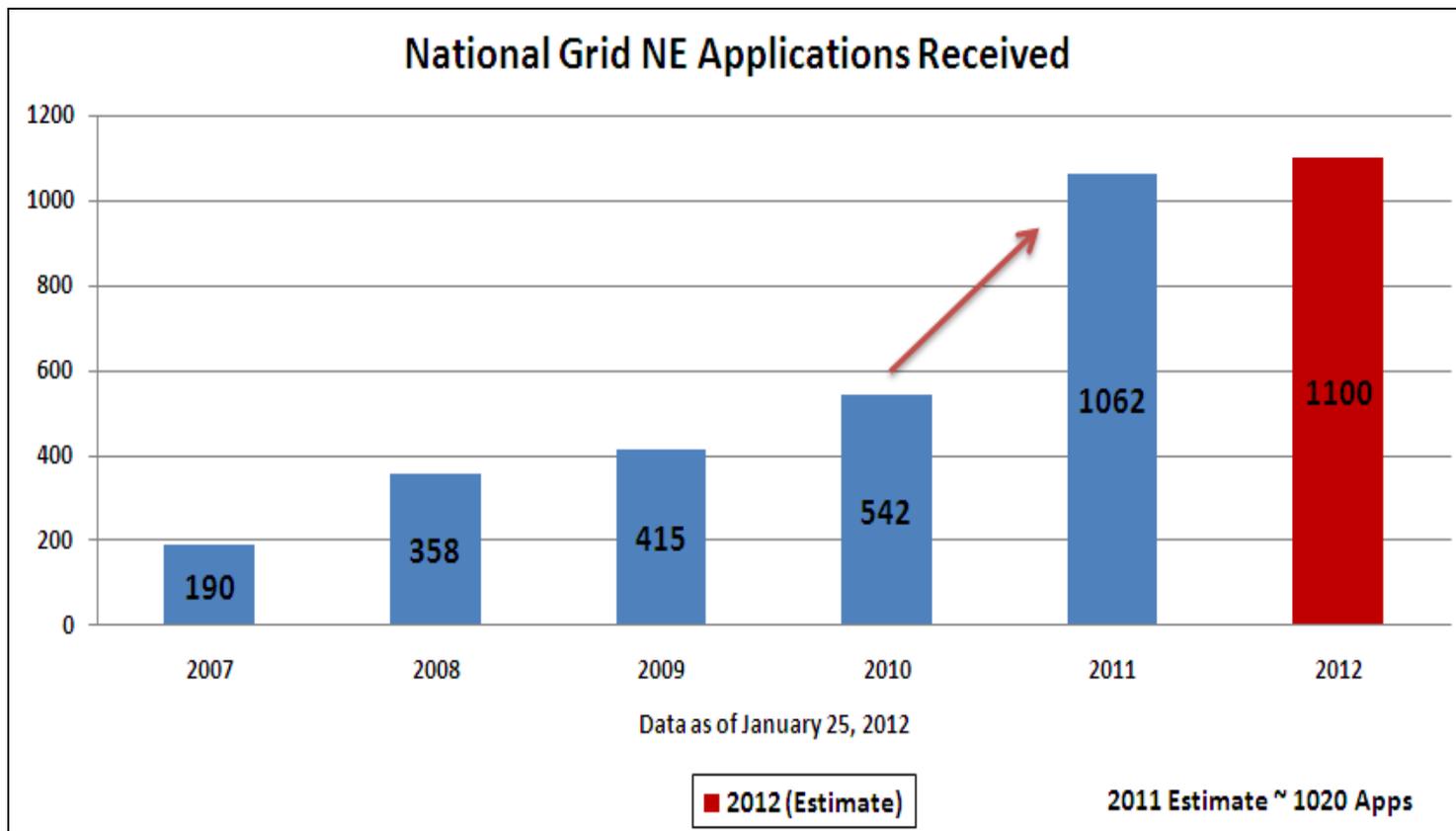


- RI PUC Website:
<http://www.ripuc.org/utilityinfo/electric.html>



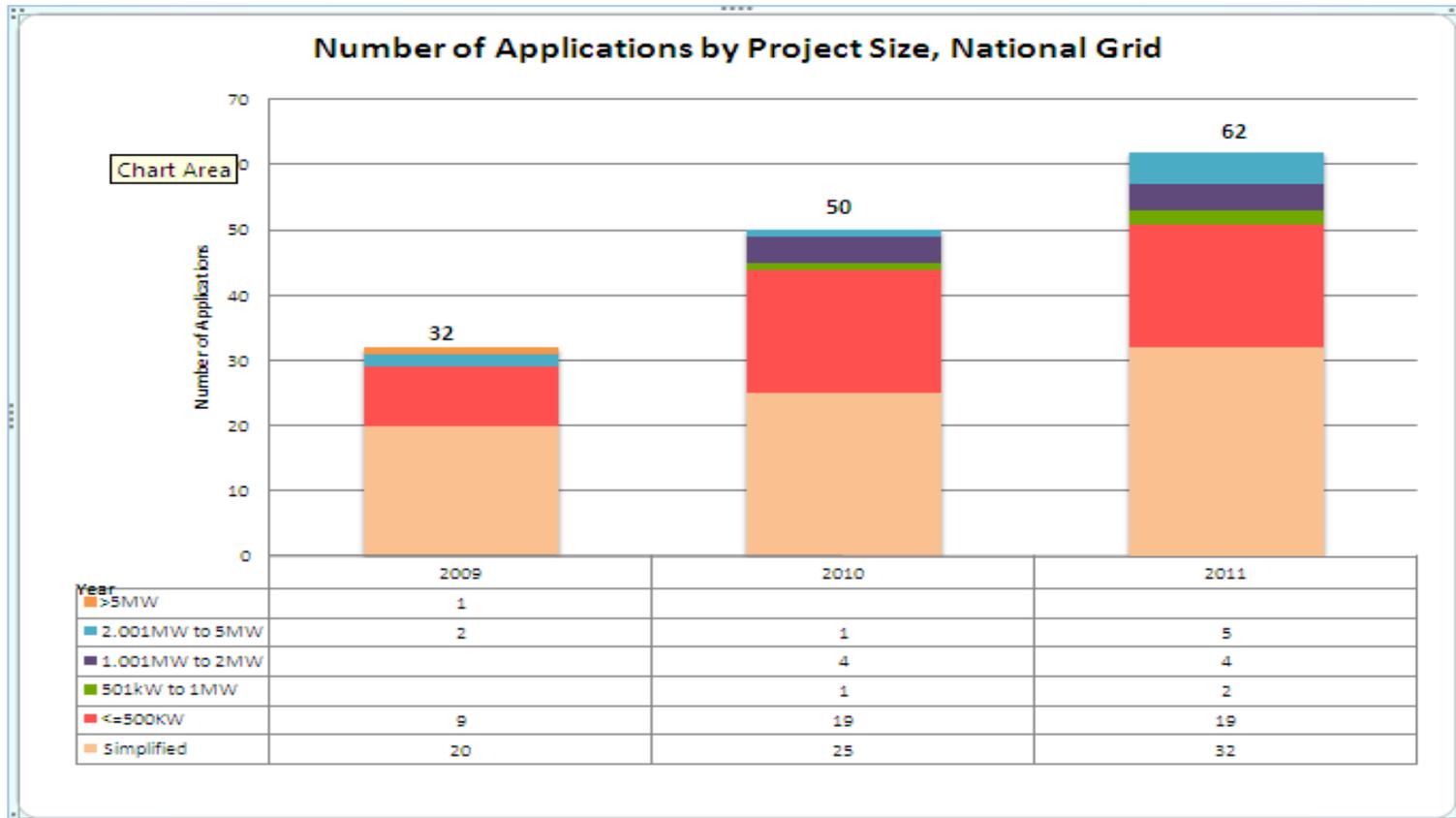
DG Activity Trends - NE

- Received over **1062** applications worth more than **360 MW** of interconnection applications in 2011
- Received over 700 applications; more than 265 **MW** in the last 5 months of 2011 and we anticipate receiving more unprecedented volume in 2012



DG Activity Trends - RI

- Received over **62** applications worth more than **30 MW** of interconnection applications in 2011
- We expect activity to increase in similar proportions in 2012.



DG Contracts
ISO Process
Net Metering

RI DG Standard Contracts

- Long-term standard contracts for the purchase of energy, capacity and RECs for 15 year terms from eligible DG facilities
- Three “enrollments” per year for a total of 40 MW nameplate over 4 years
 - By December 30, 2011: 5 MW (nameplate)
 - By December 30, 2012: an aggregate of 20 MW
 - By December 30, 2013: an aggregate of 30 MW
 - By December 30, 2014: an aggregate of 40 MW
- Eligible Projects
 - “Newly Developed Renewable Energy Resource”¹
 - Located in the Narragansett Electric Company ISO-NE load zone
 - Nameplate capacity no greater than five (5) MW
 - Connected to the electric distribution company’s power system

¹As defined under R.I.G.L. § 39-26-5 and Section 5 of the Rules and Regulations governing the Implementation of a Renewable Energy Standard, effective July 25, 2007

RI DG Standard Contracts

- Small DG projects – nameplate capacity no larger than the following:
 - Solar: 500 kW; Wind: 1.5 MW; and Other Technologies: 1 MW
 - Receive applicable ceiling price²
- Large DG projects – nameplate capacity larger than the Small DG limits set forth above, but no greater than 5 MW
 - Bid a fixed bundled price below applicable ceiling price
- Ceiling Prices are fixed bundled prices for energy, capacity and RECs
- Projects must be built within 18 months of contract execution
- Two week open enrollment
 - Submit conforming application
 - Submit completed feasibility study or impact study with application
- 2 Applications and Standard Contracts according to facility size
 - Nameplate capacity of 500kW or less
 - Nameplate capacity greater than 500kW

²Ceiling Prices, Classes and Targets are set by OER, until Board is constituted.

State vs. ISO-NE Process

- This presentation will review the interconnection standard (Interconnection Tariff) applicable to generators that will connect (grid tied) to the Distribution System (either to a 69 kV line or lower).
- Generally, generation systems are considered DG if they are going to connect to the distribution system. In this case, the owner must follow the local utility's interconnection process.
- If you would like to apply to the transmission system (generally larger systems), you need to apply to the New England Independent System Operator (ISO-NE), and are not considered DG.
- If you will be selling your power to a third party, you may have to apply through ISO-NE
- If circuit is already "FERC Jurisdictional" you may need to apply to ISO-NE.
http://www.iso-ne.com/genrtion_resrcs/nwgen_inter/index.html

When is ISO-NE Notification or Study Required?

- Proposed Plan Applications (PPA):
 - 0 - 0.999 MW cumulative increase* - no form required
 - 1.000 - 4.999 MW cumulative increase* - notification form required to go to **Reliability Committee**.
 - Submitted after Impact Study is completed.
 - Transmission Owner submits PPA if generator is not a NEPOOL participant.
 - If generator is NEPOOL participant, Transmission Owner must review PPA first.
 - > 4.999 MW cumulative increase* - PPA and studies required to go to **Stability** and **Transmission Task Forces** and **Reliability Committee**
 - After Impact Study completed, determine if any Substation / Transmission upgrades required.
 - Transmission Owner and Task Forces need to agree if transmission study will/will not be required.
 - Transmission Owner submits PPA if generator is not a NEPOOL participant.
 - If generator is NEPOOL participant, Transmission Owner must review PPA first.
 - A stability model will likely be required.
- Refer to Planning Procedure 5-1

* NOTE = cumulative increase from last approved PPA

When is an Interconnection Request Submitted to ISO-NE?

- Interconnecting generation to a distribution circuit which already has a wholesale transaction (FERC Jurisdictional)
- You will be selling your power to a third party
- Increasing capacity of an existing generating facility*
- Materially modify an existing generating facility*
- Changing from energy only (NR) to energy and capacity unit (CNR)
- There is no minimum size

* NOTE = Generation facility with wholesale sales of electricity in interstate commerce (i.e. not Net Metered or compensated under Power Purchase Schedule).

Net Metering in Rhode Island

- December 2011 Net Metering Provision Tariff
 - **“Eligible Net Metering Resource”** shall mean eligible renewable energy resource as defined in R.I.G.L. Chapter 39-26-5 including biogas created as a result of anaerobic digestion, but, specifically excluding all other listed eligible biomass fuels.
 - **“Eligible Net Metering System”** shall mean a facility generating electricity using an Eligible Net Metering Resource that is reasonably designed and sized to annually produce electricity in an amount that is equal to or less than the Renewable Self-generator’s usage at the Eligible Net Metering System Site measured by the three (3) year average annual consumption of energy over the previous three (3) years at the electric distribution account(s) located at the Eligible Net Metering System Site.

Net Metering in Rhode Island

- **“Eligible Net Metering System Site”** shall mean the site where the Eligible Net Metering System is located or is part of the same campus or complex of sites contiguous to one another and the site where the Eligible Net Metering System is located or a farm in which the Eligible Net Metering System is located.
 - Except for an Eligible Net Metering System owned by or operated on behalf of a municipality or multi-municipal collaborative through a municipal net metering financing arrangement, the purpose of this definition is to reasonably assure that energy generated by the Eligible Net Metering System is consumed by net metered electric delivery service account(s) that are actually located in the same geographical location as the Eligible Net Metering System.
 - Except for an Eligible Net Metering System owned by or operated on behalf of a municipality or Multi-municipal Collaborative through a Municipal Net Metering Financing Arrangement, all of the Net Metered Accounts at the Eligible Net Metering System Site must be the accounts of the same customer of record and customers are not permitted to enter into agreements or arrangements to change the name on accounts for the purpose of artificially expanding the Eligible Net Metering System Site to contiguous sites in an attempt to avoid this restriction. However, a property owner may change the nature of the metered service at the delivery service accounts at the site to be master metered (as allowed by applicable state law) in the owner’s name, or become the customer of record for each of the delivery service accounts, provided that the owner becoming the customer of record actually owns the property at which the delivery service account is located.
 - As long as the Net Metered Accounts meet the requirements set forth in this definition, there is no limit on the number of delivery service accounts that may be net metered within the Eligible Net Metering System Site.

Net Metering Credits

- Energy use is “netted” over the billing month
 - If there is net energy use – utility will bill customer for net use
 - If net energy export – export kWh * the following
 - Renewable installations will be credited at near retail rate for excess kWh (minus conservation and renewable energy charges).
- Tariff allows credits to be allocated (with limitations)
- Customer still responsible for customer charges and demand charges

			Credit the following charges			
min	max	Type	Default Service	Distribution	Transmission	Transition
0	5,000 KW	Renewable	X	X	X	X

Net Metering Credits

- If there is excess at the end of the year
 - **“Excess Renewable Net Metering Credit”** shall mean a credit that applies to an Eligible Net Metering System for that portion of the Renewable Self-generator’s production of electricity beyond one hundred percent (100%) and no greater than one hundred twenty-five (125%) of the Renewable Self-generator’s own consumption at the eligible net metering system site during the applicable billing period. Such Excess Renewable Net Metering Credit shall be equal to the Company’s avoided cost rate, defined for this purpose as the Standard Offer Service kilowatt-hour (kWh) charge for the rate class and time-of-use billing period, if applicable, applicable to the delivery service account(s) at the Eligible Net Metering System Site.
- Customer must file Schedule B in the net-metering tariff to apply
 - https://www.nationalgridus.com/narragansett/home/energyeff/4_net-mtr.asp

THE NARRAGANSETT ELECTRIC COMPANY
NET METERING PROVISION

Schedule B

INFORMATION REQUIRED FOR APPLICATION OF RENEWABLE NET METERING
AND EXCESS RENEWABLE NET METERING CREDITS

Date: [REDACTED]

Net Metering Customer ("NMC"): [REDACTED]

NMC Address:

[REDACTED]
[REDACTED]
[REDACTED]

Estimated annual generation in kWhs of Eligible Net-Metering System:

[REDACTED]

Net Metered Account(s)

The following information must be provided for each individual Net Metered Account:

Name: [REDACTED] (Except in the case of a municipal or Multi-municipal Collaborative, the customer of record must be the same as the NMC)

Service Address: [REDACTED]

National Grid Account Number: [REDACTED]

Three (3) years average kWh usage for this account: [REDACTED]

Total three (3) years average kWh usage for all accounts listed: [REDACTED]

Net Metering Summary

- If planning to Net Meter, submit Schedule B with interconnection application
- Correctly fill out Schedule B
 - Name must match electric account of Host Customer
 - Must be signed by Host Customer
- If allocating, verify name/address/account info of customer(s) – or will need to submit corrected form

Compensation if not Net Metered

- If the customer will never export power – no concern
- If customer will export power – they can sell their exported power to the market through a registered market participant.
 - If customer has a Qualifying Facility (QF) certificate from FERC for the generator, they can “sell” to local utility (Power Purchase Schedule).
 - Customer can work with any registered market participants to sell power
 - Customer must pay for all power they use.

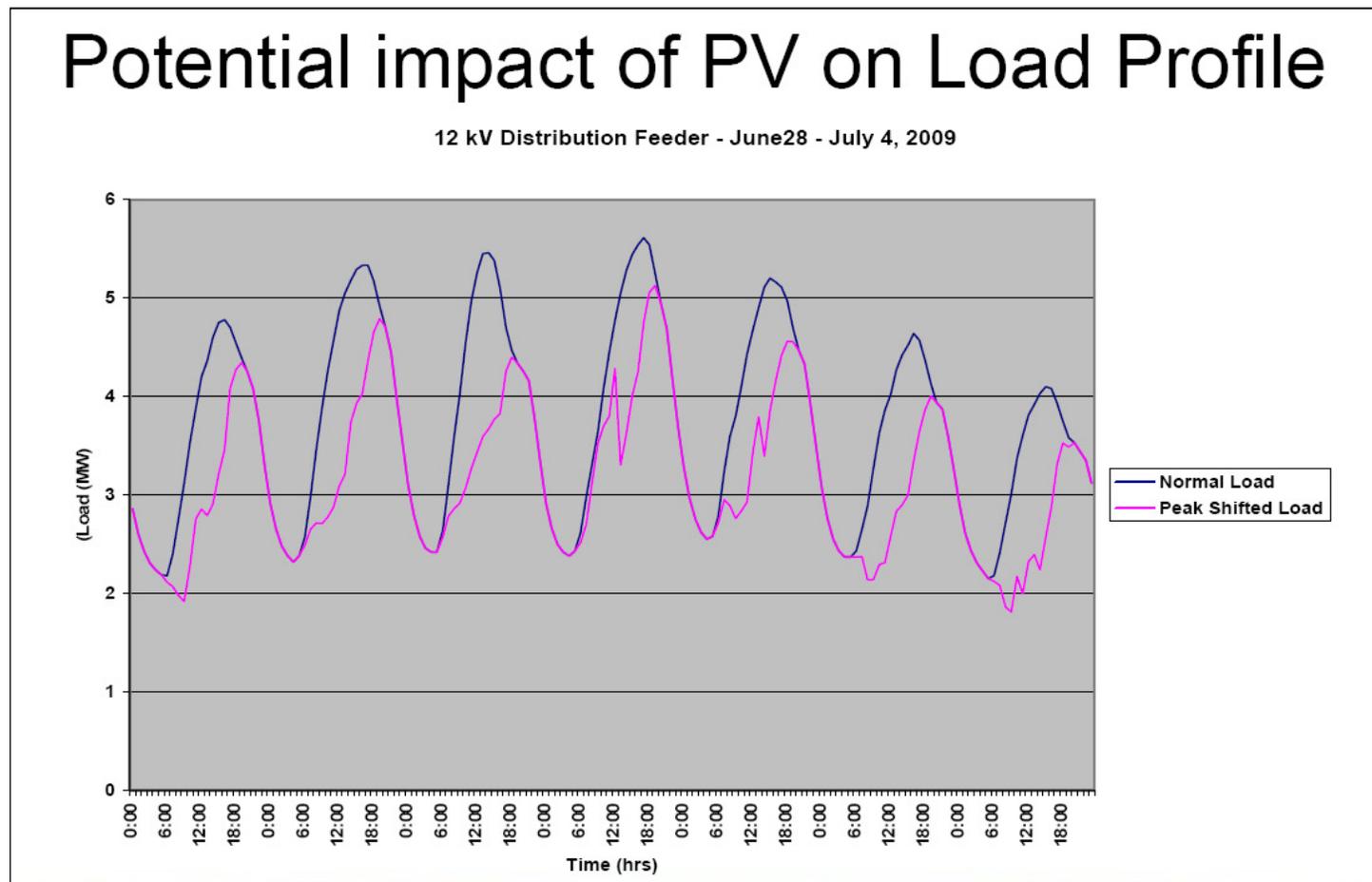
FERC QF page: <http://www.ferc.gov/industries/electric/gen-info/qual-fac.asp>

Break: 5 Minutes.

Interconnection of Distributed Generation: Impacts and Issues Created

Technical Issues – Accommodating DG

- DG reduces load on the system
- Multiple systems on a line can pose unique challenges



Technical Issues - Size

- Interconnection Applications on **non-dedicated** circuits:
 - Largest wind application is 4.5 MVA on 13 kV class circuits
 - Largest Solar application is 6 MVA on 23 kV class circuits
- Interconnection Applications on **dedicated** circuits:
 - Largest wind application is 30 MVA on ?? kV class circuits
 - Largest Solar application is 9 MVA on 13 kV class circuits

Upgrades and System Modifications

Typical Costs & Schedules for Upgrades

- Distribution Feeder
 - Regulator \$60-200K 2-6 mos.
 - Cap move \$3-10K 1-3 mos.
 - New Capacitor \$17-25K 1-6 mos.
 - Re-conductor \$200-400k/mi 6-12 mos.
 - Express Feeder \$350-600k/mi 8-18 mos.
- Transformer
 - Line Xfrmr \$2-25K 1-3 mos.
 - Substation Xfrmr \$2-4 million 18-24 mos.

Technical Issues: Area Networks

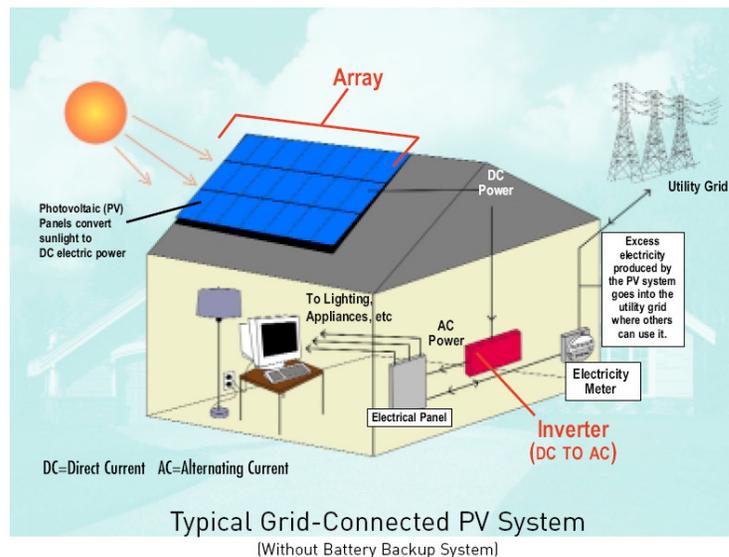
Area Networks consist of one or more primary circuits from one or more substations or transmission supply points arranged such that they collectively feed secondary circuits serving one (a spot network) or more (an area network) Interconnecting Customers.

Portions of Pawtucket and Providence, RI are served by area networks(customers in these areas should ask where the nearest radial system is located for possible tie-in).

Technical Aspects of Integrating DG^{nationalgrid} with National Grid's Distribution EPS

➤ Objective:

Our focus will be for Developers, Installers, and DG Customers on **technical issues** and **installations of DG facilities** on National Grid's distribution electric power systems within **jurisdictional interconnection standards**.



Interconnection Standards: Jurisdictional Tariffs

nationalgrid

- **Jurisdictional Tariffs (MA, Upstate NY, RI, and NH and FERC)**

- ***RI: R.I.P.U.C. 2078***

https://www.nationalgridus.com/narragansett/home/energyeff/4_interconnect.asp

- ***MA: M.D.P.U. 1176***

https://www.nationalgridus.com/non_html/Expedited%20Standard%20Interconnection/InterconnectStds_MA.pdf

- ***Upstate NY: PSC No. 220, Rules 36, 37, & 53***

http://www.nationalgridus.com/niagaramohawk/non_html/rates_psc220.pdf

<http://www.dps.state.ny.us/distgen.htm>

- ***NH: N.H.P.U.C. 17***

https://www.nationalgridus.com/non_html/Interconnect_stds_NH.pdf

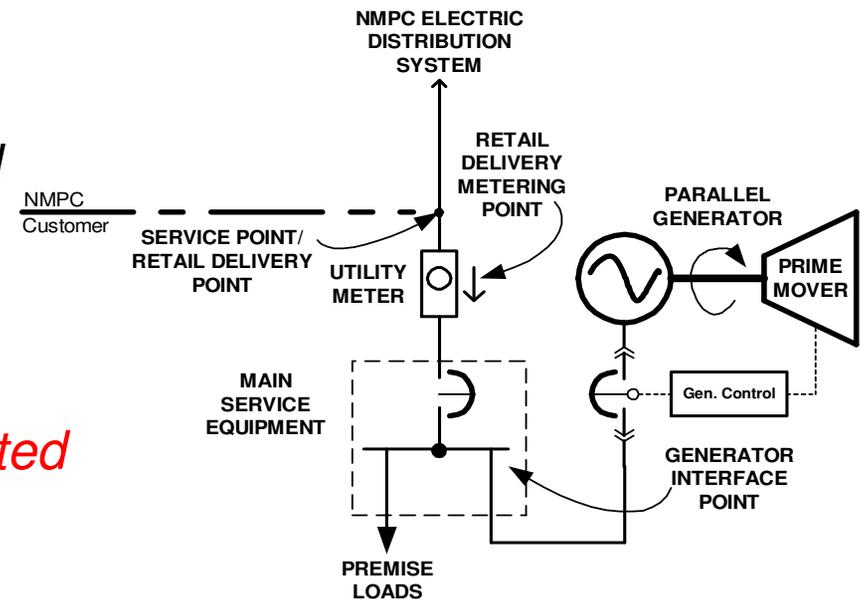
- ***FERC Small Generator Interconnection Procedures (SGIP)***

Interconnection Standards: (cont'd)

Industry Standards and Codes

What are **industry standards and codes** that apply to **DG interconnections to the EPS?**

- IEEE standards applicable to DG installations:
 - **IEEE 929** “IEEE Recommended Practice for Utility Interface of Photovoltaic (PV) Systems”
 - **IEEE 1094** “IEEE Recommended Practice for the Electrical Design and Operation of Windfarm Generating Stations”
 - **IEEE 1547** “Standard for Distributed Resources Interconnected with Electric Power Systems”



PARALLEL GENERATION EXAMPLE

Interconnection Standards: *(cont'd)* nationalgrid

Industry Standards and Codes

➤ Other IEEE standards:

- **IEEE 519** “Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems”
- **IEEE 1453** “Recommended Practice for Measurement and Limits of Voltage Flicker on AC Power Systems”
- **IEEE C37.90.1** “Standard Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus”
- **IEEE C37.90.2** “Standard Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers”
- **IEEE C37.90.3** “Standard Electrostatic Discharge Tests for Protective Relays”

Interconnection Standards: *(cont'd)*

Industry Standards and Codes

➤ Product Standards

Applicable standards:

- UL 1703 | UL 61730 | **UL 1741**
- **UL 1741 “Inverters, Converters and Charge Controllers for Use in Independent Power Systems”**
- IEC 61215 | IEC 61646 | IEC 61730



<http://www.ul.com/>

✓ **Inspections** are needed for safe, quality installations!

Interconnection Standards: *(cont'd)* nationalgrid

Industry Standards and Codes

- **NERC Standard FAC-001-0 - Facility Connection Requirements**
 - ✓ **Summary:** *To avoid adverse impacts on reliability, Transmission Owners must establish facility connection and performance requirements.*
 - ✓ items R2.1.1 through R2.1.16
- **Northeast Power Coordinating Council**
 - **Standard *PRC-002-NPCC-01 - Disturbance Monitoring***
 - ✓ **Purpose:** *Ensure that adequate disturbance data is available to facilitate Bulk Electric System event analyses. All references to equipment and facilities herein unless otherwise noted will be to Bulk Electric System (BES) elements.*
 - **Criteria Document *A-15 - Disturbance Monitoring Equipment Criteria***

Interconnection Standards: *(cont'd)*

Industry Standards and Codes

➤ NFPA

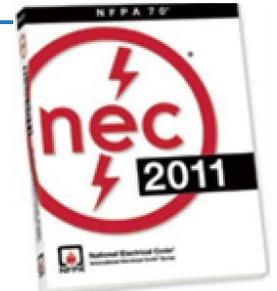
- **NFPA 70** “*National Electrical Code*” (**NEC**)
- **NFPA 70B** “*Recommended Practice for Electrical Equipment **Maintenance***”
- **NFPA 70E** “*Standard for Electrical **Safety** in the Workplace*”
- **NFPA 850** “*Recommended Practice for **Fire Protection** for Electrical Generating Plants and High Voltage Direct Current Converter Stations*”

Interconnection Standards: *(cont'd)*

Industry Standards and Codes - NEC

Codes for Installing Renewable Energy Sources

- *Article 690 National Electrical Code*
 - Requirements for Photovoltaic Installations in Premises Wiring
 - *Article 692 National Electrical Code*
 - Requirements for Fuel Cell Installations in Premises Wiring
 - *Article 694 National Electrical Code*
 - Requirements for Small Wind Electric Energy System Installations in Premises Wiring
 - *Article 705 National Electrical Code*
 - Requirements for Interactive Installations in Premises Wiring
- ✓ **Inspections** are needed for safe, quality installations!



Interconnection Standards: Local Rules – National Grid

What are the local rules that apply to DG interconnections?

- **National Grid ESB 756 Parallel Generation Requirements**
 - *Originates from the **ESB 750 Series** and applicable Company **tariffs** in each state jurisdiction*
 - ***ESB 756** main document*
 - ***Appendices** to ESB 756 for Jurisdictional Requirements*

Some **key factors** that influence the revision/update of Electric Service Requirements are:

- **Government**

- DPU (Massachusetts), PSC (NY), and PUC (one each for NH & RI)
- FERC
- Federal, State, and Local Laws

- **Company tariffs**

- **Company policies & practices**

- **National codes**

Each utility has their requirements pursuant to the regulations that govern them as varying from state-to-state based on the NESC.

Interconnection Standards: *(cont'd)*

National Grid ESB 750 Series

Key Points for Electric Service Requirements:

- Require some means of **disconnect and main overcurrent protection**, i.e., **service equipment**.
- Billing **meters secure**.
- Interface points clear to **avoid potential operating and safety problems**.

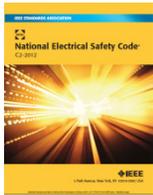


Key Points for **Parallel Generation** Requirements:

- **Company determines** the interconnect voltage and method of interconnection.
- **Prior notification to and approval by the Company** is required for any generation to be installed or operated in parallel with the Company EPS.

ESB 750 Figure 2-1 TYPICAL SERVICE INSTALLATION DIAGRAM BELOW 600 VOLTS – EXCLUDING NETWORK

➤ **Supply Side**



NESC Rule 011

NEC 90.2(B)

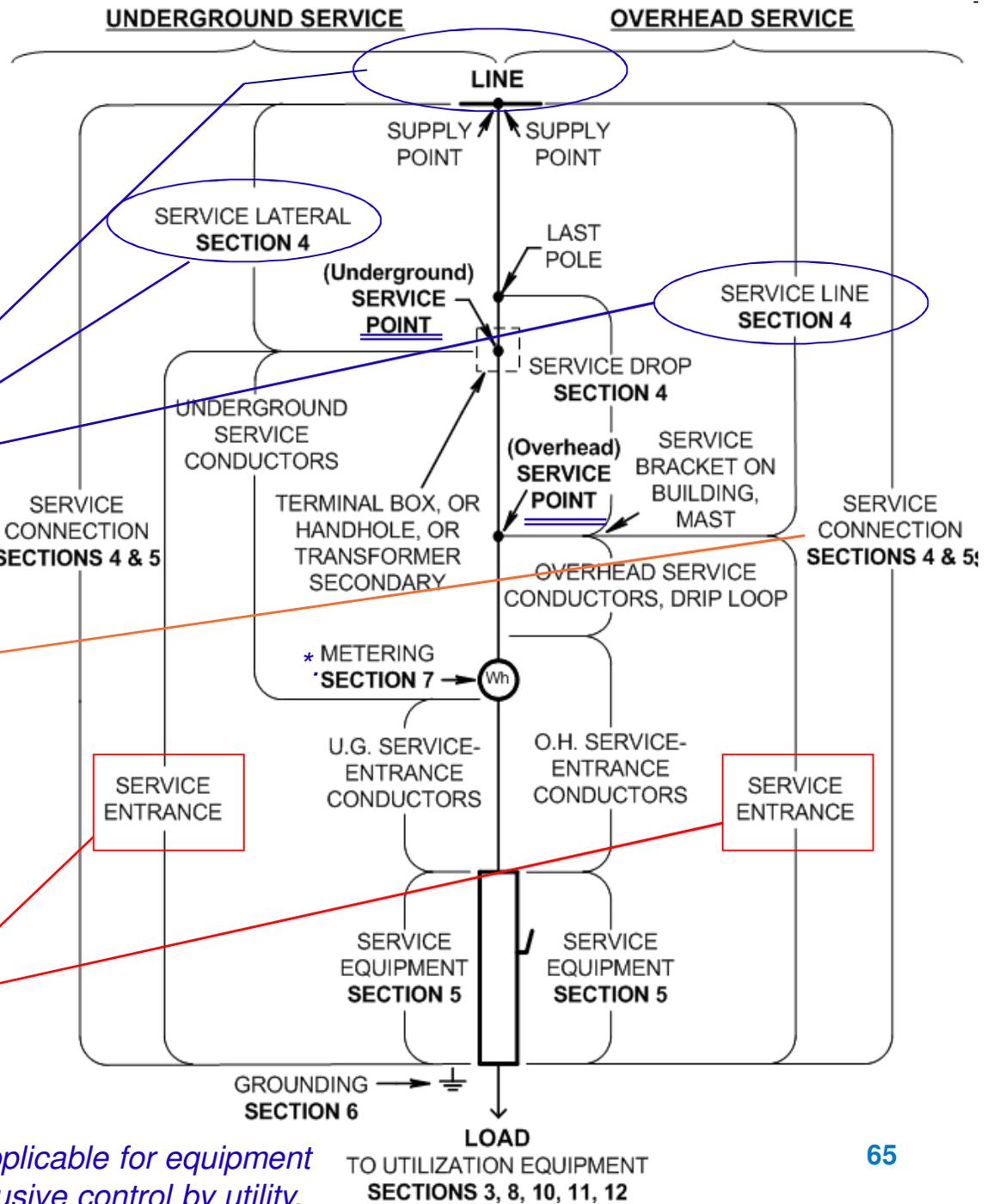
➤ includes the service lateral or service line, service entrance conductors, meter provision, service equipment, and grounding where the Electric Utility has Mutual Interest

➤ **Premises Wiring**



NEC 90.2(A)

* NESC applicable for equipment under exclusive control by utility.

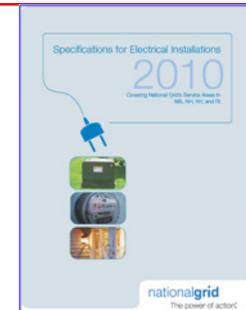


Interconnection Standards: (cont'd) National Grid ESB 756 - ESB 750 Series

nationalgrid

ESB 750 Specifications for Electrical Installations

- ESB 751 General Requirements Above 600-volt Service (*under development*)
- ESB 752 Service above 15,000 volts
- ESB 753 Primary Meter Pole
- ESB 754 Outdoor Pad Mounted or Vault Enclosed Three Phase Transformer
- ESB 755 Operation & Maintenance Requirements for Service Above 600 volts



ESB 756 General Requirements for Parallel Generation Connected to a National Grid Owned EPS

- **Appendix A** Requirements for Parallel Generation Connected to National Grid Facilities in NY
- **Appendix B** Requirements for DG Connected to National Grid's Distribution per the NYS SIR
- **Appendix C** Requirements for Parallel Generation Connected to National Grid Facilities in Massachusetts
- **Appendix D** Requirements for Parallel Generation Connected to National Grid Facilities in Rhode Island
- **Appendix E** Requirements for Parallel Generation Connected to National Grid Facilities in New Hampshire

- ESB 757 Network Services
- ESB 758 Primary Service to Metal Enclosed Gear
- ESB 759A Underground Residential Distribution (URD) Installation and Responsibility Guide
- ESB 759B Underground Commercial Distribution (UCD) Installation and Responsibility Guide

✓ The **Appendices** to **ESB 756** are intended for **jurisdiction-specific requirements**.

http://www.nationalgridus.com/non_html/shared_constr_esb756.pdf⁶⁶

Interconnection Standards: *(cont'd)* nationalgrid

National Grid ESB 756

- ESB 756 references all requirements for parallel generation connected to National Grid facilities located in Massachusetts, Upstate New York, Rhode Island, and New Hampshire.

The **purpose** of this National Grid Electric System Bulletin (ESB) is to:

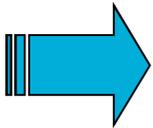
- 1. Provide general requirements and recommendations for all generators connected in parallel with the electric power system (EPS) operated by National Grid (Company).** *Stand alone generators serving isolated load, which can never be connected in parallel with the Company EPS, are not subject to these requirements.*
- 2. Ensure compliance with NERC Standard FAC-001-0 – Facility Connection Requirements, effective April 1, 2005.** *Along with all of the Company's Electric System Bulletins, the most current version of ESB 756 is available electronically on its National Grid USA web page at: www.nationalgridus.com/electricalspecifications.*
- 3. Ensure that the electrical reliability and security of the Company EPS and the larger power system grid is maintained following connection of the parallel generator to the utility supply.**
- 4. Refer Generator-owners to the applicable FERC or state-specific tariff regulations pertaining to parallel generators.**

Interconnection Standards: *(cont'd)*

National Grid ESB 756 - Appendix D

- **ESB 756 Appendix D** applies to the Rhode Island Standards for Connecting Distributed Generation

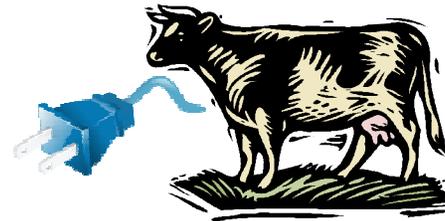
- According to Narragansett Electric Company Standards for Connecting Distributed Generation, R.I.P.U.C. No 2078, December 2011
- Describes the process and requirements for National Grid's customers in Rhode Island for those instances when a Customer desires to connect a customer-owned Generating Facility to the **Narragansett Electric's distribution system**.



1. *Will include new tariff – Second Quarter 2012.*
2. *Purpose to assist customers desiring to interconnect DG projects to National Grid's Rhode Island distribution system for State jurisdictional projects.*
 - *Provides general requirements, recommendations, and assistance to customers regarding the DG facilities connected in parallel to the Company's distribution electric power system. These projects are typically 5 MWs or smaller in size.*

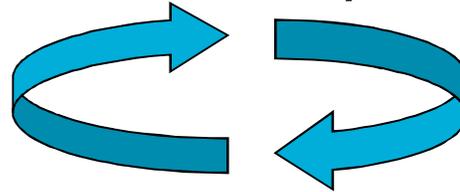
Interconnection of Distributed Generation: Technical Issues

nationalgrid



Technical Issues:

- **Technical Process End-to-End (Study to Energization/Synchronization) with National Grid**



- **Technical Submittals for Utility Review**
- **Potential Impacts of Parallel Generation on Distribution Electrical Power Systems (EPS)**
- **Limits on National Grid Distribution EPS**
 - *Radial Systems*
 - *Network Systems*
- **Service Connections of Small Net Metered DGs < 600V**
- **Typical Distribution EPS Upgrade Costs for Complex DG Installations**

Technical Issues: Technical Process End-to-End



Refer to the appropriate **Appendix** of ESB 756 for the state jurisdiction where DG application is made.

- For example in RI, see **ESB 756 Appendix D** (*coming soon*)
 - See **Section 4.0** for *Interconnection Requirements*
- Ensure all technical information required in the DG application under the applicable National Grid tariff is complete and legible. *Additional manufacturer technical data may be submitted for understanding the specified electric source's characteristics to perform the studies.*

Technical Issues: (cont'd)

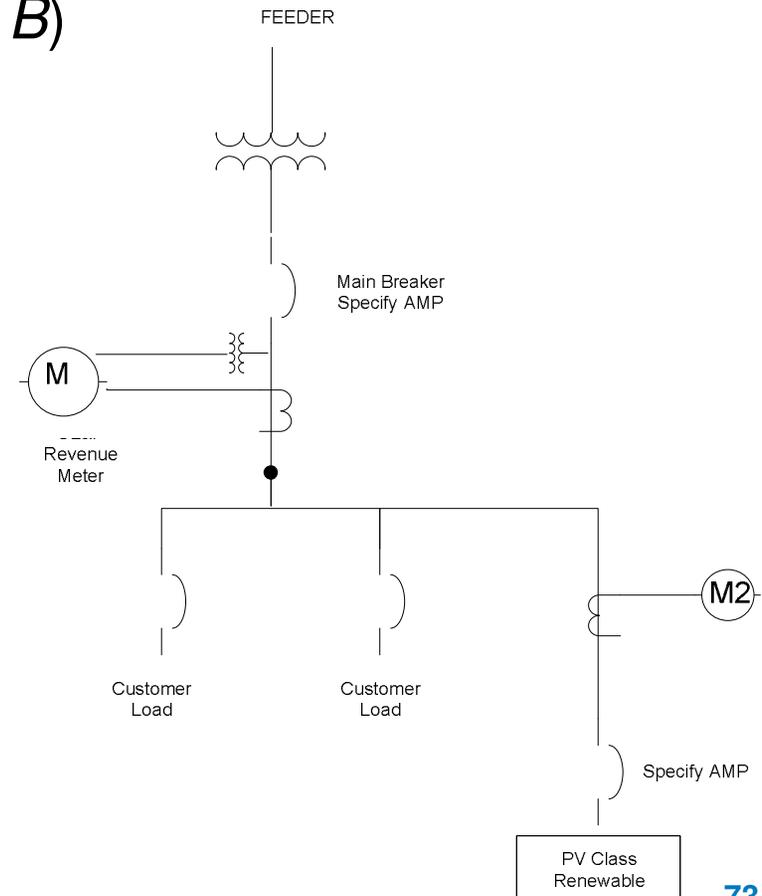
Technical Process End-to-End ✓ Tips

- ✓ **Contact local utility** to inquire about the service configuration of the specific DG customer location
- ✓ **Apply early** – each job is unique
- ✓ If needed, **obtain the services of an engineer** qualified in protection issues
- ✓ The **interconnection standard** contains a wealth of information – get to know it
- ✓ The **timeframes in the standard are working days** and assume utility isn't waiting for information from the interconnecting customer
- ✓ **Regional ISO** (NE or NY) **notification or application** is not included in time frame
- ✓ **Interconnection costs** should be budgeted into the DG customer project
- ✓ The **number and complexity of interconnection applications** is remarkably increasing – get into the queue
- ✓ A **large DG interconnection application takes longer** to study
- ✓ **Independent Power Producer** (IPP) interconnection application for a generation facility that has no load behind the meter **takes longer** to study
- ✓ **Interconnection timeframes** do not apply to Electric Power System (EPS) construction if required.

Technical Issues: Technical Submittals for Utility Review

Recommended Guidelines for Residential and Commercial Single-line Diagram Submittals (for example, see Exhibit 5 & Figures 1 & 2 in ESB 756 Appendix B)

- ✓ 1. **Identify the project**, Company's electric service order (ESO) number, location and submitter's name and address.
- ✓ 2. Indicate standard and any non-standard system **voltages**, number of phases, and **frequency** of the incoming circuit. Indicate **wye and delta systems**; show whether **grounded or ungrounded**.
- ✓ 3. **Identify cable, conductors and conduit, the type and number including Point of Common Coupling**. (The Company is interested in how the power is getting from the service point to the protective equipment.)



Technical Issues: *(cont'd)*

Technical Submittals for Utility Review

One-Lines *(cont'd)*

- ✓ 4. Identify **wiring troughs and/or junction boxes** where used.
- ✓ 5. **Use standard symbols.** (See NFPA 70B or IEEE Standard 141 for symbols in typical electrical single-line diagram development.)
- ✓ 6. Identify the **service equipment's switch and fuse or circuit breaker as to manufacturer, type, rating, catalog number, etc.** Catalog cuts are not required for most major manufacturers. *Service equipment must be able to safely interrupt the maximum available fault current from the supply; refer to NEC Articles 110 and 230.*
- ✓ 7. **Show billing meter trough or instrument transformers' cabinet (C.T. cabinet) in circuitry. Indicate source and load for the circuit.** *Refer to Section 7 in the Company's ESB 750 for acceptable metering configurations.*
- ✓ 8. **Identify other protective devices and ratings.** Include ratings in volts and amps, the interruption rating, and type and number of trip coils on circuit breakers. Also, note any special features of fuses (current limiting, dual element, etc.).
- ✓ 9. **Identify ratios of current and potential transformers, taps** to be used on multi-ratio transformers, and *connection of dual ratio* current transformers if used.
- ✓ 10. **Identify any relays**, if used, and their functions.
- ✓ 11. **Show connections and ratings of power transformer windings** for any to be used.
- ✓ 12. **Identify Generator Disconnect and its ratings.**

Technical Issues: (cont'd)

Technical Submittals for Utility Review

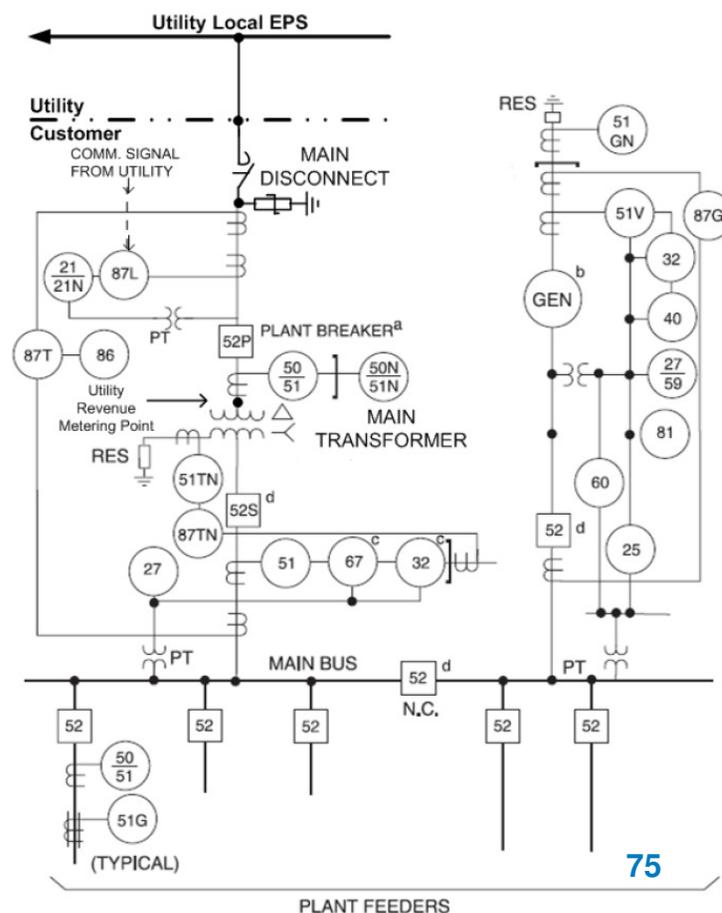
Recommended Guidelines for Functional Single-line Diagram Submittals (for example, see Exhibit 6 & Figures 3 & 4 in ESB 756 Appendix B)

In addition to those items in the previous slides:

- ✓ 13. On functional single-line diagram submittals, **industry standard device numbers are necessary.** (Refer to the Standard Device Numbers in latest edition of ANSI C 37.2.)

For Protection Schemes:

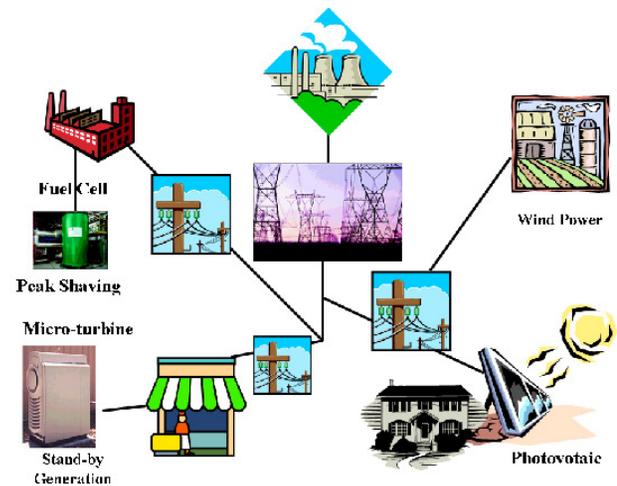
- ✓ **Three Line (AC Schematic)**
 - ✓ Including all AC Current and Voltage circuits
- ✓ **Control Schematic (DC Elementary Diagram)**
 - ✓ Including protection functions
 - ✓ Tripping schemes



Technical Issues:

Potential Impacts of DG on Distribution EPS

- Customer generation connected to the distribution system can cause a variety of system impacts including steady state and transient voltage changes, harmonic distortion, and increased fault current levels.
- The purpose of impact studies is to identify the severity of system impacts of the Customer's generators and the upgrades needed to avoid problems on the Company's distribution electric power system (EPS).

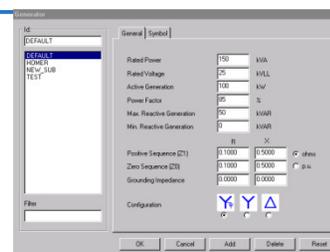


- *Specifically in accordance with the regulatory requirements whether state or federal under the Company's ESB 756.*
- *Typically will be performed by the utility to determine if the proposed generation on the circuit results in any relay coordination, fault current, and/or voltage regulation problems.*

Technical Issues: System Modeling Studies

➤ Studies will identify:

- **Thermal overload** or **voltage limit** violations (steady state) for summer and winter peak loading conditions.
- **Sensitivity study** (steady state only) to assess the impact of the project **during light load conditions**.
- Identify the **impact of the project on the bulk and local power network(s)**.
- **Recommended interconnection configurations** with a list of system upgrades required.



Careful engineering can effectively eliminate the potentially adverse impacts that distributed resource (DR) penetration could impress on the electric delivery system, such as exposing system and customer equipment to potential damage, decrease in power quality, decrease in reliability, extended time to restoration after outage, and potential risks to public and worker safety.

*The **IEEE** supports the following system issues that the utility industry faces with DR penetration on the local electric power system (EPS).*

Technical Issues: *(cont'd)*

System Modeling Studies

- **System issues include, but not limited to:**
- ✓ *voltage,*
 - ✓ *capacitor operations,*
 - ✓ *voltage regulator and LTC operations.*
 - ✓ *protection coordination,*
 - ✓ *feeding faults after utility protection opens,*
 - ✓ *interrupting rating of devices,*
 - ✓ *faults on adjacent feeders,*
 - ✓ *fault detection,*
 - ✓ *ground source impacts,*
 - ✓ *single phase interruption on three phase line,*
 - ✓ *recloser coordination.*
 - ✓ *conductor burndown,*
 - ✓ *loss of power grid,*
 - ✓ *vulnerability and overvoltages due to islanding,*
 - ✓ *coordination with reclosing, and*
 - ✓ *system restoration and network issues.*
 - ✓ *Harmonic distortion contributions*
 - ✓ *Voltage flicker*
 - ✓ *Ground fault overvoltages*
 - ✓ *Power system stability*
 - ✓ *System reinforcement*
 - ✓ *Metering*

Technical Issues: (cont'd)

Potential Impacts ✓ Tips

-
- ✓ If **aggregate generation** on a feeder is **over 7.5%** of peak feeder load, there may be special reviews required. (This is the limit in the MA and RI tariffs for the expedited process.)
 - ✓ **Feeder voltage** may **impact the size of generator** that can be safely interconnected at the distribution level. (e.g. 4kV, 15kV, 23kV, 34.5kV, 69kV classes).
 - ✓ **If the generator will sell on the market** and has to apply through the Regional ISO (NE or NY), the process may take longer than the standard time frames.
 - ✓ Generators **over 50kW** may likely require **three-phase** service.
 - ✓ **High fault current** may impact the DG customer's interconnection costs.
 - ✓ Some **tips for what must happen** between the time an application is received and a system can go on line:
 1. During initial analysis and various studies, there is usually an **exchange of information** which takes time and **timelines can stop and start**.
 2. System **modifications can take time**, especially if specialty equipment must be ordered (lead times for substation equipment can be several to many months) after interconnection agreement is executed.
 3. ISO-NE Reliability Council review if **1 MW or larger**
 4. Asset registration to ISO-NE if **60kW or larger and will export power**. 79

Technical Issues: (cont'd)

Potential Impacts ✓ Metering, Disconnection and Data Acquisition

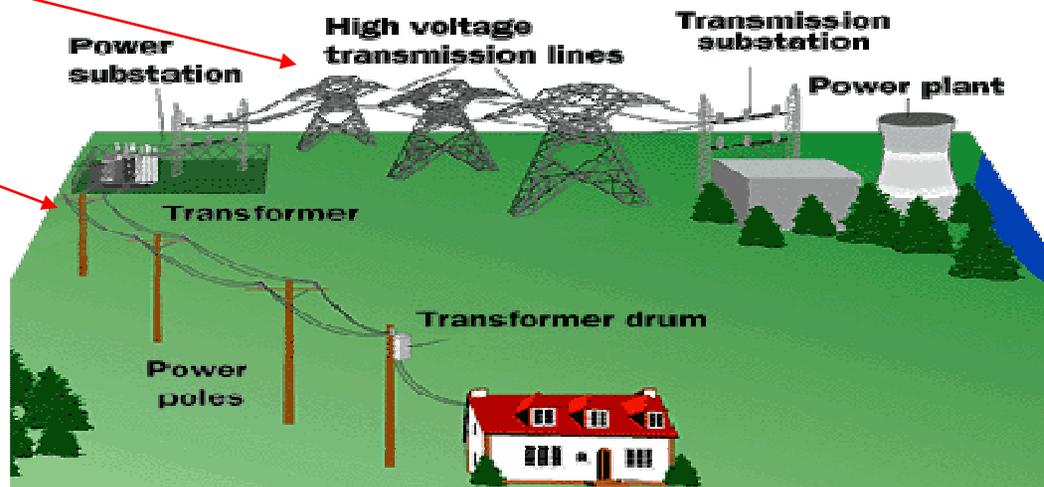
- ✓ *Generator **must be installed** behind utility revenue meter*
- ✓ *Cannot interconnect in meter socket or trough*
- ✓ ***Cold sequence metering required***
- ✓ ***Approved disconnect means must be provided** to isolate metering instrument transformers*
- ✓ ***Metering with remote data access required** for all **generation 60kW and larger** that will export power onto utility EPS*
- ✓ ***Installation over 1 MW** will also **require a recloser with remote control and data access** to be installed to:*
 - ✓ *Monitor voltage, current*
 - ✓ *Act as a utility controlled redundant protection system*
 - ✓ *Provide for remote disconnect*

Technical Issues: Limits on Distribution EPS

➤ Radial Systems

➤ *Distribution or Transmission?*

- MA, NH, NY, and RI interconnection standards apply to generators that will connect (grid tied) to the **Distribution System** (below 69kV).
- For **Transmission System**, apply to the Independent System Operator, ISO (New England or New York).



Limits on Distribution EPS - Radial

- The distribution system was not designed with Distributed Generation in mind. **Large generation** at this type of system **causes challenges** (*i.e. protection, power regulation...*) to distribution and transmission systems.
- Based on experience to date, **upper limits are established** that represent the maximum possible DG capacity under ideal situations and assumes that on the National Grid Distribution EPS there are no additional limitations as indicated by site specific system studies (*e.g., available short circuit current contributions, minimum network loading in light loading seasons, voltage regulator interactions, etc.*).
- When a DG facility (or aggregate DG facility) on a feeder or local EPS of a feeder is **above the limits**, these warrant **further study** by National Grid to determine feasibility and remedial action.

Technical Issues: (cont'd)

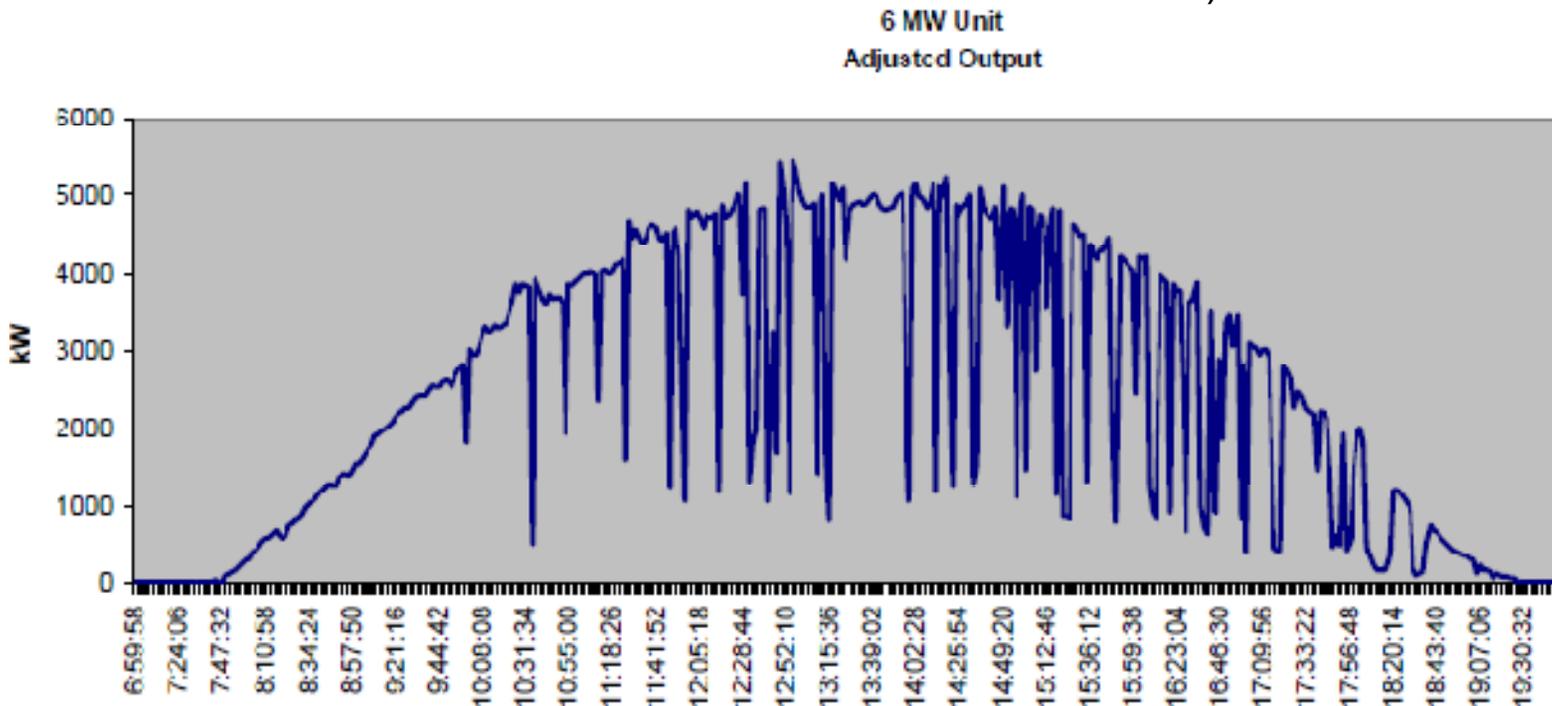
Limits on Distribution EPS - Radial



As an example about **Large PV Inverter-based Generators:**

- **Ramp rates** of large PV inverter-based generators **can affect EPS operations and power quality.**
- Geographic diversity effects not yet fully understood.

✓ **First check** – “How is EPS affected and how much is acceptable on it (*other customers on the feeder*)?”



Technical Issues: (cont'd)

Limits on Distribution EPS - Radial

Types of Wind Turbine Generators (WTG)

Note the minimum “**fall zone**” clearance of the WTG by the local AHJ or **125% of height** to Utility Distribution Lines

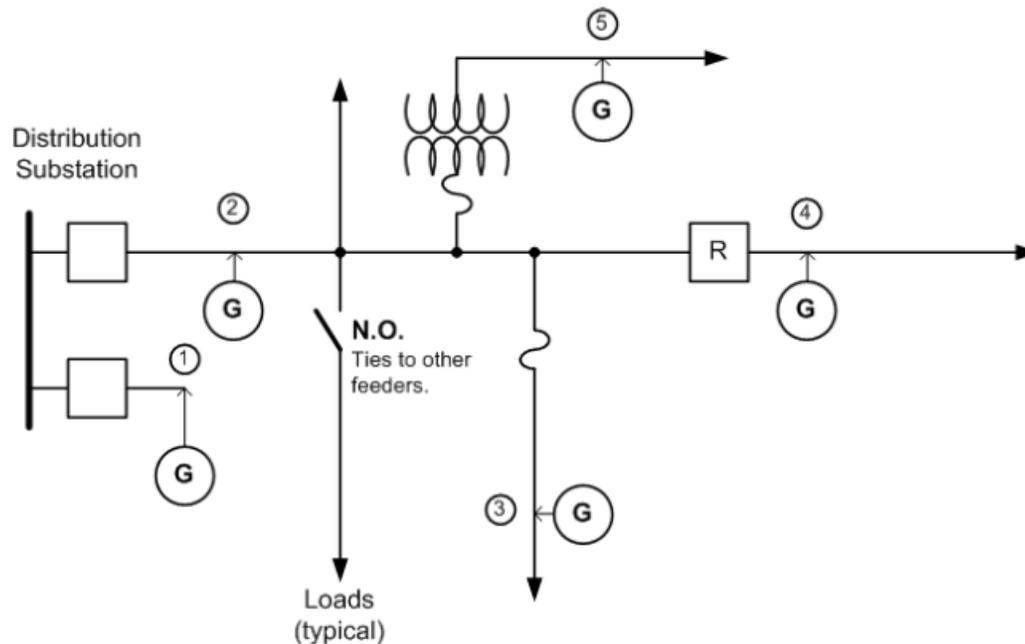
- **Type 1:** Squirrel cage induction generator directly coupled to the grid. May have pitch control
- **Type 2:** Wound rotor induction machine with external rotor resistance control
- **Type 3:** Wound rotor Doubly-fed induction generator (Voltage injected in the rotor winding)
- **Type 4:** Synchronous or induction generator, the stator is connected to the grid via power converter.



Technical Issues: (cont'd)

Limits on Distribution EPS - Radial

- **Classification Types** for Typical DG Installation Areas on Radial Distribution Feeders (for example, see Section 4.0 in ESB 756 Appendix B)



“O” - DG Interconnection Location Point on Feeder

1. Express (dedicated) radial feeder
2. Feeder Main
3. Feeder Branch protected by fuse
4. Sectionalized Feeder Main
5. Feeder Branch protected by fuse with ratio transformer

- Types of Generators



Technical Issues: (cont'd)

Limits on Distribution EPS - Radial

➤ Typical Planning Limits for DG Connection to Radial Distribution Feeder

Typical Gross Generation Capacity Limit (see notes below)		
DG Location on Feeder	3-phase Radial Distribution Voltage Class System	
	4 or 5kV	15kV
1. Express (dedicated) Radial Feeder	2.8MVA	9.0MVA
2. Feeder Main	0.75MVA	2.5MVA
3. Feeder Branch protected by Fuse	75kVA	250kVA
4. Sectionalized Feeder Main	100kVA	300kVA
5. Feeder Branch protected by Fuse with Ratio Transformer	50kVA	150kVA

- a. *These generation capacities are on a per-generator basis on full nameplate ratings and at unity power factor. It should be noted, however, that the aggregate generation (sum of the total gross generation of all DG systems connected to a particular segment of the National Grid system) is considered for all points along the distribution feeder. National Grid will evaluate each application before deciding on the maximum MVA allowed onto the National Grid system at a given point.*
- b. *Limits apply to synchronous and induction rotating generator machines. The DG facility shall maintain power factor at the PCC in accordance with the NY SIR; at 0.90 Power Factor leading or lagging (for Var or voltage support can also be considered within machine ratings). See ESB 750 regarding disturbances and capacitor installation.*
- c. *Inverter-based systems such as Photovoltaic (PV) Systems are limited in aggregate to 500kVA on 4 or 5kV and 3.0MVA on 15kV class systems.*

DG installations are classified into two types - those interconnecting to the National Grid system on a **dedicated radial feeder** and those interconnecting on a **non-dedicated radial feeder**. When a DG (or aggregate DG) on a feeder or local EPS of a feeder is **above the limits in the table**, these warrant further study to determine feasibility and remedial action.

Technical Issues: (cont'd)

Limits on Distribution EPS - Radial

- DG facilities typical of synchronous generator and power factor corrected induction generator types ranging in size from 750kVA to 2.8MVA at 4 or 5kV class or from 2.5MVA to 9.0MVA at 15kV class, and installed on non-network systems are considered for connection to express radial distribution feeders since the light load condition on the existing feeders may not meet the acceptable norm to avoid islanding.
- Certain other DG types will have different limits.
- So, evaluation checks:
 - ✓ During screenings, check 5-year Plan and if substation can be expanded for feasibility of express feeder
 - ✓ **>3MVA PV** in aggregate of large units $\geq 500\text{kVA}$ on a feeder
 - ✓ *Small (e.g. residential rooftop) PV – insignificant additional affect until aggregate of these exceeds 500kVA*
 - ✓ **>2.8MVA** aggregate of all DG types on substation 4kV or 5kV bus when supply is 38kV class (depending on VR & Thermal)
 - ✓ **>9MVA** aggregate of all DG types on substation 15kV bus when supply is 121kV class (depending on VR & Thermal)

Technical Issues:

Anti-Islanding on Distribution EPS - Radial

➤ Anti-Islanding Protection

The Company's position is that the interconnection of all parallel generators requires safeguards for synchronization and back-feed situations. **A parallel generator is prohibited to energize a de-energized Company circuit.**

The Company uses **three main “tests”**; *any determine if anti-islanding protection is required for exceeding minimum load issue or a protection issue or operating concern:*

1. **“Feeder Load versus Generation Test”**
2. **“Fault Sensitivity Test”**
3. **“Feeder Selectivity Test”**

Tips

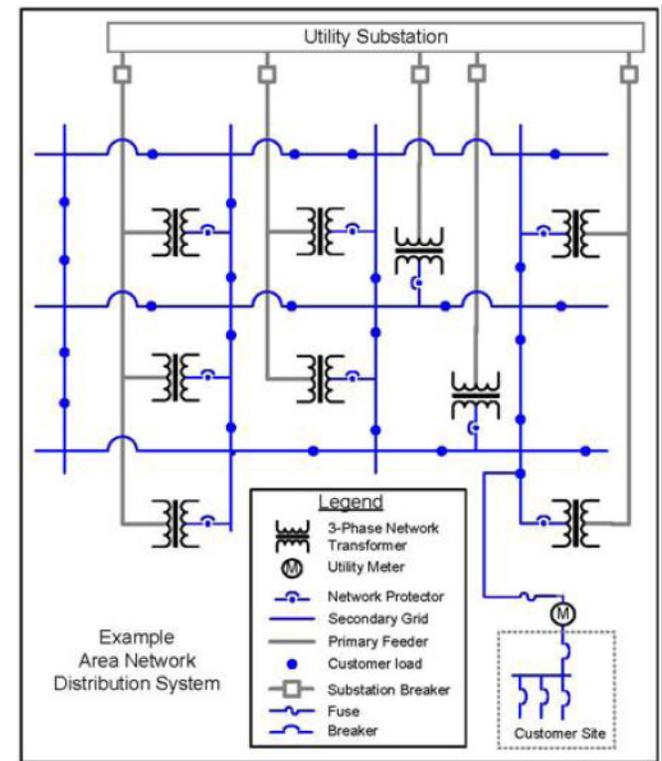
- ✓ DG Customer's protective device coordination study demonstrates **generation voltage and/or frequency protection will trip within 2.00 seconds for the loss of the utility source.**
- ✓ **Type-tested inverter-based parallel generation** operated in regulated current mode, **transient overvoltage protection** is required upon detection of an island.
- ✓ When DTT is specified for a parallel generation project, the Company will determine the **requirements and responsibilities for equipment**, installation, and communications media in the interconnection study.

Technical Issues: Protection Requirements

- A parallel generator will contribute to the fault continuously. *Hence, overcurrent (OC) protection is required.*
- Over/Under (O/U) voltage and frequency protection can be used based on the application (*Load, Generation, etc.*)
- Some typical relays used to protect the DGs
 - ✓ 51: Time Over Current (*Mostly for Synchronous Generators*)
 - ✓ 51C: Time Over Current (*Current pickup is constant and is activated when the voltage drops below a certain limit*)
 - ✓ 27: Under Voltage (*For all DGs*)
 - ✓ 59: Over Voltage (*If the utility side of the step up transformer is Delta*)
 - ✓ 81: Frequency – O/U (*All DGs*)

Technical Issues: Limits on Distribution EPS - Network

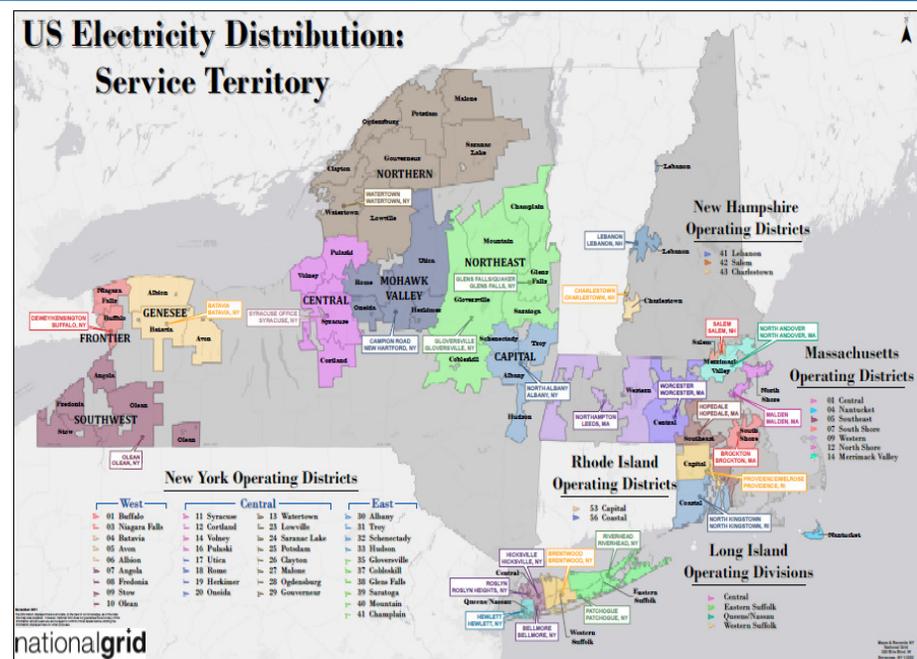
- Unlike radial distribution systems that deliver power to each customer in a single path from source to load, **underground secondary area network systems** deliver power to each customer through a complex and integrated system of multiple transformers and underground cables that are connected and operate in parallel.
- **Area Networks** consist of **one or more primary circuits** from one or more substations or transmission supply points **arranged such that they collectively feed secondary circuits** serving one (a spot network) or more (an area network) electric customers.



Technical Issues: (cont'd)

Limits on Distribution EPS - Network

Portions of the following cities are served by area networks (customers in these areas should ask where the nearest radial system is located for possible tie-in):



- ✓ Brockton, Lynn, and Worcester in Massachusetts;
- ✓ Pawtucket and Providence in Rhode Island; and
- ✓ Albany, Buffalo, Cortland, Glens Falls, Niagara Falls, Schenectady, Syracuse, Troy, Utica, and Watertown in New York. (See Exhibit 3 in ESB 756 Appendix B.)

Technical Issues: (cont'd)

Limits on Distribution EPS - Network

- The connection of customer DG facilities on networks is an emerging topic, which
 - ✓ (i) poses some issues for the Company to maintain adequate voltage and worker safety and
 - ✓ (ii) has the potential to cause the power flow on network feeders to shift (*i.e., reverse*) causing network protectors within the network grid to trip open.
- To ensure network safety and reliability **additional information will be required** for the Company's engineering analysis such as:
 - ✓ Electric **demand profile** showing minimum load during peak generation time,
 - ✓ Expected **generation profile** shown for a 24-hour period and typical 7-day duration, and
 - ✓ Customer's **complete electric service single-line diagram** up to the service point supplied by the Company's secondary network EPS.

Technical Issues: *(cont'd)*

Limits on Distribution EPS - Network

-
- Connecting customer generation to the **low voltage network** poses some issues for the Company.
 - ✓ The **generation can cause the power flow on network feeders to shift** (*i.e., reverse*) causing network protectors within the network system to trip open.
 - ✓ **No synchronous generators are permitted** for interconnection to the Company's secondary voltage network systems.
 - ✓ **Small induction and inverter-based generators** are considered on the secondary voltage network systems on a **case-by-case basis**.
 - ✓ Connection of distributed generators on the **spot networks** may be permitted
 - ✓ if the **secondary bus is energized by more than 50% of the installed network protectors** as required by the Institute of Electrical and Electronics Engineers (IEEE) Std. 1547-2003.

Technical Issues:

Small Net Metered DG Installations less than 600V

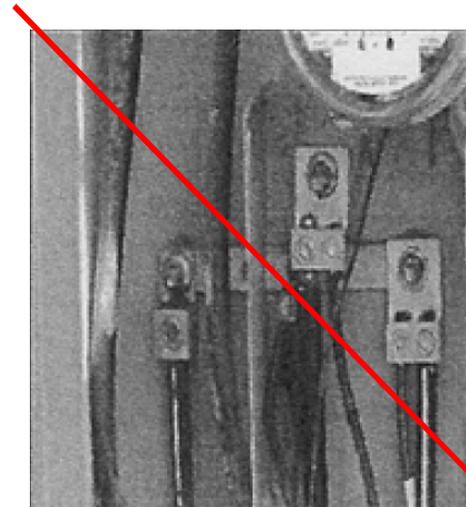
➤ Taps Ahead of Service Equipment for DG Interconnection – Concerns

- *The Company's position is consistent with the rules and regulations for electric service contained in the Company's ESB 750-2010 "blue book" regarding taps and splices ahead of service equipment and in meter sockets.*

- *In addition, our rules are consistent with other utility practices.*

- *Taps and splices in meter sockets having National Grid meters are prohibited according to the electric service requirements of ESB 750.*

- *Doing so causes undue pressure on the meter socket blocks, increasing the chance of the blocks breaking, and causing a flash when the meter is removed.*



Technical Issues: (cont'd)

Small Net Metered DG Installations less than 600V

- ✓ **Where taps and splices are to be considered ahead of service equipment and on the load side of the Company's revenue meter, please refer to the following guidance according to ESB 750 and the NEC.**
- 1. *The proposed tap or splice shall be made in an approved enclosure external from the revenue meter enclosure.*
- 2. *The junction (line tap) box and conduit for service conductors shall meet NEC requirements for the specific installation and its location.*
- 3. *Rigid galvanized steel conduit should be used between the revenue meter socket enclosure, junction (line tap) box, existing main service equipment, and distributed generator service equipment.*
- 4. *Wire bending radius shall meet NEC requirements and not cause undue pressure on terminations to devices.*
- 5. *Service conductor splice shall be in accordance with the NEC and listed materials.*
- 6. *The distributed generator system's disconnect shall be listed and labeled service equipment and installed immediately adjacent to the existing service equipment. (See definition of "service equipment" in Section 2.0 of ESB 750.)*
- 7. *Each service equipment shall be labeled according to the NEC (see Article 230).*
- 8. *Service grounding system shall be installed in accordance with the NEC for the two adjacent service equipment means (see Article 250).*
- 9. *The distributed generator system connection shall comply with the NYS SIR, National Grid's PSC No. 220 Rule 53, ESB 756 Appendix B, and the NEC.*
- 10. *Where modifications to existing service equipment are proposed, the installer shall obtain the manufacturer requirements in writing (see 110.3(B) in the NEC). (This will be required for the local AHJ Code Enforcement requirements to be met.)*
- 11. *An approved electrical inspection certificate of the premises wiring changes is required according to Section 1.9 in ESB 750.*

Technical Issues: Upgrades and System Modifications

NOTE: This information was supplied by an organization outside of RI and is not necessarily representative of RI costs or timelines.

Some Upper End Typical Utility Interconnection Costs & Duration Scheduling for Complex DG Installations

Distribution EPS Upgrade Item	Upper End Order-of-Magnitude Cost	Upper End Duration Scheduling
Voltage Regulator changes/phase	\$50k	6 months
Capacitor Bank moves or new	\$17k	3 months
Pole Top Recloser move/addition	\$80k	6 months
Re-conductor 3-phase Line (includes pole replacements)	\$450k/mi.	12 months
Convert from 1 to 3-phase Line (includes pole replacements)	\$400k/mi.	12 months
Express 3-phase Feeder (open wire configuration)	\$600k/mi.	18 months
Express 3-phase Feeder (lashed cable configuration)	\$750k/mi.	18 months
Customer 3-phase Transformer change/addition (Pole or Pad)	\$45k	3 months
Supply Station Transformer	\$4M	24 months
DTT transmit addition to supply station	\$300k	11 months
Communications media equipment additions to support DTT equipment at supply station	\$100k	6 months
EMS-RTU (status & control) addition at DG site (in NY) or supply station	\$80k	6 months
Metering PTs & CTs at DG site (excludes structure)	\$15k	8 months
Plus Company labor for acceptance review DG Customer's design, compliance verification activities, and project management	\$100k	Dependent on DG Customer

Notes:

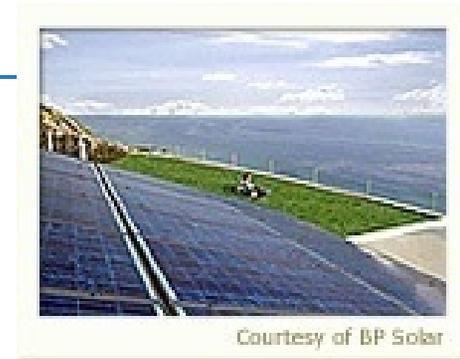
- 1) Distribution EPS relates to 15kV class system.
- 2) These are representative estimates only and are not inclusive of all costs [*i.e. land rights, removal costs, taxes, etc.*] which will vary from job to job and that they are presented here for budgetary purposes only.

Questions?

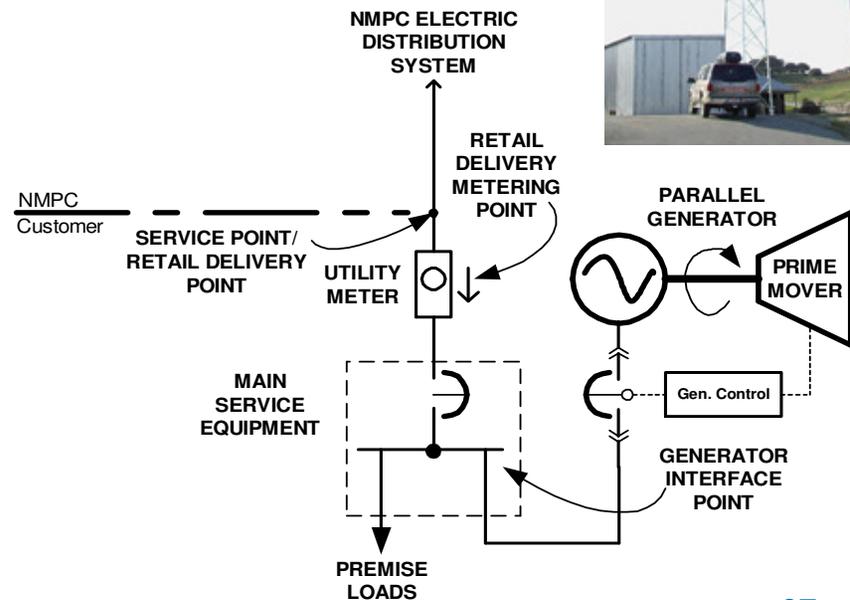


What we covered:

- ✓ National Grid's **jurisdictional interconnection standards**
- ✓ **technical issues** integrating DG into distribution electric power systems
- ✓ **installations** of DG facilities



Courtesy of BP Solar



PARALLEL GENERATION EXAMPLE

Future 2012 DG Seminars

Date	Utility
January	National Grid
February	Nstar (on February 22)
March	Wmeco
April	National Grid (April 26)
May	Nstar (on May 16)
June	Wmeco
July	Unitil
August	Nstar (on Aug 22)
September	Wmeco
October	National Grid (Oct 25)
November	Unitil
December	Wmeco

Interconnection of Distributed Generation & Net Metering Seminar

Questions ?

Thank You for Attending!

Hosted by: **nationalgrid**

Technical Sales and Engineering Support Department