

**ENWIN POWERLINES LTD.**

**EMBEDDED GENERATION GUIDELINE**

**AND INTERCONNECTION PROCEDURE**

**AND REQUIREMENTS**

**FOR GENERATORS OF LESS THAN 10 MVA**

**ENWIN POWERLINES LTD.**

**EMBEDDED GENERATION (EG) GUIDELINE**  
**INTERCONNECTION PROCEDURE AND REQUIREMENTS**  
**FOR GENERATORS LESS THAN 10 MVA**  
**TABLE OF CONTENTS**

<b>SECTION</b>	<b>TOPIC</b>	<b>PAGE</b>
1.0	Introduction	3
2.0	EnWin Powerlines Ltd. Distribution System	3
3.0	EPL Utility Practices	4
4.0	EG Interconnection Requirements and Procedure	5
4.1	Initial Contact and EG Interconnection Application	5
4.2	Preliminary Review for Connection Requirements	6
4.3	Detailed Study to Determine Connection Requirements	7
4.4	Agreements	9
4.5	Commissioning	9
5.0	General Responsibilities	10
5.1	Embedded Generator Responsibilities	10
5.2	EPL Responsibilities	11
6.0	Important Technical Requirements for Connection	12
Appendix # 1 – Connection Process Flowchart		14
Application Form		16

## 1.0 INTRODUCTION

Customers of EnWin Powerlines Ltd. (EPL) may choose to supply some or all of their electrical energy needs through the installation of an on-site, customer owned generation facility. EPL will provide non-discriminatory access to their electrical distribution system for a generator and will make every effort to respond promptly to a generator's request for connection. For the purpose of this document, a generator that request connection to the EPL distribution system will be referred to as an 'Embedded Generator' (EG).

This guideline outlines the typical technical requirements and procedural activities required of a prospective EG, of 10 MVA or less, to connect to the EPL electrical distribution system to ensure safe and reliable distribution system operation. Generation facilities of

10 MVA or higher will be reviewed on a case by case basis as these will require a greater degree of difficulty for connection and significantly higher costs. This guideline also insures that EPL and the EG comply with the requirements of the Ontario Energy Board (OEB) Distribution System Code (DSC), Section 6.2, the EPL Conditions of Service and the Ontario Electrical Safety Code, Section 84. The DSC is available on the OEB web site at [www.oeb.gov.on.ca](http://www.oeb.gov.on.ca).

The guideline focuses on protections required to detect and isolate the generator from the EPL distribution system when faults/disturbances occur on the distribution system, to protect the EPL system and other customers on the distribution system. The EG should consider these typical protection requirements when preparing the proposed protection package for EPL's review; however, **this guide is not intended to take the place of a detailed final design**. A detailed final design should be completed by a competent person or organization and should include consideration of proposed power and protective equipment, and local conditions, including existing and future equipment loading, and operating conditions.

## 2.0 ENWIN POWERLINES LTD. DISTRIBUTION SYSTEM

Hydro One (HO) owns the high voltage transmission system and some transformation facilities that supplies power to EPL at the 27.6/16 kilovolt levels, which in turn, EPL distributes to various customers throughout their electrical distribution system. EPL also owns transformation facilities that supply power to EPL customers. Because of this arrangement, an EG must also comply with HO requirements for connection, as an embedded generator could have a serious impact on the Hydro One system under fault conditions.

It is assumed that the embedded generating facility will be designed, constructed, owned and operated by a developer independent of EnWin Powerlines Ltd. All embedded generator interconnection arrangements must be acceptable and approved by EPL and for some specific relay protection areas by HO. An EG facility that includes a generation unit rated at 10 MVA or higher or whose embedded generation facility is comprised of

generation units whose net output is greater than 50 MVA, will require approval of the Independent Electricity Market Operator (IMO). Such a facility must meet the applicable IMO performance standards identified in Chapter 4 of the 'Market Rules for the Ontario Electricity Market'. These market rules are available on the IMO web site at [www.theIMO.com](http://www.theIMO.com).

### 3.0 EPL UTILITY PRACTICES

The major elements of a utility connection for an embedded generation facility include a circuit breaker for fault current interruption, a transformer for matching the generator and utility system voltages and a connecting line to the utility facilities. Control, metering and protective relaying facilities are also necessary for both the EG and EPL operations. EPL will have operating control of the circuit breaker at the interface between the EG and the EPL distribution system.

Protection systems are required at the generation facility and these protection systems must be capable of automatically isolating the EG from the EPL system. The EG should provide protection systems to cover the following conditions:

- Internal faults (i.e. faults within the EG),
- External faults (i.e. faults on the EPL system to which the EG is connected),
- Certain abnormal system conditions that could result in EG islanding (e.g. conditions where the EG becomes separated from the EPL system along with some load), and
- Additional protection features, such as Remote Trip or Voltage Supervision, may be required in some applications.

The purpose of the connection and protection requirements outlined in this guide are to:

- Consider the health and safety of the general public and of EPL employees in the performance of their duties,
- Preserve the security and reliability of the EPL and Hydro One distribution systems,
- Preserve acceptable quality of the electrical supply to other EPL customers, and
- Ensure operating flexibility during normal or emergency conditions.

Once a prospective EG customer decides to proceed with the installation of a generation facility, they will be responsible to reimburse the cost reasonably incurred by EPL with making an offer to connect a generator. The amount that EPL may charge a EG to construct the expansion to connect a generator to the EPL distribution system shall not exceed the generator's share of the present value of the projected capital costs and on-going maintenance costs for the equipment. Projected revenue and avoided costs from the generator shall be assumed to be zero, unless otherwise determined by rates approved by the OEB. The economic methodology and inputs that EPL will follow are presented in EPL's Contributed Capital Policy.

Costs that could be reasonably incurred by EPL include costs associated with:

- Preliminary review for connection requirements,

- Detailed study to determine connection requirements, and
- Final proposal to connect the generator.

This guideline is prepared for one EG on a EPL distribution feeder. If there is a second EG to be connected to the same feeder then total generation versus minimum feeder load must be considered and the protection package must be designed accordingly. If additional equipment protection is required for the EG already connected to the feeder, the second EG may be responsible for the modification costs.

An embedded generator will be required to comply with all of section 5.2 of the DSC in regards to metering requirements for a generating facility. For an OEB licensed generator connected to the EPL system that sells energy and settles through the EPL's settlement process, the EG must install a four-quadrant interval meter. EPL will meter customers with generation that does not require a OEB licence, such as back-up capability or generation for load displacement, in the same manner as EPL's other load customers.

An EG that wishes to become connected to EPL's distribution system must enter into a Connection Agreement with EPL. This Connection Agreement shall contain specific terms and conditions relating to the connection, operations, maintenance and communications requirements of the generator and EPL.

#### **4.0 EG INTERCONNECTION REQUIREMENTS AND PROCEDURE**

A prospective EG should contact EPL for information and request the form "Application to Connect an Embedded Generator". As connection costs are to be paid by the generating facility, most applicants will want to determine the point of connection and expected costs prior to committing the project. This information can only be provided after a preliminary review is conducted by EPL and HO based on the information included in the "Application to Connect an Embedded Generator".

The preliminary review includes a verification of the voltage and power ratings of the EG installation to confirm that they are compatible with those of the distribution system. The impact of the proposed connection on reliability, power quality and equipment and personnel safety will also be assessed. Once the preliminary review is completed and should the EG installation be pursued further, more detailed analysis, specifications and information will need to be provided by the EG.

Listed below are the recommended steps involved in proceeding to have a EG connect to the EPL electrical distribution system. For an overview of this connection process, refer to Appendix # 1 for the 'Embedded Generator - Connection Process Flowchart'.

#### **4.1 Initial Contact and EG Interconnection Application**

- 1) Contact the EPL Technical Services Department, Manager of Engineering Services, to identify an interest in connecting a EG onto the EPL electrical distribution system and obtain the form “Application to Connect an Embedded Generator”, a copy of the EPL Conditions of Service Manual and a copy of the EPL cost recovery policy.
- 2) Provide EPL with a written request for connection along with the completed application form, including the preliminary technical information (two copies) describing the proposed EG facility. As a minimum, this would include the following information pertaining to the connection:
  - Site location with a scaled map referencing the site relative to existing lot line, easements, road allowances and power line that identifies the facility location.
  - A brief description of the proposed plant design and operating characteristics, including expected monthly peak power and net energy production for each month of the year. If the EG intends to purchase power from EPL to supplement its EG production to meet its total plant load, a monthly estimate of this expected purchase should also be provided.
  - Short and long term site development plans and installation schedule and the preferred point of connection to the EPL system.
  - Preliminary single line diagram showing generator(s), transformer(s), grounding arrangements and main isolating devices.
  - Type and rating of main isolating device, generator(s) and transformer(s) and nameplate data if available.
  - Proposed preliminary relay protection schemes.
  - Proposed revenue-metering equipment (i.e. 4-quadrant interval metering).
- 3) Once EPL has received the required information to begin an analysis, EPL will proceed with a preliminary review of the EG connection requirements.

#### **4.2 Preliminary Review for Connection Requirements**

- 1) The applicant will be responsible to reimburse EPL for all reasonable costs incurred in completing the preliminary review.
- 2) EPL will review the application and its associated documents and if insufficient information has been provided, EPL will advise the EG of its requirements and will put on hold its review until all sufficient data is provided. In general, the preliminary review will be conducted as follows:
  - Determine the acceptability of the location and voltage level of connection to the EPL system.
  - Determine the EG plant capacity limitations for the proposed connection.
  - Confirm that the voltage and power ratings of the EG installation are compatible with those of the EPL distribution feeder. Where a mismatch between distribution line and EG capacity ratings is revealed, the feeder may

require reconductoring or upgrading. To determine this compatibility, the following checks will be completed; feeder current rating, surge impedance loading, voltage regulation, reliability, power quality and safety considerations.

- Depending on the total generation to be connected to the EPL feeder and the minimum feeder load, remote trip protection facilities between the transformer station (supply) and the EG may be required. EPL and HO will determine if this requirement is necessary.
  - The size of the generator and the EG transformer configuration will determine the feeder protection modifications and requirements at the supply station. This information will also help to determine any specific connection and equipment requirements, e.g. requirement for a remote trip protection scheme, voltage supervision, etc.
  - Consult with HO on any possible relay protection modifications or additions.
- 2) EPL will provide the applicant with a written response to the preliminary review for connection within 30 calendar days of starting the review. EPL will also provide a preliminary cost estimate to the applicant for connecting the generator onto the distribution system. A more detailed estimate can only be provided after a detailed connection review is completed.
  - 3) If the proposed EG finds the preliminary review acceptable, they must confirm in writing to EPL its acceptance and request EPL to proceed with a detailed review. The EG must commit to reimburse EPL all reasonable costs incurred in completing the detailed review.

#### **4.3 Detailed Study to Determine Connection Requirements**

The complete detailed engineering package including relay settings must be submitted to EPL before the detailed review can proceed. EPL will provide the EG with an offer to connect within 60 calendar days of starting the detailed review, unless other necessary information outside of EPL's control is required before an offer to connect can be made.

1. The EG must provide EPL with detailed technical information (two copies) describing the proposed EG facility. As a minimum, this would include the following information pertaining to the connection:
  - Project construction and commissioning schedule.
  - Site details, including power line to be constructed, transformer location, isolating switch location and connection location relative to the EPL feeder circuit.
  - Final single line diagrams showing voltage levels, transformer connections, isolating devices, safety interlocks, fusing and metering (statistical and revenue metering).
  - Nameplate data for protective relays (provide descriptive bulletins), load interrupter switch, generator(s) (include auto/manual synchronization scheme), transformers, breakers and station service.

- Generator Specifications, including:
    - a) Inertial constant in kWsec/kVA
    - b) Maximum MVAR limit
    - c) Neutral ground resistance in Ohms
    - d) Short circuit unsaturated reactance in per unit on the generator's MVA and kV base
    - e)  $X_d$  – Synchronous reactance in p.u.
    - f)  $X'_d$  – Direct axis transient reactance in p.u.
    - g)  $X''_d$  – Direct axis sub-transient reactance in p.u.
    - h)  $X_2$  – Negative sequence reactance in p.u.
    - i)  $X_0$  – Zero sequence reactance in p.u.
  - Power transformer positive and zero sequence impedance's in per unit on the transformer rating base as measured between each pair of windings:
    - $R_1$
    - $X_1$
    - $R_0$
    - $X_0$
  - Large motor specifications; in order to calculate voltage drops due to motor starting.
    - a) Motor Type (synchronous, induction, etc.)
    - b) Rating in HP or kW
    - c) Power Factor
    - d) Transient Reactance in p.u.
    - e) Sub-transient Reactance in p.u.
  - Relaying single line diagram showing complete protective relaying and tripping schemes.
  - Provide settings for the various protective-relaying schemes.
  - AC and DC elementary drawings for control and protection.
  - Short circuit (fault) calculations and voltage drop study (including all appropriate reactance's for the generator(s) and transformer(s), relay settings, fuse selection and coordination study of the protection scheme). Short circuit calculations will be based on IEEE Standard #ANSI/IEEE C37.04.
  - Electrical equipment Layouts.
  - Station ground design and ground potential rise study.
  - Phasing diagram showing all transformer connections.
3. EPL in association with HO will review the detailed electrical package and determine the acceptability of the interface design as it affects the EPL and HO systems and provide written comments to the EG.
  4. It is recommended that the EG not begin procurement of electrical equipment until EPL, the Electrical Safety Authority and HO have provided, in writing, the acceptability of the EG interface design.
  5. Once the EG agrees to proceed with the construction of the generating facility, the EG must enter into various agreements with EPL.

**Note:** EPL will not provide any consulting services to an EG but only evaluate proposed generating facilities as to how it may impact on the EPL distribution system.

#### **4.4 Agreements**

Before a generator installation begins operation, the EG applicant must enter into various agreements with EPL. These agreements must clearly define the obligations and privileges of each party that need to be executed between the EG owner and EPL. The EG may be required to enter into all or some of the following agreements:

Construction Agreement: this agreement between the EG and EPL will detail the connection requirements and cost recovery terms.

Construction Agreement: In the event that the HO system requires modifications to connect the EG, this agreement will describe the obligations of EPL and HO to complete the connection and cost recovery terms.

Customer Account Contract: in the event that the EG is also a load customer of EPL, this contract describes the terms and applicable rates for firm power and backup power and conditions under which backup power is granted and revoked.

Connection Agreement: This is a technical document which identifies; common language and procedures to be used for normal and emergency situations, installed protection equipment, ownership and operating control of equipment, expected levels of maintenance and testing by both parties, contact names and telephone numbers, definitions, and containing all necessary schematic diagrams for proper communication between EPL and the EG.

Operations Agreement: (if required) this agreement between HO and EPL will include provisions for safe and effective operation in presence of the EG's equipment connected to the EPL system. This agreement may only be required if the EG affects other parties connected to the EPL distribution system.

#### **4.5 Commissioning**

Prior to the EG facility being connected to the EPL electrical distribution system, EPL Engineering Department staff, or their delegate, will review and witness the EG's commissioning tests to the extent that is necessary to ensure acceptable security to the EPL and HO distribution systems.

## 5.0 GENERAL RESPONSIBILITIES

### 5.1 Embedded Generator Responsibilities

- Design the generating facility electrical and protection package to meet the EPL, HO and DSC connection requirements and Electrical Safety Authority Inspection requirements. For Electrical Inspection requirements refer to the Electrical Safety Authority Code, Section 84 and Electrical Inspection Department Bulletin #84-1-1 or the most recent version.
- Ensure that the generating facility produces no objectionable harmonics or voltage flicker on the EPL system. If objectionable harmonics or voltage flicker do occur, the EG will be responsible to modify the generating facility to correct the problem.
- EPL operates its' system within CSA Standard C235 entitled "Preferred Voltage Levels for AC Systems, 0-50,000 volts", which recommends voltage variation limits on customer circuits. Any EG interconnected with the EPL supply system must not cause voltages, as measured at customer service entrances, to deviate more than the amounts indicated in the CSA standard.
- The output of a EG, when connected in parallel with the EPL supply system, must not adversely affect the voltage, frequency or wave shape of the EPL electrical distribution system.
- If a remote trip protection scheme and/or a voltage supervision scheme is utilized, HO will be required to modify equipment at HO owned transformer stations and therefore, the EG will be responsible to cover reasonable costs incurred.
- If a remote trip protection scheme is required, the EG must arrange for and pay the leased circuit costs on data communications circuits.
- Provide telephone communications inside the generating facility to allow for communication with EPL staff.
- EPL may require the installation of a 'Remote Terminal Unit' (RTU) which will provide data input to the EPL Supervisory Control Assisted Data Acquisition (SCADA) system. EPL will require the EG to allow for space, in their substation, for the RTU and provide an a.c. supply circuit for the unit. EPL will arrange for a leased data circuit for the SCADA unit and pay the monthly charges for this leased circuit.
- The EG connected to the EPL system must install its own meter in accordance with EPL's metering requirements and provide EPL with the technical details of the metering installation.

- The EG metering must be installed at the point of supply. If it is not practical to install the meter at the point of supply, EPL will apply loss factors to the generation output in accordance with the loss factors applied for retail metering settlement.
- An EG's substation must include space for a metering compartment for the installation of instrument transformers and other devices for revenue metering.
- It will be the responsibility of the EG to forward a detailed electrical package to the Electrical Safety Authority for their review of the proposed generation facility.
- Obtain all appropriate permits for the construction and operation of the generation facility (e.g. Electrical Safety Authority approvals, generator licenses, municipal construction permits, etc.).
- Advise EPL of the timetable for commissioning tests of the generator(s) in order that EPL, or its delegate, may review and witness the tests.

## 5.2 EPL Responsibilities

- Identify and explain the EPL cost recovery policy to the prospective EG.
- Review the EG electrical design package and determine if it meets the minimum requirements to permit connection to the EPL system.
- Design and modify, as required, the EPL facilities to incorporate the EG.
- Discuss and review with HO any relay protection modifications that may be required on the EPL supply feeder(s).
- EPL Engineering Department will be responsible to coordinate the parallel connection between the EG and the EPL electrical distribution system.
- EPL will initiate the preparation of agreements between the EG and EPL.
- As required by the Market Rules for the Ontario Electricity Market, EPL will notify the IMO of the generation connection.

**Note:** EPL will not provide any consulting services to a EG but only evaluate proposed generation facilities to assess its' impact on the EPL distribution system.

## 6.0 IMPORTANT TECHNICAL REQUIREMENTS FOR CONNECTION

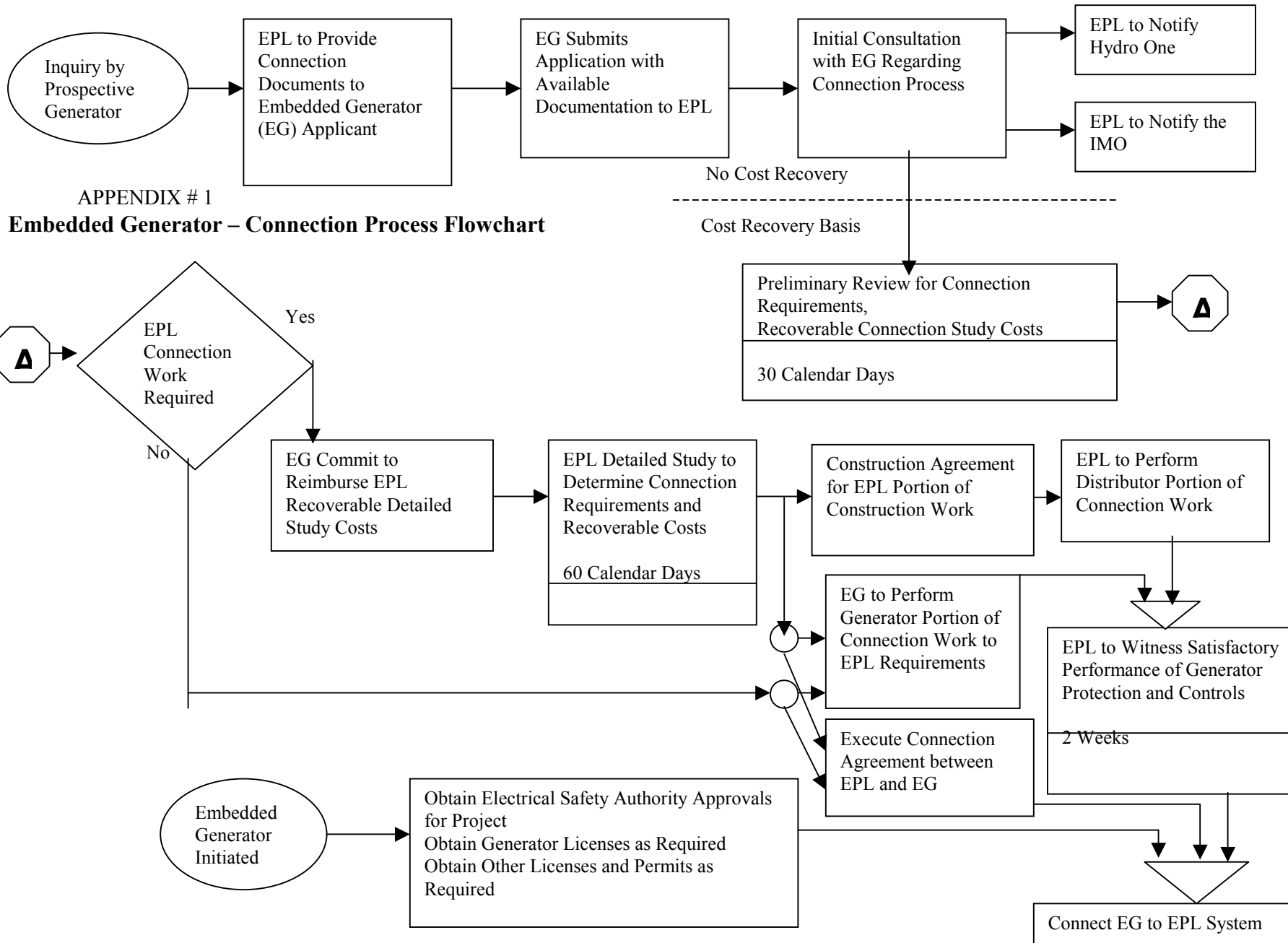
The EG's electrical and protection package shall provide the following:

- Provide a 3 phase, gang-operated, visible load break switch with provision for padlocking at the point of connection to the EPL system and must be accessible to EPL staff. EPL will have operating control of this isolating point.
- Provide a fault interrupting/synchronizing device with suitable rating for each generator.
- Provide automatic tripping of generator(s) for all faults on the EG side of the connection point.
- Provide automatic tripping of generator(s) for phase and ground faults on the EPL electrical distribution system.
- EPL operates a three phase four wire system and therefore, the appropriate transformer connection between the EG and the EPL system can be either;
  1. High Voltage wye-grounded and a Low Voltage delta;
  2. High Voltage delta and a Low Voltage wye-grounded; or
  3. High Voltage wye-grounded and a Low Voltage wye-grounded.

The preferred transformer connection for generator units above 2 MW's is a High Voltage wye-grounded and a Low Voltage delta.
- Provide suitable transformer protection.
- Install protective relays to prevent the EG from delivering power to the EPL feeder line when that line has become isolated or islanded from the rest of the EPL system. (This will usually include over/under frequency relays and over/under voltage relays.)
- For EG load displacement projects with no power purchase by EPL, 'Reverse Power Protection' will be required.
- Normal reclosing time of the EPL supply station feeder breaker is 0.8 seconds. Short time delay for reclosing (ie, < 1.0 second) will increase the risk of EG damage and may emphasize the need for a remote trip protection and voltage supervision scheme since the EG islanding protection may be too slow.
- Remote trip may be required between the EG and the feeder circuit breaker because the EG is connected at a critical location on the distribution system. This feature will provide for isolation of the EG when certain faults or system disturbances are detected at the feeder circuit breaker location.
- Provide synchronizing facilities for each synchronous generator.
- Provide a ground potential rise study to satisfy EPL and the Electrical Safety Authority for step/touch potential and to satisfy Communications Company for incoming voice/data circuit/personnel protection.
- The communication requirements for the EPL metering equipment and possible remote trip circuit must be confirmed with EPL before installation.
- For induction generators, ensure that the power factor is greater than 0.9. This may require the installation of automatically disconnected capacitors. EG's with synchronous generators will be required to operate as near to unity power factor as possible.

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**Note:** EnWin Powerlines Ltd. continually strives to provide the most up to date information to our customers, therefore we reserve the right to amend this guideline and its requirements at any time upon the sole discretion of the EnWin Powerlines Ltd.



APPENDIX # 1  
**Embedded Generator – Connection Process Flowchart**

**REFERENCES**

Electrical Safety Authority Code (22<sup>nd</sup> Edition, 1998).

Electrical Safety Authority Bulletin #84-1-1 (January 2000).

Connecting Small Generators to Utility Distribution Systems (June 1994), by A.B. Sturton Consultants Inc. and Acres International Limited, Canadian Electric Association

CSA Standard C235, Preferred Voltage Levels for AC Systems, 0 - 50,000 volts.

IEEE Standard #ANSI/IEEE C37.04

Hydro One, Protection & Control Department.

IEEE Paper, Electrical Impact of a NUG Under 5MW Rating When Connected to a Distribution Feeder With Various Transformer Connections, (March 1994), by D. Kundu, E.G. Neudorf, N. Perris, L.M. Szeto and D.V. Krause

Ontario Energy Board, Distribution System Code – July 14, 2000

The Market Rules for the Ontario Electricity Market – October 10, 2000

**ENWIN POWERLINES LTD.**

**APPLICATION TO CONNECT AN  
EMBEDDED GENERATOR (EG)**

Received by EPL
Date _____.

Date \_\_\_\_\_.

1. Name of Applicant \_\_\_\_\_.

Address \_\_\_\_\_.

Telephone \_\_\_\_\_ Fax \_\_\_\_\_ E-mail \_\_\_\_\_.

2. Project Name \_\_\_\_\_.

Project Location \_\_\_\_\_.

Project Contact Name & Telephone No. \_\_\_\_\_.

3. Project Consultant(s) Name \_\_\_\_\_.

Address \_\_\_\_\_.

Telephone \_\_\_\_\_ Fax \_\_\_\_\_ E-mail \_\_\_\_\_.

4. Project Type: (e.g. Cogeneration, Combined Cycle, Hydraulic, etc)

5. Construction Schedule:

Projected Start-Up of Construction	-
Construction Power Requirement	-
Site Begins to Generate Power	-
Projected In-Service Date of EG	-

6. With this application, please provide the following information:

- Site Plan with scaled map referencing the site relative to existing lot lines, easements, road allowances, etc.

- Preliminary single line diagram showing generator(s), transformer(s) and main isolating devices and proposed electrical connection point to the EPL system (if known). Include as much information on the electrical protection scheme as is possible.
- Nameplate information on each generator, power transformer and motor in excess of 25% of the generator capacity. Information requirements are listed below.

Generator Specifications, including:

- Manufacturer
- Fuel type
- Rated MVA
- Rated MW
- Rated Voltage
- Rated Power Factor

Power Transformer specifications, including:

- Manufacturer
- Voltages and power rating(s)
- Winding configurations
- Specifications of connected neutral reactors or resistors, if installed

Large motor specifications:

- Motor Type (synchronous, induction, etc.)
- Rating in HP or kW
- Power Factor

## 7. Expected Monthly Peak and Energy Production and Consumption

Load Displacement Generators and Merchant/Load Displacement Generators (generator supplies on-site electrical loads not directly related to operation of generation equipment).

	<b>Generator Output</b>		<b>Site Sales</b>		<b>Site Purchases</b>	
	<b>kWh</b>	<b>Peak kW</b>	<b>kWh</b>	<b>Peak kW</b>	<b>kWh</b>	<b>Peak kW</b>
January						
February						
March						
April						
May						
June						
July						
August						
September						
October						
November						
December						

8. In addition to the above, please provide:

- Future site development plans;
- A brief description of the proposed plant design and operating characteristics;
- Provide a brief description of the proposed operating procedures and technical personnel to be employed by the generating facility;

**AUTHORIZATION:**

I request EnWin Powerlines Ltd. to proceed with a preliminary review of this embedded generation interconnection application and I agree to reimburse EPL the cost associated with completing this review.

I have reviewed the EPL document “Embedded Generation Guideline for Interconnection Requirements and Procedure, the requirements of the EPL Conditions of Service Manual, the Distribution System Code and the Ontario Electrical Safety Code.

I further consent to EnWin Powerlines Ltd. providing information to the Independent Market Operator, Hydro One and other distributors as required.

\_\_\_\_\_  
Name: (please print)

\_\_\_\_\_  
Signature:

\_\_\_\_\_  
Date:

\_\_\_\_\_  
Title: