Document No.	**EMB-DLF-GLR-01**
Title:	**DISTRIBUTION LOSS FACTOR CALCULATION METHODOLOGY FOR AMCOR GAWLER GLASS FACTORY**

Document Status

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00C	TiHaur Tan	Paul Troughton	17/02/09	External (Confidential Information Withheld)

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Distribution Loss Factor Calculation Methodology

1 *Introduction*

Energy Response (ER) is engaged by exempt network operator, Amcor Packaging (Australia) Pty Ltd (APENO) as an intermediary for the registration of Amcor's Gawler Glass Factory embedded generators as non-scheduled market generators in the National Electricity Market (NEM).

The embedded generators are connected to APENO's exempt network within the Gawler plant. This document describes the methodology used by ER to calculate the distribution loss factor (DLF) for these embedded generator connection points for the 09/10 financial year.

Rather than developing a new methodology, we have adopted that used by Ergon Energy and Energex for embedded generators, as approved by the Queensland Competitive Authority (QCA) and described in **Report NCM 17699 Determination of Distribution Loss Factors for Embedded/Local Generators**. A copy of this report is provided as Attachment 1 to this document.

1.1 AMCOR GAWLER GLASS FACTORY

The Amcor Gawler plant is located at Argent Road, Gawler Belt SA 5118; APENO operates an 11kV and 415V exempt network which is connected at 11kV to the ElectraNET Roseworthy transmission substation.

APENO has two 11kV intakes from the Roseworthy transmission substation which are connected to the plant's 11kV main switchboard and separated by a bus-tie. The bus-tie is normally open and only closes when either one of the intakes experiences a supply failure.

1.2 AMCOR GAWLER EXEMPT NETWORK SERVICE

Figure 1 below shows the location of various connection points.

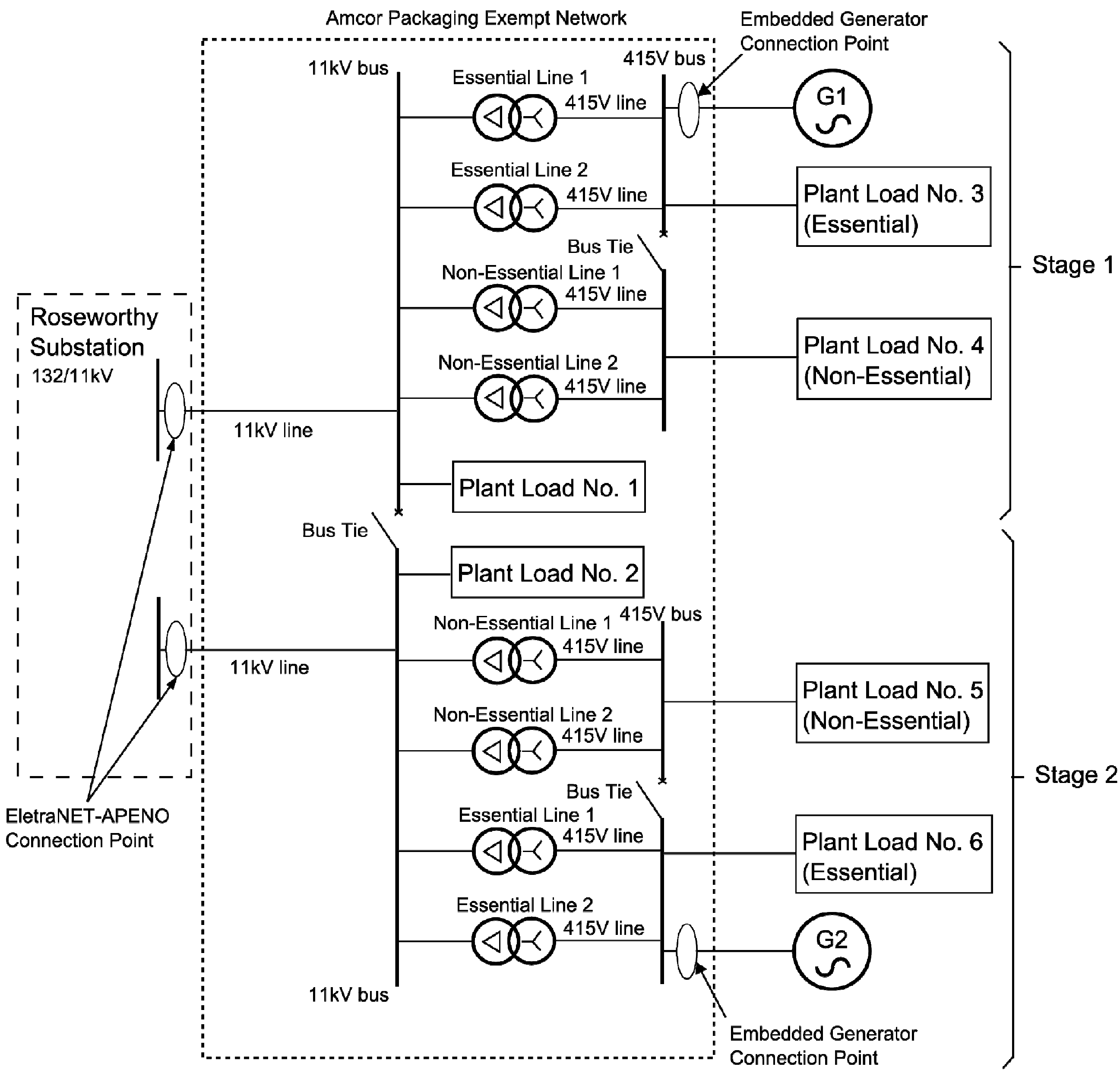

Figure 1 - Simplified representation of the APENO exempt network

1.3 GENERATOR OPERATING STATES

The embedded generators on APENO's exempt network will not be running continuously. They will be run as a peaking plant, in response to high spot prices in the South Australian market. Extrapolating from historical market data, we expect this to be 20-80 hours per year, and would be surprised if it exceeded 150 hours. The generators may also be run at ElectraNET's request to relieve network constraints, or as part of a NEMMCO reserve programme, or under NEMMCO's direction. They will also continue to be run for test and maintenance purposes, and as required for plant operations.

Amcor Gawler Glass Factory has a fairly consistent energy consumption profile 24 hours a day, 7 days a week, and 365 days a year. This is confirmed by the historical meter data obtained from the ElectraNET-APENO connection point, as well as from the plant's Energy Management System records. An energy consumption profile of the plant for the period 17 Dec 2007 till 17 Dec 2008 is provided as Attachment 2 to this document.

The embedded generators are connected to the Essential Switchboards. When instructed to run, Stage 1 generator typically supplies 600kW out of the typical 700kW loads connected to Stage 1 Essential Switchboard; whereas Stage 2 generator typically supplies 700kW out of the typical 800kW loads connected to Stage 2 Essential Switchboard. (100kW load is still supplied by the grid as a buffer to prevent reverse power from the embedded generator to the grid in the event of sudden load drop from the Essential Switchboards.)

The Marginal Loss Factor for the embedded generator connection points is calculated based on the net reduction in distribution losses within the APENO exempt network when the generators run.

2 Amcor Gawler Generator DLF Calculation

The site specific DLF for the Amcor Gawler embedded generators will be calculated using a Marginal Loss Factor (MLF) approach as described in **Report NCM 17699 Determination of Distribution Loss Factors for Embedded/Local Generators.**

2.1 APPROACH

The DLF is a static loss factor which is to apply to the embedded generator exempt network connection point for the full financial year. The steps undertaken to calculate the DLF are summarized as follows:-

1. Request Amcor Gawler Glass Factory consumption data for the past year – from Amcor Packaging (Australia) Pty Ltd.
2. Request plant equipment data and specifications for the APENO exempt network – from Amcor Packaging (Australia) Pty Ltd.

3. Develop an equivalent network model for the APENO exempt network by incorporating all relevant equipment data and specifications.
4. Calculate the estimated distribution losses due to APENO exempt network's impedance.
5. Calculate the MLF and DLF in accordance with the methods described in **Report NCM 17699 Determination of Distribution Loss Factors for Embedded/Local Generators**.

Notes:

- The losses in the APENO exempt network have been calculated using the impedance values of the distribution equipment and cables.
- The relevant distribution losses are those between the 11kV APENO connection point at Roseworthy and the embedded generator connection points.
- The plant has a fairly consistent load profile with minimal changes in consumption trends, and there are no significant changes to the plant's loads expected in the foreseeable future. Therefore it is assumed that the historical consumption data from the past year is a sufficiently accurate estimate for the forecast DLF for 09/10 financial year.

2.2 IDENTIFICATION OF DISTRIBUTION LOSSES

ER has segmented APENO's exempt network into three levels between the ElectraNET-APENO connection point and the embedded generators for both Stage 1 & Stage 2:-

- Stage 1
  - 11kV Incomer Network
  - Essential Line No. 1 - 11kV Feeder, 11kV/415V Transformers, 415V Busduct & 415V Incomer
  - Essential Line No. 2 - 11kV Feeder, 11kV/415V Transformers, 415V Busduct & 415V Incomer

- Stage 2
  - 11kV Incomer Network
  - Essential Line No. 1 - 11kV Feeder, 11kV/415V Transformers, 415V Busduct & 415V Incomer Network No. 1

- Essential Line No. 2 - 11kV Feeder, 11kV/415V Transformers, 415V Busduct & 415V Incomer Network No. 2

The distribution losses for each of these were derived in turn:-

2.2.1 11kV Incomer Network (Stage 1 & Stage 2)

The main contributions to losses on the 11kV incomer network have been identified as follows:-

- Copper Losses across the 11kV cables from the Roseworthy substation to the 11kV switchboard
- Copper Losses across the 11kV Main Switchboard Incomer Circuit Breakers

It has been assumed that negligible losses are developed across the 11kV main switchboard busbars; therefore those losses are ignored.

2.2.2 Essential Line No. 1 & No. 2 (Stage 1 & Stage 2) - 11kV Feeder, 11kV/415V Transformers, 415V Busduct & 415V Incomer

The main contributions to losses on the Essential Lines No. 1 & No. 2 have been identified as follows:-

- Copper Losses across the 11kV Main Switchboard Feeder Circuit Breakers
- Copper Losses across the 11kV cables from the 11kV switchboards to the 11kV/415V transformers
- Copper Losses across the transformer winding
- Iron Losses in the transformer core
- Copper Losses across the 415V Busduct from the transformer to the 415V Essential Switchboard
- Copper Losses across the 415V Essential Switchboard Incomer Circuit Breakers

It has been assumed that negligible losses are developed across the 415V essential switchboard busbars; therefore those losses are not considered.

Attachment 3 lists the technical details obtained from Amcor Packaging (Australia) Pty Ltd.

3 Modelling of Distribution Losses

Based on the sources of losses identified in (2.2) and on data obtained in (2.1), we can calculate the parameters for the equivalent network model of the APENO exempt network as detailed in Attachment 2 and Attachment 3. Subsequently, the equivalent network as referred to 11kV can be obtained as follows:-

(NOTE: Cable, busduct & transformer inductances are not included in the equivalent network because we are only interested in the active power losses of the APENO exempt network.)

[Confidential Network Information Withheld]

4 Calculation of Distribution Loss Factors

We can arrive at the distribution losses without and with generators running for both Stage 1 and Stage 2 as follows:-

[Confidential Network Information Withheld]

4.1 MLF & DLF CALCULATION

In accordance with the methods described in **Report NCM 17699 Determination of Distribution Loss Factors for Embedded/Local Generators**, we can obtain the MLF for the embedded generator connection points as follows:-

MLF = **1.0050**

[Confidential Network Information Withheld]

Converting the MLF to DLF:-

DLF = $\sqrt{(1.0050)}$

= **1.002**

References

1 Oaky Creek Distribution Loss Factor Calculation Methodology dated 25/02/2008 by Hill Michael

2 Moranbah North Power Station Distribution Loss Factor Calculation Methodology dated 25/03/2008 by Hill Michael

3 Capcoal Distribution Loss Factor Calculation Methodology dated 25/02/2008 by Hill Michael

4 Determination of Distribution Loss Factors for Embedded / Local Generators dated 02/03/2007 by Ergon Energy & Energex NCM17699

Version Management

Version	Date	Reason For Change	Author	Approved
00A	14/01/2009	First draft	TiHaur Tan	
00B	20/01/2009	For Review	TiHaur Tan	Paul Troughton
00C	17/02/2009	Amended as per Comments	TiHaur Tan	Paul Troughton

ATTACHMENT 1:

REPORT NCM 17699

DETERMINATION OF DISTRIBUTION LOSS FACTORS FOR EMBEDDED/LOCAL GENERATORS

DETERMINATION OF DISTRIBUTION LOSS FACTORS FOR EMBEDDED/LOCAL GENERATORS

REPORT NCM17699

1.0 Introduction

Section 3.6.3 of the National Electricity Code describes the requirement for Distribution Loss Factors for Market Generators (or market generating units). The NEC goes on to describe the Distribution Loss Factor for a market generating unit as:

> "a site specific factor that describes the volume weighted average electricity loss incurred in the *distribution* of electricity between a *transmission network connection point* and the relevant *Generator's connection point* for a defined period of time and associated operating conditions."

This Code clause indicates that non-scheduled market generators are to be allocated an average rather than a half hourly marginal distribution loss factor. This interpretation is consistent with previous decisions of the Jurisdictional Regulator in relation to distribution loss factors for generators not directly connected to the transmission network.

This paper sets out the process that ENERGEX Limited and Ergon Energy Corporation Limited ("the Distributors") propose to use for calculating DLF's for those NEMMCO registered embedded generators who are not selling their entire energy output to the local retailer and therefore require a DLF.

2.0 Calculation Methodology

The procedure developed by the Distributors for calculation of DLF's for distribution network connected market generators is:

Step 1

The appropriate part of the subtransmission network should be modelled by including all directly connected 132kV, 66kV, 33kV, 22kV, and 11kV customers along with direct connected loads representative of the 22kV and 11kV feeders (lumped at the 22kV and 11kV buses and/or distributed along the feeder on which the embedded generator is connected). The Embedded Generators should be modelled at their metering points. The Transmission Network Connection Point may be modelled as an infinite bus.

DETERMINATION OF DISTRIBUTION LOSS FACTORS FOR EMBEDDED/LOCAL GENERATORS

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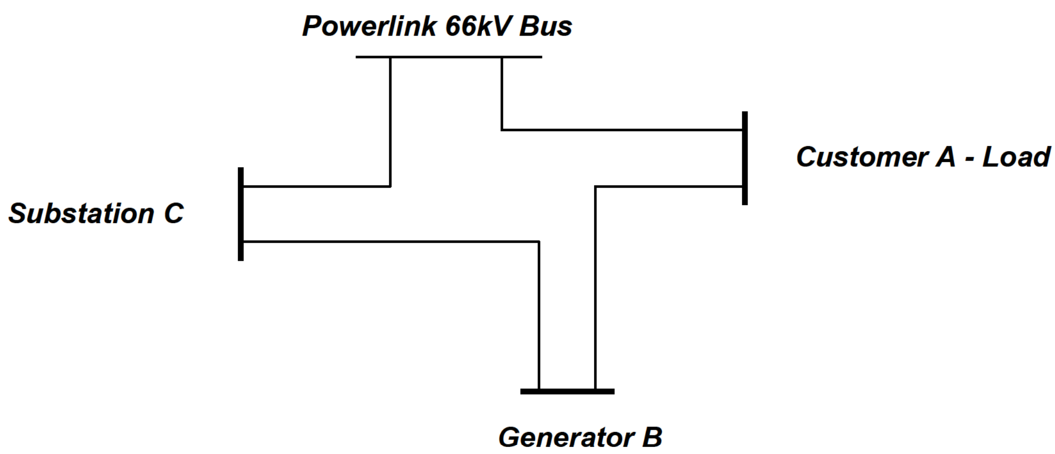
A set of generator operating states is developed relative to the network load and generation patterns with a state for each reasonable distinguishable discrete generator/load condition. Each state will be defined by a time period, a constant average load and a constant average generator output. The load and generation are the averages during the time period of the operating state being studied. The operating states combined must occupy the full time frame associated with the required DLF. This will normally be one year.

A table of operating states with time periods, average loads and average generator outputs should be developed

An example network is described below:



Customer A has a single shift operation and a load of 10MW between 0700 and 1700.

Generator B has an output of 15MW over the period 0600 to 2100. The generator output and operating periods for the full year are to be specified by the Financially Responsible market Participant. Only one average DLF will be calculated for the year.

Substation C is a domestic type load which can be characterised by 0700 to 1800 – 5MW, 1800 to 2100 – 8MW and 2100 to 0700 - 2MW

The resultant discrete operating states table would be :

State	*Duration*	*Load A*	*Gen B*	*Sub C*
1	0700 – 1700	10MW	15MW	5MW
2	1700 – 1800	0	15MW	5MW
3	1800 – 2100	0	15MW	8MW
4	2100 – 0600	0	0	2MW
5	0600 – 0700	0	15MW	2MW

State 4 does not need to be modelled as the Generator is not operating during that period.

As an alternative the operating states table may be developed from a load duration curve when sufficient data exists and the generator output is reasonably constant

Step 2

A load flow study is run for each of the relevant operating states with the average load and average generation in that state.

The output from the embedded generator is incremented and the load flow studies are repeated for each of the relevant operating states with the same average loads

The net increase in system demand (generation output plus Transmission Network Connection Point load) for each operating state is recorded.

The Marginal Loss Factor for that generator in that operating state is calculated by dividing the net system demand (generator output plus load at the Transmission Network Connection Point) increase by the increase in generation and subtracting the result from 1. [There has been no change in load so that the net system demand change is a loss change

due to sourcing the increment from the generator instead of from the Transmission Network Connection Point].
MLF = 1 - (System Demand Increase/Generator Output Increase)

Step 3

Convert the set of Marginal Loss Factors to an equivalent set of Distribution Loss Factors by taking the square root of the MLF.
Note:
- *Distribution Loss Factor (average)= SQRT(MLF X LF)*
- *As we are using constant average loads to model for each operating state, the Load Factor (LF) = 1 for that state*
- *Thus in this model DLF (average) = SQRT(MLF)*

An operating states table is then built with MLF, DLF' and the energy exported by the Generator during that operating state.

The table developed for our example is:

State	***MLF***	***DLF***	***Energy Exported***
1	1.04	1.02	150 MWh
2	0.96	0.98	15 MWh
3	0.98	0.99	45 MWh
5	0.88	0.94	15 MWh

Step 4

The annual volume weighted distribution loss factor for each generator is calculated from the tabulated DLF's and generation energy exported for each of the discrete operating states .

For example, in our test network the DLF would be

$$DLF = \frac{1.02 * 150\ MWh + 0.98 * 15MWh + 0.99 * 45\ MWh + 0.94 * 15MWh}{(150 + 15 + 45 + 15)\ MWh}$$

$= 1.006$

Step 5 - Two or more generators in the network

Steps 1 to 4 are undertaken to calculate the DLF for each generator separately The DLF for any generator is calculated by incrementing only that generator's output and running all the load flow studies with the average generation from each of the other generators.

3.0 Reality Check

A generator which is reducing losses in the system will have a DLF greater than unity. That is, the losses in the network are reduced by taking incremental supply from the generator rather than from the Transmission Network Connection Point and therefore more capacity is saved at the Transmission Network Connection Point than was added by the generator. A DLF greater than unity will result in the generation energy adjusted to the Transmission Network Connection Point being greater than the metered generator energy output

A generator which increases losses will have a DLF below unity.

These DLF's for embedded generators are consistent with the TLF's applied to transmission grid connected generators. That is if the generator adds to the total amount of losses in the system, then the DLF or TLF will be less that unity. If the generator reduces the losses in the system, the DLF or TLF will be greater than unity.

K Kehl
NETWORK COMMERCIAL MANAGER – CAPRICORNIA REGION

ATTACHMENT 2: Summary of Amcor Gawler Plant Consumption Details for the period 17/12/2008 till 17/12/2008

[Confidential Network Information Withheld]

ATTACHMENT 3: Amcor Gawler Plant Technical Details

[Confidential Network Information Withheld]