

Duquesne Light Company

FACILITY INTERCONNECTION REQUIREMENTS (FAC-001)

GENERATION FACILITIES

TRANSMISSION FACILITIES

END-USER FACILITIES

12/30/2015

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I. INTRODUCTION

This document contains the standard minimum requirements for the safe and effective operation of a Generating Facility (GF) in parallel with the Duquesne Light Company (DLC) system. The standards are general and may not cover specific details for every case. A Site and Connection Agreement for each installation covered under Class II and Class III will cover the specific details. The standards normally applied may be altered by DLC to cover unanticipated technical problems that may occur despite the fact that the proposed installation is similar to a previously accepted installation. All of the standards specified in this document for the parallel operation of GFs with DLC are also applicable to the operation of Demand Side Management (DSM) installations in parallel with the DLC system. DLC may elect to exempt installations of new generation technology from the requirements specified in this document on a case-by-case basis provided that the risk associated with the parallel operation of these facilities with DLC is determined to be negligible. The GF shall submit an application to DLC requesting approval for parallel operation with DLC. The application shall include the information requested on the appropriate interconnection application/agreement (see attached Appendix). The GF shall also submit plans and specifications prepared by a registered Professional Engineer for all Class II and Class III installations for review by DLC. The submittal shall be discussed with DLC before purchasing or installing equipment. This is necessary to ensure public safety, equipment protection, high level quality of service to other customers on the same circuit, and the safety of DLC employees. DLC will accept or reject the plans submitted by the GF within the timelines required by the Pennsylvania Public Utility Commission (PUC) or the Federal Energy Regulatory Commission (FERC). DLC shall make reasonable efforts to meet all deadlines provided by the Pennsylvania PUC and FERC unless DLC and the GF agree to a different schedule. If DLC cannot meet a deadline, it shall notify the GF, explain the reason for the failure to meet the deadline, and provide an estimated time by which it will complete the applicable interconnection procedure.

In order to achieve the required system performance, DLC requires a planning study for all facility additions connecting to the DLC transmission system at 100kV and above. DLC will perform studies involving generation requests to interconnect with the DLC transmission system or participate in studies involving requests from other transmission entities to interconnect with the DLC transmission system, through coordination with its Regional Transmission Organization, PJM Interconnection LLC and other impacted transmission systems when necessary. These studies will include power flow, short circuit, power quality and stability analysis as required which will be determined via the planning study process. Any facility upgrades necessary to maintain the reliability of the interconnected transmission system will also be addressed. Results of the planning study shall be shared with the customer, other impacted transmission system owners and PJM where applicable. Procedures for notification of new or modified facilities to others can be found in PJM Manual 3 and PJM Manual 14.

The proposed service will be detailed in the form of a DLC Project Scope issued by the Transmission Planning Department.

A. Policy Statement of Purpose

This document is intended to comply with the Pennsylvania Public Utility Commission Alternative Energy Portfolio Standards, Subchapter C: Interconnection Standards and FERC Order No.2006.

As stated in the Introduction, the standards in this document are general in nature and may not cover specific details for every case. Because of the variety of possible generator interconnections with DLC, it is not feasible to specify a single standard set of interconnection protection equipment that is universally applicable. Instead, these standards are meant to provide the basic guidelines that are used to develop the appropriate interconnection protection for each GF.

B. Definitions

1.	DLC	Duquesne Light Company, Utility, or Company
2.	GF	Generating Facility
3.	GO	Generation Owner
4.	DSM	Demand Side Management
5.	Cogenerator	Facility using residual energy from a manufacturing process to generate power
6.	Renewable Energy Sources	Include Solar, Wind, Hydro, Municipal Solid Waste, Biomass, or other Tier I and Tier II alternative energy sources listed in Chapter 75. Alternative Energy Portfolio Standards
7.	LCI	Line commutated inverters
8.	FCI	Force commutated inverters
9.	NERC	North America Electric Reliability Corporation
10.	OATT	Open Access Transmission Tariff
11.	Low Voltage Network Service	Two or more DLC supply circuits connected to a low voltage (≤ 600 V) secondary network bus
12.	DLC Transmission System	Equipment with nominal operating voltages of 69kV, 138kV, and 345kV
13.	DLC Distribution System	Equipment with nominal operating voltages of 23kV or below.

C. Responsibility of Cost

1. The GF shall be responsible for all costs incurred by DLC, directly related to the connection and subsequent removal of the GF, in addition to any costs to serve the GF's electrical load, in accordance with the DLC Electric Service Installation Rules.
2. Any DLC power utilized by a GF to service this load shall be purchased as a Customer of DLC under the appropriate DLC tariff. Station service and other load shall be fed from a separate metered service when required by metering limitations as determined by DLC
3. Installations where the interconnection protection facilities are owned, operated, and maintained by the GF, if the actual performance of the GF equipment proves to be unacceptable to DLC, it will be the responsibility of the GF to reimburse DLC for expenses incurred due to corrective action taken.

D. Indemnification

The GF shall indemnify and hold DLC harmless for all damages, injuries and fatalities to DLC or others arising out of the GF's use, ownership, or operation of its facilities, and caused in whole or in part by the GF's equipment failure or negligence. The GF is solely responsible for providing adequate protection for its facilities operating in parallel with DLC's system and shall release DLC from any liability for damages or injury to its facilities arising out of such parallel operation, unless caused solely by DLC's negligence.

II. GENERAL REQUIREMENTS

A. Definition of Classes

1. Class I - < 51 kW
2. Class II - 3Ø: 51 to 2000 kW
3. Class III - 3Ø: > 2000 kW

B. Voltage Level, MW, MVAR

1. Types of Electric Service, Distribution

Aside from the services and demand limits in the following table available from distribution supply lines operating at 2,400 volts or higher with facilities located on customer's property, it is not necessary for DLC to provide equipment.

DLC will make every effort to accommodate the required injection at the requested point of interconnection. The study process will determine the feasibility of the request and identify any subsequent upgrades.

SUPPLY LINE VOLTAGE THREE-PHASE, FOUR-WIRE CIRCUITS						
TYPE OF SERVICE			2,400/4,160 VOLTS		13,200/23,000 VOLTS	
VOLTAGE	PHASE	WIRE	OVERHEAD LIMITS (kVA) Min.-Max.	UNDERGROUND LIMITS (kVA) Min.-Max.	OVERHEAD LIMITS (kVA) Min.-Max.	UNDERGROUND LIMITS (kVA) Min.-Max.
120/240	1	3	1-50	1-50	1-100	1-100
230/460	1	3	1-50	UNAVAILABLE	1-100	UNAVAILABLE
120/208	3	4	30-300	50-500	30-300	50-1,500
230	1	2	1-50	1-50	1-100	1-100
230	3	3	1-300	50-500	1-300	50-1,000
277/480	3	4	UNAVAILABLE	150-500	50-500	150-2,000
460	1	2	1-50	UNAVAILABLE	1-100	UNAVAILABLE
460	3	3	50-500	150-500	50-500	150-2,000
2,400	1	2	1-50	UNAVAILABLE	50-100	UNAVAILABLE
2,400	3	3	UNAVAILABLE	UNAVAILABLE	UNAVAILABLE	225-2,000
2,400/4,160	3	4	150-500	150-500	150-500	225-2,000
13,200/23,000	3	4	UNAVAILABLE	UNAVAILABLE	500-2,000	500-2,000

NOTE: HIGHER LIMITS ARE AVAILABLE IN SOME LOCATIONS. CHECK WITH DLC

2. Standard Overhead Conductor Ratings by Voltage

VOLTAGE (V)	TYPICAL RATING (kVA)
23,000	14,540 – 18,720
69,000	102,200
138,000	222,700
345,000	1,244,200

3. Service and Demand Limits Available from Sub-transmission and Transmission Supply Lines

SUPPLY LINE VOLTAGE THREE-PHASE, FOUR-WIRE CIRCUITS						
TYPE OF SERVICE			23,000	69,000	138,000	345,000
VOLTAGE	PHASE	WIRE	ONE BANK LIMITS (kVA) Min.-Max.	LIMITS (kVA) Min.- Max.	LIMITS (kVA) Min.- Max.	LIMITS (kVA) Min.- Max.
120/208	3	4	300-1,500	NOT AVAILABLE		
230	3	3	300-1,500			
277/480	3	4	300-3,000			
460	3	3	300-3,000			
2,400**/**	3	3	300-10,000			
2,400/4,160*	3	4	300-10,000			
11,500**/**	3	3	NOT AVAILABLE			
23,000*	3	3	AVAILABLE			
13,200/23,000*	3	4	SOME LOCATIONS			
69,000**/**	3	3	NOT AVAILABLE	NOT AVAILABLE		
138,000*	3	3	NOT AVAILABLE	NA		
345,000*	3	3	NOT AVAILABLE	NA		

NOTE: CHECK WITH THE COMPANY FOR kVA LIMITS FOR AVAILABLE SERVICES

For end-use customers, DLC does not have a MVAR capacity requirement at the point of interconnection and follows the RTO standards for FERC jurisdictional connections.

*Customers requesting service from high voltage power lines should contact the Major Accounts Department for information on which service voltages are available.

**Limited applications for this voltage level

C. Voltage, Reactive Power, and Power Factor Control

1. Voltage and Reactive Control

Generator power factor requirements, coupled with the reactive requirements, effectively control the voltage. In real time, voltage is monitored according to voltage operating criteria. Requirements will be specified by DLC depending upon the type and size of the GF's generator and load, the DLC circuit or specific voltage system it is connected to, and other DLC customer(s) connected to the same circuit. Additionally, generation control, operation, and supervision shall meet the requirements and guidelines of the NERC.

a. Transmission-connected Generator Requirements

All generators interconnected with the transmission system, except as the RTO may determine otherwise for small generation resources of less than 20 MW, shall be designed to maintain a composite power delivery at continuous rated power output at the generator's terminals at a power factor of at least 0.95 leading to 0.90 lagging.

This requirement also applies to increases in existing generation. DLC or its RTO will provide for certain exceptions to existing generators that apply for increases of less than 20 MW. Increases of more than 20 MW to existing generators must be designed to maintain the original power factor capability for grandfathered MWs and a power factor range of at least 1.0 (unity) to 0.90 lagging for all incremental MW increases.

DLC applies this standard to voltage levels, 69 kV, 138 kV, and 345 kV on its system.

All GFs connected to the transmission system must install and have available generator field-excitation regulators. The reactive output of transmission-connected GFs must be regulated in the manner specified by DLC, and/or its RTO.

DLC will provide a predetermined voltage schedule or a reactive generation level for transmission-connected GFs. Under normal operations, the transmission-connected GF shall operate the facility with automatic voltage regulation equipment in service at all times, except for outages of the regulator for maintenance or equipment failure.

Overvoltage and undervoltage protection systems must be capable of allowing abnormal system operations within DLC post-contingency operating limits. Momentary voltage fluctuations are permitted provided they neither disturb service provided by the RTO or the GF on their respective systems nor hinder DLC or its RTO from maintaining proper voltage conditions on its system.

During an emergency, the GF must participate in a voltage reduction declared by DLC or its RTO and operate the facility at the voltage level requested by DLC. Unless a manual adjustment is required, the GF must maintain the facility's automatic voltage regulator(s) in service during an emergency.

The GF must notify DLC or its RTO with as much lead-time as possible prior to performing all voltage regulator maintenance. In addition, the GF shall notify DLC at least 30 minutes

prior to removing or returning the voltage regulator to service. In the event that automatic voltage regulating devices are out-of-service, the GF shall provide manual voltage regulation to maintain the prescribed voltage schedule or reactive power schedule.

b. Transmission-connected Generator Operations

The GF, at the option of DLC or its RTO shall operate the facility either according to a predefined voltage schedule provided by DLC, or according to a reactive power schedule provided by DLC and consistent with the facility's generation capability. Both schedules must recognize transmission equipment limits and must be coordinated with DLC.

When operating to a pre-determined voltage or reactive schedule, the GF reactive output must not violate appropriate pre/post contingency voltage limits.

When maintaining a voltage schedule, the GF shall be operated with automatic generator field-excitation regulators in service and must maintain voltage within +/- 0.5% of the prescribed schedule.

When DLC or its RTO determines that system conditions warrant a change, the GF may be required to deviate from the predetermined voltage or reactive power schedule. DLC or its RTO may direct a facility to operate in lead, lag, or unity power factor as long as the specified power factor is within the unit's capability.

c. Transmission-connected Generators Reactive Power Requirements (MVAR)

The amount of reactive power that must be supplied will be determined based on the reactive power support necessary to maintain transmission voltages within limits. DLC or its RTO will provide documentation to the GO specifying the required tap settings or setting changes, a timeframe for making the changes, and technical justification for these settings or setting changes. The GF (Generation Owner) shall provide notification to DLC or its RTO when the changes have been implemented. (See *also* Section G.8.a.)

d. Low Voltage Network Interconnection Requirements

- (1) DLC will specify the connection requirements which the GFs installation shall meet.
- (2) GFs located in areas provided with low voltage network service shall not be connected to secondary network buses (600 Volts or less). In these cases, GFs that

wish to operate in parallel with the DLC system must be connected directly to the 23 kV (or 12 kV) system through a dedicated transformer(s).

- (3) Requirements for GFs that operate in parallel with DLC not pursuant to Rider 21, will be determined on the basis of RTO criteria.

D. Safety Requirements

1. Codes and Standards

The GF installation must comply with the requirements of the current National Electrical Code (NFPA-70/ANSI), National Electrical Safety Code (ANSI C2), IEEE-80 grounding standard, other applicable national, state, and local codes and ordinances, and the DLC Electric Service Installation Rules.

2. Disconnect Devices

- a. GFs shall be capable of being isolated from DLC by means of a lockable, visible-break isolation device accessible by DLC. The isolation device shall be installed, owned, and maintained by the owner of the GF and located between the GF and the point of interconnection. A draw-out type circuit breaker with a provision for padlocking at the draw-out position can be considered an isolation device for purposes of this requirement.
- b. GFs may elect to provide DLC access to an isolation device that is contained in a building or area that may be unoccupied and locked or not otherwise readily accessible to DLC, by installing a lockbox provided by DLC that shall provide ready access to the isolation device. The GF shall install the lockbox in a location that is readily accessible by DLC and the GF shall permit DLC to affix a placard in a location of its choosing that provides clear instructions to DLC operating personnel on access to the isolation device.
- c. The GF shall provide an automatic disconnect device with load break and fault interrupting capability to separate its generating equipment from the DLC system in the event of a DLC outage. This includes separation for both single phase and multiphase faults on the DLC system. Separation should be effected immediately. Adequate test data or technical proof that the device meets the above criteria must be supplied.

d. When the GF is connected to the DLC distribution system and the visible break isolation device is not 24-hour accessible to DLC, an isolation load break disconnecting device will be required between the GF's generator and DLC system interface point. DLC will operate the load break disconnecting device at the interface point for the purpose of performing maintenance, testing, or repair; or because of a system emergency, disturbance to other DLC customers, or deficiencies in the GF's equipment as determined by DLC.

3. Drawings (Class II and III Only)

Drawings showing detailed electrical design characteristics of the GF's generating equipment controls, protection system relating to the DLC system, grounding grid in the vicinity of the interconnection equipment, and proposed connections to the DLC system must be submitted for review and comment.

DLC will approve only those portions of drawings that apply to the protection relating to the DLC system. DLC may comment on other areas that appear to be incorrect or deficient but will not assume responsibility for the correctness of the protection pertaining to the GF's system.

4. Inspection Requirements

Inspection of structural and electrical work shall be performed by DLC to determine compliance with the DLC requirements. Prior to energizing the interconnection, the GF shall arrange and pay for an inspection of the station and interconnection facilities by a qualified inspection agency and a copy of the Certificate of Completion shall be furnished to DLC.

a. Commissioning (Class II and III Only)

Commissioning tests of the GF's installed equipment shall be performed pursuant to applicable codes and standards. DLC must be given at least five (5) business days written notice, or as otherwise mutually agreed to by the parties, of the tests and may be present to witness the commissioning tests.

b. Pre-installation Inspection, Testing and Documentation (Prior to Generation Cut-in)

DLC reserves the right to inspect the GF's protective and safety equipment prior to generation cut-in and witness functional tests of this equipment within ten (10) days of

receipt of the Certificate of Completion. It is the responsibility of the GF to have the protective and safety equipment tested by a qualified testing agency and inspected by a qualified inspection agency. Documentation of test results shall be submitted to DLC for review.

- c. If DLC, based on inspection or testing, identifies any defects or failures to comply with applicable standards in the GF, DLC shall notify the GO of any identified defects or failures within 20 days after DLC's receipt of the results of such inspection or testing. The GF shall take appropriate actions to correct any such defects or failure at its sole cost and expense, and shall obtain DLC's acceptance of the corrections, which acceptance shall not be unreasonably delayed, withheld or conditioned.
- d. Within 10 days after satisfactory inspection and/or testing of GF (including, if applicable, inspection and/or testing after correction of defects or failures), DLC shall confirm in writing to the GO that the successfully inspected and tested facilities are acceptable for energization.
- e. **Post-installation Inspection and Testing (After Generation Cut-in)**
Following installation DLC reserves the right to inspect and require tests. If the GF's installation causes a disturbance that adversely affects service to other DLC customers, DLC will require that the generating unit(s) be isolated while the GF takes corrective action.

E. Operating Requirements

1. Quality of Service – Power Quality

The design and operation requirements specified in these standards for the connection of a GF to the DLC system must be met to assure the integrity and safe operation of the DLC system, with no deterioration of safety, quality, or reliability of service to other DLC customers.

Operation of the GF should not create disturbances such as voltage surges, voltage dips, frequency deviations or wave shape distortions, which are unacceptable for the quality of

service to other DLC customers, or have an adverse effect on the operation of DLC equipment. The GF shall be responsible for the purchase and installation of additional corrective equipment if required by DLC.

Section G of this document. "DLC Electrical System Specifications" expands on these power quality requirements.

2. Conditions for Disconnecting

DLC may initiate isolation between the GF's generator and the DLC system by operating the load break disconnecting device at the interface point for the purpose of performing maintenance, testing, or repair; or because of a system emergency, disturbance to other DLC customers, or deficiencies in the GF's equipment as determined by DLC.

3. Synchronization

The GF must obtain prior approval from DLC or its RTO when synchronizing the facility to, or disconnecting the facility from the electrical system. In addition, DLC must be notified when synchronizing to or disconnecting from DLC's system. DLC approval is not required for disconnection to prevent injury to personnel or damage to equipment. If the disconnection occurs without prior DLC or RTO approval, the GF shall immediately notify DLC as to the cause, energy reduction, and the expected return time.

The GF must keep DLC and the RTO dispatchers informed at all times of the facility's availability or any change in status.

The facility shall normally be operated with all of the GF's protective relays (primary and back-up) in service whenever the facility is connected to, or operating in parallel with, the DLC electric system. The facility may operate for a limited time to perform maintenance with one set of protective relays in service. DLC and its RTO shall be notified of such occurrences.

The GF shall be responsible for synchronizing between its generation and the DLC system. The GF's installation shall be equipped and interlocked with appropriate synch-check protection to prevent the undesirable connection of the GF's generation to the DLC system for an out-of-phase condition or de-energized line condition.

- a. Synchronization shall be performed using phase-to-phase potential across one (1) breaker at a time.
- b. If the first synchronization attempt is unsuccessful, there shall be no subsequent attempts permitted until contact is made with DLC for authorization of further action.
- c. Potential Transformer (PT) sources used for synchronizing shall accurately reflect the magnitude and phase angle of the voltages appearing on either side of the synchronizing breaker.

4. Reclosing

Automatic reclosing of GF generation connected to the DLC system will NOT be permitted.

Before GF generation is reconnected after a system disturbance, the operator of that generation must:

- a. Verify the integrity of the GF's electrical system
- b. Contact the DLC system operator to verify that system conditions permit the GF to resynchronize and close the GF breaker(s). The GF's breaker synchronizing shall be interlocked to insure that it cannot be closed into a de-energized DLC line. Reclosing of the DLC circuit breakers by DLC is usually automatic, consisting of multiple reclosing attempts, which include instantaneous and time delayed reclosing on circuits with overhead lines. However, the reclosing cycle may be adjusted for circuits to which GF generators are connected, at the discretion of DLC.

F. Types of Generation

1. Induction Generators and Line Commutated Inverters

Induction generators do not have a separate excitation system and, as such, require that their output terminals be energized with AC voltage and supplied with reactive power to develop the necessary magnetic flux. As a result, induction generators are usually not capable of supplying sustained fault current for failures on the DLC system.

It is also recognized that induction generators are generally not capable of supplying isolated load when separated from the DLC system. However, it is possible for an induction generator to become self-excited if a sufficient amount of capacitance exists at its output terminals.

Under conditions of self-excitation an induction generator will be capable of supplying isolated load, providing the load is within the unit's capability. When self-excitation of an induction generator occurs, it will be accompanied by a sudden increase in terminal voltage.

DLC and its customers must be protected from overvoltages, which can occur when an induction generator becomes self-excited and is supplying a small block of load that has become isolated from the DLC system.

Overvoltage protection can limit the duration but not the magnitude of such overvoltages because of the rapid voltage rise, which occurs with self-excitation. Therefore, where self-excitation problems appear likely, special service arrangements may be required in order to reduce the possibility of the induction generator becoming isolated with small amounts of load. In many cases, the additional expense for such special service connections may outweigh the cost savings associated with induction generators.

Reactive power supply for induction generators may pose difficult design problems depending on generator size. For larger size installations, it will likely be required that power factor correction capacitors be installed to limit the adverse effects of reactive power flow on DLC system voltage regulation. However, the installation of capacitors for reactive power supply at or near, an induction generator greatly increases the risk of self-excitation. Because of these problems, reactive power supply for large induction generators must be studied on an individual basis.

2. Synchronous Generators and Force Commutated Inverters

Synchronous generators can be either separately-excited or self-excited. They are capable of operating independently of the DLC system and can supply isolated load within their output capability.

They can also supply continuous fault current to faults on the DLC system and therefore appropriate overcurrent protection will be required. For synchronous generators, sufficient generator reactive power capacity shall be provided by the GF to handle normal voltage changes on the DLC system. This will help to minimize power adjustment monetary charges and enhance generator stability. The generator voltage – VAR schedule, voltage regulator

settings and transformer tap ratio settings (see also Section G.8.a) will be jointly determined by DLC and the GF to ensure proper coordination of voltages and regulator action.

G. DLC Electrical System Specifications

1. Voltage Magnitude and Fluctuation

Overvoltage and undervoltage protection shall be provided by the GF to trip its disconnect device and isolate the GF's system from the DLC system.

a. Distribution Voltage Limitations.

- (1) Pennsylvania PUC Electric Regulations require that voltage variations not exceed $\pm 5\%$ of nominal system voltage for longer than one minute and a total voltage variation of $\pm 8\%$ from minimum to maximum during normal system operation.

b. Transmission Voltage Limitations

- (1) Typical limits

Limit	345 kV	138 kV	69 kV
High	362 (1.05 p.u.)	145 (1.05 p.u.)	72.5 (1.05 p.u.)
Low	328 (0.95 p.u.)	131 (0.95 p.u.)	65.5 (0.95 p.u.)
Load Dump	310 (0.90 p.u.)	124 (0.90 p.u.)	62 (0.90 p.u.)
Voltage Bandwidth	$\pm 5.0\%$	$\pm 5.0\%$	$\pm 5.0\%$

- (2) Requirements contained in VAR-001-2 of the NERC Reliability Standards, require DLC to specify the voltage and reactive power requirements of generators within the DLC control area and maintain a list of generators exempt from voltage and reactive power schedules. Therefore, specific voltage and reactive power schedules will be generated for each GF.

c. For transmission operational issues, operators monitor unit status and output, voltage levels, MVAR and MW output, automatic voltage regulation (AVR) status and output breaker status.

d. Voltage fluctuation (flicker) limitations shall be specified by DLC for each installation.

2. Frequency

Overfrequency and underfrequency protection shall be provided by the GF to trip its disconnect device to isolate the GF's system from the DLC system.

a. Distribution

- (1) Pennsylvania PUC Electric Regulations require that frequency variations not exceed $\pm 3\%$ of nominal 60 Hz.

b. Transmission

- (1) The Generator must deliver the electric energy generated by the facility to the RTO at the point(s) of interconnection in the form of 3-phase, 60-Hertz alternating current at the nominal system voltage at the point(s) of interconnection.

c. Operational Issues

- (1) Generators larger than 20 MW and their protective systems (relaying, V/Hz, etc.) must be capable of operating at a frequency of 57.5 Hz for 5 seconds or longer, or 58.0 Hz for 30 seconds or longer, to coordinate with system preservation underfrequency load shedding. Additionally, generators and their protective systems must be capable of operation at overfrequency up to 62 Hz for a limited duration.

3. Harmonics

The generator shall not be a source of excessive harmonic voltage and current distortion and/or voltage flicker. The GF shall limit the amount of total harmonic voltages imposed in the DLC system to 3% of the fundamental voltage with the largest single harmonic not to exceed 1%. At no time shall the operation of the GF, including the associated generators or any of their auxiliary devices, result in an electrical output in which harmonic distortion exceeds the recommended limits contained in the current IEEE Standard 519, which defines voltage waveform and harmonic content.

4. Short Circuit Duty

If requested by the GF, DLC will provide the value(s) of short circuit current that can be supplied by the DLC system at the point of interconnection.

5. Breaker Duty

DLC does not specify a breaker duty cycle for any MW/V level combinations but the GF is required to have breakers with interrupting capability that exceed the maximum short circuit duty.

6. Grounding Requirements

The grounding system shall be designed in accordance with the current National Electrical Safety Code and the IEEE 80 grounding standard. Before any grounding system equipment is purchased or installed, the grounding system design, ground resistance measurement test data, calculations of step potential, touch potential, and ground potential rise must be submitted to DLC for review and comment.

Prior to energizing the interconnection, the GF shall arrange and pay for an inspection of the grounding system by a qualified inspection agency and a copy of the certified approval report shall be furnished to DLC.

7. Specific Service Grounding Requirements

The customer shall install service grounding at the service equipment in accordance with the National Electrical Code, the requirements of the inspecting authority having jurisdiction, and the DLC Electric Service Installation Rules.

Services to be Grounded

Phase	Wire	Voltage
1	2	120
1	2	2,400
1	2	13,200
1	3	120/240
1	3	120/208
1	3	230/460
3	4	120/208
3	4	277/480
3	4	2,400/4,160
3	4	13,200/23,000

The customer must furnish a properly sized, fully rated grounding conductor from the primary circuit neutral, the transformer neutral grounding point or the service line neutral to ground on the supply side of the service equipment. The grounding conductor shall be installed in the same conduit as the service-entrance conductors or in close proximity where there is no conduit.

a. Services Not to be Grounded

The following types of service will be normally supplied ungrounded. The customer shall not ground the conductors of these installations without specific written permission from DLC.

Services Not to be Grounded

Phase	Wire	Voltage
1	2	230
1	2	460
3	3	230
3	3	460
3	3	2,400
3	3	23,000
3	3	69,000
3	3	138,000

b. Grounding Electrode Conductors

The grounding electrode conductor size shall be not less than No. 6 copper or aluminum. Larger services shall have grounding electrode conductors sized as specified in Article 250-94 of the National Electrical Code (NEC). NEC Article 250-23 shall determine where the grounding electrode conductor is connected to the grounded service conductor. The meter enclosure (base) shall not be used for this connection because it is not accessible when sealed.

c. Primary Water Pipe Electrode

The grounding electrode conductor shall be run without splices or joints to a continuous metallic underground water piping system if available. All parts of the water piping system that are likely to become disconnected, such as water meters or service unions, shall be suitably bonded.

The grounding electrode conductor shall be connected to the metal water piping system in the building if one is available. If the water utility does not permit grounding to its system, an insulating bushing may be used outside the building.

d. Supplemental Electrodes

The metal water piping system shall be supplemented by two electrodes of the type specified in Article 250 of the NEC. The grounding electrode conductor shall be extended

without splices to these electrodes. The supplemental electrodes will become the primary electrodes if a metallic underground water pipe system is not available.

8. Transformer Configuration

The transformer configuration will be determined by DLC for each installation. The GF shall be interconnected to the DLC system through a dedicated transformer(s). This is necessary to reduce the chance of the generation being isolated with a small amount of other DLC customer load, and serves to confine voltage fluctuation or harmonics produced by the GF to its own system.

a. Transmission generator step-up transformers

For generator step-up transformers and auxiliary transformers with primary voltages equal to or greater than the generator terminal voltage, the GF will provide tap settings, available fixed tap ranges, impedance data, and the +/- voltage range with step-change in percent for load-tap changing transformers.

DLC requires GFs connected at 69 kV and above to provide this data. For each GF connected to the DLC transmission system, that GF's Connection and Site Agreement or Interconnection Service Agreement requires the GF to supply the necessary modeling data to satisfy NERC requirements.

After installation, DLC will consult with the GF regarding any future necessary step-up transformer tap changes, and will provide documentation to the GF specifying the required tap changes, a timeframe for making the changes, and technical justification for these changes. The GF shall provide notification to DLC when the changes have been implemented.

9. Interrupting and Isolating Devices

- a. A single phase load break device with visible clearance and fuse (or voltage contactor) shall be provided by the GF as the interface disconnect device for Class I single phase installations. If required, the GF must also provide a single phase load break disconnect device with visible clearance, padlockable and accessible to DLC at the output of the generation.

- b. A three phase load break device with visible clearance shall be provided by the GF as the interface disconnect device for all 3Ø installations. Load break switches, sectionalizers, reclosers, circuit breakers, or vacuum switches that satisfy equipment requirements imposed by DLC electrical system parameters are acceptable. If required, the GF shall also provide a three phase load break disconnect device with visible clearance, padlockable and accessible to DLC at the output of the generation.

10. Equipment Ratings

The ratings of the interface interrupting and isolating devices will be determined by DLC on a case-by-case basis. The information provided shall include insulation levels, interrupting ratings, and momentary ratings.

11. Metering & Telecommunication Requirements

- a. Any metering necessitated by the use of the GF shall be installed at the interconnection customer's expense in accordance with FERC, state, local regulatory, or DLC requirements or the Transmission Provider's specifications.
- b. The GF must meet all Transmission Provider telecommunication requirements.
- c. The type, size, and location of metering equipment will be determined and specified by DLC. At DLC's discretion the GF can be required to install and maintain a dedicated communications link, compatible with DLC's equipment, to telemeter the instantaneous kW output and hourly kWh output simultaneously to DLC's Operation Center. GF installations where net power flow across the interconnection can be very small compared to the maximum power flow require special consideration.

It is not possible to accurately meter loads, which are small in relation to current transformer (CT) ratios involved. DLC reserves the right to require that the generation and load(s) be separated and metered individually if it becomes evident that the interconnection metering is not registering accurately.

- c. A GF facility used for net metering shall be equipped with a single bi-directional meter that can measure and record the flow of electricity in both directions at the same rate. A dual meter arrangement may be substituted for a single bi-directional meter at DLC's discretion.
- d. If the GF's existing electric metering equipment does not meet the requirements in b., DLC shall install new metering equipment for the GF at DLC's discretion. Any subsequent metering equipment change necessitated by the GF shall be paid by the GF. The GF has the option of utilizing a qualified meter service provider to install metering equipment for the measurement of generation at the GF's expense.
- e. Additional metering equipment for the purpose of qualifying alternative energy credits owned by the GF shall be paid for by the GF.
- f. DLC shall take title to the alternative energy credits produced by the GF and pay for and install the necessary metering equipment, should the GF expressly reject title to the credits.
- g. Meter aggregation on properties owned or leased and operated by a GF shall be allowed for purposes of net metering, but shall be limited to meters located on properties within two (2) miles of the boundaries of the GF's property that are located within DLC's service territory.
- h. Physical meter aggregation shall be at the GF's expense. DLC shall provide the necessary equipment to complete physical aggregation.
- i. GF requests for virtual meter aggregation shall be provided by DLC at the GF's expense. The GF shall be responsible only for any incremental expense entailed in processing his account on a virtual meter aggregation basis.
- j. At DLC's discretion, the GF can be required to install and maintain a dedicated communications link and devices, compatible with DLC's equipment, to provide telemetry (SCADA) to DLC's Operation Center. The required telemetry with associated data quality codes is specified in the table: SCADA Telemetry Requirements by GF Class. This information is used by DLC's Operations Center to ensure DLC's electrical system integrity.

SCADA Telemetry Requirements by GF Class

Class	Gen CB Status	Volts	Amps	MW	MVAR	MWH	Frequency¹
Class I (< 51 kW)	No	No	No	No	No	No	No

Class II (3Ø: 51 – 2,000 kW)	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Class III (3Ø: > 2,000 kW)	Yes	Yes	Yes	Yes	Yes	Yes	Yes

¹ Only for generators connected to 69 kV and above

The preferred communications protocol for RTU communications is DNP 3.0 over TCP/IP. If Ethernet is not available, serial DNP 3.0 will be used. Reference Table: Guidelines for Meter Installation by GF Class. The installations shall comply with the current NERC Cyber Security standards CIP-002-3 to CIP-009-3, where appropriate.

Guidelines for Meter Installation by GF Class

Class	IED	Data Model	Configuration	Monitoring Period	Protocol
Class I (< 51 kW)	No	No	No	No	No
Class II (3 \emptyset : 51 – 2,000 kW)	Data Concentrator	All Data Types	Dedicated Ethernet or Serial Channel	2-Second Periodic	DNP 3.0
Class III (3 \emptyset : $> 2,000$ kW)	Data Concentrator	All Data Types	Dedicated Ethernet or Serial Channel	2-Second Periodic	DNP 3.0

- k. Telecommunications (voice and data) circuits, which must be reliable and secure, should be tested regularly and/or monitored online, with special attention given to emergency channels. Installation of communications facilities (internet service, leased telephone circuits, fiber optics, etc.), communications facility operation and maintenance, and other ongoing costs are the responsibility of the Interconnection Customer. Installation of communications facilities (typically leased telephone circuits), communications facility operation and maintenance, and other ongoing costs are the responsibility of the customer. In addition, the customer shall follow the telecommunications requirements outlined in PJM Manuals.

H. Maintenance and Maintenance Coordination

It is the GF's responsibility to maintain all structures, equipment, and associated devices owned by the GF so as to ensure their proper operation at all times.

1. Planned Outages

a. RTO Market Participants

GFs participating in an RTO energy/capacity market must follow the RTO's Planned or Maintenance Outage Requirements.

b. Non-RTO Market Participants

The GF may not remove any equipment from service without prior notification to the RTO and/or DLC except in the case where equipment must be disconnected from the system without RTO approval to prevent injury to personnel or damage to equipment.

2. Unplanned Outages

a. RTO Market Participants

GFs participating in an RTO energy/capacity market must follow the RTO's planned or maintenance outage requirements.

b. Non-RTO Market Participants

The GF may not remove any equipment from service without prior notification to the RTO and/or DLC except in the case where equipment must be disconnected from the system without RTO approval to prevent injury to personnel or damage to equipment.

I. Communications and Procedures – Class III Only

1. Unplanned or Forced Outage

a. If the GF has any advance knowledge of an unplanned or forced outage, the GF shall notify DLC with as much lead-time as practical. For reliability reasons, the GF shall notify DLC as soon as reasonably possible of the following:

- The starting time of the outage.
- The energy reduction resulting (or expected to result) from the outage.
- The estimated time the equipment incurring the outage is expected to return to service.
- The time the GF equipment is actually returned to service.
- The reason for the outage.

The GF must submit a record of the events and circumstances giving rise to the unplanned or forced outage to the RTO as soon as reasonably possible. The GF must also notify the RTO of any unusual operating conditions, which may result in the reduction of output or tripping of multiple generators offline.

In addition, the GF must notify the RTO of any system conditions, whether a result of equipment failure or mandated restrictions (plant, governmental, etc.), which may result in potential generation reduction or controlled shutdown of any generators.

2. Planned Outage

a. Class III GFs will give DLC seventy-two (72) hours notice for a planned outage and supply the following information:

- The starting time of the planned outage.

- The energy reduction resulting (or expected to result) from the planned outage.
- The estimated time the equipment incurring the planned outage is expected to return to service.
- The time the GF equipment is actually returned to service.
- The reason for the outage.

The GF must submit a record of the events and circumstances giving rise to the planned outage to the RTO. The GF must also notify the RTO of any unusual operating conditions, which may result in the reduction of output or tripping of multiple generators offline.

3. Coordinated Joint Studies for New Facilities

- a. For procedures involving coordinated joint studies of new facilities and their impacts on the interconnected transmission systems, DLC will coordinate with the RTO that administers the interconnection studies. These procedures can be found at in the PJM Manuals listed in Appendix B.

4. Notification of New or Modified Facilities to Others

- a. DLC follows specific procedures for notification to others (those responsible for the reliability of the interconnected transmission systems) of new or modified facilities as soon as feasible as part of the RTO interconnection procedures and discusses these facilities with all stakeholders during the RTO's Regional Transmission Expansion Planning process. These procedures can be found at in the PJM Manuals listed in Appendix B.

III. SYSTEM PROTECTION AND PROTECTION COORDINATION REQUIREMENTS

DLC will specify and install the equipment required to protect DLC system equipment, personnel, and customers from the GF's generation. DLC will own, operate, and maintain the protection equipment specified. When specified, equipment such as CTs, PTs and the DC battery required by DLC for interconnection protection shall be separate from the CTs, PTs and battery utilized for the GF system protection.

The GF's protection shall be compatible and coordinate with the DLC system protection so that faults on the GF system do not cause outages or disturbances to the DLC system and other DLC

customers. Coordination of protection devices shall be in accordance with NERC Reliability Standards including PRC-001.

The GF's protection shall be capable of sensing any type of fault or outage on the interconnection and must isolate the GF's generator from the DLC system and other DLC customers even if one protective device fails to operate.

The GF is responsible for protecting its system from faults and other disturbances on the DLC system.

A. Class I (< 51 kW)

1. Induction Generators and Line Commutated Inverters (LCI)

For isolation of faults on the DLC system from induction generators and LCI, a voltage contactor that drops out at 90% voltage and remains open until normal voltage has been re-established shall, in most cases, be acceptable. In general, no other protection shall be required. However, in cases where there is sufficient capacitance in the vicinity of an induction generator or LCI facility to create a reasonable possibility of self-excitation, the protection requirements shall be the same as for Class I synchronous generators and force commutated inverters.

2. Synchronous Generators and Force Commutated Inverters (FCI)

- a. Appropriate phase and ground fault protection shall be provided to isolate faults on the DLC system from the GF's generation.
- b. It is unlikely that installations of this small size could support a block of load which has become isolated from the DLC system; thus, in general, no protection for islanding is required. However, in those instances where DLC determines there is a reasonable possibility that the generation could support an isolated block of load, over/under voltage and over/under frequency sensing devices shall be required.

B. Class II (3Ø: 51 – 2000 kW)

1. Induction Generators and Line Commutated Inverters (LCI)

In general, for installations of this size, the GF shall be required to supply the VAR requirements at the generation site. Therefore, these facilities will be capable of self-excitation

and the protection requirements shall be the same as for Class II synchronous generators and force commutated inverters.

2. Synchronous Generators and Force Commutated Inverters (FCI)

- a. Appropriate phase and ground fault protection shall be provided to isolate faults on the DLC system from the GF's generation.
- b. Unlike Class I installations, for installations of this size, it is a reasonable possibility that the GF's generation could support a block of load, which has become isolated from the DLC system. Therefore, protection for islanding consisting of over/under voltage and over/under frequency sensing devices shall be required.
- c. For installations that are interconnected to DLC through single phase interrupting devices such as fuses, the GF shall provide negative sequence overcurrent protection.

C. Class III (> 2,000 kW)

1. Induction Generators and Line Commutated Inverters (LCI)

In general, for installations of this size, the GF shall be required to supply the VAR requirements at the generation site. Therefore, these facilities will be capable of self-excitation and the protection requirements shall be the same as for Class III synchronous generators and force commutated inverters.

2. Synchronous Generators and Force Commutated Inverters (FCI)

- a. Appropriate phase and ground fault protection shall be provided to isolate faults on the DLC system from the GF's generation.
- b. The required protection for minimizing islanding shall consist of two (2) sets of equipment. Primary protection shall be provided by an out-of-synchronism scheme, which will compare the GF system voltage with the DLC system voltage at a remote substation. Secondary protection shall consist of over/under voltage and over/under frequency sensing devices.
- c. For installations that are interconnected to DLC through single phase interrupting devices such as fuses, negative sequence overcurrent protection shall be required.
- d. Requirements for supervision of local alarms by the DLC system operator shall be determined by DLC on a case-by-case basis.

IV. SURGE PROTECTION, INSULATION AND INSULATION COORDINATION

A. Surge Protection

Specific surge protection will be specified by DLC for all classes of installation.

DLC Surge Protection/Insulation Coordination Levels			
Voltage	Basic Insulation Level (BIL) (kV)	Surge Arrester Ratings	
		Duty Cycle (kV)	MCOV (kV)
Distribution			
4.16 kV	60	3	2.55
23 kV	125	18	15.3
Subtransmission			
23 kV	150	21	17
Transmission			
69 kV	350	54	42
138 kV	650	108	84
345 kV	1300	276	220

Compact line designs and GIS installation require special insulation coordination studies to achieve desired transient overvoltage performance.

B. RTO Design and Application of Insulation Coordination and Surge Protection

1. General Requirements

Insulation coordination is the coordination of electrical insulation levels with overvoltage protection. It includes subject of shielding from lightning, application of surge arresters, insulator contamination, switching surge mitigation, and temporary overvoltage control. The nominal voltage ratings of the effectively grounded transmission systems are 69 kV, 138 kV, and 345 kV. The 138 kV and 345 kV systems operate between 131-145 and 328-362 kV respectively. All insulation shall be capable of operating at these continuous voltages, and withstanding the transient overvoltages allowed by the overvoltage protection. IEEE 1313.1 "Standard for Insulation Coordination Definitions Practices and Rules", and IEEE 1313.2 "Guide for the Application of Insulation Coordination" should be followed when selecting surge arrester ratings and station and equipment insulation levels.

2. Shielding from Direct Lightning Strokes

All facilities connected to the DLC transmission system shall be shielded from direct lightning strokes. IEEE Standard 998 "IEEE Guide for Direct Lightning Stroke Shielding of Substations" should be used as a guide in designing lightning shielding. Lightning shielding

may be accomplished through masts, overhead ground wires, or other tall conducting structures. Overhead ground wires (static wires) crossing over busses and other circuits should be avoided.

3. Insulation Coordination Studies

Detailed studies including lightning, traveling wave analysis, switching surge analysis, temporary overvoltage (TOV) analysis, harmonic resonance, etc., need to be conducted to balance the number and location of surge arresters with proposed insulation levels.

Power transformers will require surge arrester protection on all terminals. Additionally, line entrance arresters are required. Any normally or frequently open position will be a positive reflection point for fast front transients and deserve special attention.

Generally, non-self-restoring insulation is protected by a dedicated set of surge arresters at its terminals. In addition to power transformers this will include: underground cable, gas insulated switchgear (GIS), and metal clad or metal enclosed switchgear. Exceptions may include instrument transformers (column CTs, PTs, CCVTs), outdoor circuit breakers, and capacitor banks.

Compact line designs may require use of line type arresters. In any case, compact line designs require special insulation coordination studies to achieve desired transient overvoltage performance.

Appendix B

[PJM Manual 3: Transmission Operations](#)

[PJM Manual 13: Emergency Operations](#)

[PJM Manual 14A: Generation and Transmission Interconnection Process](#)

[PJM Manual 14B: PJM Region Transmission Planning Process](#)

[PJM Manual 14C: Generation and Transmission Interconnection Facility](#)

[PJM Manual 14D: Generator Operational Requirements](#)

[PJM Manual 14E: Merchant Transmission Specific Requirements](#)

REVISION HISTORY

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7	Annual review of entire document	Joe Palumbo	Jason Harchick	12/30/2013
6	Add Appendix B with document links and references to those links on page 23.	Megan E. Sullivan	Megan E. Sullivan	7/11/2011
5	Add title page for entire connection document. Annual review of entire document.	Megan E. Sullivan	Megan E. Sullivan	5/13/2011
4	Clarified operational overfrequency requirements. Annual review of entire document.	Joe Palumbo	Megan E. Sullivan	12/1/2010
3	Annual review of entire document. Consolidate with End-User document.	Kelly Geer	Megan E. Sullivan	6/26/2009
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1	Update to Generation Interconnection Standards			9/21/2000
0	Original: Standards for the Connection of Generating Facilities Which are Operated in Parallel with Duquesne Light Co.			3/9/1983

Duquesne Light Company

FACILITY INTERCONNECTION REQUIREMENTS (FAC-001)

TRANSMISSION FACILITIES

12/30/2015

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Introduction

This document contains the standard minimum requirements for the safe and effective connection of a Transmission owner/developer to the Duquesne Light Company (DLC) or (the Company) system. The standards are general and may not cover specific details for every case. The standards, normally applied, may be altered by DLC to cover unanticipated technical problems that may occur despite the fact that the proposed installation is similar to a previously accepted installation. Since the standards specified in this document are minimum DLC requirements, they must also meet national, state and local codes and regulations including all applicable NERC, ReliabilityFirst, and PJM standards. If national, state, local, PJM or NERC requirements cause DLC minimum requirements to change, parties must meet with the Company and document such changes in writing.

Duquesne Light Transmission Interconnection Requirements

1.0 TRANSMISSION PLANNING STUDY REQUIREMENTS

1. DLC requires a planning study for all facility additions 100 kV and above. DLC will perform studies involving transmission requests to interconnect with the DLC transmission system or participate in studies involving requests from other transmission entities to interconnect with the DLC transmission system, through coordination with PJM and other impacted transmission systems when necessary. Procedures for notification of new or modified facilities to others can be found in PJM Manual 3 and PJM Manual 14. Transmission facility developers requesting interconnection to the DLC system shall provide all technical information necessary to perform the individual analyses. Information provided shall be in a format compatible with the Siemens Power Technologies, Inc. (PTI), PSS/E program. In addition to DLC transmission studies, all proposed transmission facilities interconnecting to the DLC transmission system shall be coordinated and reviewed through the Transmission Planning process described in PJM Manual 14.
2. All transmission line interconnections are studied in accordance with the PJM Regional Transmission Expansion Planning (RTEP) Process. Merchant Transmission projects are evaluated according to the PJM process summarized below. PJM Manual 14 describes the process in detail.
 - a. A Feasibility Study is performed to provide a high level approximation of the transmission-related costs to accommodate the interconnection and alternative plans to meet established reliability criteria. The PJM thermal criteria are 100% of the continuous rating for base case and 100% of the emergency rating for contingencies. Voltage screening is performed using criteria outlined in PJM Manual 3 Section 3.
 - b. System Impact Studies are required to provide a detailed evaluation of the requested interconnection. Stability studies are documented in the System Impact Study.
 - c. After acceptable completion of the System Impact Study, a Facilities Study is required to determine the detailed facility interconnection requirements. The Facilities Study will address network upgrades, cost estimates and construction scheduling estimates in detail.

1.1 TRANSMISSION FACILITIES CONNECTION REQUIREMENTS

1. Connection requirements are dependent on several factors including capacity and configuration of the transmission system at the point of interconnection. DLC Transmission Planning will determine requirements by applying all applicable DLC, PJM, Reliability *First* (RFC) and NERC standards.
2. The status of all new merchant transmission projects can be located in the PJM Merchant Queues on the PJM website.
3. For all transmission lines connecting to the DLC transmission system, the point of interconnection shall be located at either an existing or new DLC station. At a minimum, all new stations shall be a ring bus arrangement. Other arrangements may be considered where appropriate.
4. Listed below are the safety and technical aspects concerning the connection of transmission facilities:

a. DLC Safety Requirements

- (i) The Transmission facility shall not energize DLC circuit(s) when the circuit(s) is de-energized for any reason.
- (ii) The DLC transmission systems are effectively grounded wye-connected systems. The grounding scheme of the transmission interconnection facility shall not cause overvoltages that exceed the rating of DLC connected equipment and shall not disrupt the coordination of the ground fault protection of the DLC circuit(s).
- (iii) The transmission facility's circuit interrupting devices shall have sufficient interrupting capacity for all faults that might exist at the point of common coupling. Maximum available RMS symmetrical fault current at the interconnection location from DLC system is available from DLC Transmission Planning Department.
- (iv) The transmission facility shall have a readily accessible, lockable, visible-break isolation device located at the point of common coupling accessible without notice by DLC personnel. It shall be mechanically interlocked in a manner that ensures continuous current has been interrupted allowing the visible break device to be operated.
- (v) The transmission facility connecting to the DLC transmission system shall comply with the following guidelines for insulation coordination, continuous, momentary and interrupting current (i.e. breaker duty, surge protection):
 - Bus Supports – All bus supports shall be rated as follows:
 - 138 kV – 650 kV BIL
 - 345 kV – 1300 kV BIL
 - Switches –The minimum rating for air break disconnect switches is as follows. Higher ratings may be required based on Transmission Planning Department studies.
 - 138 kV – 145 kV, 650kVBIL, 2000A continuous, 100,000A momentary
 - 345 kV – 362 kV, 1300kVBIL, 3000A continuous, 120,000A momentary
 - Circuit Breakers – The transmission connected circuit breaker(s) shall be single pressure, spring operated, SF-6 type and rated as follows. Higher interrupting ratings may be required based on Transmission Planning Department studies.
 - 138 kV – 145 kV, 650kVBIL, 2000A continuous, 63kA interrupting rating
 - 345 kV – 362 kV, 1300kVBIL, 3000A continuous, 50kA interrupting rating
- (vi) The transmission facility's electrical system installation shall comply with DLC standard practices, the current edition of the National Electrical Safety Code and applicable portions of the National Electrical Code at the time of acceptance testing.

b. Reliable Operations

- (i) **System Design, Installation and Maintenance:** The transmission facility owner/developer assumes sole responsibility to design, install and maintain their system to comply with all technical requirements and properly operate on the DLC system.
- (ii) **Protective System:** The transmission facility owner/developer is also responsible for ensuring that the protective system and the associated devices are maintained in reliable operating condition. This includes maintenance of

structures and vegetation control within the interconnection station. DLC reserves the right to inspect and test all protective equipment and assure its correct operation. Unreliable operation of protective system equipment, improper maintenance of structures and lack of vegetation control shall be considered a safety issue.

- (iii) **Responsibility:** The transmission facility owner is solely responsible for the installation, operation and maintenance of any equipment used to interconnect with DLC and is liable for any claims, demands, suits, actions and judgments, and all costs expenses, pecuniary or other loss which may arise directly or indirectly from any act or omission of the transmission facility owner, its agents, servants or employees, particularly caused by improper installation, improper operation, or defective equipment.

c. Service Quality

All voltage and frequency parameters specified in these requirements shall be met at the point of common coupling (PCC), unless otherwise stated.

- (i) **Voltage Fluctuation:** The transmission facility shall connect and disconnect from the DLC system without causing a voltage fluctuation at the PCC greater than +/- 5% of the prevailing voltage level.
- (ii) **Harmonics:** Transmission owner equipment shall not inject non-sinusoidal current nor adversely affect voltage, frequency or wave shape of power supplied at the PCC. The injection of excessive harmonics shall be levels of current or voltage distortion at the PCC between DLC and the transmission owner outside the levels recommended in the current version of IEEE Standard 519. If DLC determines that the transmission owner has created excessive harmonics that cause or are reasonably likely to cause customers to receive unsafe, unreliable or inadequate electric service, DLC will provide a written notice to the transmission owner creating excessive harmonics. The notice will give the transmission owner a reasonable time to cure the harmonic problem.
- (iii) **Response to Abnormal Conditions:** DLC shall review all protective relay settings and synchronizing for transmission interconnections.

d. Voltage, Reactive Power & Power Factor Control

- (i) DLC's transmission system is designed to operate reliably over a wide range of loads, weather conditions, generation dispatch, and contingencies. The DLC transmission system operates with normal operating voltages of 345kV and 138kV. Voltages at all buses within the DLC system shall remain within the limits listed below.

Voltage	Hi (p.u.)	Low (p.u.)	Load Dump (p.u.)	Voltage Bandwidth
345 kV	1.05	.95	.90	±5.0%
138 kV	1.05	.95	.90	±5.0%

- (ii) The power factor at the point of interconnection shall comply with the requirements outlined in PJM Manual 14 E Section 3.

1.2 FINANCIAL OBLIGATION OF THE TRANSMISSION OWNER/DEVELOPER

1. The transmission owner/developer shall reimburse DLC fully for the costs to interconnect to the DLC transmission system.
2. The following are examples (but not a complete list) of the Interconnection costs that will be the responsibility of the transmission owner/developer:
 - a. Study analyses and related expenses to determine:
 - (i) Feasibility of the interconnection
 - (ii) Transmission facilities required for interconnection
 - (iii) DLC system upgrades required for the interconnection
 - (iv) Project and construction schedules
 - (v) Cost estimates and other related information required by DLC / PJM or requested by the transmission owner/developer
 - (vi) Maintenance on transmission facilities required for interconnection.
 - b. Preparation and presentation of study results to appropriate regional oversight committees or planning groups
 - c. Land and rights-of-way, including any required licensing or permitting
 - d. The transmission owner/developer's Interconnection Facilities
 - e. Meter installation, testing, and maintenance, including all parts and labor
 - f. Meter reading and scheduling
 - g. Telemetry installation, testing, and maintenance, including all parts and labor
 - h. Operating expenses, including communication circuits
 - i. DLC protective device installation, testing, equipment cost, and related labor
 - j. Transmission owner/developer's protective device and interlock review of design, inspection, and testing/witnessing
 - k. Programming costs to incorporate data into DLC's Energy Management System (EMS)

Any cost responsibilities detailed in the facility specific transmission interconnection agreement between DLC and the transmission owner/developer that conflict with this section will take precedence over these Guidelines.

1.3 CONSTRUCTION, OWNERSHIP, OPERATION

1. DLC shall own all appropriate Interconnection Facilities and System Upgrades as determined by DLC. This includes, but is not limited to, revenue meters, relaying, control systems, breakers, switches, and bus work. DLC may, at its option, contract with the transmission facility owner/developer/operator or a third party for construction of any or all of these facilities.
2. If the transmission owner/developer plans to contract DLC to maintain facilities, specific design considerations are required that go beyond the minimum technical requirements described in this document. To ensure the safety of DLC personnel and to minimize the opportunity for human error, the transmission owner/developer is required to use certain DLC design standards or certain approved equipment manufacturers which may include but are not limited to: breakers, switches, control panel layouts, personal ground attachments placed in approved locations, and electrical clearances. The transmission owner/developer will pay for the training of DLC personnel, if required, to operate and maintain this equipment.

1.4 PROTECTIVE RELAYING AND CONTROL SYSTEMS

1. Protective relaying and control systems shall adhere to the requirements of PRC-001, PRC-004, PRC-005, PRC-023, and all applicable NERC, RFC, and DLC standards. The specific requirements outlined in this section are to be considered minimum protection requirements. In recognition of the variables that can affect protection system requirements (variations in available fault current, system stability requirements, system configuration, voltage level, etc.) additional system protection requirements shall be assessed and may be required on a case-by-case basis. When the final protection requirements are known, DLC will provide the transmission owner/developer with DLC protection one-lines, detailed schematics, detailed control panel layout and wiring, equipment wiring, and control building layout drawings. This documentation is to be used by the transmission owner/developer where applicable as a model for engineering the specific interconnection facility. DLC will provide the manufacturer, type, and model number of all protective relays that are to be used. All protective relays are to be microprocessor based and meet the requirements of ANSI/IEEE Standard C37.90. Any deviation from the supplied documentation or relay types must be pre-approved in writing by the DLC Engineering Department, Protection Engineer.
2. DLC will develop and supply all protective relay settings and review the customer relay settings to check for proper coordination. This process is necessary to insure the protective relaying adheres to all applicable industry standards.
3. Remote monitoring and control of the interconnecting facility is required through the DLC supervisory control and data acquisition system (SCADA). The specific manufacturer, type, and model number of the remote terminal unit (RTU) to be installed will be supplied to the transmission owner/developer.
4. Where required by RFC standard PRC-002-RFC-01, fault recording equipment will be installed. The specific manufacturer, type and model number of the fault recording equipment will be supplied by DLC to the transmission owner/developer.
5. Fiber-optic communications terminated as a node on the DLC Sonet is required for all new transmission lines > 100kV. This node will provide the redundant, high-speed communications path required for protective relay functions (line differential and transfer-trip), control and monitoring.
6. It is the responsibility of the transmission owner/developer to have the protective and safety equipment tested by a qualified testing agency and inspected by a qualified inspection agency. Documentation of test results shall be submitted to DLC for review. DLC reserves the right to have an on-site inspector observe the installation, testing, and function checking of the protective relay and control systems. DLC Control Technicians and Substation Electricians will perform the final energization and commissioning of new facilities.
7. Listed below are the minimum requirements that apply to a transmission facility interconnection and may vary for a specific application or specific location on the electrical system.
 - a. Protective relaying shall operate the Circuit Breaker(s) associated with the transmission owner/developer transmission facility and shall consist of the following:
 - (i) 87/79/25 – Line Differential/Sync./Reclose Relay
 - (ii) 21/79/25 – Distance/Sync./Reclose Relay
 - (iii) 50 (A,C,G) – Current interlock/breaker failure Relay

- b. DLC shall provide its own circuit breaker(s) and associated equipment located on the utility side of the metering interconnection point. The DLC circuit breaker(s) installation shall be accessible by DLC personnel to operate without notice to the transmission owner/developer.
 - c. Based on the method of interconnection, the transmission owner/developer may be required to provide its own high voltage circuit breaker(s) with visible, group operated, isolation switches; the breaker(s) installation shall be accessible by DLC personnel to operate, without notice, during system emergencies and outage restoration activities. The high voltage, power circuit breaker(s) and disconnect switches shall meet the requirements of Part 1.5 – Circuit Breaker and Associated Disconnect Switch Specifications.
8. The transmission owner/developer shall provide a separate, secure, environmentally controlled area for any DLC protective and control equipment required at the transmission owner/developer facilities.

1.5 CIRCUIT BREAKER AND ASSOCIATED DISCONNECT SWITCH SPECIFICATIONS

1. When the interconnection substation requires a transmission owner/developer circuit breaker(s) to interface with the DLC transmission system, it shall be suitable for the application as determined by ANSI C37 standards. Listed below are the common requirements of such breaker(s), however a detailed list will be supplied on a case-by-case basis.
- a. Breaker(s) shall be single pressure SF6 type with one interrupter per phase.
 - b. Breaker(s) fault interrupting rating will be shown on the nameplate at the DLC specified X/R ratio.
 - c. Multi-ratio current transformers (MRCTs) at the accuracy specified by DLC will be supplied for DLC exclusive use.
 - d. Circuit breaker(s) trip coils, close coil and charging motor will utilize a 125 VDC battery source. A separate 125 VDC trip coil will be supplied for DLC exclusive use.
 - e. The breaker shall have local mechanical tripping capability clearly identified for DLC personnel emergency use.
 - f. The associated breaker disconnect switch(es) shall be used to provide a visible opening in the high voltage circuit and provide safety clearances for breaker maintenance. The disconnect switch(es) shall be airbreak, group operated with arc horns capable of interrupting line charging current.
 - g. DLC will supply approved manufacturers for this equipment.
 - h. DLC engineering will be an active partner for vendor drawing approval.

1.6 METERING AND TELECOMMUNICATIONS

1. The transmission owner/developer SHALL FURNISH AND INSTALL the following equipment for the Company's metering system:
- a. Foundations and structures for mounting the metering current and voltage instrument transformers and mounting the metering transformer test switch enclosure.
 - b. A rigid, galvanized steel, underground conduit system, 1.5 inch diameter with pull line, from the substation yard test switch enclosure(s) to DLC weatherproof meter enclosure mounted at a mutually agreed on location.

- c. Access to 120 volt AC via a standard duplex outlet in close proximity to DLC metering equipment to facilitate testing etc.

2. DLC will provide the following metering equipment and/or service:

- a. Revenue accuracy instrument current (CT) and voltage (VT) transformers, three (3) of each.
- b. DLC will provide the customer with outline drawings of the revenue metering transformers, unless structure designs are provided by DLC.
- c. Metering transformer test switch enclosure(s) on the instrument transformer structure(s) in the substation yard.
- d. Revenue metering enclosure
- e. Secondary wiring and conduit to connect the metering instrument transformers to the substation yard test switch enclosure.
- f. Secondary wiring from the test switch enclosure to the revenue meter enclosure.
- g. DLC will pull and terminate all required metering secondary wires and cables.

The mutually agreed upon location of the meter equipment enclosure shall be within 150 cable feet of the substation yard metering instrument transformer test switch enclosure(s).

If changes are made in/at the transmission owner/developer premises, thereby making the existing meter equipment location unsafe, unsuitable or inadequate, the transmission owner/developer shall be required to provide a suitable alternative location for this metering equipment. If relocation of the meter equipment is necessary, the customer will be billed an appropriate service charge for this work.

All meters and metering equipment shall be locked/sealed on the transmission owner/developer premises.

The transmission owner/developer is not permitted to install meters or instruments in the metering transformer secondary circuits. Metering data pulses and/or interval time pulses can/shall be provided to the customer from DLC metering equipment for load control and/or monitoring systems at the customer's request. A designated fee is charged for this service.

Telecommunications (voice and data) circuits, which must be reliable and secure, should be tested regularly and/or monitored online, with special attention given to emergency channels. Installation of communications facilities (internet service, leased telephone circuits, fiber optics, etc.), communications facility operation and maintenance, and other ongoing costs are the responsibility of the transmission owner/developer. Installation of communications facilities (typically leased telephone circuits), communications facility operation and maintenance, and other ongoing costs are the responsibility of the transmission owner/developer. In addition, the customer shall follow the telecommunications requirements outlined in PJM Manuals.

1.7 ACCEPTANCE AND ROUTINE TESTING

1. The purpose of acceptance testing is to assure that equipment will operate successfully during all modes of operation including normal, abnormal, maintenance, emergency and contingent operations.

2. It is the responsibility of the transmission owner/developer to have the protective and safety equipment tested by a qualified testing agency and inspected by a qualified inspection agency. Documentation of test results shall be submitted to DLC for review.
3. If DLC, based on inspection or testing, identifies any defects or failures to comply with applicable standards in the transmission owner/developer facility, DLC shall notify the transmission owner/developer of any identified defects or failures within 20 days after DLC's receipt of the results of such inspection or testing. The transmission owner/developer shall take appropriate actions to correct any such defects or failure at its sole cost and expense, and shall obtain DLC's acceptance of the corrections, which acceptance shall not be unreasonably delayed, withheld or conditioned.
4. DLC personnel shall have the right to witness or perform acceptance testing prior to the facility being permitted to operate on the DLC system
5. Each transmission owner/developer shall perform routine inspection and testing of each of its interconnected facilities and equipment as may be necessary to ensure the continued interconnection of its facility with the transmission system in a safe and reliable manner. On providing advance written notice, the Company may request reasonable additional testing of the interconnected facility for good cause.

1.8 SYNCHRONIZING FACILITIES

Sync-check relays will be required at the point of interconnection. Reclosing angles will be determined by DLC Transmission Planning. For lines with generation connected, procedures for synchronization and disconnection of generation facilities are provided in PJM Manual 14D Section 7. The PJM OATT also requires that the following documentation be provided by the Interconnection Customer prior to synchronization of the Customer Facility with the transmission system:

1. As-built drawings
2. Pre-operation test reports
3. Instruction manuals

1.9 OPERATIONAL AND MAINTENANCE REQUIREMENTS

The operation of all transmission facilities shall meet the requirements outlined in PJM Manual 3. The connected facility shall have a DLC approved acceptance test and maintain all devices and control schemes for the protection of the DLC transmission system. For each interconnected facility, the transmission owner/developer shall provide the Company access to areas under its control as reasonably necessary to permit the Company to perform its obligations such as operation and maintenance. The Company shall comply with all safety rules applicable to the area to which access is obtained. Procedures provided in PJM Manual 36 should be followed during abnormal voltage and frequency conditions. Operation and maintenance of facilities must meet the requirements in PJM Manual 14E Section 3. When any 100kV and above facility is or will be out of service, PJM must be notified as outlined in PJM Manual 3 Section 4.

In addition to the electrical system maintenance, the Transmission owner/developer is responsible for maintaining the general substation property. This maintenance includes, but is not limited to fencing, grounding, UG conduit, structural steel, control house, control house HVAC, lighting, yard rock covering, access roadway(s) to the substation and vegetation management within and adjacent to the substation outer fence.

1.10 VOLTAGE LEVEL, MW AND MVAR CAPACITY

All Transmission projects connecting to the DLC system shall provide at a minimum the following information:

1. Proposed interconnection point with DLC and all points of interconnection with other utilities
2. Operating voltage of proposed facility
3. Positive and negative sequence impedance and charging on 100 MVA base
4. Capacity of facility, continuous and emergency (MVA or Amp Ratings)
5. List of all shunt and series devices connected to facility (Capacitors, Reactors, phase angle regulators (PARs), etc.)

1.11 NORMAL AND EMERGENCY OPERATING CONDITIONS

The transmission owner/developer shall install and maintain satisfactory operating communications with the Transmission Provider's system dispatcher or its other designated representative and with the interconnected Transmission Owner. The transmission owner/developer shall:

1. Provide standard voice line, dedicated voice line and facsimile communications at its facility control room through the use of the public telephone system.
2. Provide and maintain backup communication links with both the Transmission Provider and interconnected Transmission Owner for use during abnormal conditions as specified by the Transmission Provider and interconnected and Transmission Owner respectively.
3. Provide the dedicated data circuit(s) necessary to provide data to the Transmission Provider and the Company as necessary to conform with applicable PJM/DLC standards.

The criteria for acceptable system performance for normal system conditions can be found in the PJM Manual M-3: Transmission Operations, which discusses specific transmission conditions and procedures for the management of Transmission Facilities within the PJM Control Area. During emergency operating conditions, PJM may implement emergency operating procedures up to the point of a Manual Load Dump Action. Documentation is provided in the PJM Manual M-13: Emergency Operations, which focuses on how the PJM and the PJM Members are expected to respond to emergency conditions. Emergency conditions include: an abnormal electrical system condition requiring manual or automatic action, a fuel shortage, or a condition that requires implementation of emergency procedures as defined in the PJM Manuals.

Appendix A

Figure 1 – Flow Diagram for Owner / Developer Transmission Connection

Figure 2 – Typical Transmission Connection Single Line

Flow Diagram for Transmission Interconnection Facility

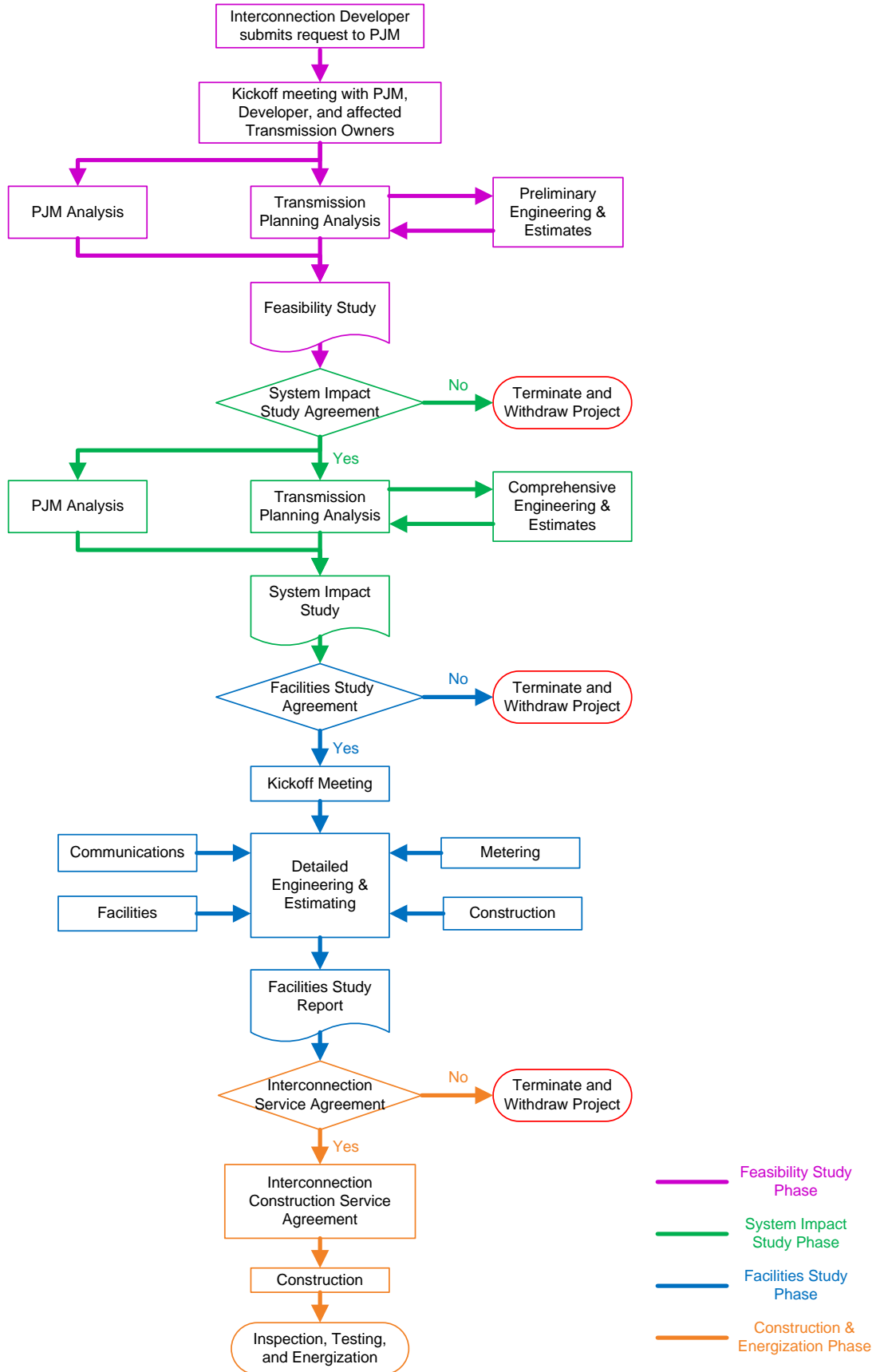
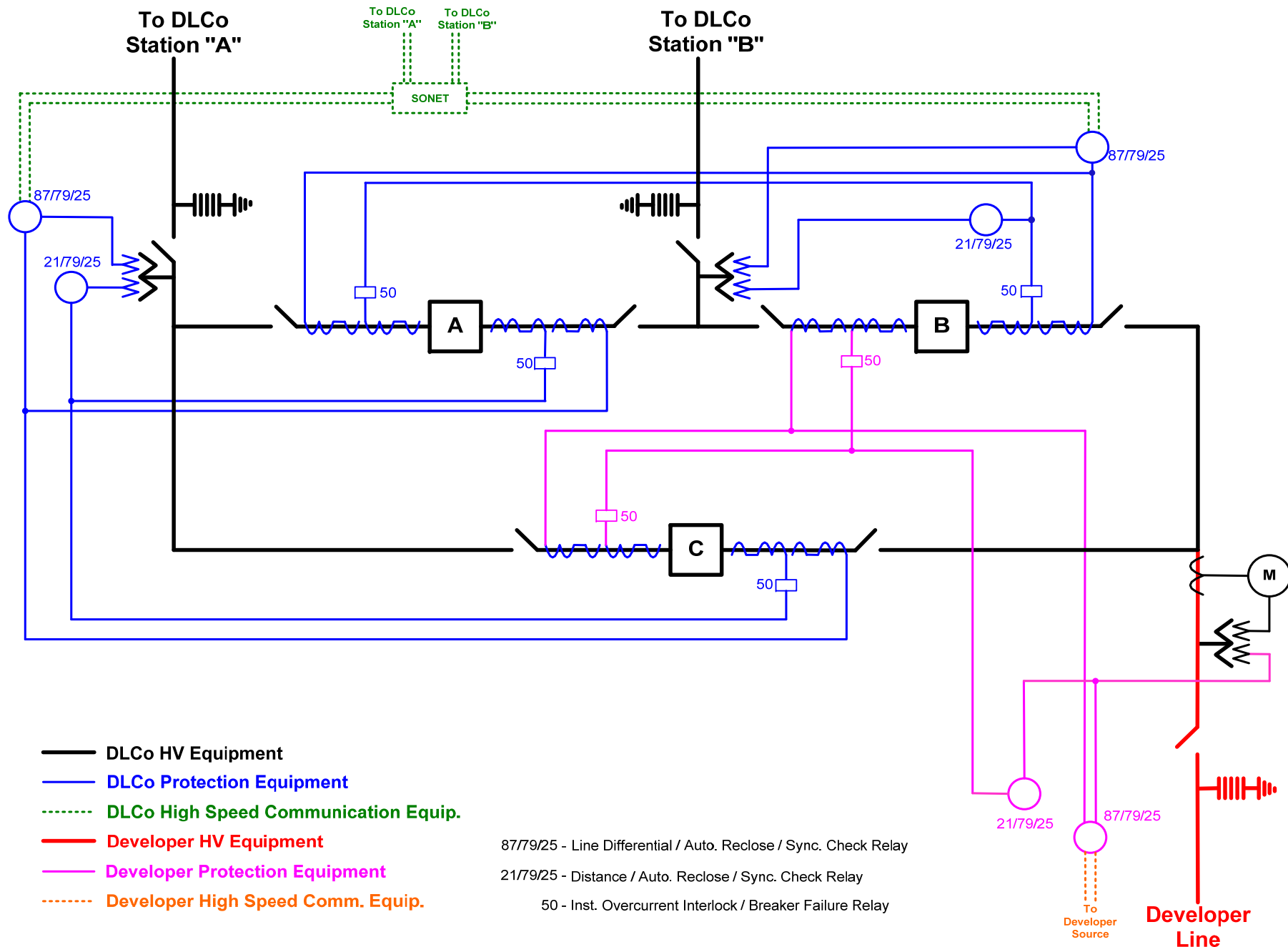


FIGURE 1



Typical Transmission Connection Single Line

FIGURE 2

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Appendix B

[PJM Manual 3: Transmission Operations](#)

[PJM Manual 13: Emergency Operations](#)

[PJM Manual 14A: Generation and Transmission Interconnection Process](#)

[PJM Manual 14B: PJM Region Transmission Planning Process](#)

[PJM Manual 14C: Generation and Transmission Interconnection Facility](#)

[PJM Manual 14D: Generator Operational Requirements](#)

[PJM Manual 14E: Merchant Transmission Specific Requirements](#)

[PJM Manual 36: System Restoration](#)

[PJM Merchant Transmission Queues: Active](#)

[PRC-002-RFC-01: Disturbance Monitoring and Reporting Requirements](#)

Revision History

Rev No:	Change:	Revised By:	Authorized By:	Effective Date
6	Comprehensive review of entire document with minor changes.	Michelle Antantis	Jason Harchick	12/30/2015
5	Modified required 138 kV breaker rating. Modified harmonic specification. Annual review of entire document.	Joe Palumbo	Jason Harchick	12/30/2013
4	Add title page for entire connection document. Annual review of entire document.	Megan E. Sullivan	Megan E. Sullivan	5/13/2011
3	Update Metering heading to Metering and Telecommunications. Annual review of entire document.	Joe Palumbo	Megan E. Sullivan	12/1/2010
2	Consolidate with Generation & End-User document.	Kelly Geer	Megan E. Sullivan	10/21/2009
1	Update Figures 1 & 2, Table of Contents, document links.	Joe Palumbo	Megan E. Sullivan	9/10/2009
0	Consolidate Transmission documents. Annual review of entire document.	Joe Palumbo	Megan E. Sullivan	6/26/2009

Duquesne Light Company

FACILITY INTERCONNECTION REQUIREMENTS (FAC-001)

END-USER FACILITIES

12/30/2015

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Introduction

This document contains the standard minimum requirements for the safe and effective connection of an End-User (customer) to the Duquesne Light Company (DLC) or (the Company) system. The standards are general and may not cover specific details for every case. The standards normally applied may be altered by DLC to cover unanticipated technical problems that may occur despite the fact that the proposed installation is similar to a previously accepted installation. Since the standards specified in this document are minimum DLC requirements, they must also meet national, state and local codes and regulations. If national, state or local requirements cause DLC minimum requirements to change, parties must meet with the Company and document such changes in writing.

Duquesne Light End-User Connection Requirements

1.0 End-User

DLC requires a planning study for all DLC transmission facility additions 100kV and above. DLC will perform studies involving end-user requests to interconnect with the DLC transmission system or participate in studies involving requests from other transmission entities to interconnect with the DLC transmission system, through coordination with the Regional Transmission Organization (RTO), PJM, and other impacted transmission systems when necessary. These studies will include power flow, short circuit, power quality and stability analysis as required which will be determined via the planning study process. Any facility upgrades necessary to maintain the reliability of the interconnected transmission system will also be addressed. Results of the planning study shall be shared with the customer, other impacted transmission system owners and PJM where applicable. Procedures for notification of new or modified facilities to others can be found in PJM Manual 3 and PJM Manual 14. The proposed service will be detailed in the form of a DLC Project Scope issued by the Transmission Planning Department.

END USER FACILITIES CONNECTION REQUIREMENTS

1.1 Qualifications

Requirements for service from the DLC transmission system are as follows:

1. Customer's estimated peak load shall be 10 MW or greater or in accordance with filed tariffs. This peak load requirement may be waived in cases where transmission service is practical and economical to both DLC and the customer. Rates for such service shall be in accordance with filed tariffs.
2. Customer shall accept service from the DLC transmission system at a mutually satisfactory single delivery point as determined by DLC and the customer.
3. If the necessary transmission capacity, as determined by DLC, is not available at or near the proposed service location;
 - a. DLC will determine what construction or transmission system reinforcements will be required to provide the necessary transmission capacity at or near the proposed service location
 - b. DLC will provide the customer a high-level estimate of the costs of the required construction or transmission system reinforcement
 - c. Refinement of the required construction or transmission system reinforcement and associated costs will not proceed beyond this stage until the customer signs a contract agreeing to cover all future engineering costs. See Figure 1 for a flow diagram of the End-User process.

1.2 DLC Impact Study Requirements

The specific voltage and connection requirements are dependent on many factors including customer load characteristics, capacity of the transmission system and configuration of the DLC transmission system at the point of interconnection. These requirements will be determined via an assessment performed by DLC Transmission Planning and documented in a DLC Impact Study. The customer shall provide location of proposed interconnection and all relevant load and equipment data (voltage, MW, MVAR, etc.) including largest motor characteristics prior to DLC performing an assessment of the proposed interconnection. The proposed service and any required construction or transmission system reinforcement will be detailed in the Impact Study report and subsequent plan issued by the DLC Transmission Planning Department.

1.3 Typical Service

Typical service from the transmission system consists of service at a single voltage at one location. The DLC transmission system (138 kV or 345 kV) is an effectively grounded wye-connected system. DLC will modify or provide and install the following facilities at a minimum for this service.

1. One three-phase line loop, operated at a voltage of 138 kV or 345 kV to interconnect the customer's facilities with the DLC transmission system. DLC shall provide and install all line side equipment to serve the customer and properly connect Company metering equipment. Customer's service point shall be on the load side of the metering equipment.
2. Protective and control equipment modifications within the DLC system as DLC considers necessary to integrate the new facilities into the DLC transmission network and provide a reasonable degree of service reliability to the customer.
3. Metering transformers and equipment to measure the quantity of real and reactive power delivered to the customer through a single delivery point, including secondary wiring, cables, test or isolation switches and meter bases/sockets. The customer is responsible for providing the mounting structure(s) for the metering equipment specified as set forth in this document.

1.4 Facilities Beyond Typical Service

Facilities beyond typical service may be negotiated if such facilities are compatible with the DLC system. These include facilities to provide increased quality of service, such as additional lines or providing a dedicated line, utilizing line and/or tie breakers, through the customer facility to provide greater reliability and/or additional points of service.

1.5 General Customer Requirements

The customer shall provide and install the following facilities:

1. A power circuit breaker with associated protective relaying to provide both protection and a means to disconnect the customer's load from the DLC transmission system. The customer's relay equipment and relay settings must be pre-approved by DLC Engineering Department. The breaker shall be equipped with a separate trip coil, close coil and current transformers specified by DLC and for DLC exclusive use.
2. Breaker isolation airbreak disconnect switches (line and load sides).

3. Foundations and structures to accommodate:
 - a. Transmission line dead-end (as specified by DLC)
 - b. Line disconnect switches (as specified by DLC)
 - c. Station or intermediate class surge arresters (as specified by DLC)
 - d. Metering transformers and isolation switches for metering equipment
 - i. Installation shall include a conduit system from the metering transformers to a mutually agreed on meter cabinet location. An additional conduit shall be provided from the voltage transformers to the, customer provided, DLC control room.
 - ii. Voltage transformers shall have dual secondary windings to separately supply metering and relay voltage.
4. An acceptable enclosure or secured space in a shared control building for DLC relay, control, communications and SCADA equipment. In either case, the customer shall be responsible for the following items within the DLC control room facility:
 - a. HVAC located by DLC
 - b. Lighting as specified by DLC
 - c. Secured equipment and man doors, as specified by DLC, restricting access to DLC authorized personnel only.
 - d. An independent 120/240 volt, 60 ampere, single phase, 3-wire AC source
 - e. Wall mounted ground bus connected to the substation ground system as specified by DLC.
 - f. Ceiling or roof structure capable of supporting the DLC cable tray system.
5. The customer's facilities shall in all ways comply with the current revision of the National Electrical Safety Code and applicable sections of the current National Electrical Code.
6. The Company shall be permitted to make periodic inspections of customer owned facilities during the construction phase to ensure conformance with specifications and plans as mutually agreed upon. The customer shall, after its facilities are completed and in its judgment it is ready for service, give DLC ten (10) business days notice prior to the proposed "in-service" date. The customer shall arrange and pay for an inspection of the station and interconnection facilities by a qualified inspection agency and a copy of the Certificate of Completion shall be furnished to DLC. The customer's facilities shall be inspected for compliance with specifications by a DLC authorized representative before energizing, i.e. interconnection with the DLC transmission system. Arrangements for scheduling inspections are to be made through the DLC Major Account Manager. The customer shall perform routine inspection and testing of its facilities and equipment as may be necessary to ensure the continued interconnection of its facility with the transmission

system in a safe and reliable manner. On providing advance written notice, DLC may request reasonable additional testing of the interconnected facility for good cause.

7. DLC reserves the right to change the capacity and/or characteristics of the supplying system as deemed necessary to meet future system requirements. In such event, DLC shall provide the customer with notification of proposed modifications and the customer shall agree to change, at its own expense, any equipment that is found to be inadequate by reason of such DLC system changes.

1.6 Detailed Customer Requirements

The DLC Major Account Manager must always be consulted regarding plans for a 69 kV, 138 kV or 345 kV service before the customer purchases any equipment. Prior to releasing for manufacturing, the customer must submit for review by DLC, the following:

1. Foundation and structure drawings with design calculations for structures supporting the following DLC equipment, unless structure designs are provided by DLC:
 - a. DLC line dead-end attachment structure
 - b. DLC incoming station or intermediate class arrester mounting
 - c. DLC line side, group-operated, airbreak, disconnect switch structure(s).
 - d. DLC metering voltage and current transformer structure(s), including mounting for meter side isolation switches.
 - e. DLC low voltage metering voltage and current transformer metering cabinet structure (where applicable).
2. Specifications for:
 - a. Customer load side, group-operated, airbreak, disconnect switch used for visible clearance to test, inspect and maintain the transmission line breaker.
 - b. Station or intermediate class surge arresters that coordinate with DLC line side arresters.
 - i. Surge Protection
All facilities connected to the DLC transmission system shall be shielded from direct lightning strokes. IEEE Standard 998 "IEEE Guide for Direct Lightning Stroke Shielding of Substations" should be used as a guide in designing lightning shielding. Lightning shielding may be accomplished through masts, overhead ground wires, or other tall conducting structures. Overhead ground wires (static wires) crossing over busses and other circuits should be avoided.
 - ii. Transmission arrester ratings/insulation coordination levels utilized by DLC are:
 - a) 42 kV MCOV, 54 kV Duty Cycle for 69 kV lines
 - b) 84 kV MCOV, 108 kV Duty Cycle for 138 kV lines
 - c) 220 kV MCOV, 276 kV Duty Cycle for 345 kV lines
 - c. Power circuit breaker including DLC specified MRCTs, trip & close coils for DLC use.

NOTE: Use of capacitor trip devices is not acceptable.

- d. Protective relays and control equipment
3. Schematic and wiring diagrams for the circuit breaker including protective relaying and associated control.

The customer must provide DLC Engineering Department, through the DLC Major Account Manager, three (3) sets of equipment physical drawings, schematic and wiring diagrams for review and approval.

1.7 Customer Equipment Arrangement

The base service equipment arrangement one line diagram is shown in Figure 2 in Appendix A. Other arrangements are possible; however, review and comment is required by DLC Transmission Planning and Engineering Departments.

1.8 Customer Equipment Specifications, Including Insulation & Insulation Coordination

1. Bus Supports – All bus supports shall be rated as follows:
69kV – 650kV BIL
138kV – 650kV BIL
345kV – 1300kV BIL

Use the following station post insulators:

69 kV – 145 kV, 650kV BIL, NEMA TR-288 Post
138 kV – 145 kV, 650kV BIL, NEMA TR-288 Post
345 kV – 362 kV, 1300kV BIL, NEMA TR-369 Tapered Post

2. Switches - All switches shall conform to voltage class BIL ratings and insulators as described in Item 1 above. The minimum rating for air break, disconnect switches is as follows:

69 kV – 145 kV, 2000A continuous, 100,000A momentary
138 kV – 145 kV, 2000A continuous, 100,000A momentary
345 kV – 362 kV, 3000A continuous, 120,000A momentary

3. Transformers – Transformers shall have their high voltage windings connected in delta. The low voltage winding connection is the customer's choice. Following is a list of suggested ratings for connection to DLC transmission system:

69kV – 69/138kV (dual wound), 550kVBIL
138kV – 138kV, 550kVBIL
345kV – 345kV, 1050kVBIL

Impedance/High Voltage Taps per ANSI STD C57.12

It is also suggested that use of one of the following Company standard low voltage ratings be used to correspond to the above high voltage ratings:

23,600Y/13,625 volts, 150kVBIL with graded 110kVBIL neutral
4160Y/2400 volts, 75kVBIL with fully rated neutral

4. Breakers – The transmission connected breaker(s) shall be SF-6 type and rated as follows:

69kV - 145kV, 650kVBIL, 63kA interrupting rated, 2000 ampere continuous rated
138kV - 145kV, 650kVBIL, 63kA interrupting rated, 2000 ampere continuous rated
345kV - 362kV, 1300kVBIL, 50kA interrupting rated, 3000 ampere continuous rated

5. Dead-End Structures – Line dead-end structures, not designed by DLC, shall be designed to withstand conductor and static wires tensions as specified by DLC.

Additional Information Regarding Insulation Coordination

Insulation coordination is the coordination of electrical insulation levels with overvoltage protection. It includes subject of shielding from lightning, application of surge arresters, insulator contamination, switching surge mitigation, and temporary overvoltage control. The nominal voltage ratings of the effectively grounded transmission systems are 69 kV, 138 kV, and 345 kV. The 138 kV and 345 kV systems operate between 131-145 and 328-362 kV respectively. All insulation shall be capable of operating at these continuous voltages, and withstanding the transient overvoltages allowed by the overvoltage protection. IEEE 1313.1 “Standard for Insulation Coordination Definitions Practices and Rules,” and IEEE 1313.2 “Guide for the Application of Insulation Coordination” should be followed when selecting surge arrester ratings and station and equipment insulation levels.

Although not typically performed for load installations, detailed studies including lightning, traveling wave analysis, switching surge analysis, temporary overvoltage (TOV) analysis, harmonic resonance, etc., may need to be conducted to balance the number and location of surge arresters with proposed insulation levels.

Power transformers will require surge arrester protection on all terminals. Additionally, line entrance arresters are required. Any frequently open position will be a positive reflection point for fast front transients and may deserve special attention.

Generally, non self-restoring insulation is protected by a dedicated set of surge arresters at its terminals. In addition to power transformers this will include: underground cable, gas insulated switchgear (GIS), and metal clad or metal enclosed switchgear. Exceptions may include instrument transformers (column CTs, PTs, CCVTs), outdoor circuit breakers, and capacitor banks.

1.9 Customer Grounding

1. DLC will perform ground tests and design requirements for the area within the substation connected to DLC transmission equipment.

2. The customer is responsible for the design and installation of the complete and integrated protective grounding system. A drawing showing the installation of the proposed grounding system with ground tests and calculations (Ref. IEEE 80) must be submitted to DLC Engineering Department for review and comment. This drawing shall include the following pertinent information:
 - a. Size and type of grounding conductors
 - b. Resistivity of soil (earth) at substation site utilizing Wenner's four-pin method (ANSI/IEEE Std. 81)
 - c. Location and burial depth of grounding conductors
 - d. Design resistance
 - e. Location and length of ground rods
 - f. Method of bonding grounding conductor to ground rods, intersecting underground conductors, underground conductor taps, fence posts, gates, structures, electrical outdoor equipment, control room equipment, control room doors, louvers, cable trays and control cable shields
3. The substation yard within the customer's fence and an apron area extending two feet beyond the customer's fence around the complete perimeter of the fence including any gate swing, shall be covered with a minimum of 4 inches of washed 2B limestone to reduce touch and step potentials and maintain the grounding system integrity by controlling vegetation.
4. The completed grounding system shall be tested prior to connection of DLC transmission conductors and shield wire(s). Certified test results of the value of resistance in ohms, using IEEE 80 Fall-of-Potential Method is to be submitted to DLC for review and approval.

1.10 Customer Equipment and System Protection

The circuit protection at the customer's service point must be coordinated with the customer's protective equipment on the load side as well as with DLC protective equipment on the source side. Prior to purchasing any interconnection protective equipment, the customer must consult with DLC to establish specifications for required equipment. In order to coordinate the protective scheme, the customer must furnish to DLC through the Major Account Manager, a one-line diagram similar to Figure #2 for all customer owned equipment. The following information shall be included on the diagram:

1. Conductor size and material for each circuit and/or bus.
2. Power transformer(s) high voltage and low voltage rating, kVA rating(s) and percent impedance of each power transformer.
3. The type of protection to be applied on the high voltage and low voltage side of each power transformer.
 - a. Relays shall be specified by manufacturer, type, catalog number, time-current characteristics.
 - b. Current transformers (CTs), used for the above mentioned relays, shall be specified by current rating, thermal rating and relay accuracy rating.

4. The location of the largest motor (if applicable), type, voltage rating, horsepower rating, starting method, inrush current and frequency of starting. The customer is responsible for specifying all protective equipment, their characteristics and protection coordination for his service entrance and distribution system. DLC will assist the customer in establishing protection coordination with transmission line protection, but assumes no responsibility in the event the protection scheme fails to operate as desired.

1.11 Metering and Telecommunications

The CUSTOMER SHALL FURNISH AND INSTALL the following equipment for the Company's metering system:

1. Foundations and structures for mounting the metering current and voltage instrument transformers and mounting the metering transformer test switch enclosure.
2. A rigid, galvanized steel, underground conduit system, 1.5 inch diameter with pull line, from the substation yard test switch enclosure(s) to DLC weatherproof meter enclosure mounted at a mutually agreed on location.
3. Access to 120 volt AC via a standard duplex outlet in close proximity to DLC metering equipment to facilitate testing etc.

DLC will provide the following metering equipment and/or service:

1. Revenue accuracy instrument current (CT) and voltage (VT) transformers (typically 2 – CTs and 3 – VTs). DLC will provide the customer with outline drawings of the revenue metering transformers, unless structure designs are provided by DLC.
2. Metering transformer test switch enclosure(s) on the instrument transformer structure(s) in the substation yard.
3. Revenue metering enclosure
4. Secondary wiring and conduit to connect the metering instrument transformers to the substation yard test switch enclosure.
5. Secondary wiring from the test switch enclosure to the revenue meter enclosure. DLC will pull and terminate all required metering secondary wires and cables.

The mutually agreed upon location of the meter equipment enclosure shall be within 150 cable feet of the substation yard metering instrument transformer test switch enclosure(s).

If changes are made in/at the customer's premises, thereby making the existing meter equipment location unsafe, unsuitable or inadequate, the customer shall be required to provide a suitable alternative location for this metering equipment. If relocation of the meter equipment is necessary, the customer will be billed an appropriate service charge for this work.

All meters and metering equipment shall be locked/sealed on the customer's premises.

The customer is not permitted to install meters or instruments in the metering transformer secondary circuits. Metering data pulses and/or interval time pulses can/shall be provided to the customer from DLC metering equipment for load control and/or monitoring systems at the customer's request. A designated fee is charged for this service.

Telecommunications (voice and data) circuits, which must be reliable and secure, should be tested regularly and/or monitored online, with special attention given to emergency channels. Installation of communications facilities (internet service, leased telephone circuits, fiber optics, etc.), communications facility operation and maintenance, and other ongoing costs are the responsibility of the customer. In addition, the customer shall follow the telecommunications requirements outlined in PJM Manuals.

1.12 Power Quality and Operational Issues

1. The injection of excessive harmonics shall be levels of current or voltage distortion at the point of connection between DLC and the customer outside the levels recommended in the latest version of IEEE Standard 519. If DLC determines that the customer has created excessive harmonics that cause or are reasonably likely to cause another customer to receive unsafe, unreliable or inadequate electric service, DLC will provide a written notice to the customer creating excessive harmonics. The notice will give the customer a reasonable time to cure the harmonic problem or provide funding for DLC to install corrective equipment in a Company facility. Payment will be made in full in advance for supplying special equipment installed under this Rule. (Duquesne Light Company "SCHEDULE OF RATES," Rules and Regulations)
2. In the event the customer refuses to remedy the condition in the timeframe specified and refuses to fund a DLC corrective installation, the Company may disconnect the customer's service. Before disconnecting service, DLC will provide written notification of its intent to disconnect at least five (5) working days before doing so.
3. If, in the investigation of a harmonic problem, DLC determines that two or more customers' harmonic loads are individually within IEEE 519 limits, but the sum of the loads are in excess of the IEEE 519 limits, the Company will require each customer to reduce its harmonic levels beyond the limits specified in IEEE 519.

1.13 Voltage, Reactive Power & Power Factor

The customer shall be required to operate his equipment in such a manner that the voltage fluctuations produced on DLC system shall not exceed the following limits, the measurements to be made at DLC substation nearest (electrically) the customer.

1. Instantaneous voltage fluctuations, defined as a change in voltage consuming two seconds or less, shall not exceed 1-1/4% more than six times a day, of which not more than one such fluctuation shall occur between 6:00 PM and midnight, and in no case shall such fluctuations exceed 3%.
2. Periodic voltage fluctuations, where the change in voltage consumes a period from 2 seconds to 1 minute, shall not exceed 1-1/4% more than five times an hour, and in no case shall such fluctuations exceed 3%. The transmission system within the DLC service territory consists of nominal operating voltages of 69 kV, 138 kV, and 345 kV. Transmission voltages are operated according to the following chart:

Limit	345 kV	138 kV	69 kV
High	362 (1.05 p.u.)	145 (1.05 p.u.)	72.5 (1.05 p.u.)
Low	328 (0.95 p.u.)	131 (0.95 p.u.)	65.5 (0.95 p.u.)
Load Dump	310 (0.90 p.u.)	124 (0.90 p.u.)	62 (0.90 p.u.)
Voltage Bandwidth	± 5.0%	± 5.0%	± 5.0%

Further information regarding transmission voltage and reactive power (transfer) limits can be found in PJM Manual M-3: Transmission Operations, which discusses specific transmission conditions and procedures for the management of Transmission Facilities within the PJM Control Area. Power Factor requirements are included in the transmission tariff where applicable, and a power factor penalty is included in Duquesne Light Company “SCHEDULE OF RATES,” Rate L.

3. The customer load demand is determined by measuring the kilowatt-hours and the reactive kilovolt-ampere hours. The billing demand is based on the two meter readings adjusted for power factor by calculation per (Duquesne Light Company “SCHEDULE OF RATES,” Rate L).

1.14 Synchronizing

Typically synchronizing of facilities does not apply to end users without any type of generation.

NOTE: This requirement does not apply to emergency or standby generation automatic transfer schemes with non-paralleling (break-before-make) operation.

1.15 Maintenance Coordination

When any 100kV and above facility is or will be out of service, PJM must be notified as outlined in PJM Manual 3, Section 4. The customer shall be responsible for the design, construction, installation, maintenance and ownership of all facilities on its side of the interconnection point, including vegetation maintenance. The connected facility shall be inspected by a DLC approved inspector and shall maintain all devices and control schemes for the protection of the DLC transmission system. Prior to performing maintenance on a transmission facility, the transmission outage is listed on the PJM OASIS. If sectionalizing is not possible without interrupting a customer, the customer will be notified of the outage by DLC. If conflicts arise, DLC will attempt to schedule the interruption at a mutually acceptable time.

In addition to the electrical system maintenance, the customer is responsible for maintaining the general substation property. This maintenance includes, but is not limited to fencing, grounding, UG conduit, structural steel, control house, control house HVAC, lighting, yard rock covering, access roadway(s) to the substation and vegetation management within and adjacent to the substation outer fence.

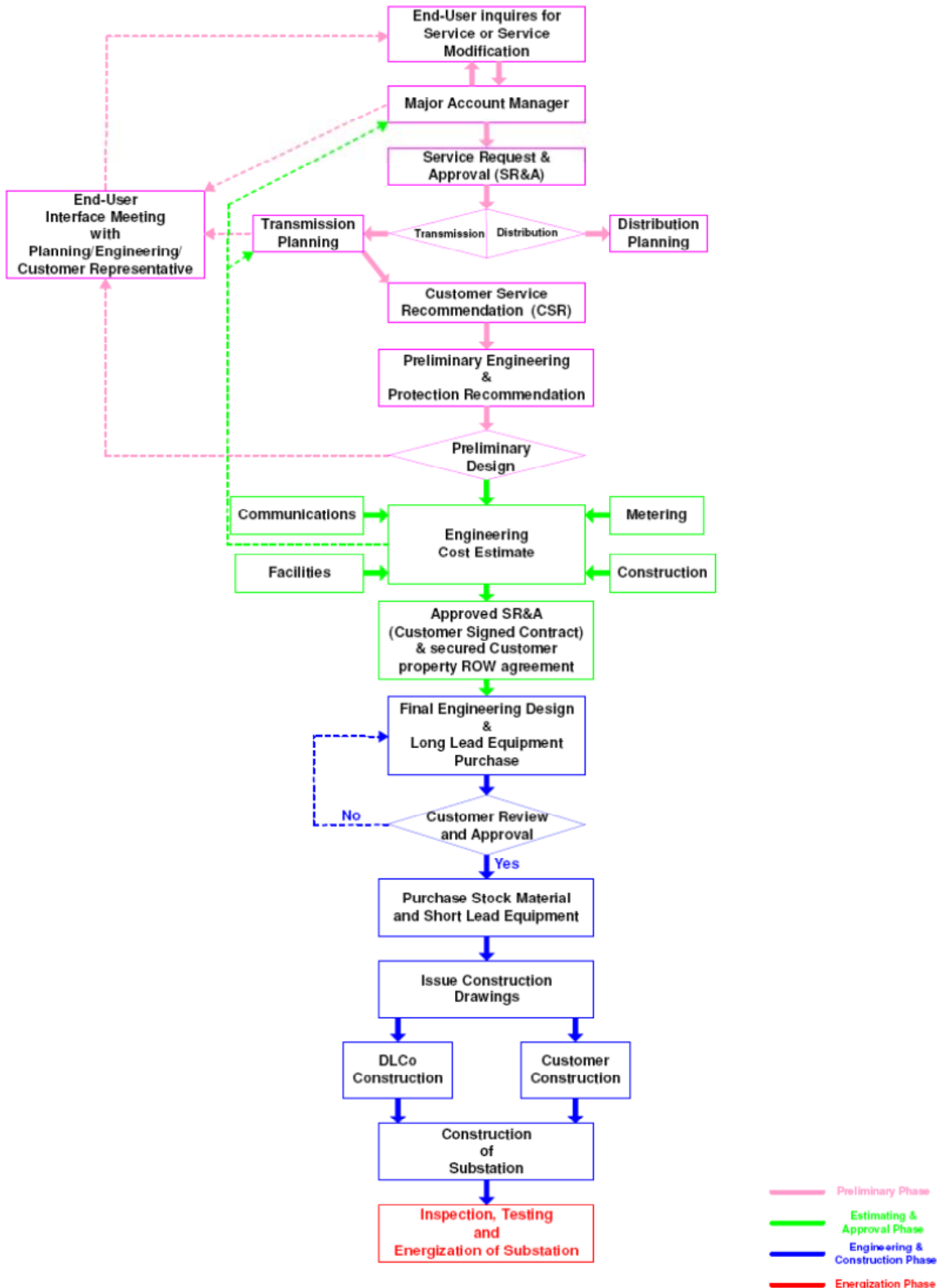
1.16 Normal & Emergency Operating Conditions

The criteria for acceptable system performance for normal system conditions can be found in the PJM Manual M-3: Transmission Operations, which discusses specific transmission conditions and procedures for the management of Transmission Facilities within the PJM Control Area. During emergency operating conditions, PJM may implement emergency operating procedures up to the point of a Manual Load Dump Action. Documentation is provided in the PJM Manual M-13: Emergency Operations, which focuses on how the PJM and the PJM Members are expected to respond to emergency conditions. Emergency conditions include: an abnormal electrical system condition requiring manual or automatic action, a fuel shortage, or a condition that requires implementation of emergency procedures as defined in the PJM Manuals.

Appendix A - Figures

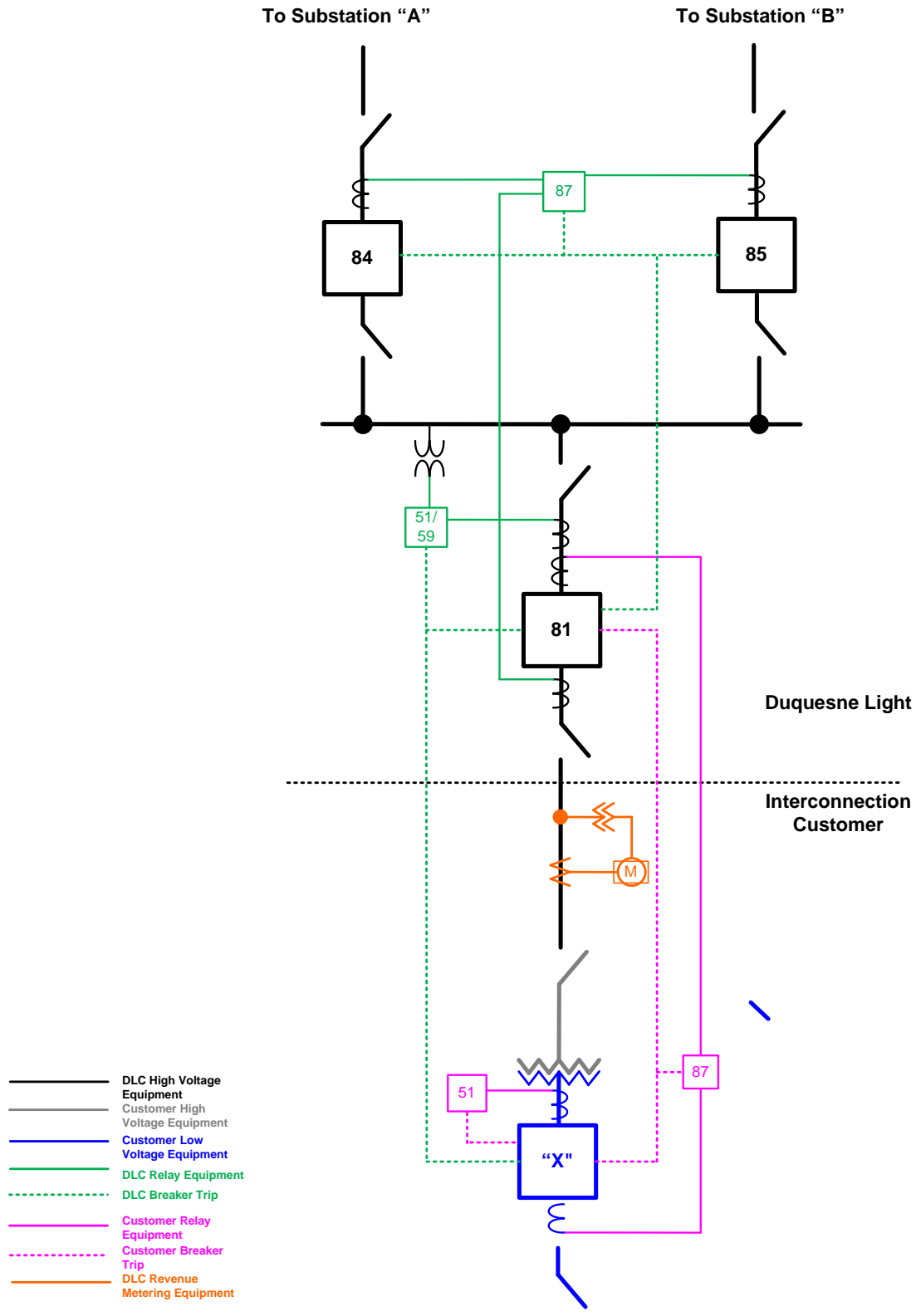
Figure 1 – Flow Diagram for End-User Facility

Figure 2 – Typical Base Service Single Line



Flow Diagram for End-User Facility
FIGURE 1

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**Typical Service Single Line
Figure 2**

12/30/2015

Appendix B - Links

[PJM Manual 3: Transmission Operations](#)

[PJM Manual 13: Emergency Operations](#)

[PJM Manual 14A: Generation and Transmission Interconnection Process](#)

[PJM Manual 14B: PJM Region Transmission Planning Process](#)

[PJM Manual 14C: Generation and Transmission Interconnection Facility](#)

[PJM Manual 14D: Generator Operational Requirements](#)

[PJM Manual 14E: Merchant Transmission Specific Requirements](#)

Revision History

Rev No:	Change:	Revised By:	Authorized By:	Effective Date
6	Comprehensive review of entire document with minor changes.	Michelle Antantis	Jason Harchick	12/30/2015
5	Modified required switch & breaker ratings. Modified harmonic specification. Annual review of entire document.	Joe Palumbo	Jason Harchick	12/30/2013
4	Add title page for entire connection document. Annual review of entire document.	Megan E. Sullivan	Megan E. Sullivan	5/13/2011
3	Update Metering heading to Metering and Telecommunications. Annual review of entire document.	Joe Palumbo	Megan E. Sullivan	12/1/2010
2	Update Maintenance section to include vegetation maintenance. Add Appendix B with document links. Consolidate with Transmission document.	Kelly Geer	Megan E. Sullivan	10/21/2009
1	Annual review of entire document. Revise Figures 1 & 2. Update Metering section. Consolidate with Generation document.	Kelly Geer	Megan E. Sullivan	6/26/2009
0	Consolidate Transmission End-User documents.	Joe Palumbo	Megan E. Sullivan	2/11/2009