DG Interconnection
and
Net Metering Seminar

October 25, 2012

North Andover, MA

Co-hosted by:

Western Massachusetts Electric
The Northeast Utilities System

MASSACHUSETTS CLEAN ENERGY CENTER

Unitil

nationalgrid

DOER
Massachusetts Department of Energy Resources

NSTAR ELECTRIC

Logistics & Introductions

- **Facilities**
  - Emergency exits
  - Restrooms
  - Designated smoking area

- **Guests and presenters**
  - DPU / DOER / Mass CEC
  - MA Utilities: National Grid / NSTAR / Unitil / WMECO

DOER Welcome Slide

DOER's role in Distributed Generation:

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

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Distributed Generation Interconnection &
Net Metering Seminar
Date: October 25, 2012
Location: 1101 Turnpike Street, North Andover, MA 01845

Agenda

9:00 a.m.	**Registration**
9:30 a.m.	**Welcome & Interconnection Process**
10:15 a.m.	**ISO-NE, Net Metering, and Proposed Tariff Changes**
10:55 a.m.	**Break**
11:00 a.m.	**Interconnection Technical Session: Electric Power System Impacts and Issues**
Noon	**Q & A – all**
12:30 p.m.	**Adjourn**

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*
  - Proposed changes to the tariff as a result of the MA DG working group
- **Net Metering**
- **Technical Session**
  - Aspects of Integrating DG with Utility System
- **Q & A**

Safety Moment

- This morning is actually a big safety moment.
  - All the benefits derived from Distributed Generation quickly lose their value if someone is injured as a result of an improper interconnection.
- Also, Hurricane Sandy, utilities have already started their preparations
  - Employees alerted
  - Mutual aid calls going out

Key Terms

Distributed Generation (DG) – Distributed generation is any electricity generating technology installed by a customer or independent electricity producer that is connected to run in parallel with grid power at the **distribution system level of the electric grid.**

Interconnection- Electricity customers seeking to operate DG in parallel with (or at the same time as receiving) grid power must follow the interconnection process of electric utilities (also known as the "Interconnection Tariff").

DPU- The MA Department of Public Utilities regulates the investor-owned utilities in the Commonwealth.

ISO-NE – The Independent System Operator of New England is the grid operator of the electric *transmission* system (as opposed to the *distribution* system regulated by the DPU).

Tariff- The rate applied by the electric utility as a result of DPU regulation. It is a standard to ensure that utilities fulfill their regulated *obligation to serve* and so that all customers are provided *equal/fair treatment*.

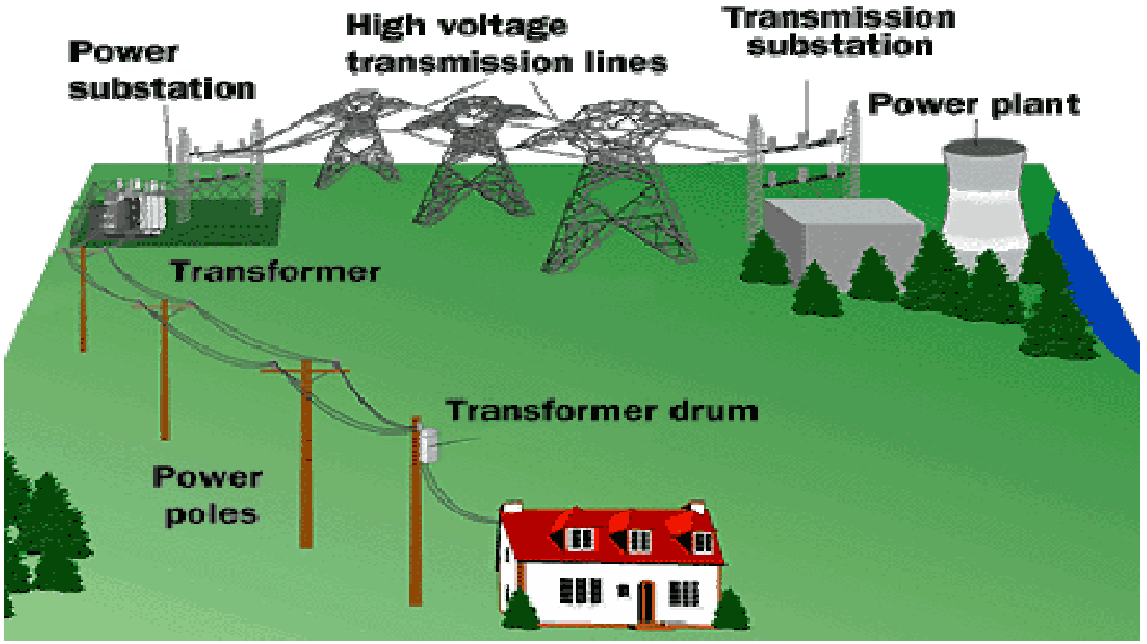
How Does the Electric Grid Work?

• **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

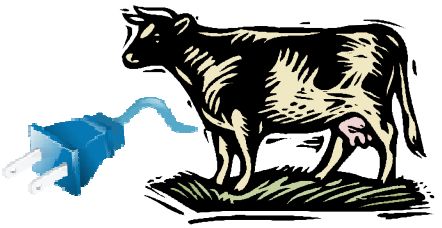
- **Behind Meter:** DG system is used to partially or fully supply an on-site load. Any unused electricity is exported to the distribution system (most projects follow the state interconnection process; *there are exceptions that follow the ISO process*).

- **Direct Connect:** DG system does not supply an on-site load, and is connected directly to the distribution system

Massachusetts Interconnection Standard

- In late 2002, the MA DTE directed the investor owned utilities to commence a collaborative process to propose unified interconnection standards, policies, and procedures for distributed generation.
- In the summer of 2012, stakeholders came together again to revise the standard
  - Waiting for DPU approval of proposed changes
- Current version of “Standards for Interconnecting Distributed Generation” is a result of countless hours of work by the DG Collaborative.
- DPU approved a new tariff in 2009 which includes net metering provisions.
- This interconnection standard covers all forms of generation operating in parallel with the grid (it does not apply to emergency generation).




Introducing Interconnection

- The Interconnection Standard (Tariff), is the ***Interconnection Bible***! It is extremely important that you **read** and **understand** the Standard.

- The utilities, DOER, and The MassCEC are resources to help you through the interconnection process. There are resources on each participant's website to make the interconnection process as simple as possible (see end of presentation).

- Keep in mind that the electricity system is complex, the process for interconnection must be followed and certain appropriate precautions need to be taken.

What is the Interconnection Process?

- Process of getting an interconnection agreement from your local utility (or distribution company) to connect a distributed generation system to their distribution system.
- This process is used by the four investor owned utilities (IOU) in Massachusetts (NSTAR, National Grid, Unitil and Western Mass Electric)
- Municipally-owned utilities are not required to follow this process, and may follow a different criteria.
- The process is used to make sure interconnecting DG systems are integrated into the distribution system responsibly with respect to impacts on reliability, power quality and safety

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 any generation. *You are proceeding at your own risk if you choose to install a system without utility approval.*

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 MA Department of Public Utilities (DPU) 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 the local utility, DOER or MassCEC for 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** $3/KW ($300 minimum and $2,500 maximum). This fee covers the initial review. (Proposed change in 2012 raises these costs)
  - **Stamped electric one-line diagram**, preferably showing relay controls (one copy) (Stamped by Massachusetts 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 Z** 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.

•Proposed changes modify some of these parameters

Review Paths Side-by-Side

Review Process	Simplified	Expedited	Standard	Simplified Spot Network
Eligible Facilities	Listed Small Inverter	Listed DG	Any DG	Listed Inverter ≤ 15 kW single-phase line
Acknowledge receipt of application	(3 days)	(3 days)	(3 days)	(3 days)
Review Application for Completeness	10 days	10 days	10 days	10 days
Complete Review of all Screens	10 days	25 days		Site review 30/90 days
Complete supplemental Review if needed		20 days		
Complete Standard Process initial review			20 days	
Send Follow-on Studies Cost/Agreement			5 days	
Complete Impact Study (if needed)			55 days	
Complete Detailed Study (if needed			30 days	
Send Executable Agreement	Done	10 days	15 days	Done (comparable to Simplified for radial
Total Maximum Days	15 days	40/60 days	125/150 days	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	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 (proposed change raises this to 15 kW) or less on a single phase service on a radial feed
  - Three phase customers with listed three-phase inverter based systems 25kW or less on a three phase service 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

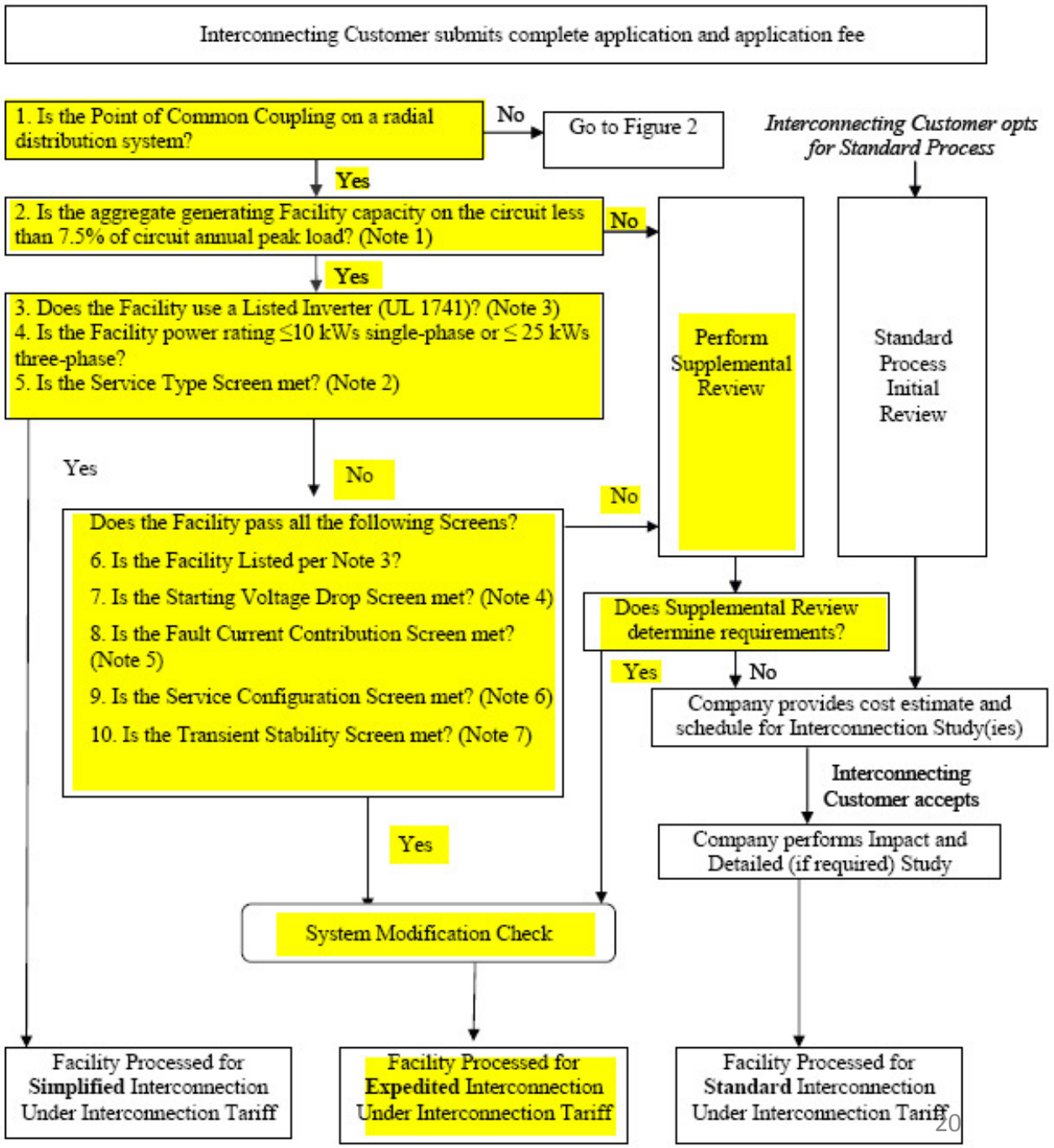
Table 1 of Section 3 in the Interconnection Tariff

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)	
Complete Standard Process Initial Review	
Send Follow-on Studies Cost/Agreement	
Complete Impact Study (if needed)	
Complete Detailed Study (if needed)	
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

Screen Process

Figure 1

- Determine which application process the applicant should follow;
- Determine whether additional studies are needed
- See section in Interconnection Tariff for details about each screen question (Figure 1 Section 3.5)



Expedited Review Path

- **Applies to:**
  - Single phase customers with listed single-phase inverter based systems >10kW (proposed 15kW) 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 10 hours of engineering time or $1,250 (if needed)
  - Raised to 30 hours, or $4,500 in proposed changes
- 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 now, proposed to be $4,500).
- 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.)
- Proposed changes add 3 other supplemental screens dealing with minimum load on the feeder, voltage quality, and reliability and safety.

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
Eligible Facilities	Any DG
Acknowledge receipt of application	(3 days)
Review Application for Completeness	10 days
Complete Review of all Screens	
Complete supplemental Review if needed	
Complete Standard Process initial review	20 days
Send Follow-on Studies Cost/Agreement	5 days
Complete Impact Study (if needed)	55 days
Complete Detailed Study (if needed	30 days
Send Executable Agreement	15 days
Total Maximum Days	125/150 days
Notice / Witness Test	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)
    - Proposed fees are $4.50/kW ($300 min and $7,500 max)
  - 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
  - Some projects may not require impact or detailed studies or EPS upgrades

Interconnection Process Fee Schedule

Review Process	Simplified	Expedited	Standard	Simplified Spot Network
	Listed Small Inverter	**Listed DG**	**Any DG**	**Listed Inverter ≤ 15 kW single-phase line**
Application Fee (covers screens)	0	$3/kW minimum $300, maximum $2,500	$3/kW minimum $300, maximum $2,500	≤ 3/kW $100, > 3kW $300
Supplemental Review or Additional Review (if applicable)	N/A	Up to 10 engineering hours at $125/hr ($1,250 maximum)	N/A	N/A
Standard Interconnection Initial Review	N/A	N/A	Included in application fee (if applicable)	N/A
Impact and Detailed Study (if required)	N/A	N/A	Actual Cost	N/A
Facility Upgrades	N/A	Actual Cost	Actual Cost	N/A
O&M	N/A	TBD	TBD	N/A
Witness Test	0	Actual Cost, up to $300 plus travel time	Actual Cost	0

Interconnection Process Fee Schedule - Proposed

Review Process	Simplified	Expedited	Standard	Simplified Spot Network
	Listed Small Inverter	**Listed DG**	**Any DG**	**Listed Inverter ≤ 15 kW single-phase line**
Application Fee (covers screens)	0	$4.50 /kW minimum $300, maximum $7,500	$4.50/kW minimum $300, maximum $7,500	≤ 3/kW $100, > 3kW $300
Supplemental Review or Additional Review (if applicable)	N/A	Up to 30 engineering hours at $125/hr ($4,500 maximum)	N/A	N/A
Standard Interconnection Initial Review	N/A	N/A	Included in application fee (if applicable)	N/A
Impact and Detailed Study (if required)	N/A	N/A	Actual Cost	N/A
Facility Upgrades	N/A	Actual Cost	Actual Cost	N/A
O&M	N/A	TBD	TBD	N/A
Witness Test	0	Actual Cost, up to $300 plus travel time	Actual Cost	0

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 (Attachment G of 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

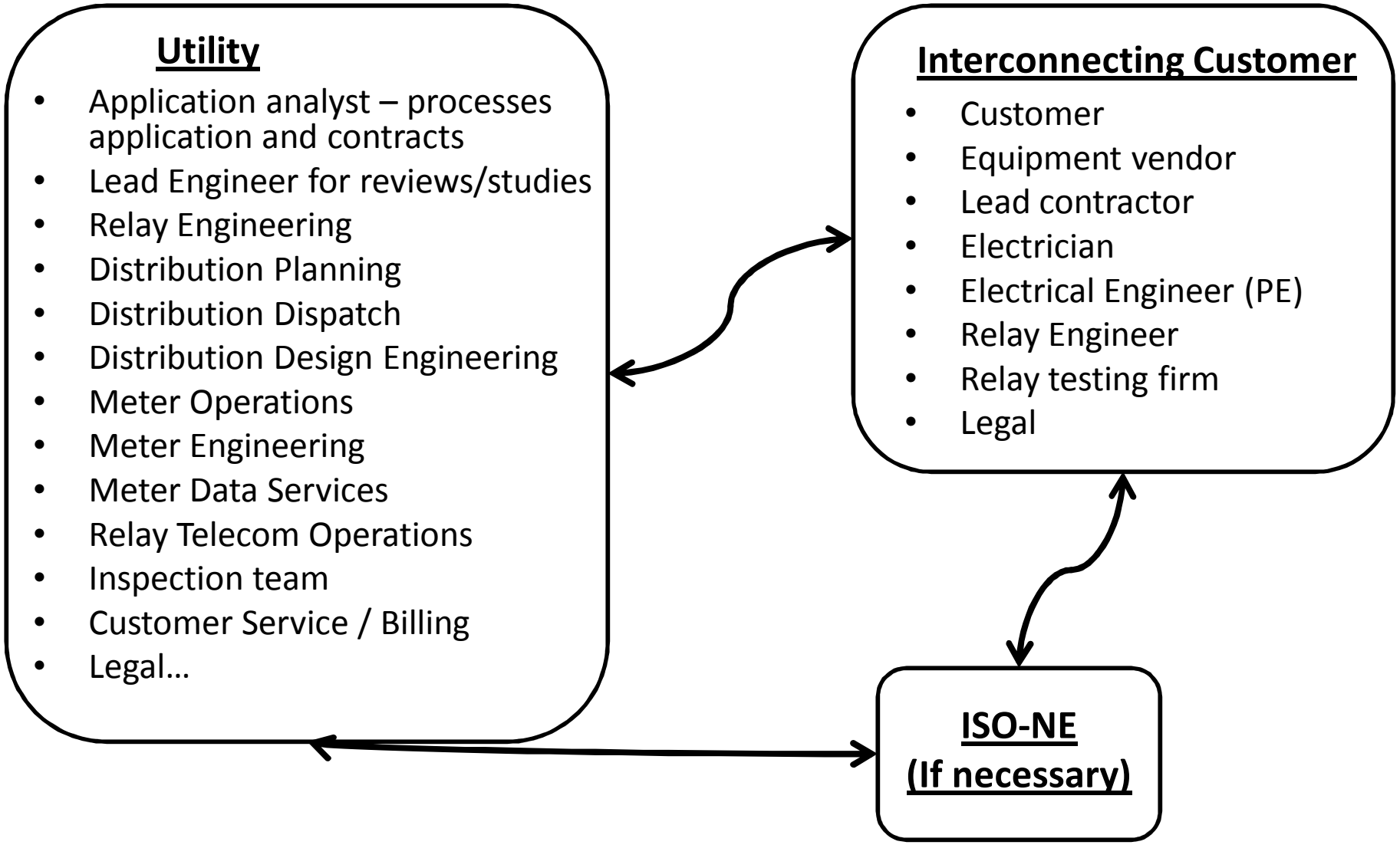
Common process delays

- 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

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.

Many Stakeholders Involved



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

- National Grid
  - Email: Distributed.Generation@us.ngrid.com
  - Phone: **Alex Kuriakose** | (781) 907-1643, **Bob Moran** | (508) 897-5656
    W. 'Adam' Smith | (781) 907-5528, **Vishal Ahirrao** | (781) 907-3002
    Sean Diamond | (781) 907-2611, **Chandra Bilsky** | (401) 784-7174
    Kevin G. Kelly | (978) 725-1325
  - http://www.nationalgridus.com/non_html/shared_interconnectStds.pdf

- NSTAR
  - **Joseph Feraci** | (781) 441-8196 (joseph.feraci@nstar.com)
  - **Paul Kelley** | (781) 441-8531 (paul.kelley@nstar.com)
  - http://www.nstar.com/business/rates_tariffs/interconnections

- Unitil
  - **Tim Noonis** | 603-773-6533 (noonis@unitil.com)
  - http://www.unitil.com/energy-for-residents/electric-information/distributed-energy-resources/renewable-energy-generation

- WMECo
  - Phone: 413-787-1087
  - Email: wmecodg@nu.com
  - http://www.wmeco.com/distributedgeneration

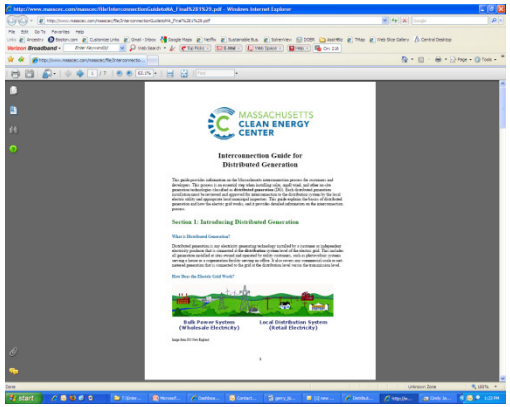
Other Information Resources

- MA DG and Interconnection Website: http://sites.google.com/site/massdgic/

- Net Metering Basics: http://sites.google.com/site/massdgic/Home/net-metering-in-ma

- Interconnection Guide for Distributed Generation (Mass-CEC):

  http://www.masscec.com/masscec/file/InterconnectionGuidetoMA_Final%281%29.pdf



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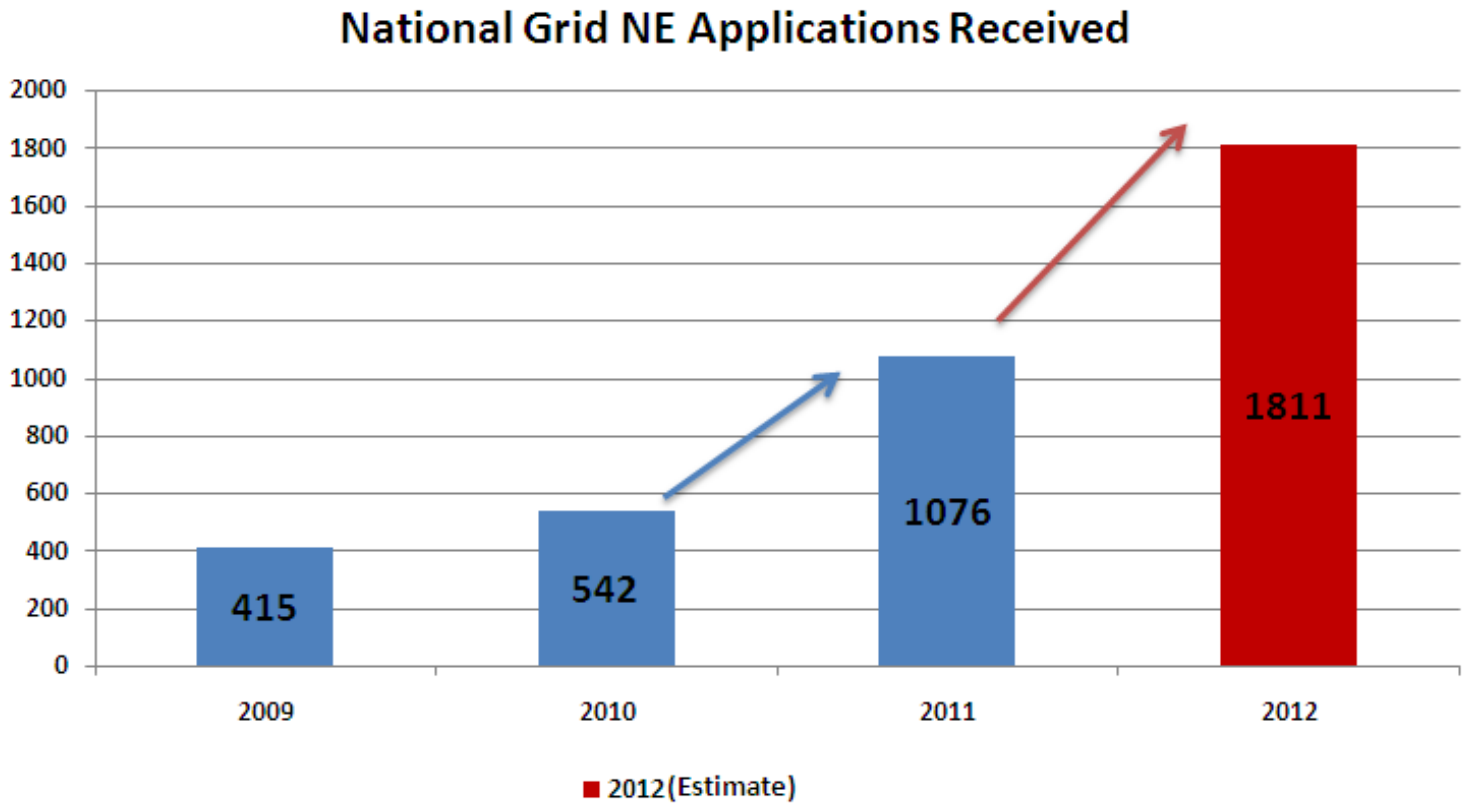
ISO-New England Process & Net Metering

DG Activity Trends – National Grid

- Received over **1349** applications worth more than **298 MW** of interconnection applications through September 2012
- Small (**<100kW**) Interconnection application are triggering large studies because of the aggregate generation on the circuit.
- More projects are in construction phase
- Some circuits have over 20 interconnected generators



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 participate.
    - 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 participate.
    - 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 Massachusetts

- December 2009 Net Metering Tariff
- This tariff is effective until MA DPU issues a new tariff
- Three Net Metering Classes
  - Class 1: Any generator up to 60 KW is eligible
  - Class 2: Agricultural, solar, or wind net metering facility over 60 KW but less than or equal to 1 MW (for municipal or government it's "per unit)
  - Class 3: Agricultural, solar, or wind net metering facility over 1 MW but less than or equal to 2 MW (for municipal or government it's "per unit")
- Recent change limits projects to 2 MWs per parcel of land and a single meter

Net Metering Tariff

- Eligible customers can apply by submitting a Schedule Z.
- Currently, eligibility determined when system approved to operate.
  - Cadmus will be running a System of Net-Metering Assurance shortly
- Class 2 and Class 3 will need a production meter on generation.
- Net Metering is limited to 3% of each utility's peak MW for private and 3% of peak for public projects – for NG-MA this total limit is 308 MWs.
- Contribution towards total 6% limit is posted on each utility's web site and updated monthly
  - NG-MA is at 44 MWs for the private and of 15 MW toward the public cap as of October 2012

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).
    - Non-Renewable credited at average monthly clearing price ISO-NE
- Tariff allows credits to be allocated (with limitations)
- Customer still responsible for customer charges and demand charges, even if net export

				Credit the following charges			
Tier	min	max	Type	Default Service kWH	Dist-ribution kWH	Trans-mission kWH	Trans-ition kWH
1	0	60 KW	Agriculture Wind, PV	X	X	X	X
2	>60 KW	1 MW	Agriculture Wind, PV	X	X	X	X
3	>1 MW	2 MW	Agriculture Wind, PV	X	Gov't only	X	X

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

For example only - your answers may vary

Schedule Z

Additional Information Required for Net Metering Service

Please fill out the form completely.

Host Customer Name: John Doe Telephon

Address of Facility: 123 Main Street

Electric Account Number: 54-134567891

Meter Number: 11223345 Application ID Number: 2A 103-2010

A) Is the Host Customer applying for net metering service an electric company, generation company, aggregator, supplier, energy marketer, or energy broker, as those terms are used in M.G.L. c. 164, §§ 1 and 1F and 220 C.M.R. 11.00?

✓ No
___ Yes (you are not eligible for net metering service)

NOTE: Definitions are:

"Electric company" means a corporation organized under the laws of the commonwealth for the purpose of making by means of water power, steam power or otherwise and for selling, transmitting, distributing, transmitting and selling, or distributing and selling, electricity within the commonwealth, or authorized by special act so to do, even though subsequently authorized to make or sell gas; provided, however, that electric company shall not mean an alternative energy producer; provided further, that a distribution company shall not include an entity which owns or operates a plant or equipment used to produce electricity, steam and chilled water, or an affiliate engaged solely in the provision of such electricity, steam and chilled water, where the electricity produced by such entity or its affiliate is primarily for the benefit of hospitals and nonprofit educational institutions, and where such plant or equipment was in operation before January 1, 1986; and provided further, that electric company shall not mean a corporation only transmitting and selling, or only transmitting, electricity unless such corporation is affiliated with an electric company organized under the laws of the commonwealth for the purpose of distributing and selling, or distributing only, electricity within the commonwealth. G.L. c. 164, § 1.

"Generation company" means a company engaged in the business of producing, manufacturing or generating electricity or related services or products, including but not limited to, renewable energy generation attributes for retail sale to the public. G.L. c. 164, § 1.

"Aggregator" means an entity which groups together electricity customers for retail sale purposes, except for public entities, quasi-public entities or authorities, or subsidiary organizations thereof, established under the laws of the commonwealth. G.L. c. 164, § 1.

"Supplier" means any supplier of generation service to retail customers, including power marketers, brokers and marketing affiliates of distribution companies, except that no electric company shall be considered a supplier. G.L. c. 164, § 1.

For the terms "energy marketer" and "energy broker," please use the definition for "Electricity Broker," which means an entity, including but not limited to an Aggregator, that facilitates or otherwise arranges for the purchase and sale of electricity and related services to Retail Customers, but does not sell electricity. Public Aggregators shall not be considered Electricity Brokers. 220 C.M.R. 11.02.

B) If applying for Net Metering as an Agricultural Net Metering Facility, please answer the following questions:

1) Is the Agricultural Net Metering Facility operated as part of an agricultural business?
___ Yes
___ No (the facility is not eligible for Net Metering as an Agricultural Net Metering Facility)
2) Has the Commissioner of the Department of Agriculture recognized the business as an agricultural business?
___ Yes
___ No
3) Is the Agricultural Net Metering Facility located on land owned or controlled by the agricultural business mentioned in Item B.1 above?
___ Yes
___ No (the facility is not eligible for Net Metering as an Agricultural Net Metering Facility)
4) Is the energy from the Agricultural Net Metering Facility used to provide electricity to metered accounts of the agricultural business mentioned in Item B.1 above?
___ Yes
___ No (the facility is not eligible for Net Metering as an Agricultural Net Metering Facility)

C) If applying for neighborhood net metering, please answer the following questions:

1) Are all participants served by the same distribution company?
___Yes
___No
2) Are all participants served by the same ISO NE load zone?
___Yes
___No
3) Do all participants reside in the same municipality?
___Yes
___No

NOTE: If any of the answers to the questions in Item C are no, then the facility is ineligible for neighborhood net metering unless granted an exception by the Department of Public Utilities under 220 C.M.R. 18.09(6).

D) Please indicate how the Host Customer will report to the Company the amount of electricity generated by the net metering facility. The information is due twice each year: (1) by January 31 for the prior year's generation; (2) by September 30 for the year-to-date generation:

___ Provide the Company access to their ISO-NE GIS account
___ Provide the Company access to their metering or inverter data
✓ Provide the Company with a report in writing of the generation by January 31 and again on September 30 each year

E) For any Billing Period in which the Host Customer earns Net Metering Credits, please indicate how the Distribution Company will apply them:

✓ Apply all of the Net Metering Credits to the account of the Host Customer (Skip Items F and G)
___ Allocate all the Net Metering Credits to the accounts of eligible Customers (Class I and II Net Metering Facilities skip Item F)
___ Both apply a portion of the Net Metering Credits to the Host Customer's account and allocate a portion to the accounts of eligible Customers (Class I and II Net Metering Facilities skip Item F)

F) If the Host Customer has a Class III Net Metering Facility, please indicate below the range that best represents the number of eligible Customer accounts to which Net Metering Credits would be allocated. Alternatively, please complete Item G. This information will allow the Company to exercise its option to purchase Net Metering Credits from the Host Customer rather than allocating such credits.

WMECO M.D.P.U. No. 1048A 12/1/09

The Company will notify the Host Customer within 30 days of the filing of Schedule Z whether it will allocate or purchase Net Metering Credits. If the Company elects to purchase Net Metering Credits, the Company will render payment by issuing a check to the Host Customer each Billing Period, unless otherwise agreed in writing by the Host Customer and Company. If the Company elects to allocate Net Metering Credits, the Host Customer must complete Item G and submit the revised Schedule Z to the Company.

_____ Allocate Net Metering Credits to fewer than 50 eligible Customer accounts (Skip Item G)
_____ Allocate Net Metering Credits to 100 or fewer eligible Customer accounts (Skip Item G)
_____ Allocate Net Metering Credits to more than 100 eligible Customer accounts (Skip Item G)

G) Please state the total percentage of Net Metering Credits to be allocated.

____% Amount of the Net Metering Credit being allocated. The total amount of Net Metering Credits being allocated shall not exceed 100 %. Any remaining percentage will be applied to the Host Customer's account.

Please identify each eligible Customer account to which the Host Customer is allocating Net Metering Credits by providing the following information (attach additional pages as needed):

NOTE: If a designated Customer account closes, the allocated percentage will revert to the Host Customer's account, unless otherwise mutually agreed in writing by the Host Customer and the Company.

Name:
Billing Address:
Account number:
Amount of the Net Metering Credit: ____%

Name:
Billing Address:
Account number:
Amount of the Net Metering Credit: ____%

Name:
Billing Address:
Account number:
Amount of the Net Metering Credit: ____%

Name:
Billing Address:
Account number:
Amount of the Net Metering Credit: ____%

Name:
Billing Address:
Account number:
Amount of the Net Metering Credit: ____%

Name:
Billing Address:
Account number:
Amount of the Net Metering Credit: ____%

Name:
Billing Address:
Account number:
Amount of the Net Metering Credit: ____%

Name:
Billing Address:
Account number:
Amount of the Net Metering Credit: ____%

Name:
Billing Address:
Account number:
Amount of the Net Metering Credit: ____%

Name:
Billing Address:
Account number:
Amount of the Net Metering Credit: ____%

H) The Company may elect to seek to obtain capacity payments from ISO-NE for the electricity generated by Class II and III Net Metering Facilities. The Company will notify the Host Customer within 30 days of the filing of Schedule Z whether it will assert title to the right to seek those capacity payments. If the Company elects to assert title to those capacity payments, the Company will include any capacity payments received from ISO-NE in the Company's annual Net Metering Recovery Surcharge reconciliation.

I) The terms of this Schedule Z shall remain in effect unless and until the Host Customer executes a revised Schedule Z and submits it to the Company. Unless otherwise required herein or mutually agreed to in writing by the Host Customer and the Company, a revised Schedule Z shall not be submitted more than twice in any given calendar year.

J) A signature on the application shall constitute certification that (1) the Host Customer has read the application and knows its contents; (2) the contents are true as stated, to the best knowledge and belief of the Host Customer; and (3) the Host Customer possesses full power and authority to sign the application.

John Doe

Host Customer

1/14/10

Date

Net Metering Production Reporting

- Net Metering Tariff requires reporting of generator's kWH output.
- Class 1 Facilities to provide in writing by January 31 and September 30
- Class 2 and Class 3 Facilities may participate in production tracking system (PTS).
  - Mass CEC provided PTS data to the utilities, still working through implementation issues
  - Utility will request data from Class 2 and 3 Facilities

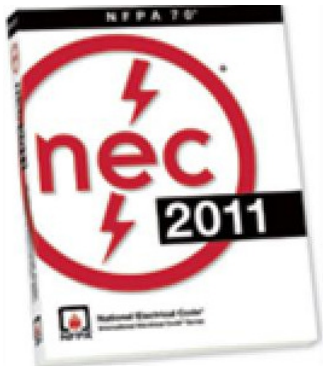
Net Metering Summary

- If planning to Net Meter, submit Schedule Z with interconnection application
- Correctly fill out Schedule Z
  - 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
- Production reporting is required.
- Over 60 kWs require registration as a settlement only generator (SOG) associated ISO OP 18 metering requirements

Break: 5 Minutes

Technical Aspects of Integrating DG with the Utility Distribution EPS

Retail Connections Engineering
National Grid



Technical Aspects of Integrating DG with National Grid's Distribution EPS

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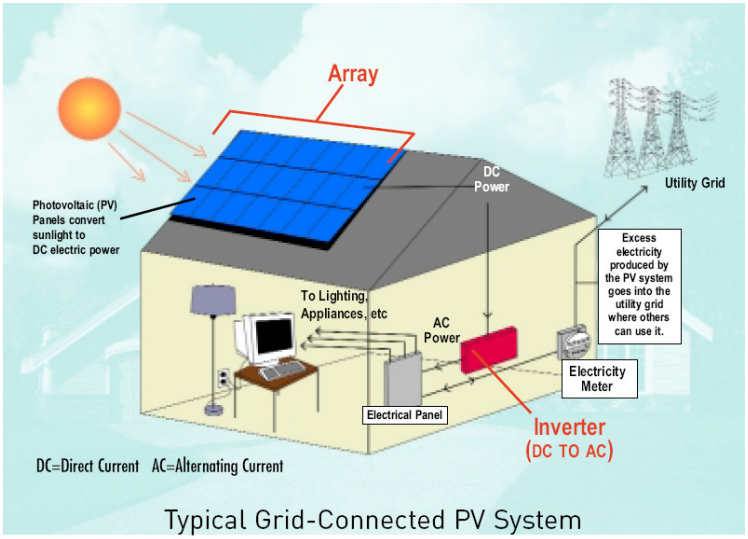
➢ Objective:

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.



Typical Grid-Connected PV System
(Without Battery Backup System)

Interconnection Standards:
Jurisdictional Tariffs

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

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

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

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

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

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

http://www.ferc.gov/EventCalendar/Files/20050512110357-order2006.pdf

Interconnection Standards: *(cont'd)*

Industry Standards and Codes

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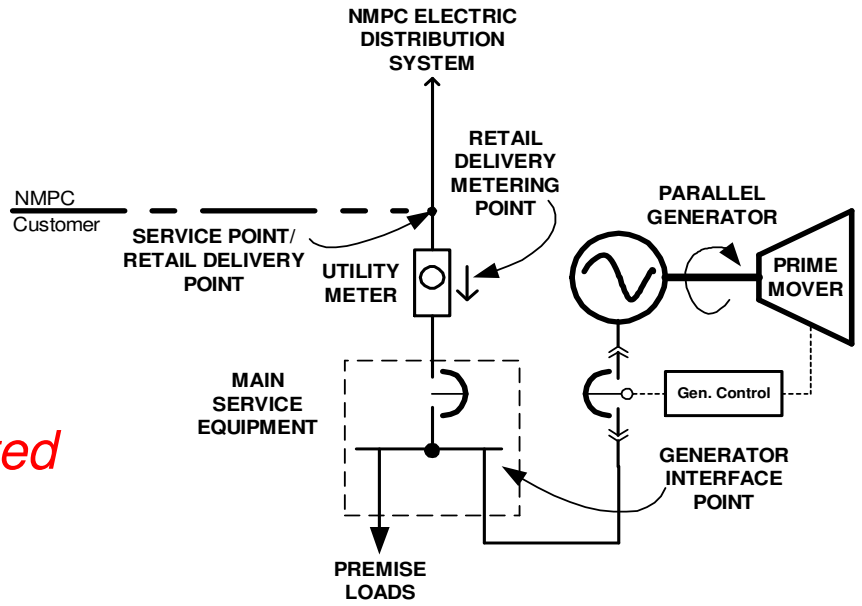
What are industry standards and codes that apply to DG interconnections to the EPS?

- 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)*

Industry Standards and Codes

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- **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

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- **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)*

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

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- **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

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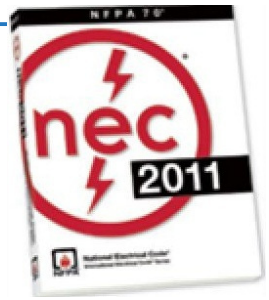
Codes for Installing Renewable Energy Sources



- *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

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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

    MA Court Rules: *Solar PV Installations are Electrical. PHYSICAL INSTALLATION of PV Systems Must Be Done by LICENSED ELECTRICIANS. [July 2012 ruling by Suffolk Superior Court]*
- **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.

www.nationalgridus.com/electricalspecifications

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

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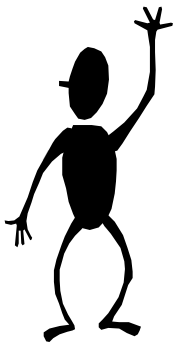
Key Points for Electric Service Requirements:

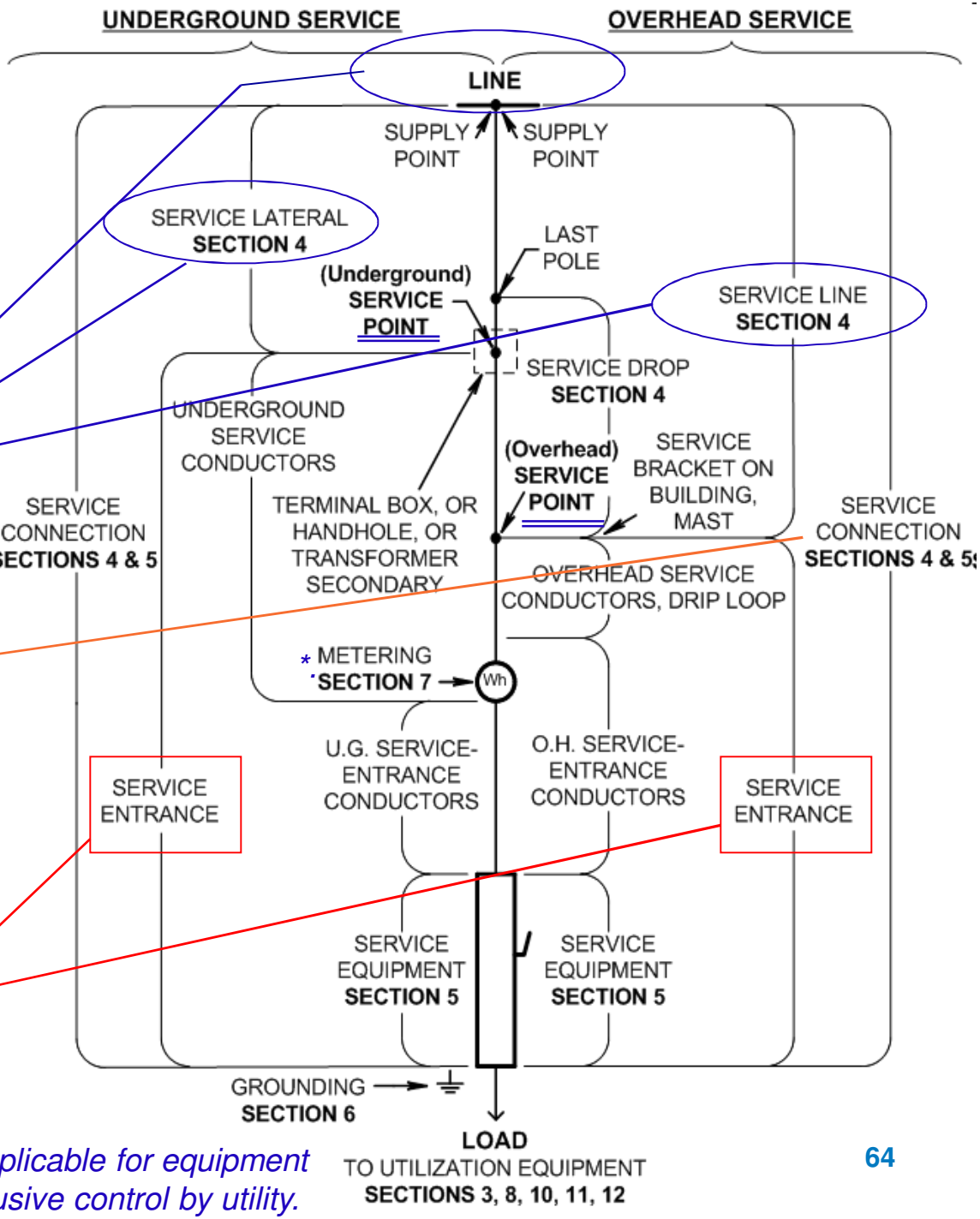
- Require some means of **disconnect and main overcurrent protection**, i.e., **service equipment**.
- Billing **meters secure**.
- Interface points clear to **avoid potential operating and safety problems**.



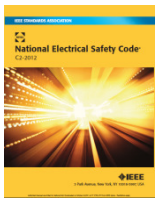
Key Points for Parallel Generation Requirements:

- **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

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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*** *Distributed Generation Connected To National Grid Distribution Facilities per the NYS SIR*
- ***Appendix C*** *Distributed Generation Connected To National Grid Distribution Facilities per the MA SIDG*
- ***Appendix D*** *Distributed Generation Connected To National Grid Distribution Facilities per the RI SCDG*
- ***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 **jurisdictional-specific requirements**.*

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

Interconnection Standards: *(cont'd)*

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)*

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National Grid ESB 756 Appendices

ESB 756 Appendix	What it Covers -
A (*May 2007*)	**NY Parallel Generation Requirements Not Covered by the NY SIR** •*Applies to wholesale energy projects under the NYISO process and FERC SGIP or LGIP* •*Also applies to retail tariff parallel generation projects exceeding 2MW under NMPC PSC No. 220 whether load shaving or retail power purchase agreement*
B (*Aug. 2011*)	**Distributed Generation ≤ 2MW Connected To National Grid Distribution Facilities according to the NY Standardized Interconnection Requirements (NY SIR or SIR)** •*Rule 53 in NMPC PSC No. 220 tariff.*
C (*May 2012*)	**Distributed Generation Connected To National Grid Distribution Facilities according to the Massachusetts Standard for Interconnecting Distributed Generation (MA SIDG or SIDG)** •*M.D.P.U. 1176, December 2009 tariff.*
D (Aug. *2012*)	**Distributed Generation Connected To National Grid Distribution Facilities according to the Rhode Island Standard for Connecting Distributed Generation (RI SCDG or SCDG)** •*R.I.P.U.C. 2078, November 2011 tariff.*
E (*Aug. 2011*)	**Requirements for Parallel Generation Connected to National Grid Facilities in New Hampshire** •*N.H.P.U.C. 17, July 2009 tariff.*

Interconnection Standards: *(cont'd)*

National Grid ESB 756 Appendices B - E

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- National Grid strongly believes that promoting the installation of Distributed Generation (DG) facilities, in accordance with state jurisdictional standardized interconnection requirements, is sound public policy.
- The state jurisdictional ESB 756 Appendix B, or C, or D, or E supplements ESB 750 and the state regulations and *provides general requirements, recommendations, and assistance* to customers regarding DG facilities connected in parallel to the Company's distribution electric power system (Company Distribution EPS).
- Will consider DG facilities on network systems to the extent technically feasible.
- If a project will be selling their energy to a third party, not National Grid as a Qualifying Facility (QF) or under the net-metering tariff, then the customer will need to apply and work with the NY ISO or ISO-NE for interconnection to the distribution system.

Interconnection of Distributed Generation: Technical Issues

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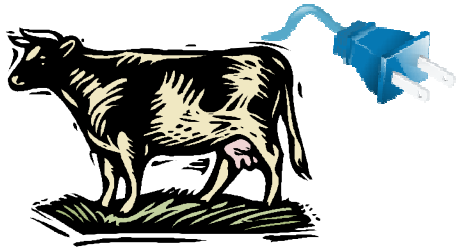

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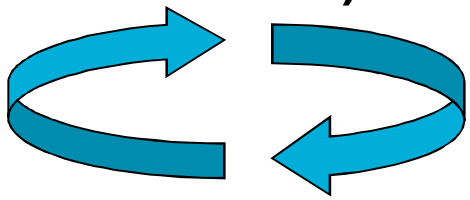
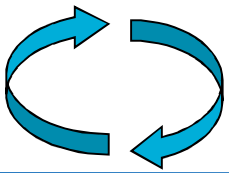
Technical Issues:

- **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



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

- For example in MA, see **ESB 756 Appendix C:**
  - ***Section 3.0*** *for Customer Interface Procedures*
  - ***Exhibit 2*** *for Company milestone requirements for projects not covered by the simplified process (i.e. complex)*
  - ***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*)

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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

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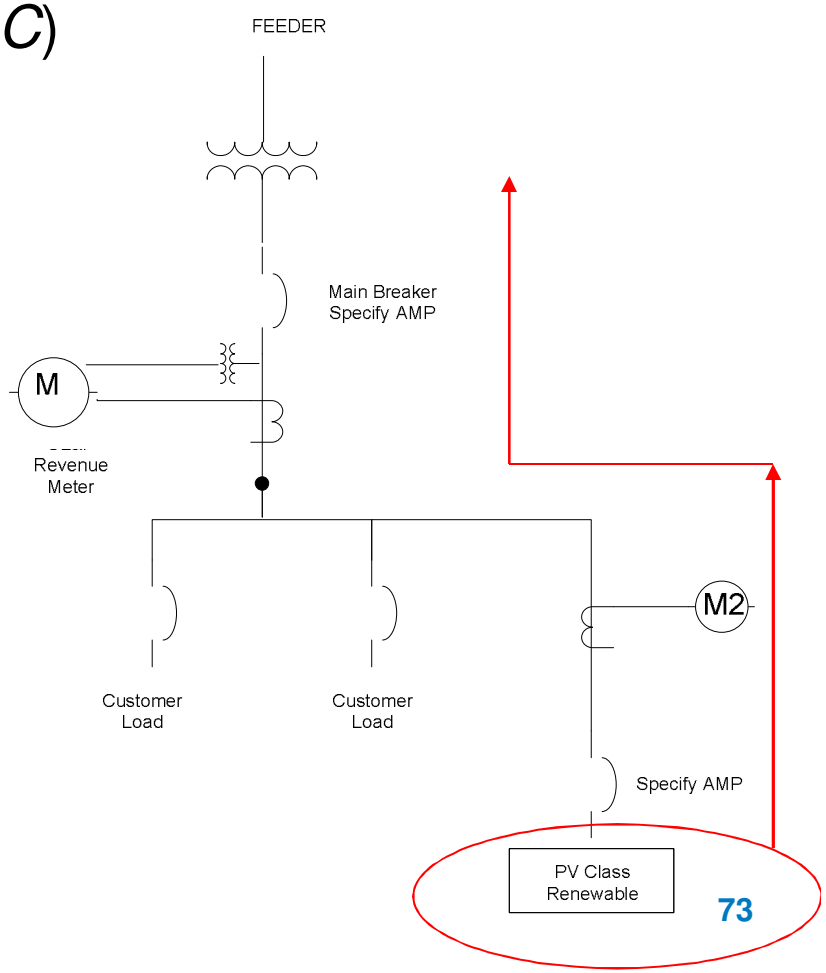
Recommended Guidelines for **Residential and Commercial** Single-line Diagram Submittals (*for example, see Exhibit 5 & Figures 1 & 2 in ESB 756 Appendix C*)

- ✓ *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

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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

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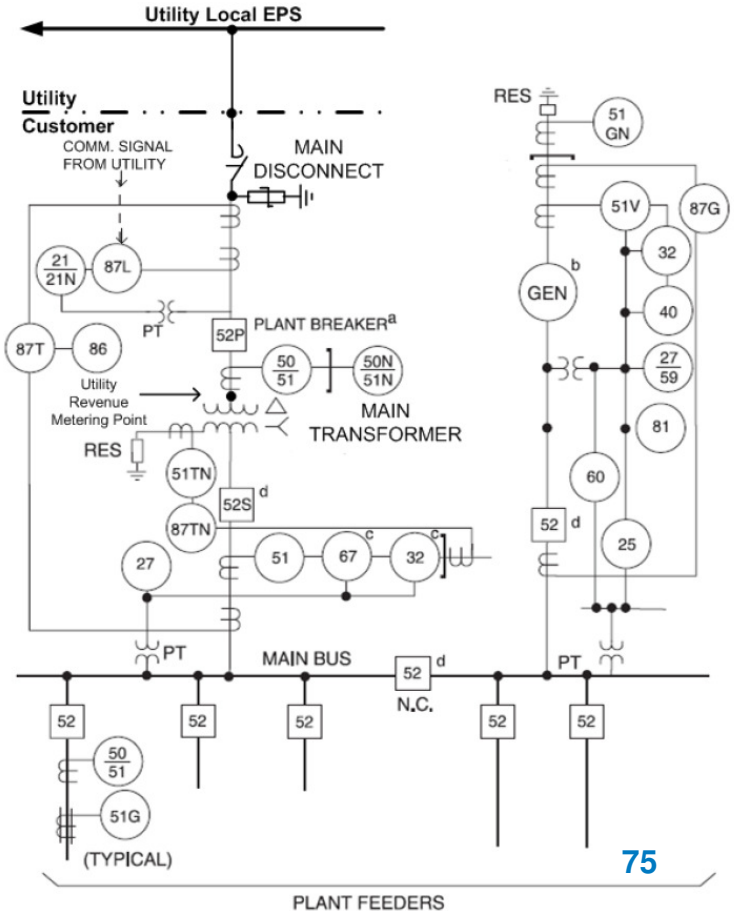
Recommended Guidelines for **Functional Single-line Diagram Submittals** (*for example, see Exhibit 6 & Figures 3 & 4 in ESB 756 Appendix C*)

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

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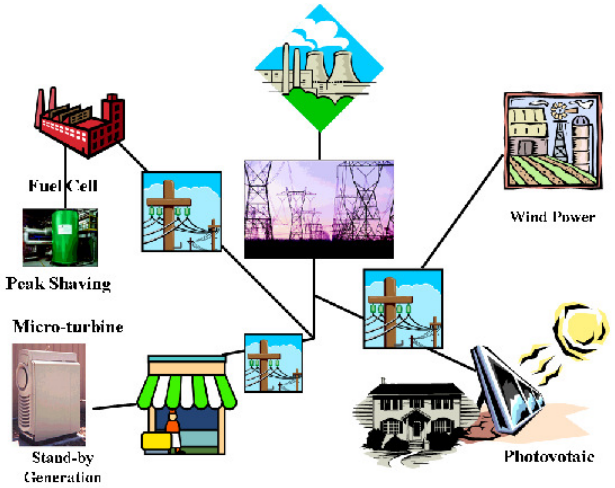
- **Customer generation connected to the distribution system can cause a variety of system impacts including steady state and transient voltage changes, harmonic distortion, and increased fault current levels.**
- **The purpose of impact studies is to identify the severity of system impacts of the Customer's 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

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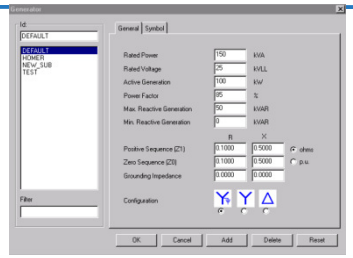
- **Studies will identify:**
  - **Thermal overload** or **voltage limit** violations (steady state) for summer and winter peak loading conditions.
  - **Sensitivity study** (steady state only) to assess the impact of the project **during light load conditions**.
  - Identify the **impact of the project 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

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- **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

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- ✓ *If **aggregate generation** on a feeder is **over 7.5%** of peak feeder load, there may be special reviews required. (This is the present 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**.*

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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 protective device for onsite utility equipment, i.e. metering for adequate coordination with the EPS*
  - ✓ *Provide for utility remote disconnect for emergency operations*

Technical Issues:
Limits on Distribution EPS

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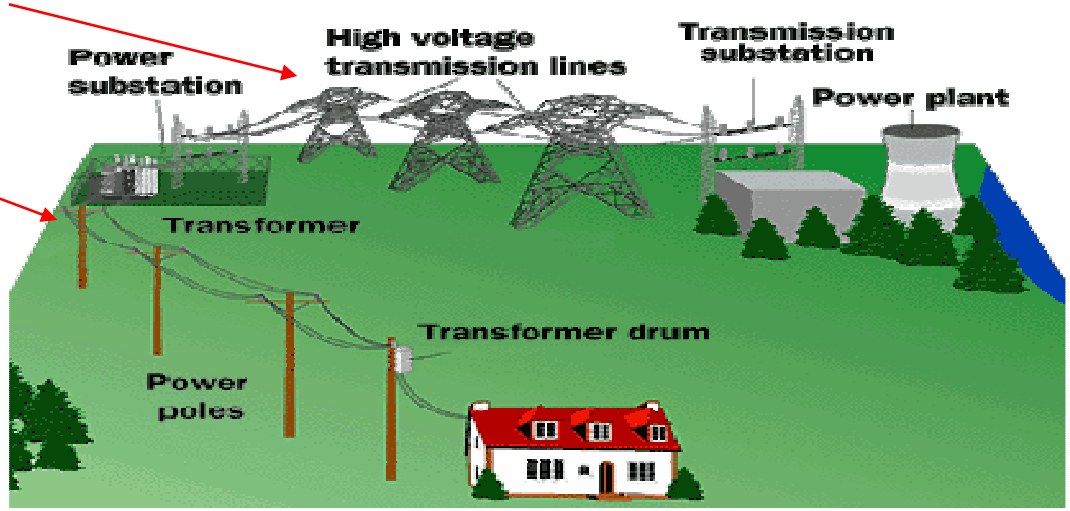
- **Radial Systems**
  - *Distribution or Transmission?*
    - MA, NH, NY, and RI interconnection standards apply to generators that will connect (grid tied) to the **Distribution System** (below 69kV).
    - For **Transmission System**, apply to the Independent System Operator, ISO (New England or New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



Technical Issues: (*cont'd*)

Limits on Distribution EPS - Radial

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- 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

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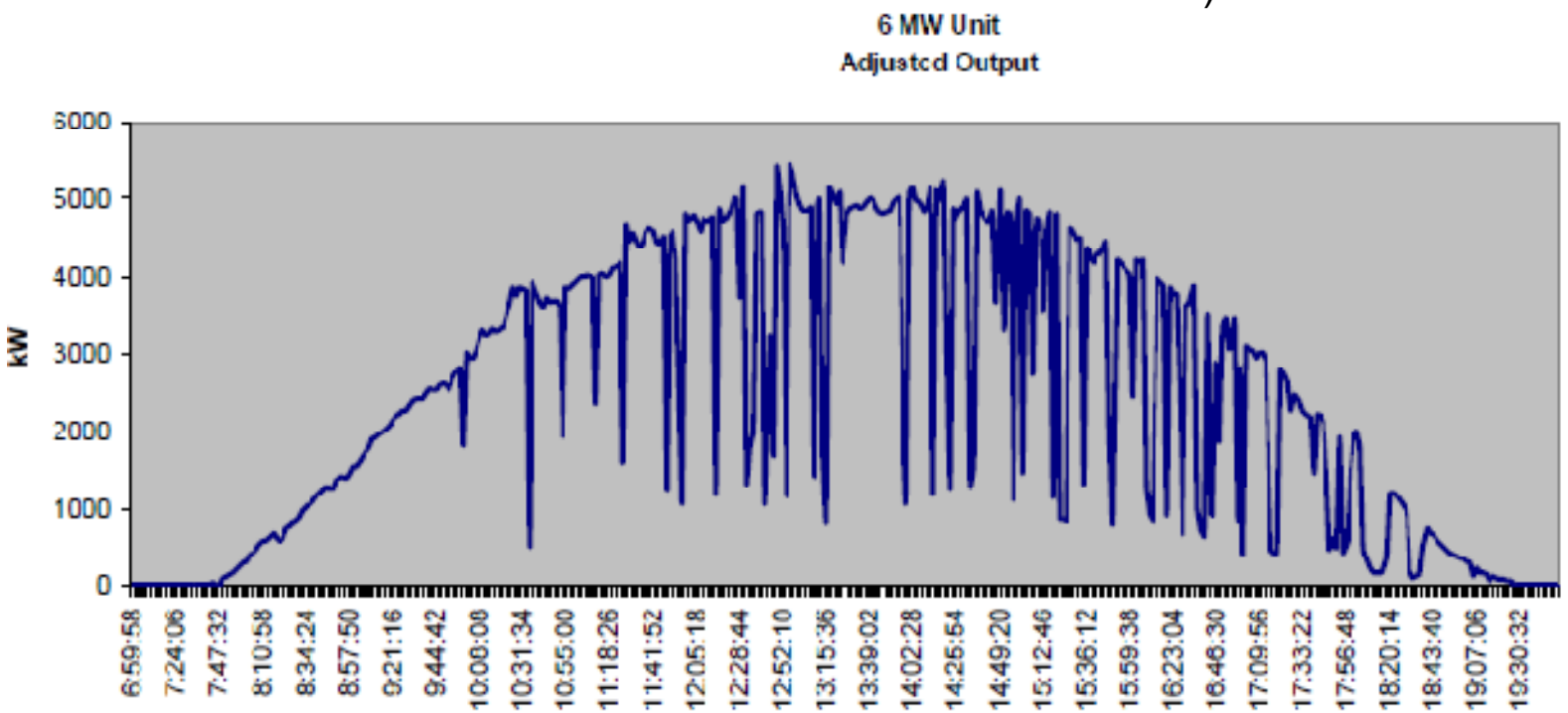
Courtesy of BP Solar

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

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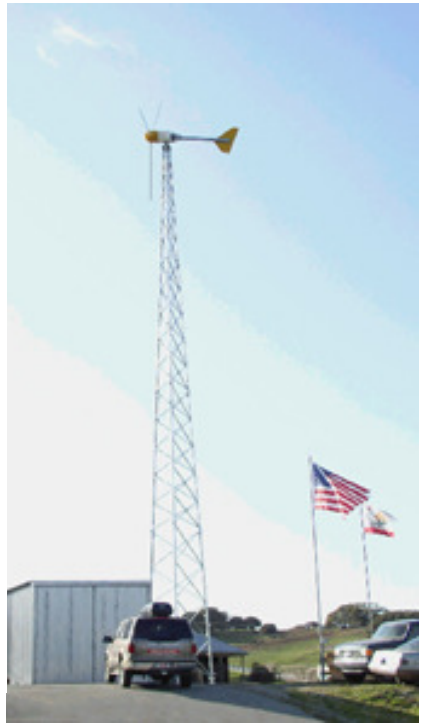
Types of Wind Turbine Generators (WTG)

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

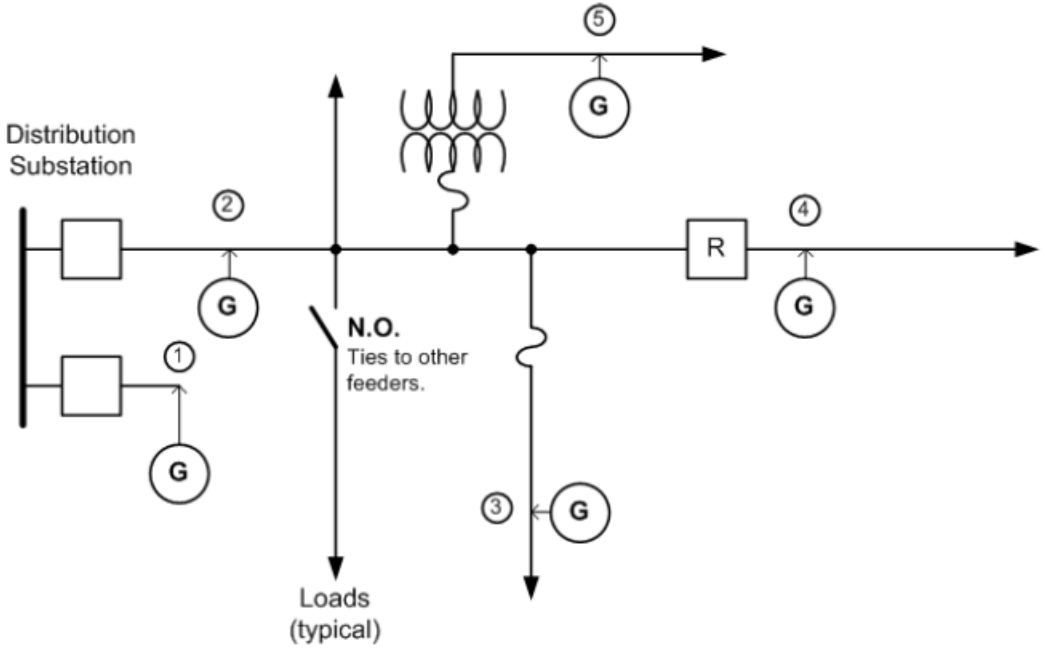
- ***Type 1:*** Squirrel cage induction generator directly coupled to the grid. May have pitch control
- ***Type 2:*** Wound rotor induction machine with external rotor resistance control
- ***Type 3:*** Wound rotor Doubly-fed induction generator (Voltage injected in the rotor winding)
- ***Type 4:*** 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 C*)



"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

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

- **Typical Planning Limits** for DG Connection to Radial Distribution Feeder - *cont'd*

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 Company's system) is considered for all points along the distribution feeder. The Company will evaluate each application before deciding on the maximum MVA allowed onto the Company's 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 MA SIDG; 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 in aggregate of large units 500kVA and above up to 3.0MVA on 15kV class systems (this is in addition to small (e.g. residential rooftop) PV until aggregate of these exceeds 500kVA). Operating issues on EPS voltage regulation occur from the effects of cloud transients on large PV systems.*

d. ***Limits for 25kV and 38kV distribution class systems*** *in Massachusetts are determined by the Company on a case-by-case basis.*

e. *On* ***single-phase radial distribution systems****, generators* ***over 50kVA*** *may require* ***three-phase service****. These situations will be determined by the Company on a case-by-case basis.*

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 ≥500kVA 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

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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

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- 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

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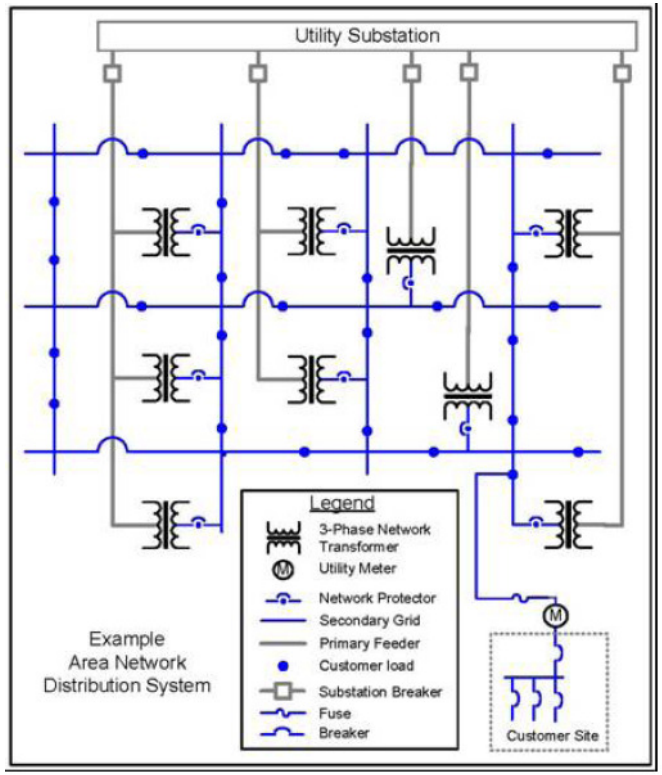
- Unlike radial distribution systems that deliver power to each customer in a single path from source to load, underground secondary area network systems deliver power to each customer through a complex and integrated system of multiple transformers and underground cables that are connected and operate 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

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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 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):

WMECo	Unitil	National Grid	NSTAR
Greenfield	Fitchburg	Brockton	Boston
Pittsfield		Lynn	New Bedford
Springfield		Worcester	Cambridge
West Springfield			

(*For National Grid, see Exhibit 3 in ESB 756 Appendix B, or C, or D.*)

Technical Issues: (*cont'd*)
Limits on Distribution EPS - Network

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- 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

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- 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

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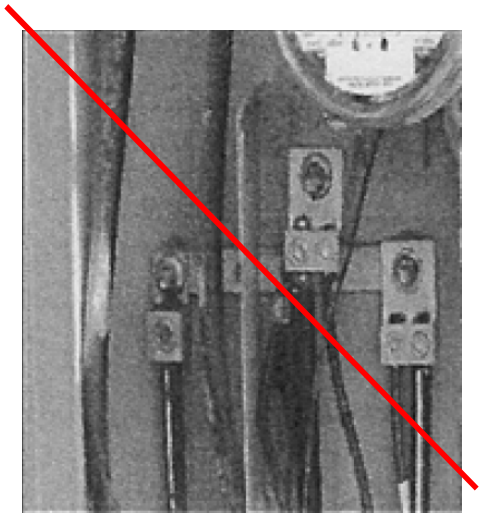
- **Taps Ahead of Service Equipment for DG Interconnection – Concerns**
  - *The Company's position is consistent with the rules and regulations for electric service contained in the Company's ESB 750-2010 "blue book" regarding taps and splices ahead of service equipment and in meter sockets.*
    - *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 applicable Company tariff, ESB 756 Appendix B, or C, or D, or E as applicable, 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

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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.

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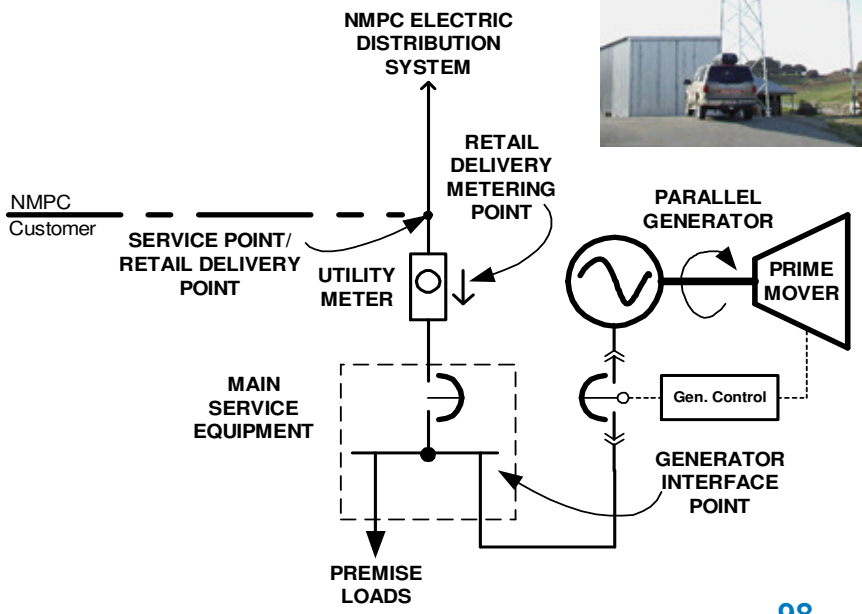
What we covered

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



PARALLEL GENERATION EXAMPLE

Questions?