WESTERN POWER DISTRIBUTION
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Company Directive

STANDARD TECHNIQUE: SD5K/6

Use of WinDebut Software

Summary
This document provides guidance on the use of WinDebut Software Version 3.1.19. WinDebut is a load flow package used for the Design of Low Voltage (LV) networks.

Author: Andy Hood

Implementation Date: January 2018

Approved by [signature]

Policy Manager

Date: 26 January 2018

IMPLEMENTATION PLAN

Introduction

ST:SD5K provides guidance on the use of WinDebut software, a load flow package used by Planners for designing or checking the capability of LV networks.

Main Changes

The maximum loop resistance values described in 4.2.10 4) have been amended in accordance with ST: SD5A and ST: SD5R

Impact of Changes

No impact. This change prevents data duplication across multiple documents.

Implementation Actions

Managers should make planning staff aware of this minor modification.

Implementation Timetable

This standard technique shall be implemented with immediate effect.

REVISION HISTORY

Date	Comments	Name
January 2018	The loop resistance limits described in 4.2.10 4) have been revised	Andy Hood
April 2017	Appendix D1 table removed and replaced with a link to ST:SD7A - The Data Sets Used with Windebut Software.	Stephen Davies
April 2014	The document has been re-written to align with the latest version of WinDebut (i.e. version 3.1.19). The main changes are described below: • The style of the document has been changed so that is provides a step-by step guide to the use of WinDebut. The previous version was written as a reference document. • *Existing Transformer* and *Transformer Search* functions are no longer available. • Generator modelling facilities have been added. • The *Distributed Load* function has been modified. • Voltage drop tables for services have been added. • Guidance on the new WinDebut features (described above) has been included. • A number of “Tips” have been added that highlight a few issues with WinDebut and provide recommendations for overcoming them. • Tables providing cable and overhead line impedances and fusing requirements have been added.	Andy Hood

CONTENTS

1.0 INTRODUCTION

WinDebut is a load flow package used for LV network design. The software was originally developed for the design of housing estate networks but it is also now used for the design of commercial and industrial networks as well.

The software may also be used to model disturbing loads (motors and welders) and the impedance data extracted from WinDebut can be used when assessing the impact of multiple disturbing loads. This latest version of WinDebut is also capable of modelling generation.

The software checks that the requirements for following parameters are satisfied:

- Voltage drop
- Voltage rise
- Phase to neutral loop resistance
- Cable ratings (based on autumn cyclic ratings)
- Transformer ratings (based on winter ratings)
- Overhead line ratings (based on spring / autumn ratings)
- Fusing requirements
- Voltage flicker limits

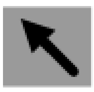
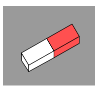
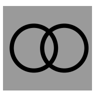
This document is a guide for the use of WinDebut.

Where any difficulty is experienced in the application of this Standard Technique the author shall be notified who will determine if a variation is appropriate.

2.0 WINDEBUT SYMBOLS / DISPLAY

2.1 Symbols

The symbols used in the current version of WinDebut are defined in Table 1.

Symbol	Name	Description
	Select	Select items (*nodes*, *cables* etc.) in the drawing area
	delete	Delete items (*nodes*, *cables* etc.) from the drawing
	*Transformer*	Menu: Add *transformer* Diagram: Denotes a *transformer*

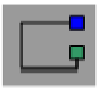
Symbol	Name	Description
L	*Load Point*	Menu: Add a *load point* Diagram: Denotes a *load point* with only load defined
	*Cable* or OH Line	Add a cable or overhead line
N	*Node*	Menu: Add a *node* without load or generation Diagram: Denotes a *node* without load or generation
M	*Motor*	Menu: Add a *motor* Diagram: Denotes a *motor*
W	*Welder*	Menu: Add a *welder* Diagram: Denotes a *welder*
LG	*Load Point with Generation*	Diagram: Denotes a *load point* with load and generation defined
D	*Distributed Load*	Diagram: Denotes load distributed along a cable or overhead line
D	*Distributed Load with Generation*	Diagram: Denotes load and generation distributed along a cable or overhead line
	*Run Calculations*	Menu: Run WinDebut Study
	*Run Record*	Menu: View record (text file) of study

Table 1 WinDebut Symbols

3.0 WINDEBUT DATA

3.1 Cables and Overhead Lines

WinDebut includes a number of different cable and overhead line types but it is only able to hold one rating for each size. The WinDebut cable and line codes are given in Table 2 and a full list of cable data is available in ST:SD7A (link in Appendix D).

Cables ratings are based on autumn cyclic ratings, with the cables being laid direct in the ground (not in ducts). Overhead lines ratings are based on spring / autumn ratings. If it is necessary to consider other overhead line or cable ratings these shall be derived from ST:SD8A (overhead lines) and ST:SD8B Part 1 (LV cables) and manually checked against the maximum current values predicted by WinDebut.

WinDebut Code	Description
Cables	
CC	Copper Concentric Service (1ph)
CCT	Copper Concentric Service (3ph)
HY	Hybrid Service (1ph)
HYT	Hybrid Service (2ph)
SCC	Split Concentric (1ph)
SCCT	Split Concentric (3ph)
AL	Aluminium Conductor PILC
CU	Copper Conductor PILC
CS	Consac
TR	Trydan / Alpex (i.e. wavecon with aluminium neutral)
WC	Wavecon (i.e. wavecon with copper neutral)
SA	Solidals (Armoured, Single Core)
Overhead Lines	
ABC	ABC (Arial bundled conductor)
AO	Aluminium Alloy
CO	Hard drawn copper and cadmium copper

Table 2 WinDebut Cable / Line Types

3.2 Transformers

Details of the different transformer codes used by WinDebut are given in Table 3. A full list of the transformer data is included in Appendix E.

WinDebut Code	Description
GMT	Ground Mounted T/F (3ph)
PMTTRP	Pole Mounted and Pad Mount T/F (3ph)
PMTSIN	Pole Mounted and Pad Mount T/F (1ph)
SPLT	Split Phase Transformer (Ground or Pole Mount)

Table 3 WinDebut Transformers

3.3 Customer Types / Profiles

WinDebut includes a number of customer profiles. These profiles are described in Table 4 and displayed in Appendix A.

WinDebut Type Profile	Description
ONE	Domestic Unrestricted - based on ELEXON Profile 1
TWO	Domestic Off Peak (e.g. Economy 7) – based on ELEXON Profile 2
THREE	Commercial Unrestricted – based on ELEXON Profile 3
FOUR	Commercial Off Peak –based on ELEXON Profile 4
FIVE	Commercial / Industrial , Load factor <20% - based on ELEXON Profile 5
SIX	Commercial / Industrial, Load factor 20% to 30% - based on ELEXON Profile 6
SEVEN	Commercial / Industrial, Load factor 30% to 40% - based on ELEXON Profile 7
EIGHT	Commercial / Industrial, Load factor >40% - based on ELEXON Profile 8
HOTPUB	Hotel / Pub profile
CHURCH	Church profile
ECOTEN	Economy 10 Profile (e.g. for use with electric flow boilers)
CONST	Flat profile, Load Factor 100% with no diversity

Table 4 Customer Types / Profiles

3.4 Generator Profiles

WinDebut includes a number of generator profiles which are described in Table 5. The generation profiles can be viewed within Windebut by select *EGD* (from the top menu) followed by *Profiles.* Most generator profiles are flat (i.e. a constant kW output) as it not possible to predict when they will be operating at full capacity, the only exception being PV profiles which are dependent on the intensity of the sunlight. These generator profiles are also given in Appendix B.

WinDebut Type Profile	Description
Wind	Wind turbine profile. This is a flat profile as the output is not influenced by the time of day.
Hydro	Hydro profile. This is a flat profile as the output is not influenced by the time of day.
CHP	Combined heat and Power generator profile. This is a flat profile as the output is not influenced by the time of day.
PV	Photovoltaic profile for commercial installations (e.g. solar farms). The profile takes account of the available light intensity through the day and assumes the peak out-put is equal to the continuous rating of the inverter.
PV(Domstc)	Photovoltaic profile for domestic installations (e.g. on house roofs). The profile takes account of the available light intensity through the day and assumes the peak out-put is 80% of the rating of the inverter. This 80% value has been found to be a conservative estimate (based on research carried out as part of the LV Templates Project).

Table 5 Generator Types / Profiles

4.0 WINDEBUT STUDIES

4.1 Modelling Services

WinDebut is capable of modelling every consumer and every service individually but this can be very time consuming. Furthermore, WinDebut often underestimates the maximum demand associated with single non-maximum demand consumers. For this reason it is normal practice to model the mains cables and overhead lines only, adding the load at the service joints or distributing the load along the mains cables and lines.

Service voltage drop can either be considered manually, by referring to the tables in Appendix C or by modelling a service and a customer at the most onerous position on the network. Where the most onerous service is modelled and the customer is domestic this customer should be set up as an MD load without diversity (i.e. with "no q"). A standard 15kW MD *Consumer Type* has been set up for this purpose.

It is generally recommended that the voltage drop across each service is kept below 1% (of 240V) but this may be exceeded as long as the total voltage drop across the whole LV network (excluding the transformer) is kept below 5.75% (of 240V).

In addition, the voltage drop across single-phase services should, as far as possible, be kept below 2% to minimise the potential (e.g. voltage) on the neutral. If the voltage drop across the service is above 2% there is a risk that a customer could experience a tingling sensation when touching metalwork that is bonded to the PME earth terminal, particularly if the person is in good contact with the ground (e.g. a person taking a shower, touching the metalwork of the shower fitting whilst standing on a wet concrete floor or on wet quarry tiles).

4.2 General

WinDebut can occasionally lock up or fail to calculate correctly, particularly if large studies are being carried out. It is recommended that studies are saved regularly to minimise the impact of such problems.

The following steps should be followed when carrying out a WinDebut study:

- Set up the basic *Network Settings* (including the number of cores available)
- Check that WinDebut defaults settings are being used and restore these defaults, if necessary.
- Set up *Consumer Types*
- Add the *Transformer*.
- Add one *Node* close to the *Transformer* for each LV circuit and specify the maximum LV fuse rating applicable to the transformer.
- Add remaining *Nodes*.
- Add *Point L*oads and the associated load and generation details
- Add *Cables* (or overhead lines).
- Add *Distributed Load* and *Distributed Generation* to the *Cables* (or overhead lines).
- Run study and check results.

4.2.1 Setting up basic *Network Properties*

It is important that the basic network properties, particularly *the number of cores available* are specified before progressing with the study. The process for doing this is described below:

1) *Select File* from the main menu followed by *Network Properties*

2) Type in a *Study Title*. This will be the file name if you decide to save the study.

3) Leave the *Network Type* as *Rural*. This selection makes no difference to the WinDebut calculations as both the *Rural* and *Urban* options use identical default settings.

4) *Default Number of Cores Available.* It is very important that the number of cores is selected, particularly if the network is single phase or split phase.

    - *Three* cores are chosen for 3 phase networks.
    - *Two* cores are chosen for split phase networks.
    - *One* core is chosen for single phase networks.

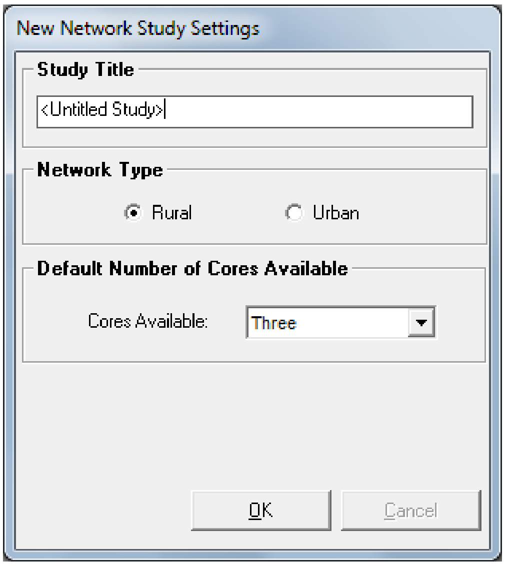


Figure 1   Network Properties

4.2.2 <u>Checking the WinDebut Default Settings</u>

When an old study is loaded WinDebut also loads the default *Network Settings* and default *Generator Profiles* that were used when the study was created. It is important that these settings are checked and, where necessary, changed to the new default values before a new study is carried out. The following steps are used to check and restore these default settings:

4.2.2.1 Default Network Settings

1) Select the *Data* menu followed by *Network Settings.*

2) Check that the settings are in accordance with those shown in Figure 2, below.

3) If the existing settings are incorrect select *Reset Global* followed by *OK*. This should restore the correct default settings.

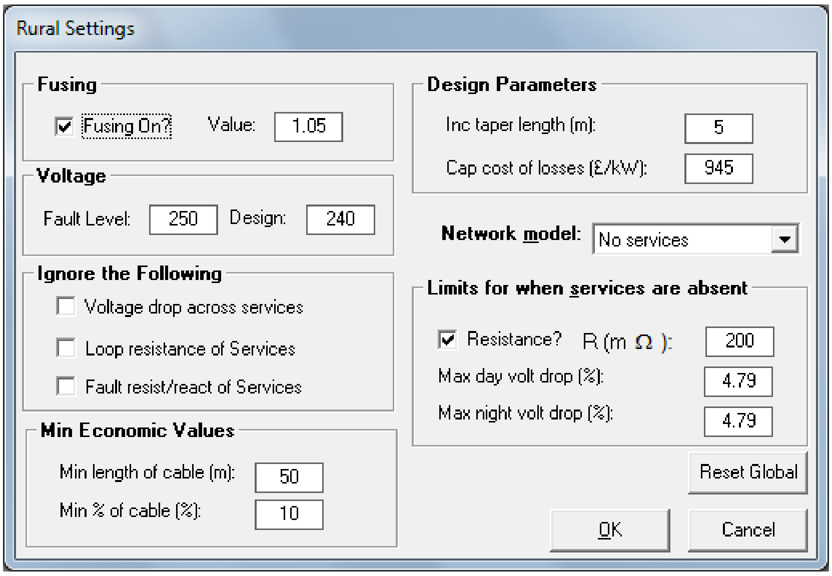


Figure 2 Network Settings

4.2.2.2 Default Generator Profiles

1) Select the *EDG* menu followed by *Profiles*

2) Check that the available profiles include both PV and PV (Domstc). If not, select *Load Default.* This will load the default generator profiles.

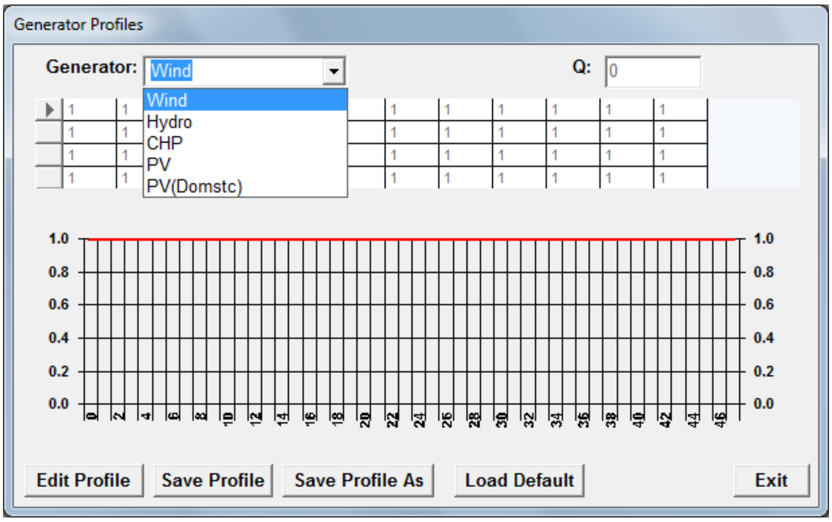


Figure 3 Generator Profiles

4.2.2.3 Load Ratio

When Load Studies are carried out, WinDebut determines the maximum load for each half hour period from the Customer data and consumer profiles. The standard consumer profiles are based on the day with the highest demand of the year (typically a cold day in winter). When Generation is added the voltage rise studies need to be based on minimum load conditions (typically a warm day in the summer). WinDebut does not hold minimum load data / profiles and so the *Load Ratio* is used to specify the ratio between each half hour value of kW or current used for load studies and the half hour values used for generation studies. The default value is set to 0.4, which is suitable for a housing estate with 30 or more houses but this value can be over-written.

WinDebut uses the following calculation for each individual half hour period to determine the minimum load for that half hour period:

Minimum Load (for given half hour) = Maximum Load (for given half hour) x Load Ratio

The Load ratio can be viewed and over written as follows:

1) Select *EDG* from the main menu followed by *Defaults*

2) Simply over-type the Load Ratio

Note, it is important that the System Voltage level is left as 240V. Changing this value will cause errors in the voltage calculations performed by WinDebut. The voltage rise limit should also be left at its default value of 1.4375% (of 240V). This equates to 1.5% of 230V.

Suggested *Load Ratios* are given in Table 6. Planners may use alternative values based on local knowledge and experience.

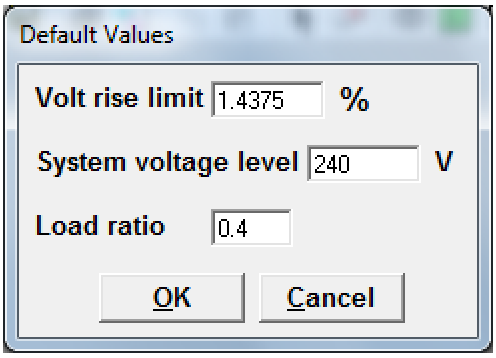


Figure 4 Load ratio

Load Ratio	Application
Domestic (Housing Estates etc.)	
0.4	Where 30 or more houses are installed
0.2	5 to 30 domestic properties
0.1	Less than 5 domestic properties
Commercial (Shops / Commercial Businesses etc.)	
0.4	Where 10 or more commercial properties are installed
0.2	5 to 10 commercial properties
0.1	Less than 5 commercial properties. Consideration should also be given to the variability of the load, holiday shut-downs and the likelihood of businesses closing down.
Farm	
0.1	Consideration should also be given to the variability of the load, holiday shut-downs and the likelihood of the farm closing down.
Industrial	
0.1	Consideration should also be given to the variability of the load, holiday shut-downs and the likelihood of the business closing down.

Table 6 Recommended Load Ratios

4.2.3 Setting up *Consumer Types*

It is recommended that any non-standard *Consumer Types* that are needed for a given study are defined at the beginning of the process (i.e. before the network is modelled). Changing a *Consumer Type* half way through a study will change the details of consumers that have already been placed in the model. In order to add non-standard *Consumer Types* follow the process below*:*

4.2.3.1 Non-MD Customers

1) Select *Data* from the menu followed by *Consumer Types*.
2) Choose an un-used *Consumer Type Number* (e.g. 12 or higher).
3) Select the relevant profile. For existing customers the profile class can be obtained from CROWN (i.e. MPAN Management, Customer Consumptions). For new customers the profile class should be selected from the following options:
    - Profile 1 (single rate domestic)
    - Profile 2 (domestic with economy 7, or equivalent)
    - Profile 3 (single rate commercial)
    - Profile 4 (commercial with off peak heating)
    - HOTPUB (hotel or pub)
    - CHURCH (church with off peak heating)
    - ECOTEN (domestic with electric heating with afternoon boost, i.e. economy 10)

    The profiles are displayed in Appendix A
4) Select *Annual Units (kWh).* Type in the estimated daytime or unrestricted annual consumption (EAC) in kWh in the *Day* field. This information can either be obtained from CROWN (i.e. MPAN Management, Customer Consumptions) or it can be estimated using the tables in ST:SD5A.
5) Type in the night time EAC in kWh for the night time period (applicable to Profile 2 and Profile 4 consumers only) and select OK. The night time period is defined as 23:30 to 07:00.

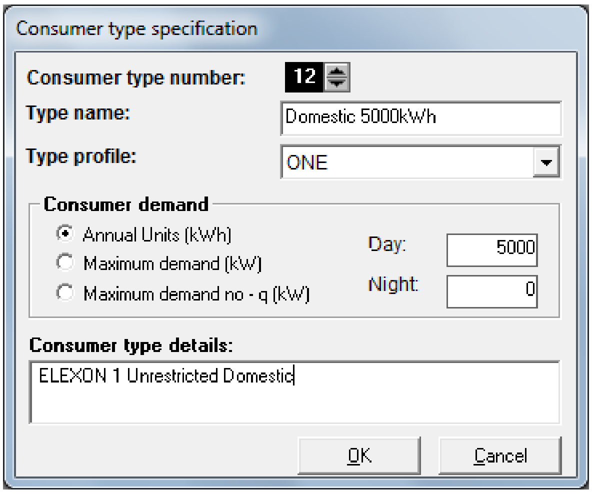


Figure 5 Consumer Type Specification; Non-MD Consumers

4.2.3.2 MD Customers

1) Select *Data* from the menu followed by *Consumer Types*.

2) Choose an un-used *Consumer Type Number* (e.g. 12 or higher).

3) Enter an appropriate name for the new Consumer Type.

4) Select the relevant profile. For existing customers the profile class can be obtained from CROWN (i.e. MPAN Management, Customer Consumptions). For new customers the profile class should be selected from Profile 5 to 8. These profiles are displayed in Appendix A.

5) *Maximum Demand no – q (kW)* is normally selected. This option prevents diversity being applied between customers of the same profile class connected to the same phase/s and it also overcomes a discrepancy in the WinDebut calculation method that arises when the *Maximum Demand (kW)* option is selected. Further information on this discrepancy is discussed in Appendix F.

6) Type in the estimated daytime or unrestricted maximum demand (MD) value in kW in the Day field and select *OK*. For existing MD customers this value can be obtained from CROWN (i.e. MPAN Management, Customer Consumptions) or alternatively their Agreed Supply Capacity (ASC) may be used instead. Some guidance on estimating MD values is given in ST:SD5A.

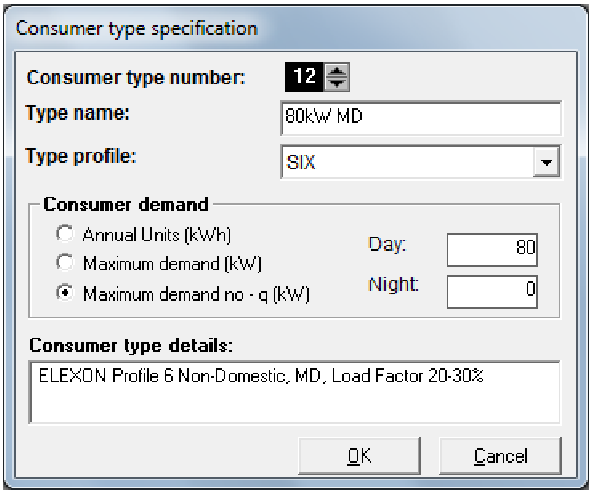


Figure 6 Consumer Type Specification; MD Consumers

Tip 1: Setting up Maximum Demand Loads

If the *Maximum Demand (kW)* option is selected, Windebut applies diversity between consumers of the same type, connected to the same phase/s. The impact of diversity is shown in Appendix A

Where the *Maximum Demand (kW)* option is selected for 3 phase connections the current calculated by WinDebut is between 10% and 30% lower than the expected value. The exact value of current depends on the customer profile and the particular half hour being considered. **For this reason, the *Maximum Demand (kW)* option should not be used for large 3 phase connections.** Further information on this issue is provided in Appendix F.

Where diversity is not required or where 3 phase connections are being modelled the *Maximum Demand no – q (kW)* option should be selected instead.

4.2.4 Adding a Transformer

This is carried out by either clicking on the transformer symbol or by selecting Mode followed by *Transformer* and then clicking on the screen.

It is possible to select a specific type and rating of transformer or to just select a transformer type (GMT, PMT 3PH, PMT 1PH or SPLIT) as shown in Figure 7. If only the transformer type is selected WinDebut will determine the most appropriate transformer rating based on the connected load and the cost of transformer losses.

The *Existing Transformer* option is no longer used in WinDebut and so selecting this option makes no difference to study. Selecting *Standard Enclosure* or *Outdoor* alters the transformer rating calculation. The *Standard Enclosure* option should normally be selected.

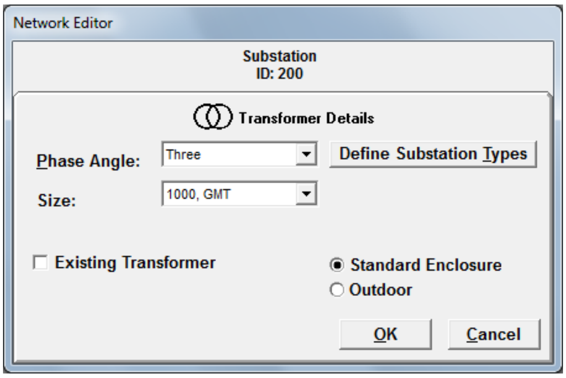


Figure 7 Transformer Editor

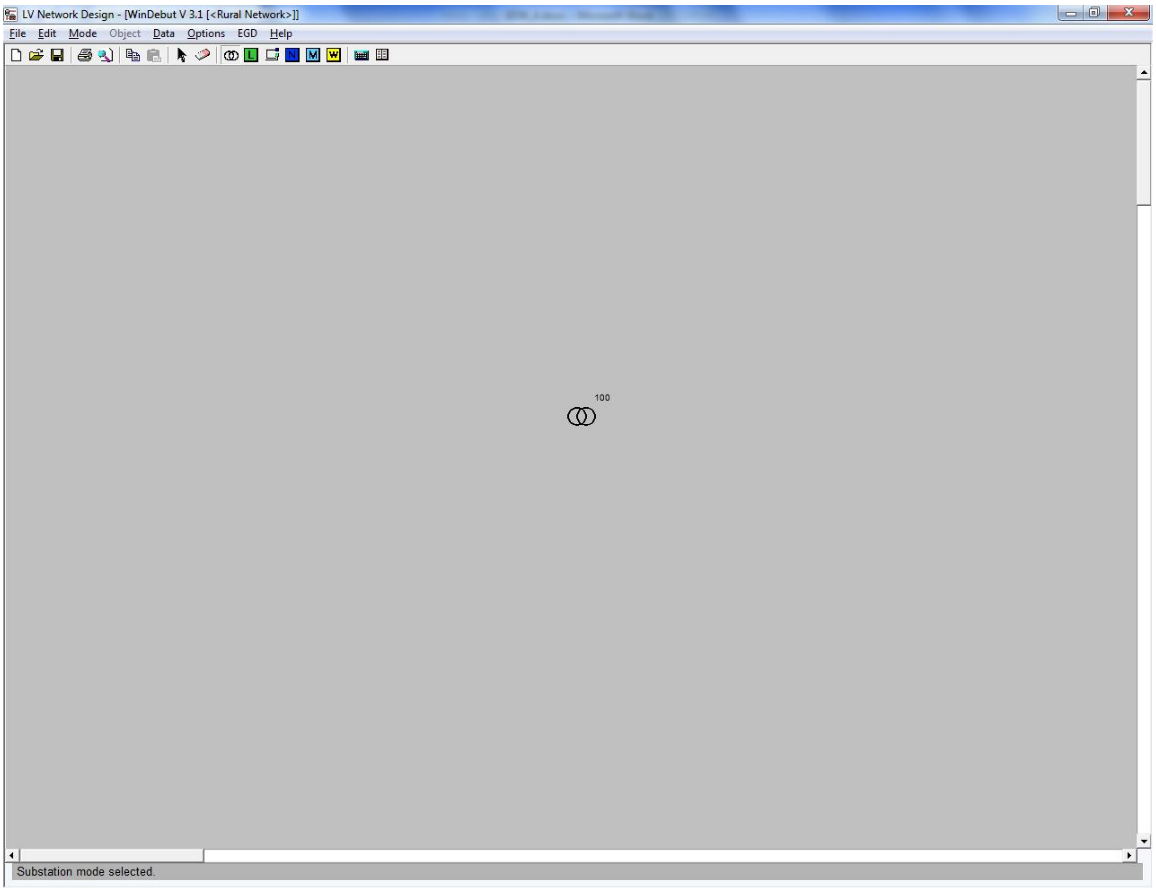


Figure 8 Adding a transformer

Tip 2: Transformer Rating Calculation

Windebut can only accurately calculate the correct transformer size if the all load (i.e. the load on all the LV feeders) is modelled. Where it is only necessary to model one circuit then all load associated with the other circuits can be grouped together at a single Point Load. This Point Load is then connected directly to the transformer.

4.2.5 Adding *Nodes* close to the *Transformer* (and Defining LV Fuse Sizes)

WinDebut checks that the LV cables and overhead lines are adequately protected. To do this correctly it is important that the correct LV fuse rating is entered at the first *node* of each LV circuit. It is therefore necessary to place one *node* for each LV circuit close to the *transformer* (i.e. with a short length of *cable or OH line* between the *transformer* and each of these *nodes*)

A node is added by clicking the node symbol or selecting *Mode* on the top menu followed by *Node* and then clicking on an appropriate location on the screen. See Figure 9.

The appropriate fuse rating is then entered in the *Default Fusing Override* box. Generally the maximum fuse sizes listed in Table 6 should be used, however, there may be cases where it is appropriate to install smaller non-standard fuse sizes, for example, where the transformer rating has been increased in order to reduce the voltage rise caused by generation but where the full capacity of the transformer will not be used). If non-standard fuses sizes are assumed this must be documented on the LV mapping system (i.e. EMU).

The *End % Volt Drop* fields should be left as 0%.

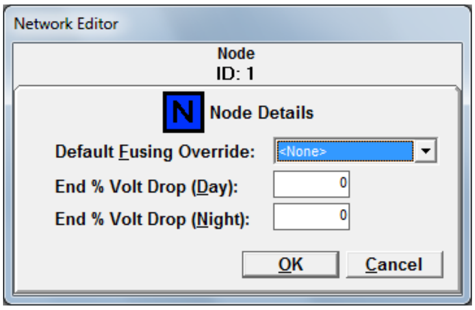


Figure 9 Node Editor

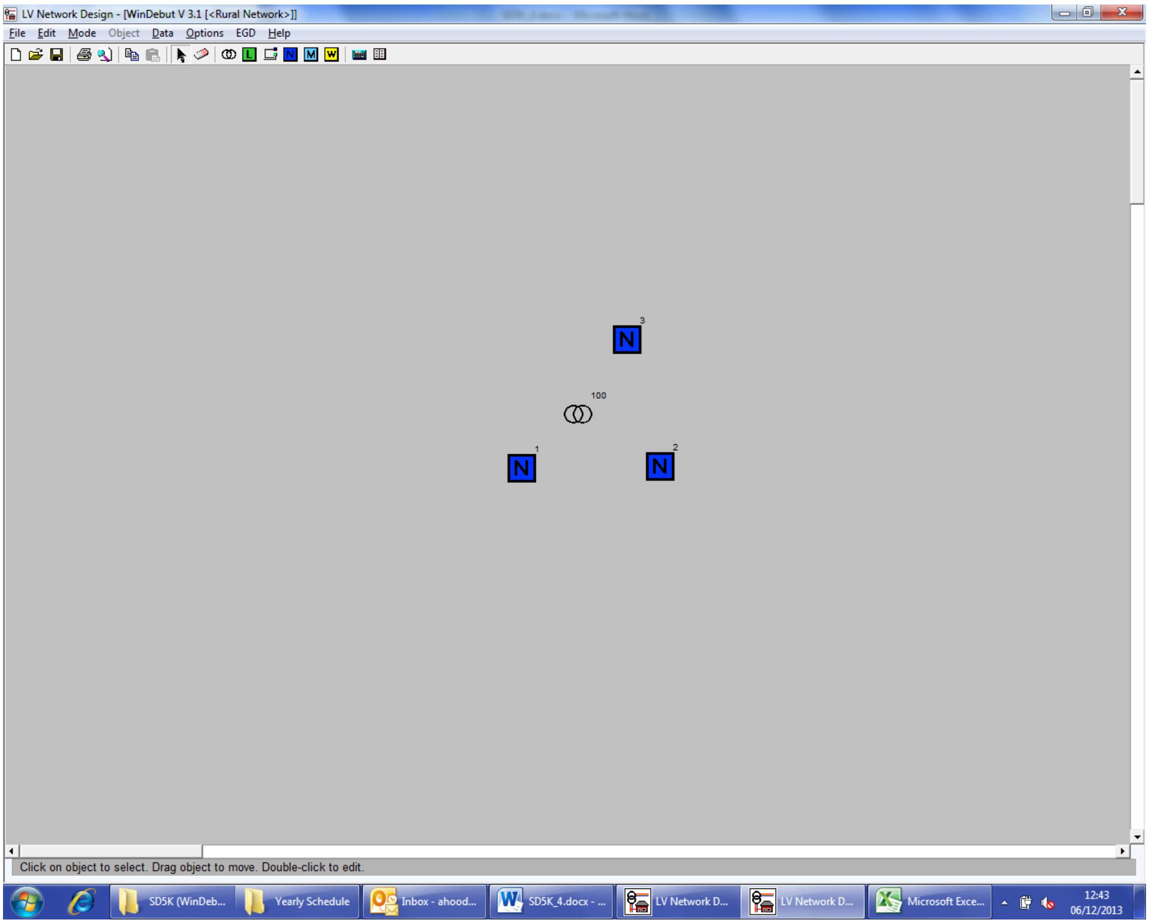


Figure 10 Adding Node/s Close to Transformer

Transformer Type	Max. LV Fuse Rating derived from ST:TP4A and ST:OH4H)	
	11kV Transformers	**6.6kV Transformers**
1000kVA GMT	500A	500A
800kVA GMT	500A	400A
750kVA GMT	500A	400A
500kVA GMT	400A	400A
315kVA GMT	315A	250A
300kVA GMT	315A	250A
200kVA GMT	200A	160A
315kVA PMTTRP	400A	400A
200kVA PMTTRP	315A	315A
100kVA PMTTRP	200A	200A
50kVA PMTTRP	160A	160A
25kVA PMTRP	100A	100A
100kVA PMTSIN	400A	315A
50kVA PMTSIN	315A	315A
25kVA PMTSIN	160A	160A
16kVA PMTSIN	100A	100A
15kVA PMTSIN	100A	100A
10kVA PMTSIN	100A	100A
5kVA PMTSIN	100A	100A
1000kVA SPLT	500A*	-
800kVA SPLT	500A*	-
750kVA SPLT	500A*	-
500kVA SPLT	400A*	-
315kVA SPLT	315A*	-
300kVA SPLT	315A*	-
200kVA SPLT	200A*	-
100kVA SPLT	315A	315A
50kVA SPLT	160A	160A
25kVA SPLT	100A	100A

Table 7 LV Fuse Ratings

* *Note: Applicable to 3 phase ground mounted transformers connected in a split phase configuration (certain parts of South Wales Area only)*

4.2.6 Adding remaining *Nodes* (without Load or Generation)

The remaining nodes are entered on the diagram. The *Default Fusing Override* and *End % Volt Drop* fields should be left as *none* and 0%, respectively.

> **Tip 3: Placing *Nodes***
>
> If you place the nodes vertically or diagonally from each other (rather than horizontally) it is generally easier to read the information and the results on the screen.

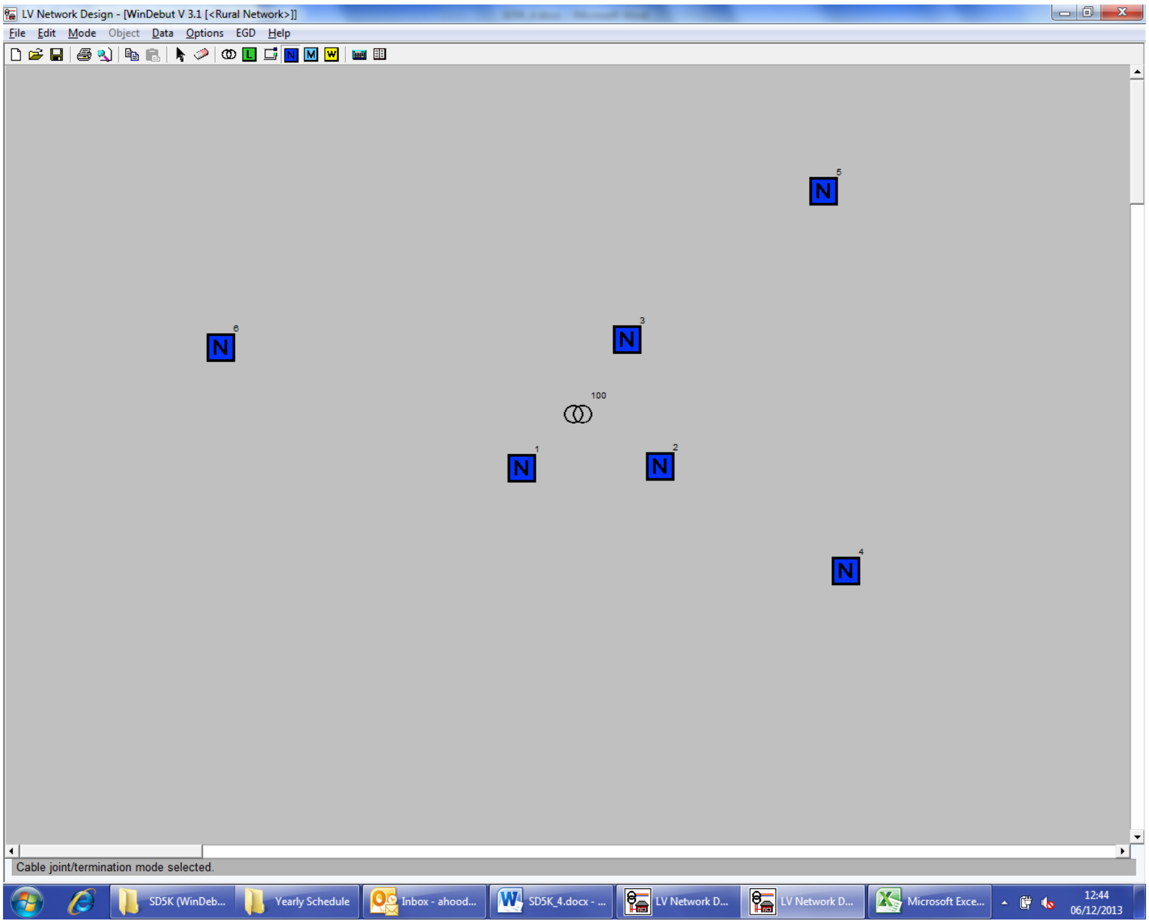


Figure 11 Adding Remaining Nodes

4.2.7 Adding Point Loads

Point Loads may be used to model :

- An individual customers and/or generator at a specific location.
- Groups of customers and generators at a single location, for example, where a multi-service distribution board is located or where a service joint is placed.

A *Point Load* is added by clicking on the *Point Load* symbol or by selecting Mode followed by *Point Load* and then clicking on the main screen where the Load Point is to be added.

4.2.7.1 Adding Load

The following steps are used to add load to a *Point Load*:

1) Select the *Group Details* tab.

2) *Settings for Consumer;* more than one *Consumer Type* can be added at a single *point load*. The first consumer at a given *Point Load* is given the reference *1*, the second is given reference *2* etc. These references are NOT related to the *Consumer Type Numbers* used when initially setting up the different consumer types.

3) *Cores Available; Three*, *Two* or *One* core must be chosen. *Two* cores should only be selected if a split phase transformer is used.

4) *Consumer Type; t*he relevant *consumer type* is selected from the default consumer types and from any non-standard ones that have been previously set up.

5) *Number of Consumers;* the number of consumers of this type at this *Point Load* is entered.

6) *Existing; w*here *Existing* is selected it is possible to type in and override the annual kWh consumption or the MD (depending on the type of consumer that is selected).

7) *Balanced; Balanced* is normally selected where the consumers are three phase. Where *single phase* or *split phase* connections are being modelled then *balanced* should not be used. In some cases it is advisable to account for some unbalance within 3 phase or single phase connections, particularly where the connection is large. Further information on un-balanced connections is provided in Appendix E.

*8) Specified Distribution; w*here *Balanced* is not selected WinDebut will automatically assume that each consumer is connected to a single phase and will try, as far as possible, to balance the three (or two) phases by distributing the consumers across the available phases. It is also possible to manually allocate the consumers to different phases. Where this is the case, the number of customers allocated to the red, yellow and blue phases must equal the total number of consumers selected and the three phases must be as balanced as possible. For example, if the total number of consumers is 5 then 2 must be allocated to one phase, 2 to another phase and 1 to the remaining phase.

9) Additional Consumer Types; if additional consumer types are required at the *Point load* then increment the number associated with *Settings for Consumer* by 1 (e.g. from number 1 to number 2) and repeat the above process.

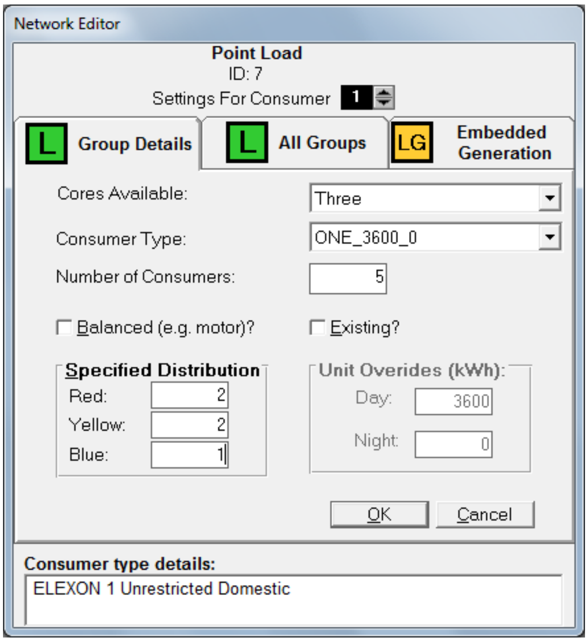


Figure 12 Group Details

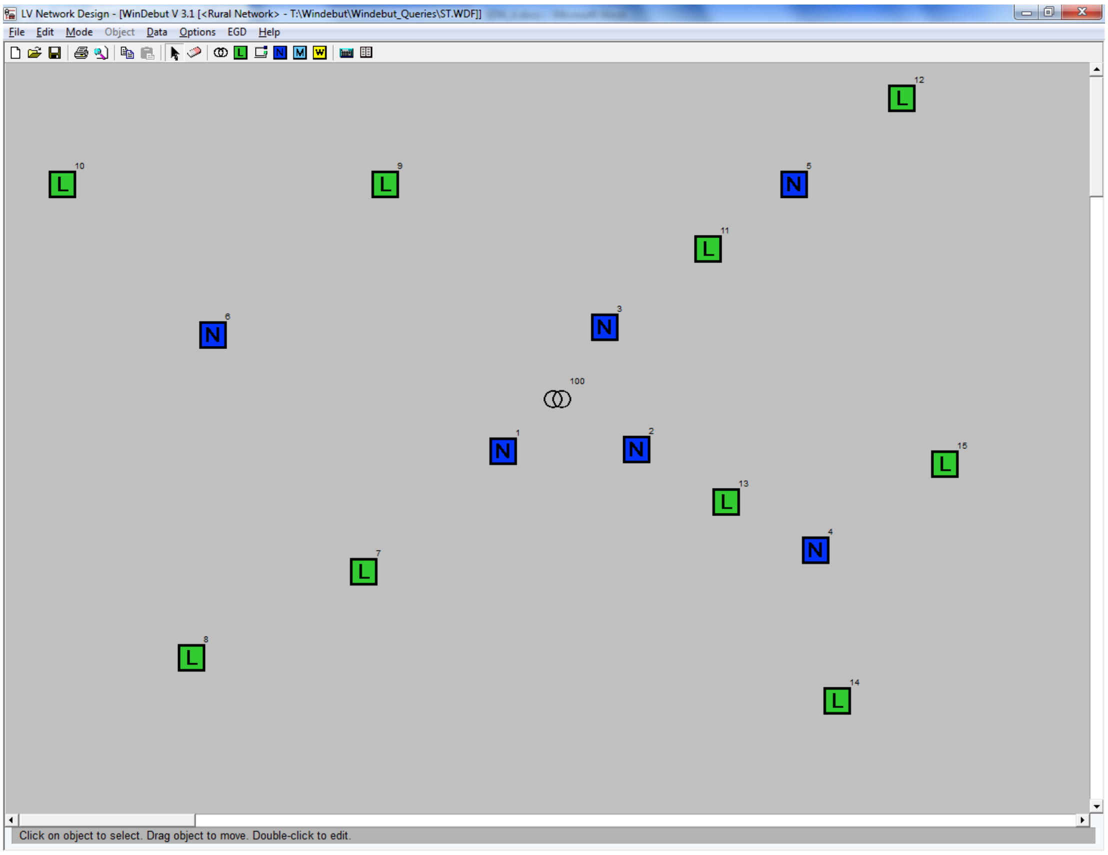


Figure 13 Adding Point Loads

Tip 4: Point Load - Consumer Number

The black coloured number "1", "2" etc. at the top of the *Point Load editor* simply denotes the customer reference at that location. For example, "1" indicates the first group of consumers at that location, "2" indicates the 2nd set of consumers at that location and so on.

This number is not related to the *Consumer Type Number* which is used when setting up the different types of consumer.

Tip 5: Point Load - Balanced Three Phase Loads

If one three phase load is modelled and *balanced* is not selected then Windebut will assume that this is a single phase load and it will automatically connected it to just one phase.

If you find that your voltage drop results are extremely high it may be that you have forgotten to select *balanced*.

Tip 6: Point Load - Unbalanced Three Phase Loads

When modelling large 3 phase customers it is recommended that a certain amount of unbalance is considered unless the load is dominated by 3 phase machines. This is carried out by modelling the customer as three separate single phase consumers (with different MD loads) at the *Load Point.* Each single phase consumer is connected to a different phase (i.e. one is connected to the R phase, another connected to the Y phase and the third connected to the B phase).

Example: If a customer with an agreed supply capacity of 180kW is to be modelled and it is expected that the load will be unbalanced this should be set up as described below:

- 1st Customer; single phase MD of 60kW connected to R phase.
- 2nd Customer; single phase MD of 60kW connected to Y phase.
- 3rd Customer; single phase MD of 30kW connected to B phase.

In this example the highest loaded phases will each deliver 60kW (i.e. 250A at 240V) and the other phase will deliver 30kW (i.e. 125A). A further 125A will flow in the neutral due to the unbalance. Further guidance is given in Appendix E.

4.2.7.2 Adding Generation

Embedded generation can be added at a *Point Load* once one or more load customers have been added, using the following steps:

1) Click on the *Embedded Generation* tab.

2) Select the phase that the generation is connected to (red phase, yellow phase or blue phase) or select balanced. Only one generator may be specified if *Balanced* is selected.

3) *Generated Power (kW)*; type in the kW rating of the generation to be added. Note, when generation is added at a *Load Point* the kW value reflects the aggregate rating of the generation (of that type) connected to the relevant phase at that *Load Point*. The generation is <u>not</u> added to each individual consumer.

4) Select The generator type followed by the *Add* button. Additional generation can be added by repeating the above exercise. Generators can be removed using the *Remove* button:

Add button: >>>

Remove button: <<<

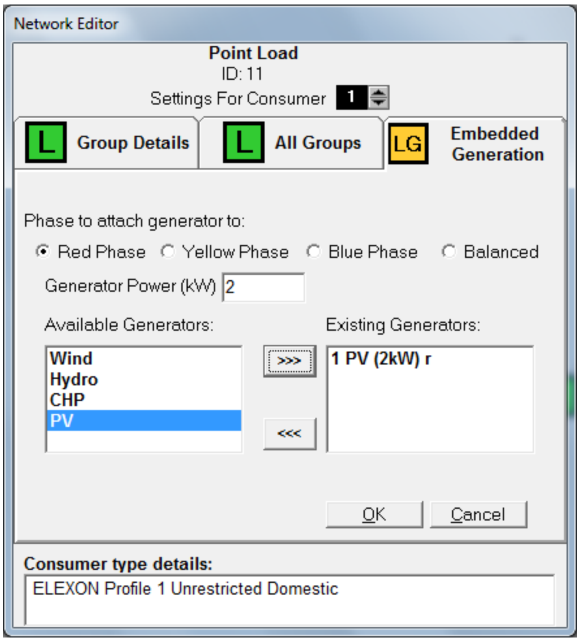


Figure 14 Point Load – Generation

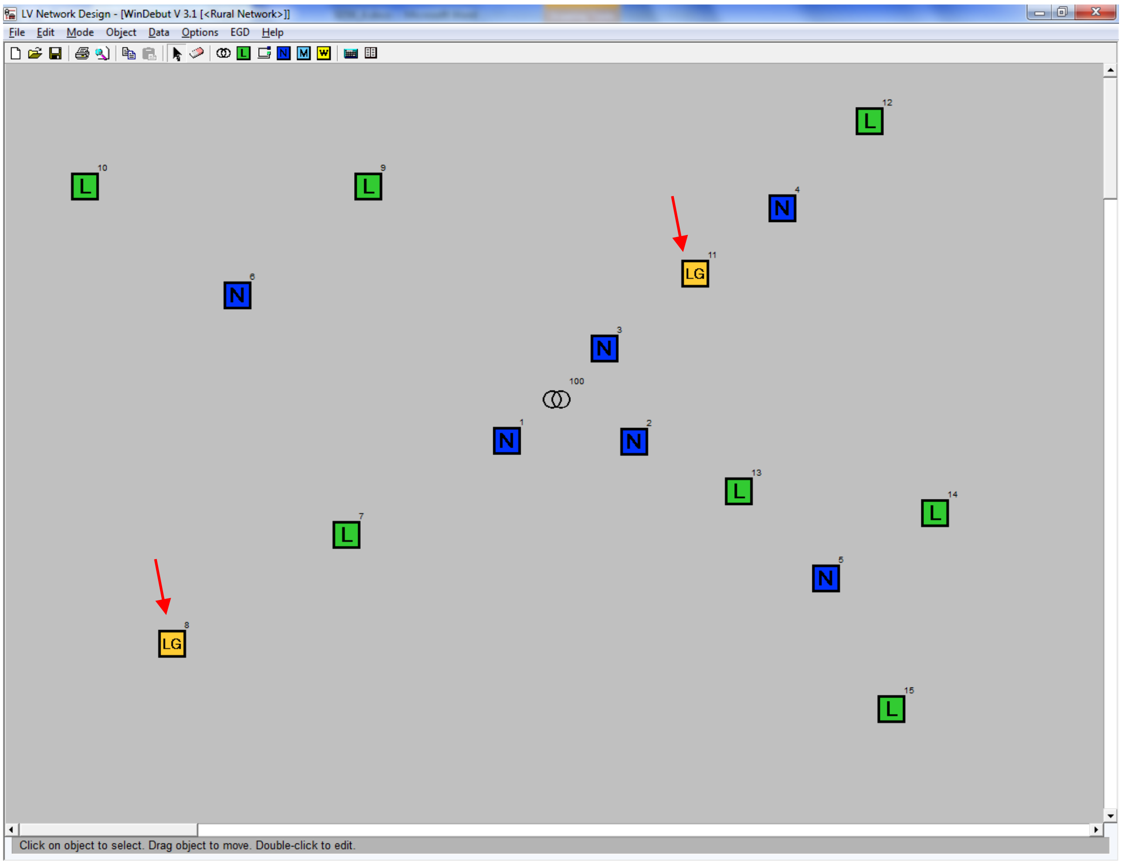


Figure 15 Adding Generation to Point Loads

4.2.8 Adding *Cables* and Overhead lines

1) Click on the *Cable or OH Line* symbol or select *Mode* from the top menu followed by *cables* and then click on one *node*, *point load* or *transformer* followed by a second *node* or *point load*. This draws a *cable or OH line* between them.

2) Select the number of *cores available.* This should either be *three*, *two* or *one* as appropriate. *Two* should only be selected where a split phase transformer is used.

3) Where existing cables or over-head lines are to be modelled select the *status* to *existing cable* and choose the relevant *cable type.*

4) If you want WinDebut to determine the best cable rating (the recommended mode for designing new networks) select *To Be Designed* followed by *Main, Service 3ph* or *Service 1ph,* as appropriate.

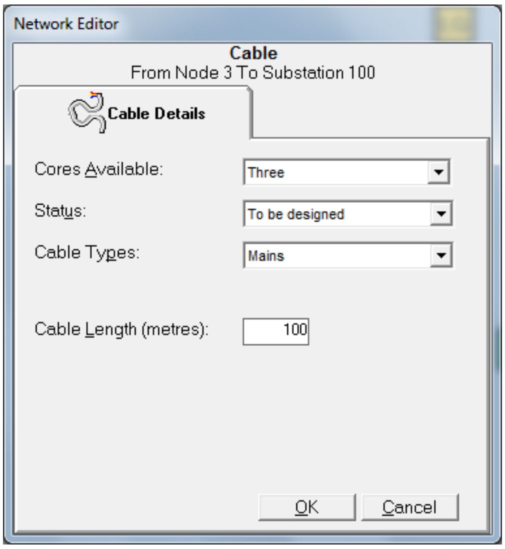


Figure 16 Cable / OH line Editor

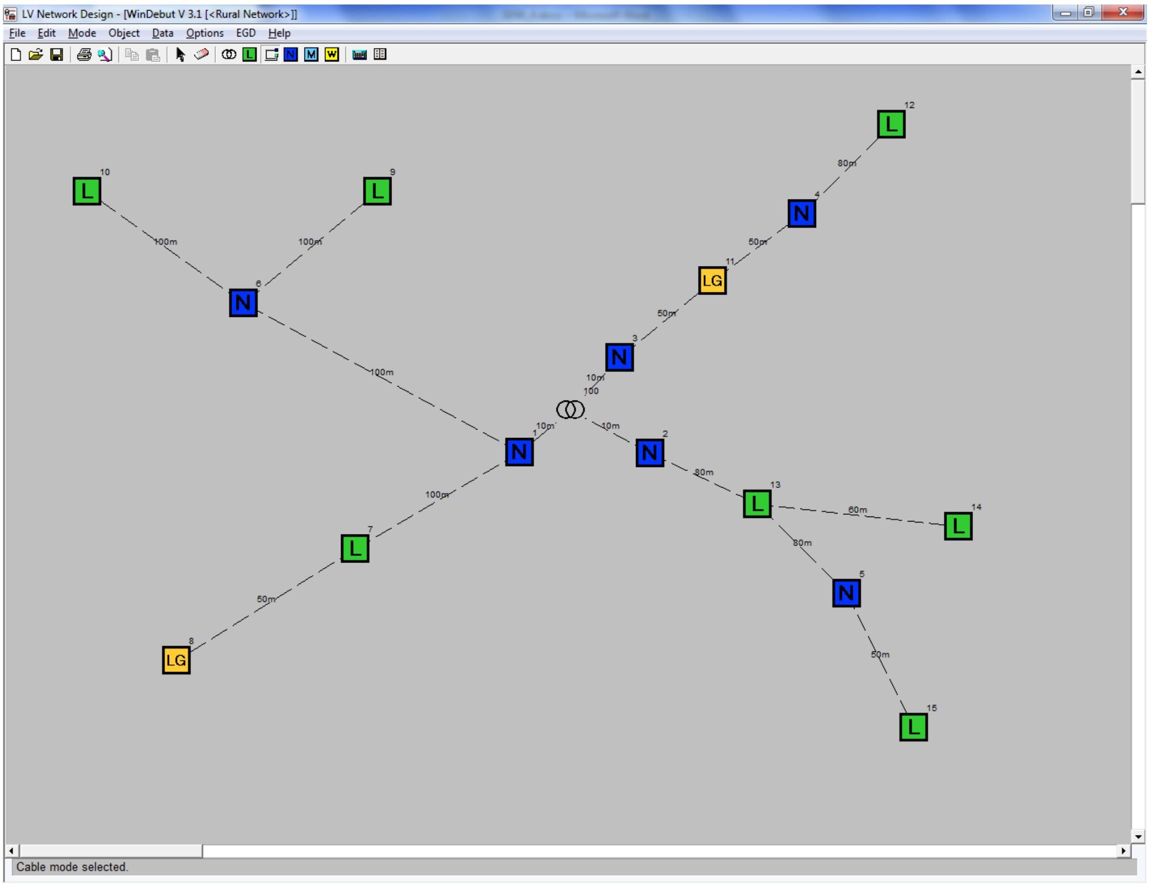


Figure 17 Adding Cables and Overhead Lines

4.2.9 <u>Adding *Distributed Load* and *Distributed Generation*</u>

Load and Generation can be distributed evenly along cables and overhead lines. When this feature is used WinDebut automatically sets up *Point Loads* (one point load per customer) spaced evenly along the selected cable / overhead line. These *Point Loads* are not displayed on the diagram.

Distributed Load and Generation is added by right clicking on the cable / overhead line and then left clicking on *Distribute.*

Note, only one *Consumer Type* can be distributed per cable or line section.

4.2.9.1 Adding Distributed Load

1) Click on the *Group Details tab.*

2) Cores available; *Three*, *Two* or *One* core must be chosen. *Two* cores should only be selected if a split phase transformer is used.

3) *Consumer Type*; the relevant consumer type is selected from the default consumer types and from any non-standard ones that have previously been set up.

4) *Number of Consumers*; type in the number of customers to be distributed along the cable or OH line.

5) *Existing*; where existing is selected it is possible to type in and override the annual kWh consumption per consumer.

6) *Balanced*; *Balanced* is normally selected where the consumers utilise three phases. Where single phase or split phase connections are being modelled then balanced should not be selected. In some cases it is advisable to account for some unbalance within 3 phase or single phase connections, particularly where the connection is large. Where such unbalance is to be modelled point loads must be used instead (see 4.7).

7) Specified Distribution; where *Balanced* is not selected WinDebut will automatically assume that each consumer is connected to a single phase and will try, as far as possible, to balance the three (or two) phases by distributing the consumers across the available phases. It is also possible to manually allocate the consumers to different phases but where this technique is used the number of customers allocated to the red, yellow and blue phases must equal the total number of consumers selected, and the three phases must be as balanced as possible. For example, if the total number of consumers is 5 then 2 consumers must be allocated to one phase, 2 to another phase and 1 to the remaining phase.

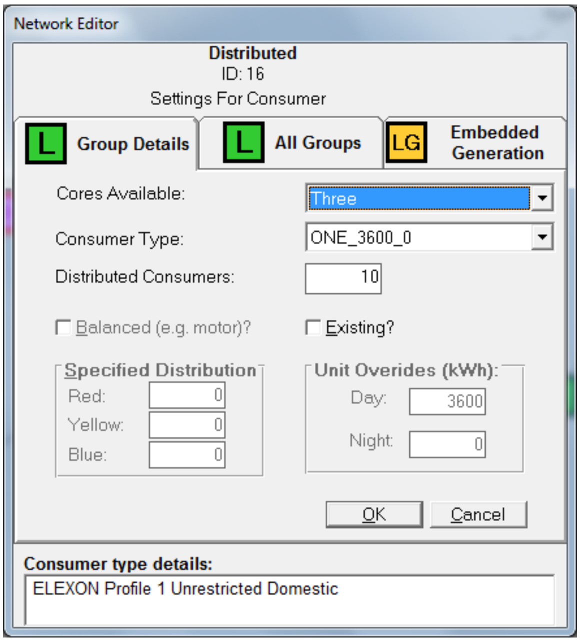


Figure 18 Group Details

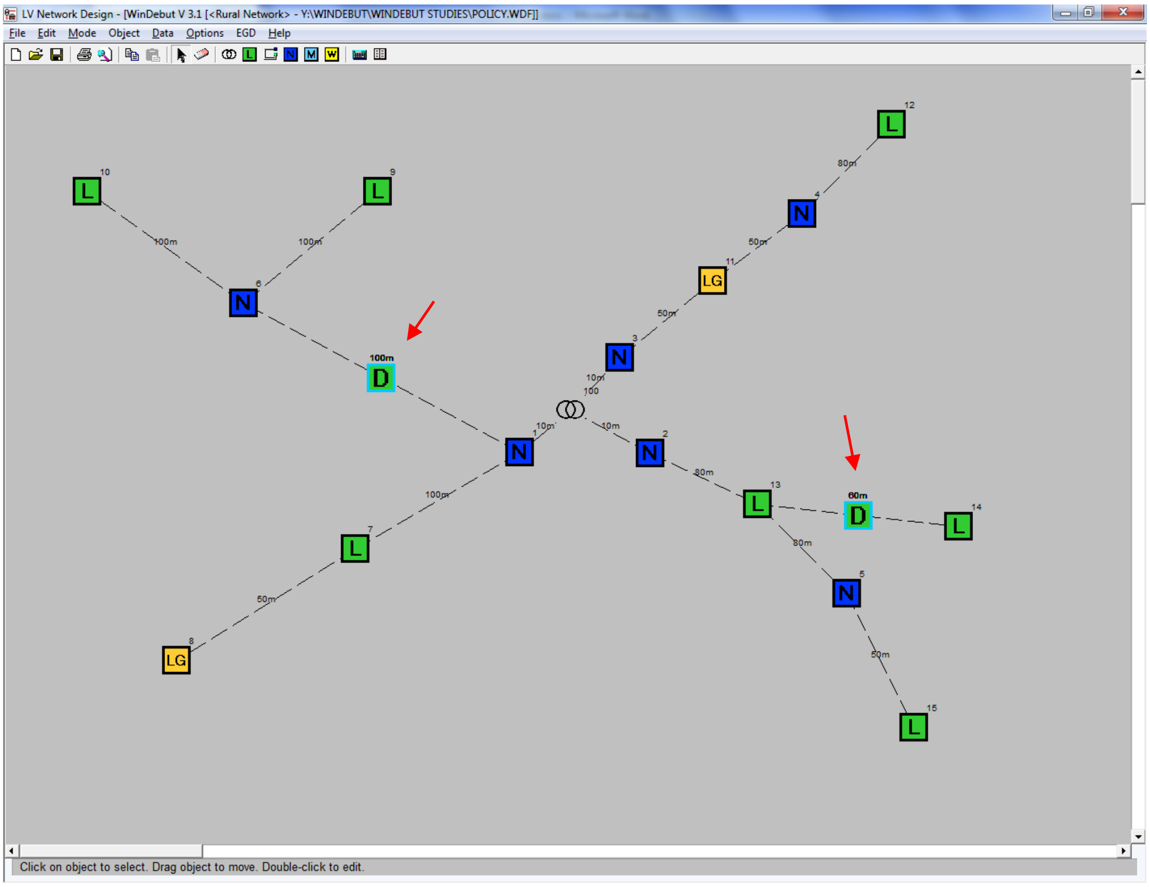


Figure 19 Adding Distributed Load

Tip 7: Distributed Load

When the distributed load option is used only one *Consumer Type* and customer consumption can be selected for each section of cable. Where different sizes of property are connected to a given section it is normally possible to select one profile type and one annual consumption (kWh) or maximum demand (kW) value that represents a "typical" customer connection.

Tip 8: Large Numbers of Distributed Consumers

Adding large numbers of distributed consumers adds significant complexity to the model and can sometimes cause the calculations to fail. It is recommended that this feature is only used sparingly (i.e. less than 150 distributed customers are used in any one model). An alternative method which simplifies the calculations is to add multiple consumers at a single *Point Load*.

Alternatively, where large numbers of the same customer type need to be modelled it is possible to reduce the number of distributed customers but increase the unit consumption accordingly for each customer (so that the total consumption within that section is the same). This method reduces the diversity applied by WinDebut as fewer customers are modelled but this has little impact as long as the revised number of distributed customers connected to the section is 25 or greater.

Tip 9: Minimum Cable Length / Customer

Where the *Distributed Load* feature is used WinDebut sets up a separate node for each customer (although these nodes are not displayed on the diagram). The minimum cable length between each customer / node is 1m. If this criterion is not satisfied WinDebut will return an error when the study is run.

4.2.9.2 Adding Distributed Generation

1) Click on the *Group Details tab.*

2) *Balance generation on phases for distributed items on cable;* when this box is selected Windebut attempts to balance the generation between the phases as best it can irrespective of the phases that are selected in the following fields. For example, if there are 5 distributed consumers and a generator is placed on the red phase the generation will be allocated on Red, Yellow, Blue, Red and Yellow phases for the 5 consumers.

3) *Phase; s*elect the phase that the generation is connected to (*red phase*, *yellow phase* or *blue phase*) or select *balanced.*

4) *Generated Power (kW);* type in the kW rating of the generation to be added <u>to each customer connection</u>. If only a proportion of the distributed consumers have generaton connected then reduce the kW value appropriately.

5) *Available Generators; s*elect the generator type followed by the *Add* button. Additional generation can be added by repeating the above exercise. Generators can be removed again using the *Remove* button:

Add button: >>>

Remove button: <<<

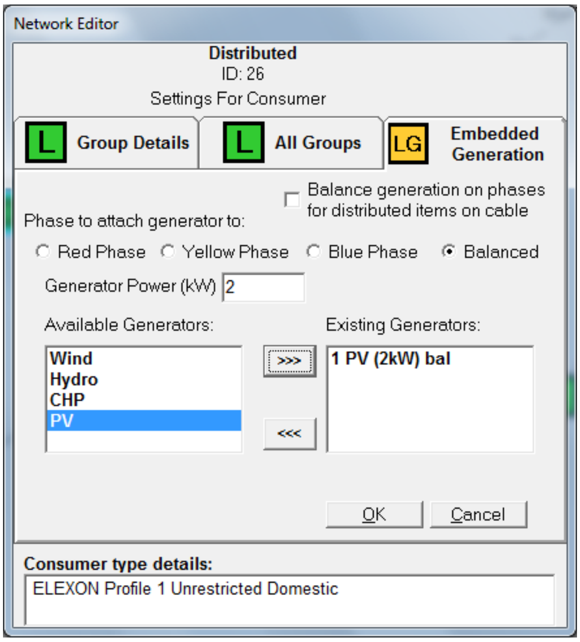


Figure 20 Distributed Generation

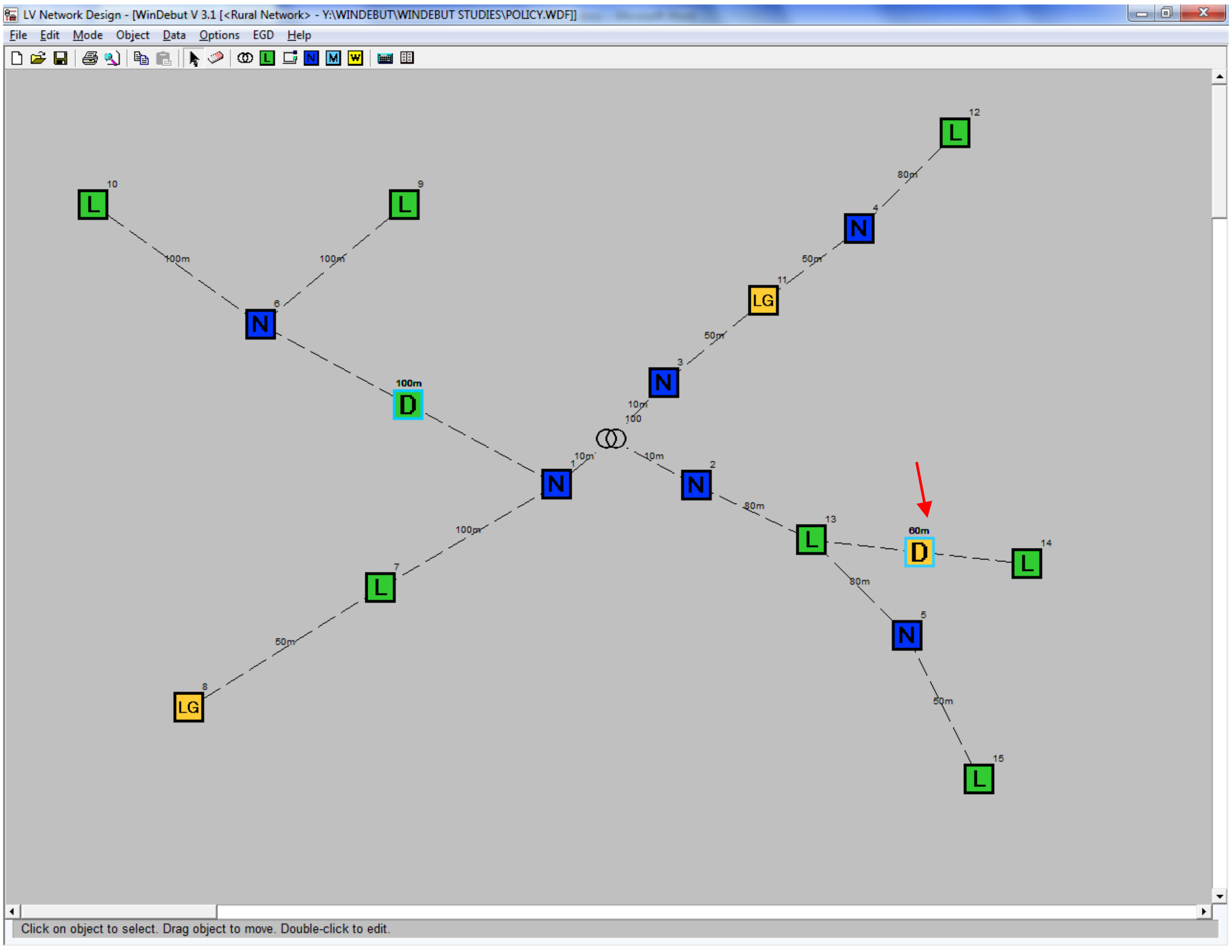


Figure 21 Adding Distributed Generation

Tip 10: Distributed Generation

The *Distributed Generation* option adds generation to every consumer defined using the *Group Details* tab. If only a proportion of these consumers have generation connected then reduce the size of the generation accordingly. For example, if a quarter of the distributed consumers have a 3.68kW PV system connected then model the generation as 3.68/4 = 0.92kW of PV per consumer.

4.2.10 Running the Study and Checking Results

Either click the *Run Calculations* icon or select options followed by *Run Debut*.

Some of the results are displayed on the diagram itself (e.g. % voltage drop and % voltage rise) and the majority of the remaining results are provided in a panel (*results* panel) that appears on the right hand side of the screen. More detailed information can be viewed by selecting the *Results* menu followed by *Result Detail* and, if generation has been added, *Results Detail EGD.* In addition a record of the study can be obtained by selecting the Run Records icon.

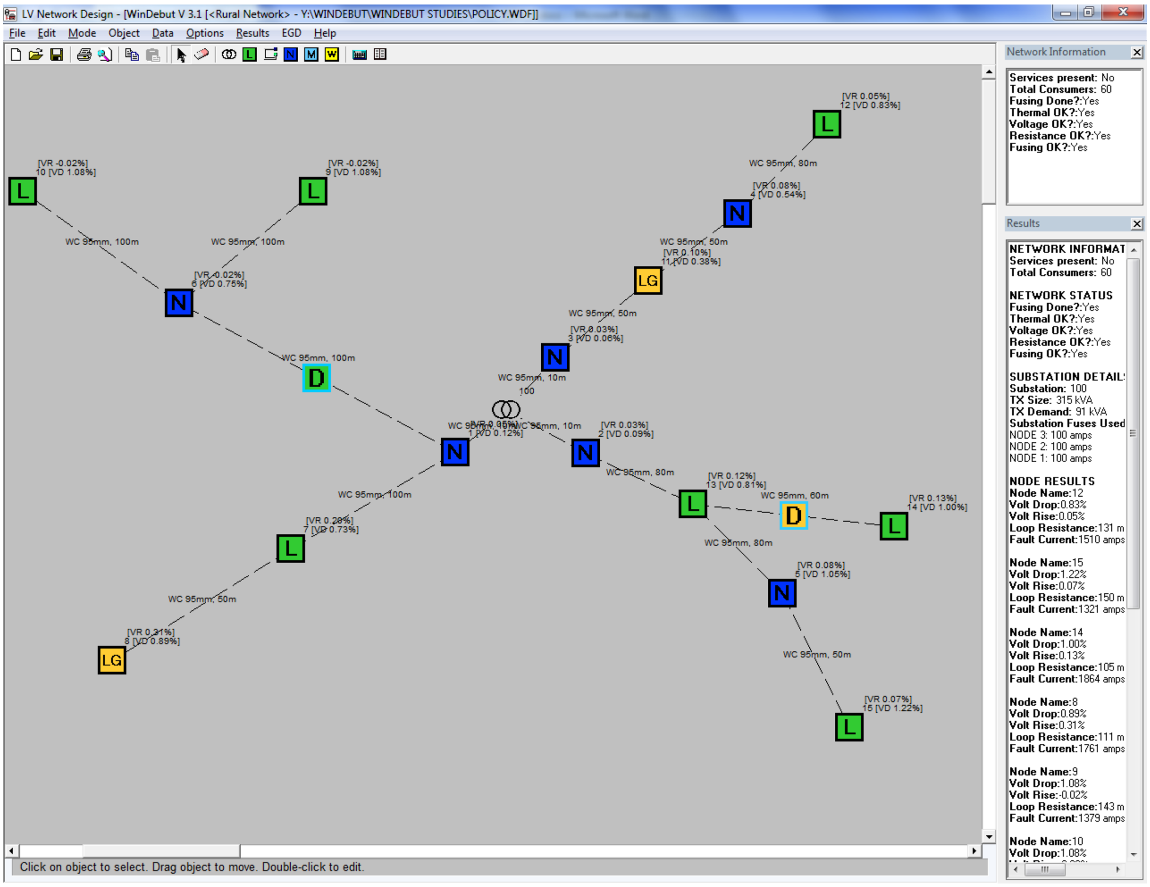
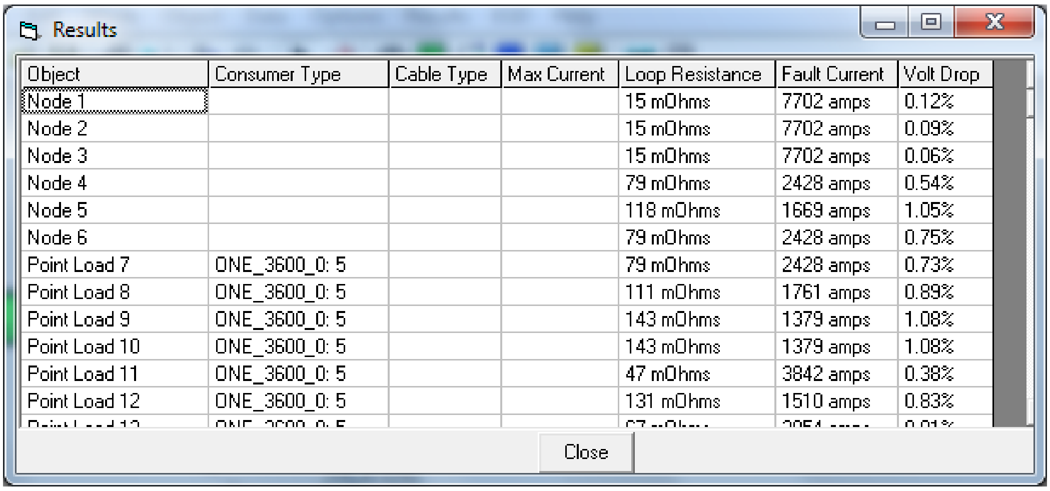


Figure 22 Results

WinDebut determines the optimum cable types and transformer size (when the user selects these items "to be designed") taking into account of the cost of the equipment and the cost of losses. WinDebut also checks the following aspects:

- Cable ratings
- Overhead line ratings (autumn/spring sustained ratings)
- % Voltage drop.
- % Voltage rise
- Phase to neutral loop resistance.
- Fusing (i.e. *cable and OH line* short circuit ratings)

1) *Cable and OH Line Ratings*: WinDebut uses autumn cyclic ratings for cables and spring/autumn ratings for overhead lines. The cable ratings are on the basis that the cables are laid direct in the ground and not in ducts. These assumptions are generally suitable for domestic and mixed domestic / commercial connections. If other ratings need to be used then manual checks must be carried out to ensure the cables are not overloaded. The *Results Detail* and *Results Detail EDG* reports can be helpful when checking cable ratings as these provide maximum current for each section of cable and overhead line (see Figure 23 and 24). If WinDebut finds that a cable is overloaded the relevant cable section is shown as a red line in red (rather than black) and in the *results* box the *Thermal OK?* check is displayed as **No**.

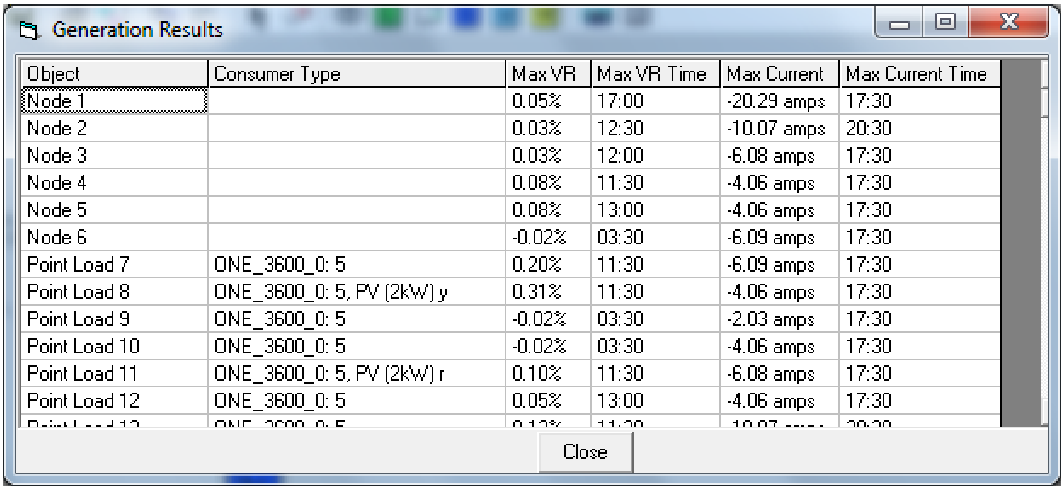


Results

Object	Consumer Type	Cable Type	Max Current	Loop Resistance	Fault Current	Volt Drop
Node 1				15 mOhms	7702 amps	0.12%
Node 2				15 mOhms	7702 amps	0.09%
Node 3				15 mOhms	7702 amps	0.06%
Node 4				79 mOhms	2428 amps	0.54%
Node 5				118 mOhms	1669 amps	1.05%
Node 6				79 mOhms	2428 amps	0.75%
Point Load 7	ONE_3600_0: 5			79 mOhms	2428 amps	0.73%
Point Load 8	ONE_3600_0: 5			111 mOhms	1761 amps	0.89%
Point Load 9	ONE_3600_0: 5			143 mOhms	1379 amps	1.08%
Point Load 10	ONE_3600_0: 5			143 mOhms	1379 amps	1.08%
Point Load 11	ONE_3600_0: 5			47 mOhms	3842 amps	0.38%
Point Load 12	ONE_3600_0: 5			131 mOhms	1510 amps	0.83%

Close

Figure 23 Results Detail Report



Generation Results

Object	Consumer Type	Max VR	Max VR Time	Max Current	Max Current Time
Node 1		0.05%	17:00	-20.29 amps	17:30
Node 2		0.03%	12:30	-10.07 amps	20:30
Node 3		0.03%	12:00	-6.08 amps	17:30
Node 4		0.08%	11:30	-4.06 amps	17:30
Node 5		0.08%	13:00	-4.06 amps	17:30
Node 6		-0.02%	03:30	-6.09 amps	17:30
Point Load 7	ONE_3600_0: 5	0.20%	11:30	-6.09 amps	17:30
Point Load 8	ONE_3600_0: 5, PV (2kW) y	0.31%	11:30	-4.06 amps	17:30
Point Load 9	ONE_3600_0: 5	-0.02%	03:30	-2.03 amps	17:30
Point Load 10	ONE_3600_0: 5	-0.02%	03:30	-4.06 amps	17:30
Point Load 11	ONE_3600_0: 5, PV (2kW) r	0.10%	11:30	-6.08 amps	17:30
Point Load 12	ONE_3600_0: 5	0.05%	13:00	-4.06 amps	17:30

Close

Figure 24 Results Detail EGD Report

2) *% Voltage Drop*: If the study includes overhead lines or cables that are deemed (by WinDebut) to be services the maximum acceptable voltage drop across the cables and OH lines is **5.75%** (of 240V) which equates to 6% of 230V. If the study does not include services the maximum voltage drop is **4.79%** (of 240V) which equates to 5% of 230V. These limits are identical to the values recommended in POL: SD4 if it is assumed a further 2% voltage drop occurs across the transformer. If WinDebut determines that the voltage limits are exceeded then half of each relevant *point load* or *node* symbol changes to red and, in the *results* box, the *Voltage OK?* is shown as **No**. In addition the % voltage displayed at each relevant *point load / node* is shown with asterisks either side, for example *5.9%*.

3) *% Voltage Rise*: The maximum voltage rise across the cables, overhead lines and transformer is set to **1.44%** (of 240V) by default. This equates to 1.5% of 230V. It should be noted that WinDebut does take account of the voltage rise/drop across the transformer when checking the voltage rise due to generation. If the voltage rise limits are exceeded this is displayed in the same way as described in 2. Above.

   In some locations the no-load voltage on the LV side of transformer has historically been set relatively high (e.g. around 250V). Where this is the case the maximum voltage rise may be reduced to 1% (of 240V).

4) *Phase to Neutral Resistance*: A maximum resistance of 190mΩ is allowed where services are not modelled and 220mΩ where they are. Note, these are resistance values and not impedance values. If the maximum resistance is exceeded then in the *results* box *Resistance OK? is shown as* **No**.

5) *Fusing*: WinDebut checks that the fuse ratings are high enough to accommodate the required load and also that the short circuit current is high enough (or fuse rating low enough) to satisfy the criteria listed in Table 7. If the fusing requirements are not satisfied then in the results box Fusing OK? is displayed as **No**.

Cable / Line Type	Short Circuit Criteria*
Underground Cables	
Mains	The fuse must operate before the short circuit rating (non –adiabatic rating) of the cable is exceeded and it must also operate within 60s.
Service	The fuse must be capable of detecting and operating for a short circuit fault at the far end of the service if the cable fails to burn off.
Overhead Lines	
All	The fuse must operate before the short circuit rating (adiabatic rating) of the overhead line is exceeded and it must also operate within 60s.

Table 8 Fusing Criteria

* *Note: The above criteria assume zero resistance at the point of fault (e.g. no arc resistance).*

4.3 Power Quality Studies

WinDebut is able to model the voltage disturbances (e.g. flicker) caused by the starting current of a motor or the fluctuating current of welder. The software can also be used to obtain short circuit data and system impedance data for an LV network. This information can be used when assessing the flicker and harmonics produced by other types of disturbing loads (and by multiple disturbing loads).

4.3.1 Adding a Motor

A single motor is added to a WinDebut study by clicking on the *Motor* symbol or by selecting *Mode* from the menu and selecting *Motor*. The following information is then added / selected:

1) *Motor Voltage and Network Type*: Table 8 describes the available options.
2) *Rating*: The motor rating can be entered in kilowatts of amperes.
3) *Type of Starter*: The type of motor starting affects the starting current calculated by WinDebut.
4) *Starting Current: WinDebut* calculates the starting current. If the installer provides credible data for the starting current this can be typed in. It should be noted that this value must be the instantaneous starting current not a value of current averaged over a period of time.
5) *Starting Power Factor: A* value of 0.3 is provided as a default. Alternative power factors can be entered, if needed.
6) *Number of Starts*: The number of times the motor is expected to start per hour, minute or day is selected. This alters the acceptable level of voltage dip.
7) *HV Fault Level and X/R ratio*: The HV fault level and X/R ratio can be entered to improve the accuracy of the flicker calculation.

Network Type	WinDebut Selection	Motor Type
3 Phase	3 Phase 415V motor on 3 phase 4 wire network	3 phase motor
	1 Phase 240V motor on 3 phase 4 wire network	1 phase motor
Split Phase	1 Phase 480V motor on 1 phase 3 wire network	Split Phase motor
	1 Phase 240V motor on 1 phase 3 wire network	1 phase motor
Single Phase	1 Phase 240V motor on 1 phase 2 wire network	1 phase motor

Table 9 Motor Types

Further guidance on obtaining and determining motor data is included in ST: SD6F.

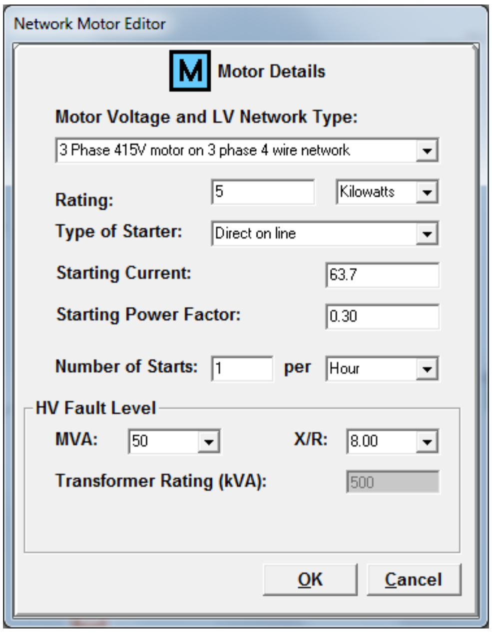


Figure 25 Motor Details

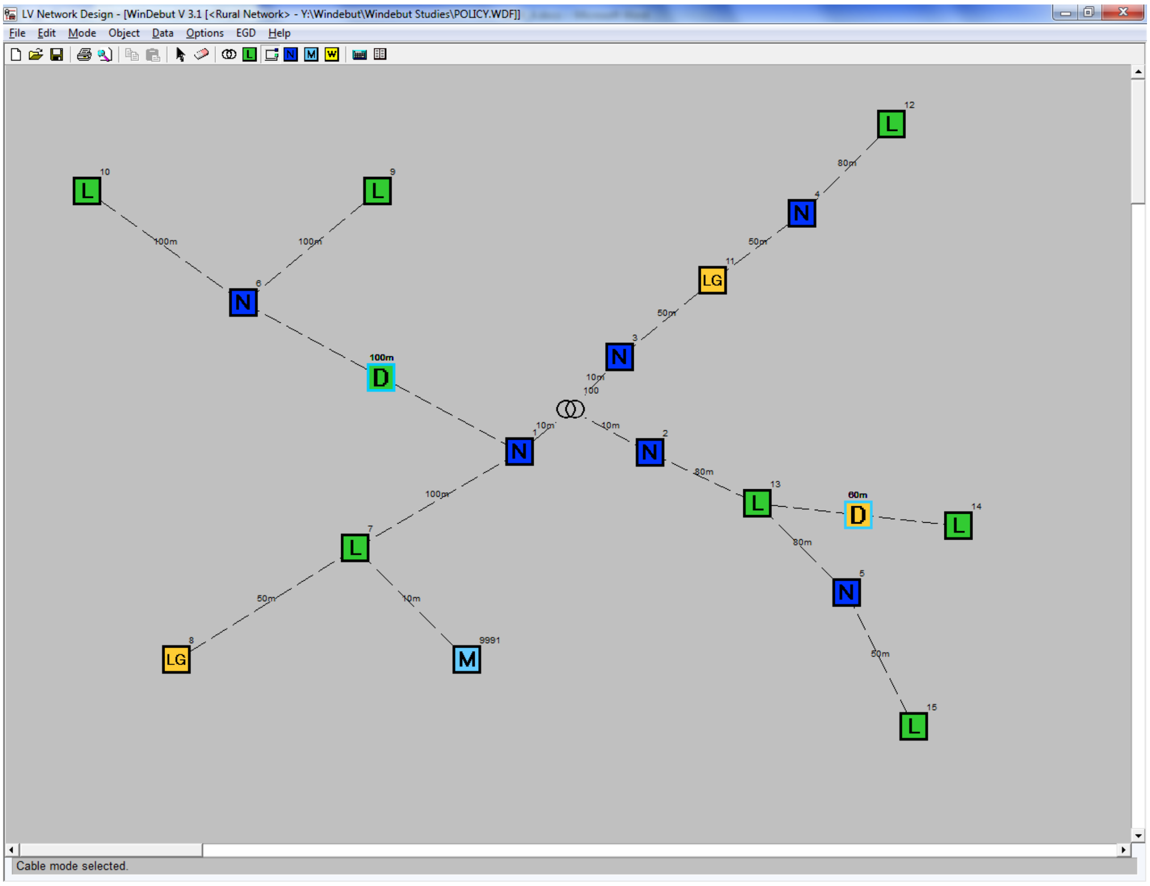


Figure 26 Adding a Motor

4.3.2 Adding a Welder

A single welder is added to WinDebut study by clicking on the Welder symbol or by selecting *Mode* from the menu and selecting Welder. The following information is then added / selected:

1. *Welder Voltage and Network Type*: Table 9 describes the available options
2. *Input kVA Rating*: If the input kVA rating of the welder is known, select this option then add the kVA rating.
3. *Open Circuit Welding Voltage:* enter data from welder name plate or welder manual (where input kVA rating is not known).
4. *Maximum Welding Current:* enter data from name plate or manual (where input kVA is not known).
5. *kVA Rating*: enter data from name plate or manual (where input kVA is not known).
6. *Burst of welding current*: enter the number of welds expected per minute, second or hour.
7. *Input Power Factor*: A value of 0.3 is used by default.
8. *Point of Wave Control*: this option is selected where point of wave control is used
9. *HV Fault Level and X/R ratio*: The HV fault level and X/R ratio can be entered to improve the accuracy of the flicker calculation.

Further guidance on obtaining and determining welder data is included in ST: SD6F.

Network Type	WinDebut Selection	Motor Type
3 Phase	3 Phase 415V DC welder on 3 phase 4 wire network	3 phase 415V welder operating at DC
	3 Phase 415V AC welder on 3 phase 4 wire network	3 phase 415V welder operating at AC
	1 Phase 415V AC welder on 3 phase 4 wire network	1 phase 415V welder operating at AC
	1 Phase 240V AC welder on 3 phase 4 wire network	1 phase 240V welder operating at AC
Split Phase	1 Phase 240V AC welder on 1 phase 3 wire network	1 phase 240V welder operating at AC
Single Phase	1 Phase 240V AC welder on 1 phase 2 wire network	1 phase 240V welder operating at AC

Table 10 Welder Types

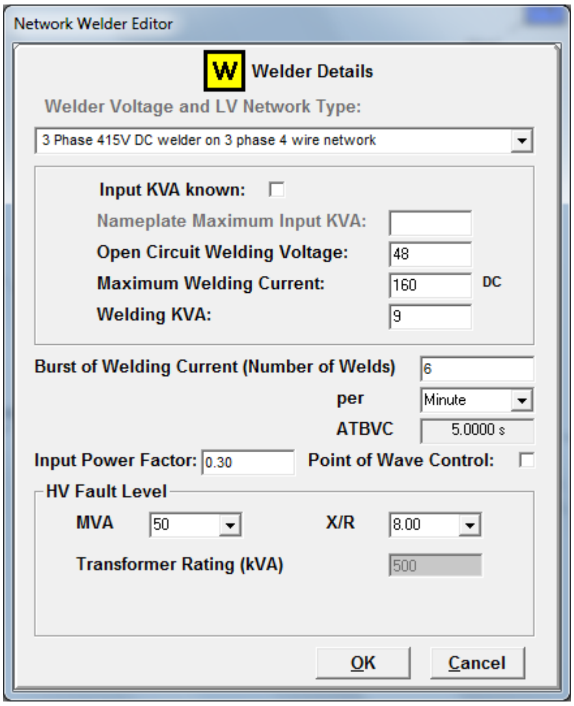


Figure 27   Welder Detail

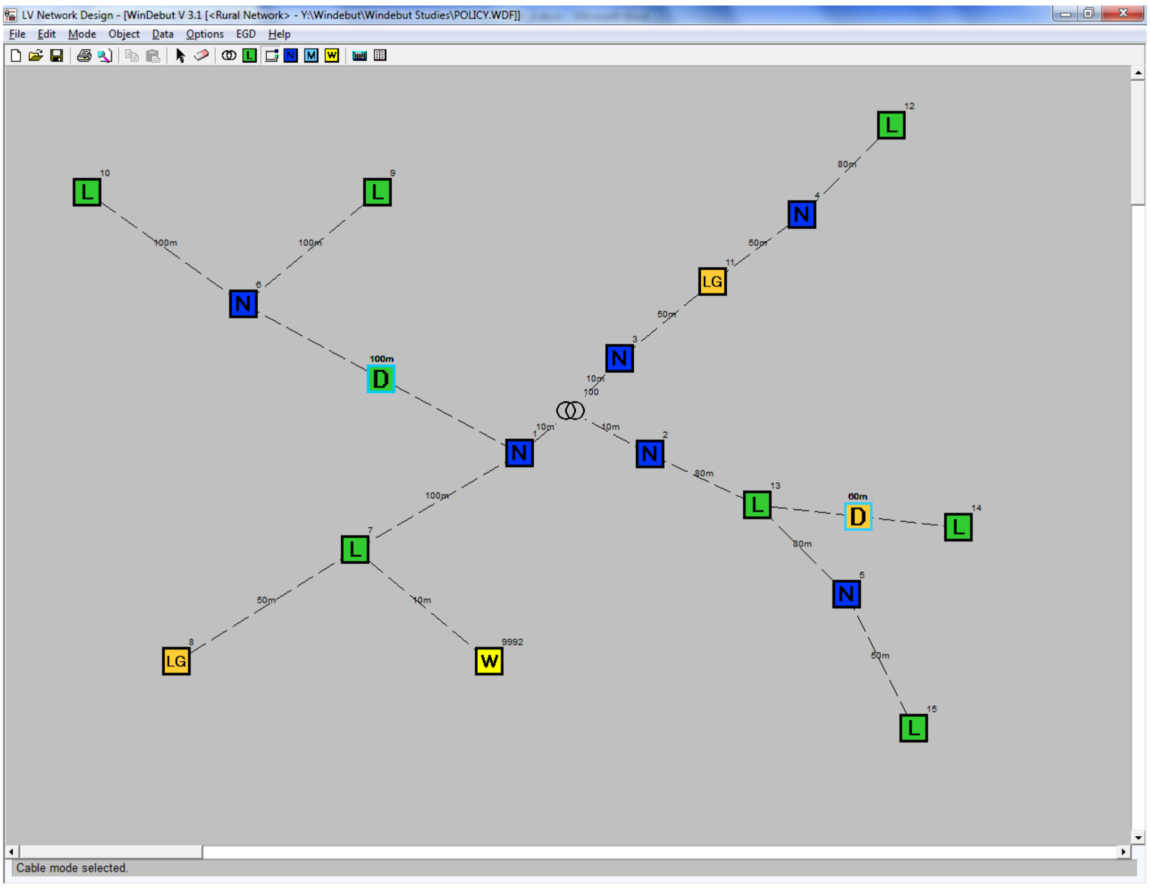


Figure 28   Adding a Welder

4.3.3 Running Motor / Welder Studies and Viewing Results

Once either a motor or welder has been added this is connected to another *node* or *point load* using a cable or overhead line. WinDebut is the run by either clicking on the *Run Calculations* icon or by selecting *Mode* from the menu followed by *Run Debut*.

Motor / welder results are displayed in the results panel on the right hand side of the screen. WinDebut calculates the voltage disturbance (in % of 240V) at each *node* and compares this value with the calculated limit, based on the frequency of motor starts or welds (the number of motor starts or welds per second, minute or hour). The limit corresponds to a short term flicker value (Pst) of 0.5 which allows a limited number of such devices to be connected without giving rise to customer complaints. If the limit is exceeded at one or more of the *nodes* or *load points* this is flagged up by displaying the values in red.

In order for the connection to be acceptable the flicker requirements must be satisfied at the point of common coupling (i.e. at the service joint or at some other position where other customers are already connected, or where they may be connected in the future. If the requirements are not satisfied at the customers supply terminals (but the requirements are satisfied at the point of common coupling) it is good practice to inform the customer that they may experience flickering or dipping lights due to their equipment.

In the case of motor calculations, WinDebut also checks to see if the voltage dip at the motor is greater than 9%. If this value is exceeded there is a risk that the motor may stall.

An example of the results from a motor calculation are shown in Figure 29 and Figure 30.

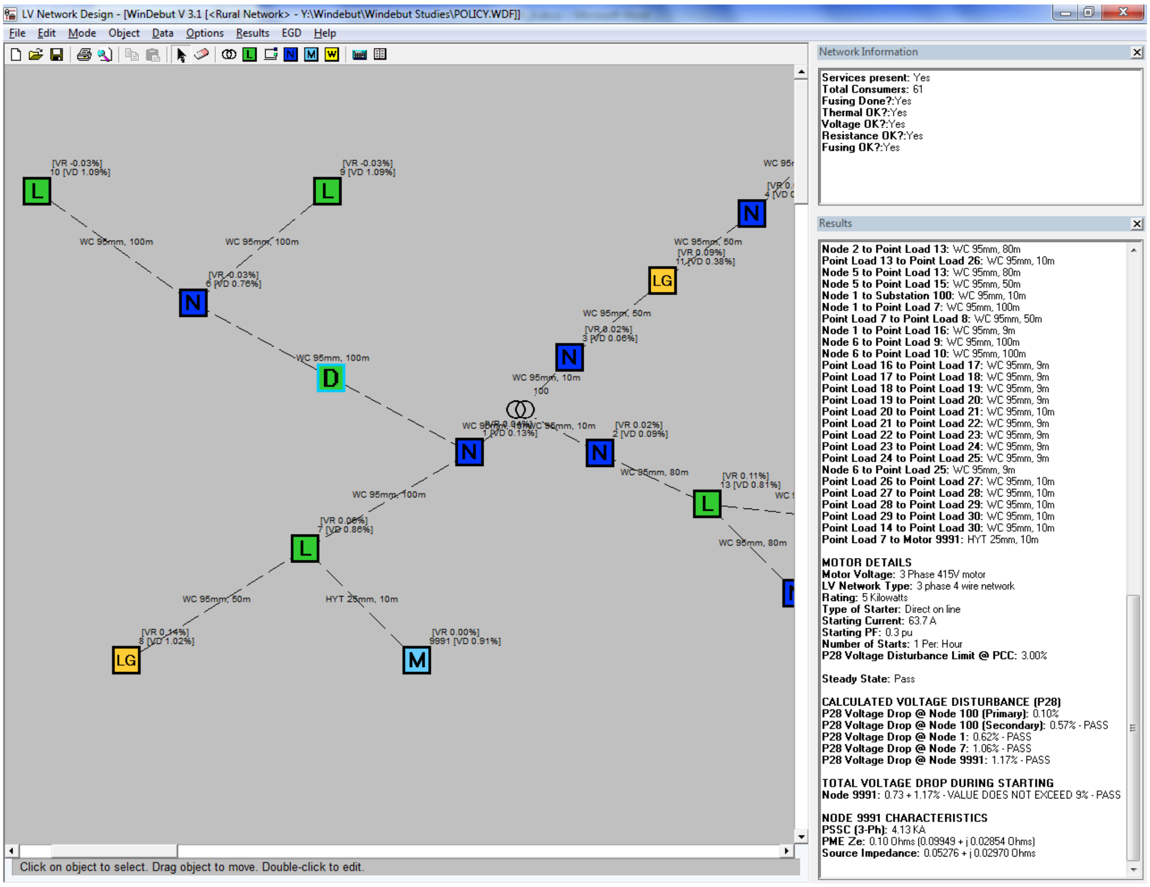


Figure 29 Motor Calculation Results

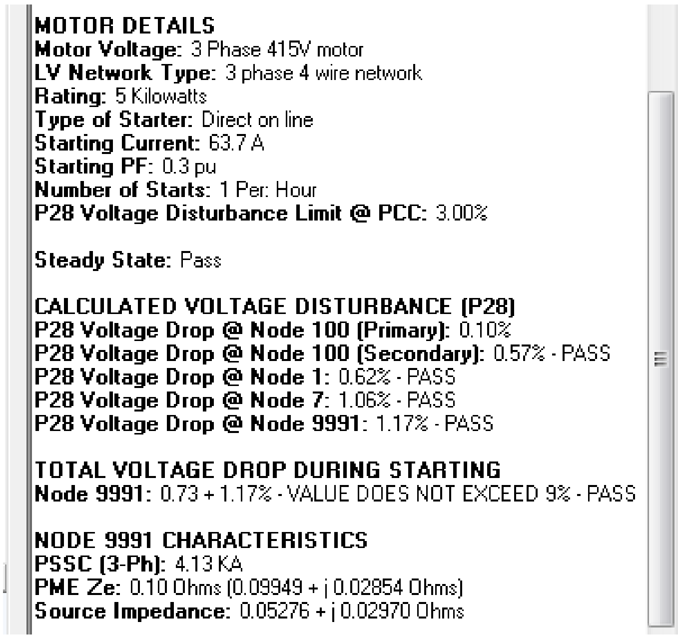


Figure 30 Motor Calculation Results

4.4 Impedance Calculations

4.4.1 It is often necessary to determine the impedance of an LV network, for example where:

- a customer has requested the earth fault loop impedance at their installation
- it is necessary to check that the phase to neutral loop impedance or the earth fault loop impedance satisfies the requirements of *ST:SD5R, Earth Fault Loop Impedances and Phase to Neutral Loop Impedances at LV installations.*
- It is necessary to check that the impedance is low enough to connect certain items of disturbing equipment (e.g. generators, motors, welders or heat pumps etc.) without exceeding flicker and harmonics limits. Further guidance on dealing with potentially disturbing loads is contained in ST:SD6F, *Dealing with Potentially Disturbing Electrical Loads/Equipment* and ST:SD6J *Connection Design - Potentially Disturbing Electrical Equipment Rated <=75A/Phase Subject to Conditional Connection*.

4.4.2 WinDebut holds two sets of resistance values for cables and overhead lines depending on whether load conditions or fault conditions are being considered. The resistance values for load conditions are based on a conductor temperature of 20°C and are lower than the fault resistance values which are based on a conductor temperature of 70°C for cables and 50°C for bare overhead lines. This means that the technique that is used to obtain the impedance values from WinDebut depends on how the information is going to be used.

4.2.1.1 Earth Fault Loop Impedances and Phase to Neutral Loop Impedances

These values are generally used to ensure that protection will operate correctly and therefore it is important they are based on the higher conductor temperatures (and therefore higher resistance values). In order to obtain these fault impedance values model the network in WinDebut, run the study and then simply click on the *Node* or *Point Load* of interest. The phase to neutral fault current at the *Node* / *Point Load* is shown in the *Load Details* display (as shown in Figure 31).

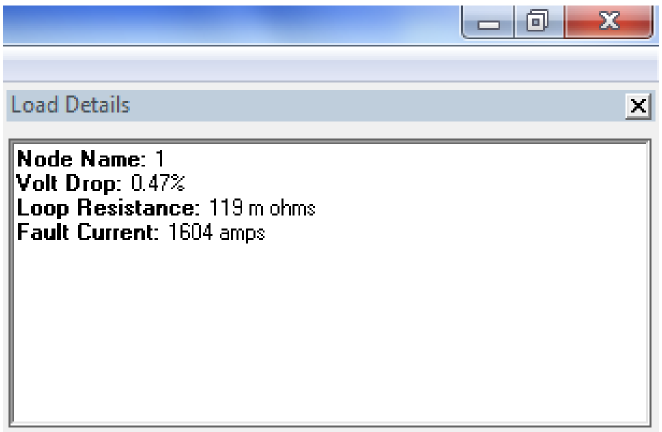


Figure 31 Phase to Neutral Fault Current

The Phase to Neutral fault current can then be used to calculate the Phase to Neutral Loop impedance (Zn) can be calculated using the following equation:

$Zn = V/I_{fn}$

V = Phase to Neutral Voltage at the transformer = 250V

I_{fn} = Phase to neutral fault current

In the above example Zn = 250 / 1604A = 0.156 Ω

4.2.1.2 Network Impedances for Power Quality Investigations

Where the network impedance is required to determine whether an item of disturbing load may be connected, this impedance should be based on the normal operating impedance of the network. The 20^{o}C resistance values should be used for this purpose. These impedance values can be obtained from WinDebut by connecting a *direct on line* motor at the required location.

The phases of the motor and type of network must be selected to correspond to the number of phases of the equipment being considered and to the type of network being considered.

The rating of the motor and the number of starts per hour must also be selected but these have no bearing on the impedance calculated by WinDebut. A value of 1kW and 1 start per hour is typically chosen.

The HV source impedance may be changed to reflect the actual HV source impedance at the substation, however this makes little difference to the result where the transformer is relatively small e.g. less than 500kVA.

Figure 32 shows motor settings that can be used to obtain the phase to neutral impedance of a 3 phase PME network.

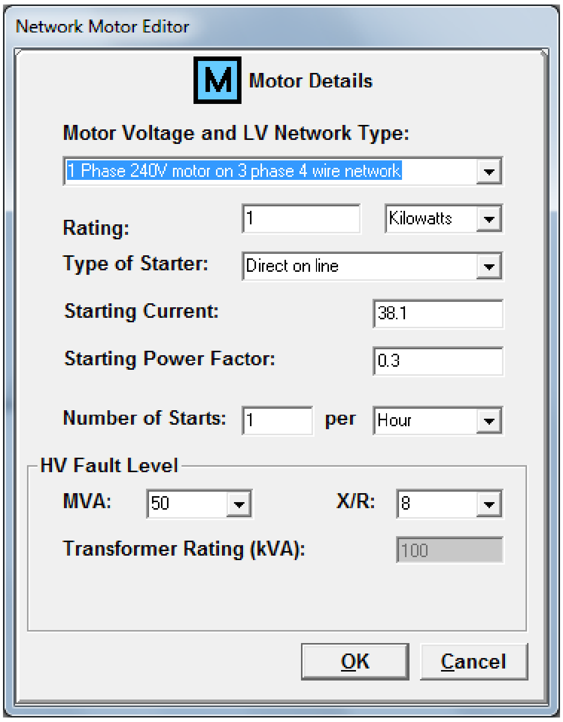
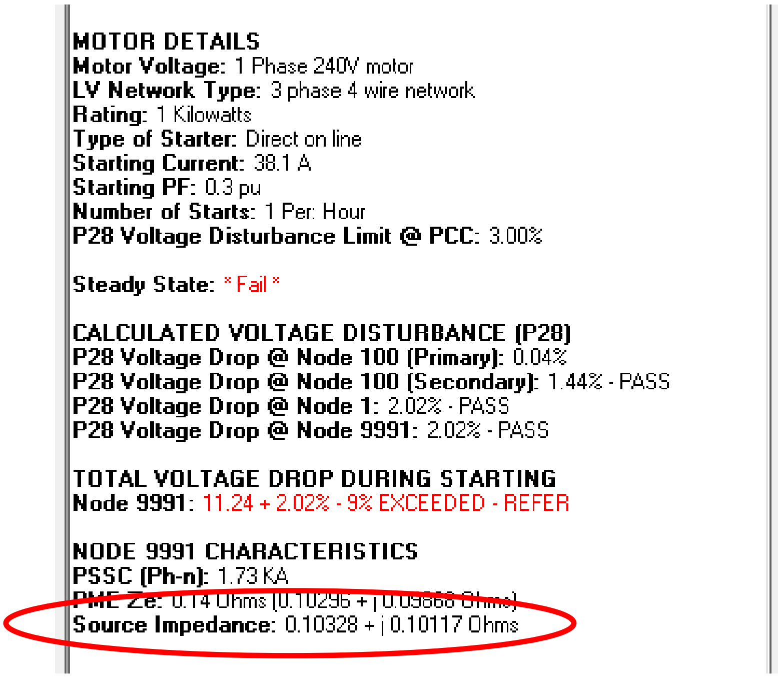


Figure 32 Motor Setup used to Provide Phase to Neutral Impedance on a 3 Phase Network

Once the motor has been connected to the relevant node and the study is run WinDebut provides the *Source Impedance* (Network Impedance) at the motor position as shown in Figure 33:



MOTOR DETAILS
Motor Voltage: 1 Phase 240V motor
LV Network Type: 3 phase 4 wire network
Rating: 1 Kilowatts
Type of Starter: Direct on line
Starting Current: 38.1 A
Starting PF: 0.3 pu
Number of Starts: 1 Per: Hour
P28 Voltage Disturbance Limit @ PCC: 3.00%

Steady State: * Fail *

CALCULATED VOLTAGE DISTURBANCE (P28)
P28 Voltage Drop @ Node 100 (Primary): 0.04%
P28 Voltage Drop @ Node 100 (Secondary): 1.44% - PASS
P28 Voltage Drop @ Node 1: 2.02% - PASS
P28 Voltage Drop @ Node 9991: 2.02% - PASS

TOTAL VOLTAGE DROP DURING STARTING
Node 9991: 11.24 + 2.02% - 9% EXCEEDED - REFER

NODE 9991 CHARACTERISTICS
PSSC (Ph-n): 1.73 KA
PME Ze: 0.14 Ohms (0.10296 + j 0.09868 Ohms)
Source Impedance: 0.10328 + j 0.10117 Ohms

Figure 33 Impedance Results

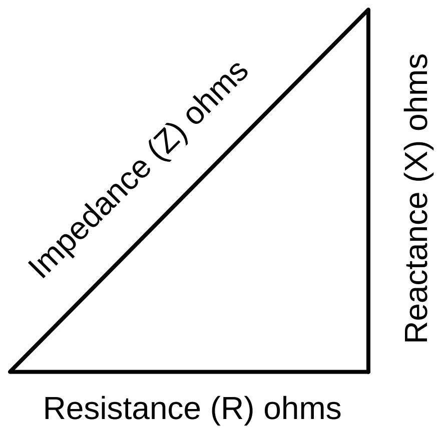
In this example the network resistance is 0.10328 ohms and the network reactance is 0.10117 ohms.

The network impedance can be obtained using the following equation (derived from Pythagoras Theorem):

$$Z = \sqrt{(R^2 + X^2)}$$

Where Z = Impedance (Ω), R = Resistance (Ω) and X = Reactance (Ω)

$$Z = \sqrt{(0.10328^2 + 0.10117^2)} = 0.14458\Omega$$



Note, the Ze value (displayed just above the *source impedance* value) must not be used to provide phase to earth fault or phase to neutral fault impedances as this is based on a 20^{o}C conductor temperature. It should also be noted that the Ze value does not include the HV source impedance, whereas the *Source Impedance* value does.

5.0 SOLVING NETWORK DEFICIENCIES

5.1 General

5.1.1 Reducing Network Impedance

Reducing the impedance / resistance of the network (e.g. installing bigger cables and overhead lines) will reduce voltage drop, reduce phase to neutral resistance values and increase the short circuit levels. This also has the benefit of reducing losses. An alternative way of reducing voltage drop or voltage rise is to increase the number of LV circuits (dividing the load between more circuits) or reduce the length of the circuits (e.g. by installing additional substations).

5.1.2 Installing a Larger Transformer

Installing a larger transformer will reduce the voltage drop that occurs across the transformer, however this may not be reflected in voltage drop values displayed in WinDebut. This is because the voltage drop limits used within WinDebut (i.e. 4.79% and 5.75%) assume that a further 2% voltage drop may occur across the transformer. The voltage drop values displayed in WinDebut ignore the voltage drop across the transformer unless this exceeds 2%. If the 2% value is exceeded then WinDebut adds the difference between the actual value and 2%, to the results.

For example, if an 80kW load (111A at 240V) is connected to a 100KVA 3 phase pole mounted transformer the voltage drop across the transformer is 4.12V which equates to 1.7% (of 240V). As this value is less than 2% then WinDebut ignores the voltage rise across the transformer.

If this load is increased to 100kW (139A at 240V) the voltage drop across the transformer increases to 5.15V (2.1%). As this value is above 2% the additional voltage drop, i.e. 0.1%, is added to the calculated voltage drop at each node.

When WinDebut completes voltage rise calculations (i.e. the minimum load and maximum generation condition) it always adds the voltage rise across the transformer to the results displayed at each node. This is because the voltage rise limit defined within Windebut (i.e. 1.44% of 240V) caters for the voltage change across both the LV network and the transformer itself.

One disadvantage of using a larger transformer is that this increases the rating of the LV fuses that are usually installed. This may introduce or exacerbate fusing issues because fuses with higher ratings take longer to operate for a given value of fault circuit current. Generally it is recommended that the largest size LV fuse for the given transformer size is modelled in WinDebut. If a smaller size fuse is modelled there is a risk that it will be replaced with a larger fuse in the future. If a smaller sized fuse is to be specified by the Planner this fuse rating must be recorded in EMU and on the circuit label at the substation.

5.1.3 Changing a Transformer Tap Position

In some cases it may be possible to manually alter the tap position of a distribution transformer (off load) and set it on a non-standard tap position to boost or reduce the LV voltage. Most transformers have 5 tap positions in steps of 2.5% of 250V (i.e. 2.6% of 240V) although some small pole mounted transformers only have 3 tap positions in steps of 5% of 250V (i.e. 5.2% of 240V).

If a transformer tap is lowered by one position (e.g. 2.6% of 240V) this means the maximum voltage drop that could be accepted will be 2.6% lower than normal (i.e. 2.19% for mains cables and lines and 3.15% at the end of services) and the voltage rise that could be accepted will be 2.6% higher than normal (i.e. 4.1% at the end of services). This option of lowering the tap position may be acceptable on an LV network that is dominated by generation but which has little load connected (e.g. a substation dedicated to a generator connection). If a non-standard tap position is selected a note must be placed on EMU and a label placed on site that states the tap position that is to be used.

5.1.4 Sub-fusing an LV Circuit

Sub-fusing LV networks (i.e. installing fuses in link boxes etc.) to resolve fusing issues is not recommended for the following reasons:

- Operation staff may not be aware the fuses have been installed (introducing possible confusion if the fuses operate).
- The fuses may, at some stage, be replaced with ones with a higher rating, or by solid links, without the impact on the LV network design being properly assessed.

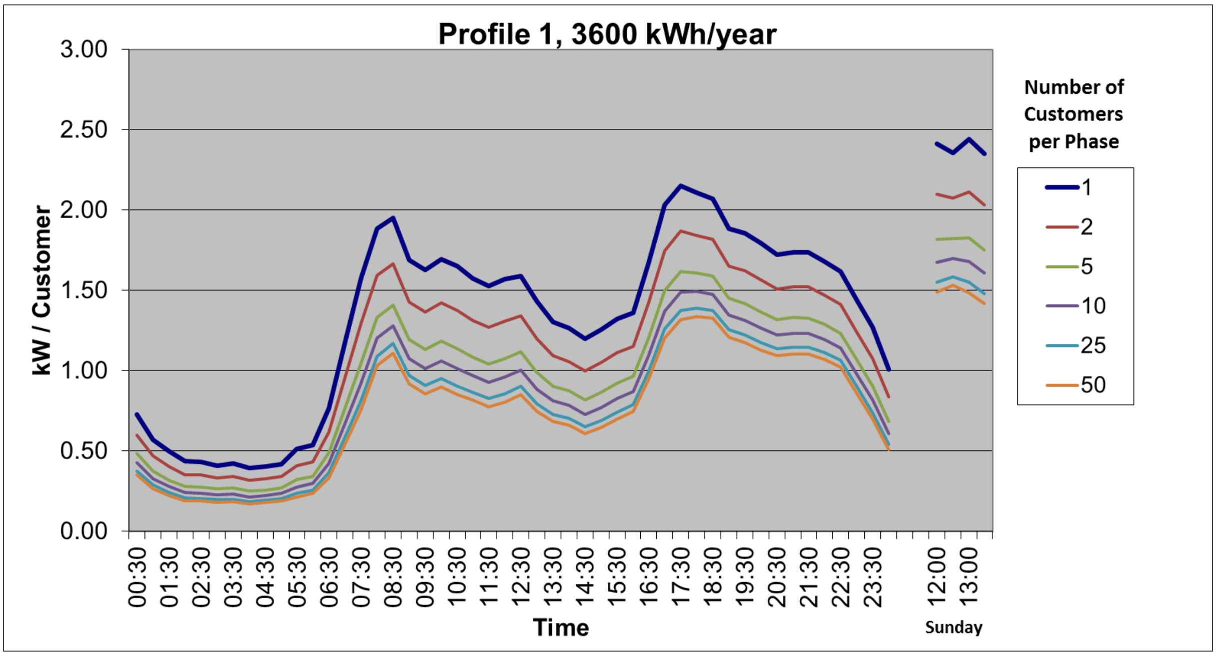
Sub-fusing may only be used at a site if this has been specifically agreed (on a site specific basis) with the Policy Section. Where this is the case the presence of the fuses and the required fuse ratings shall be recorded on EMU

Note, the above recommendation does not prevent sub-fusing being used as temporary measure for operational reasons (e.g. when an intermittent fault is suspected on a section of LV cable).

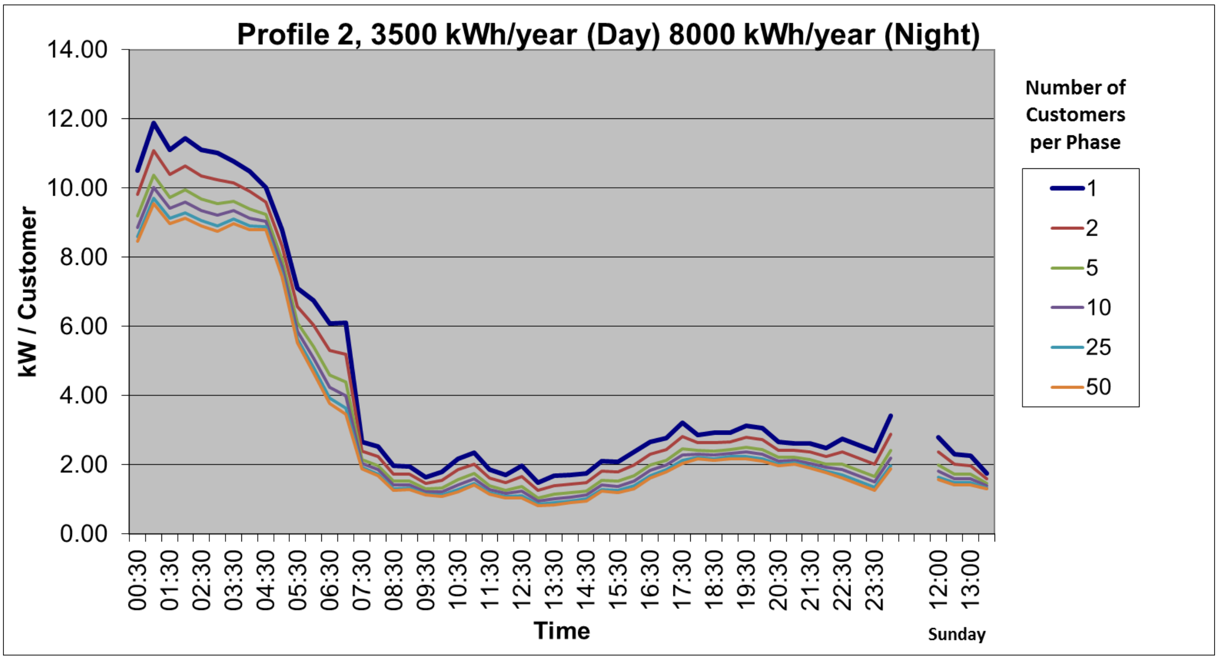
APPENDIX A

LOAD PROFILES AND THE IMPACT OF DIVERSITY

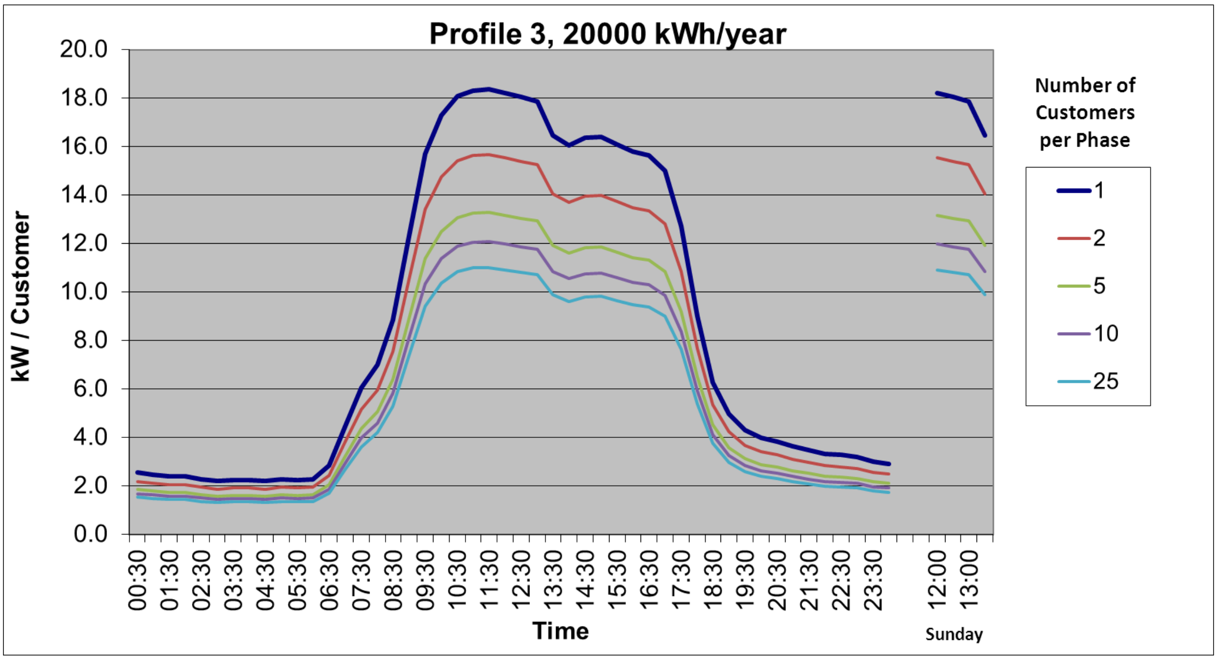
Profile 1



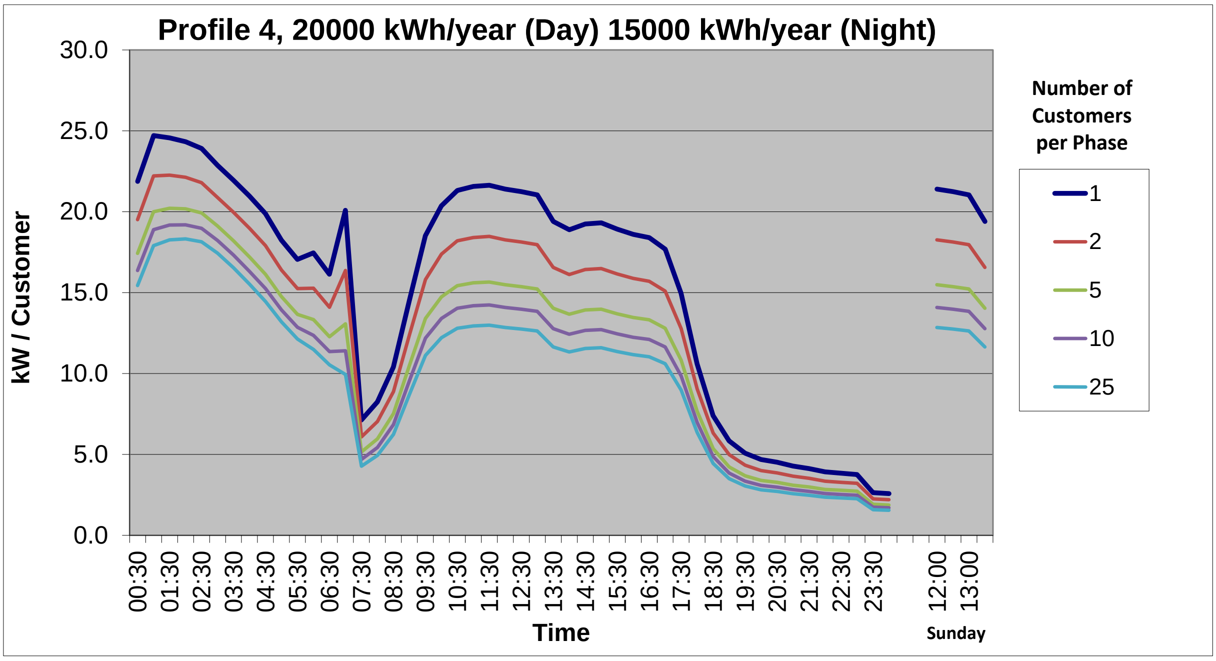
Profile 2



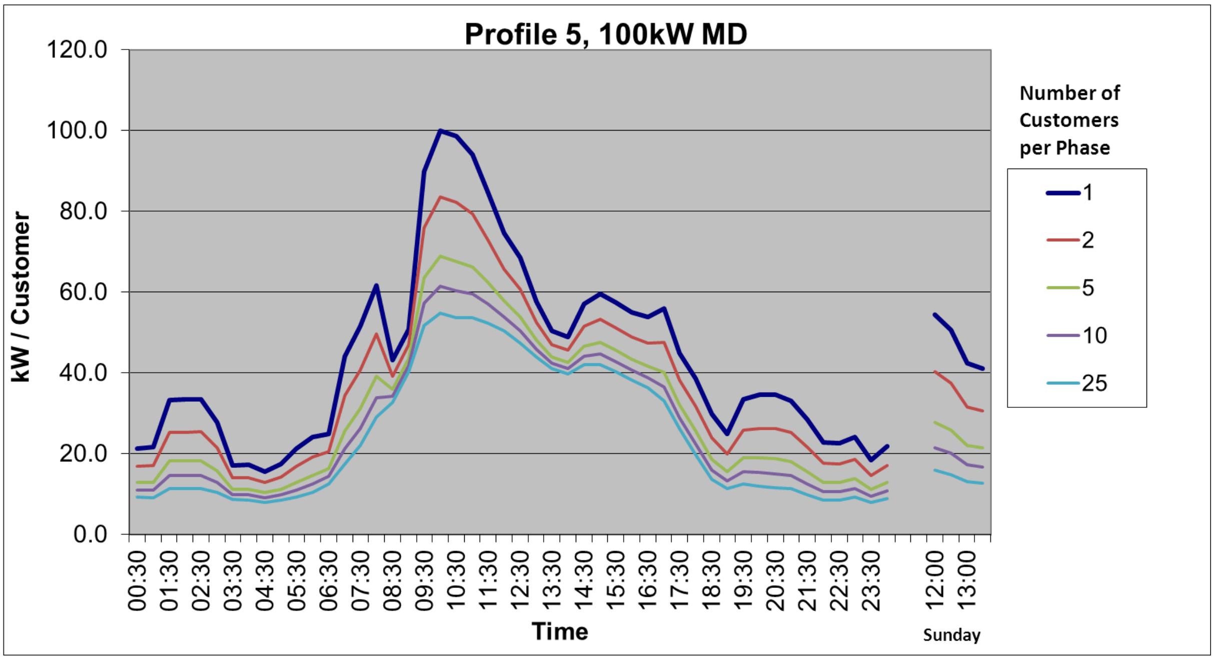
Profile 3



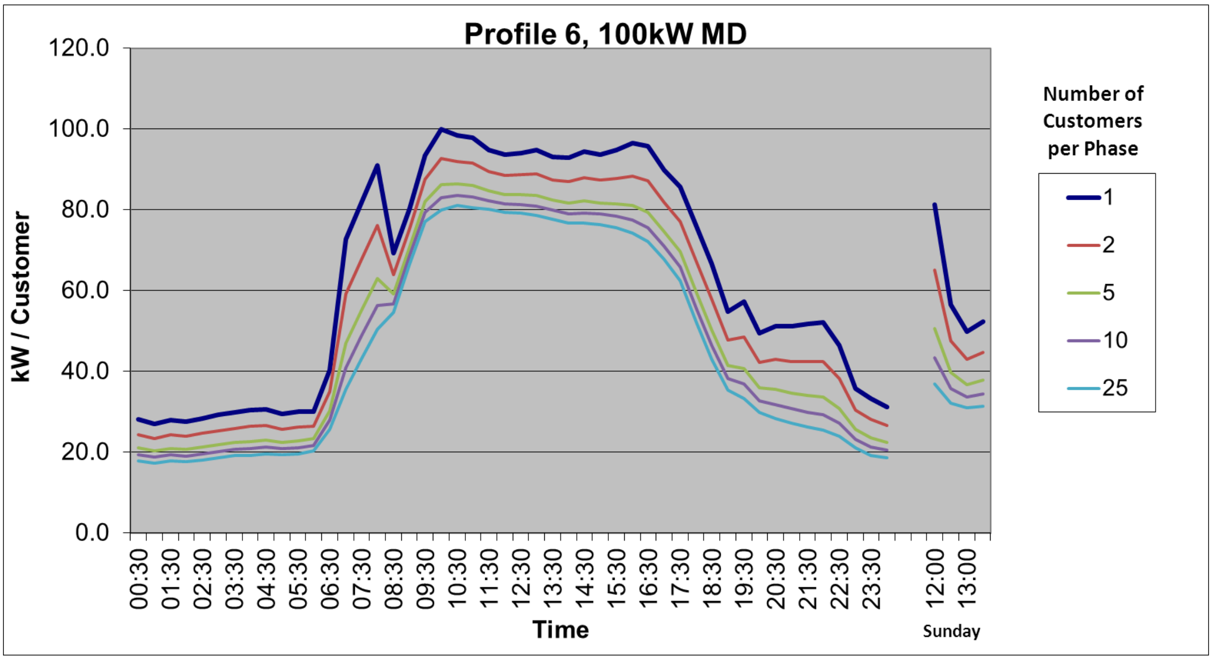
Profile 4



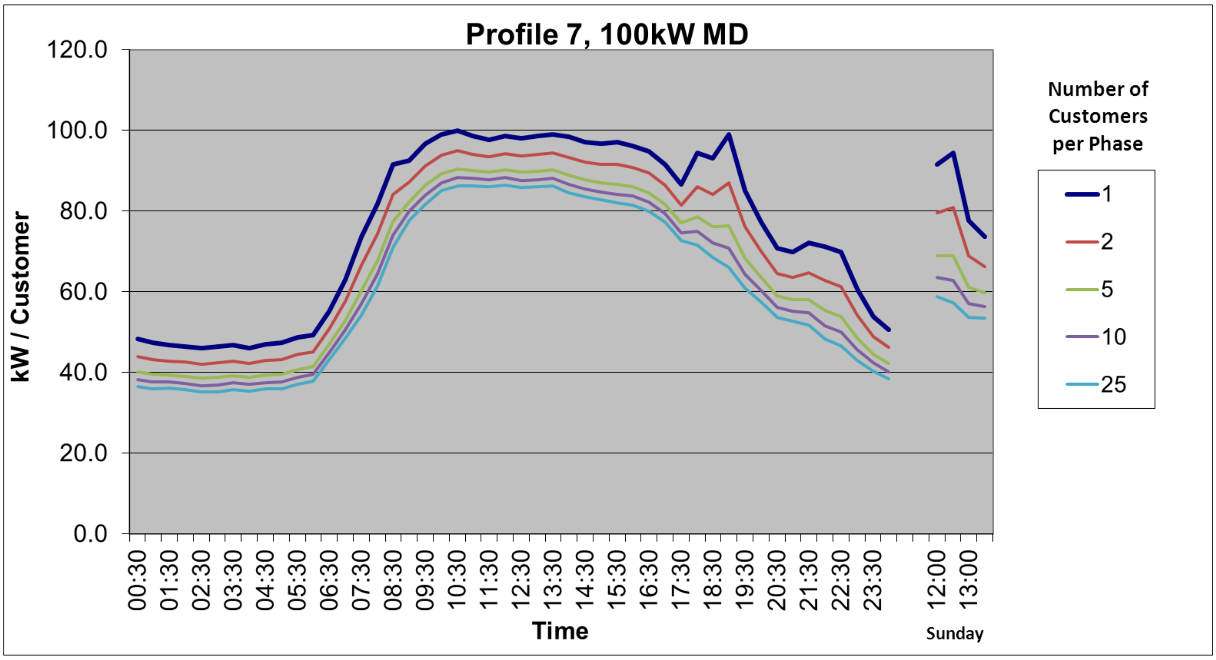
Profile 5



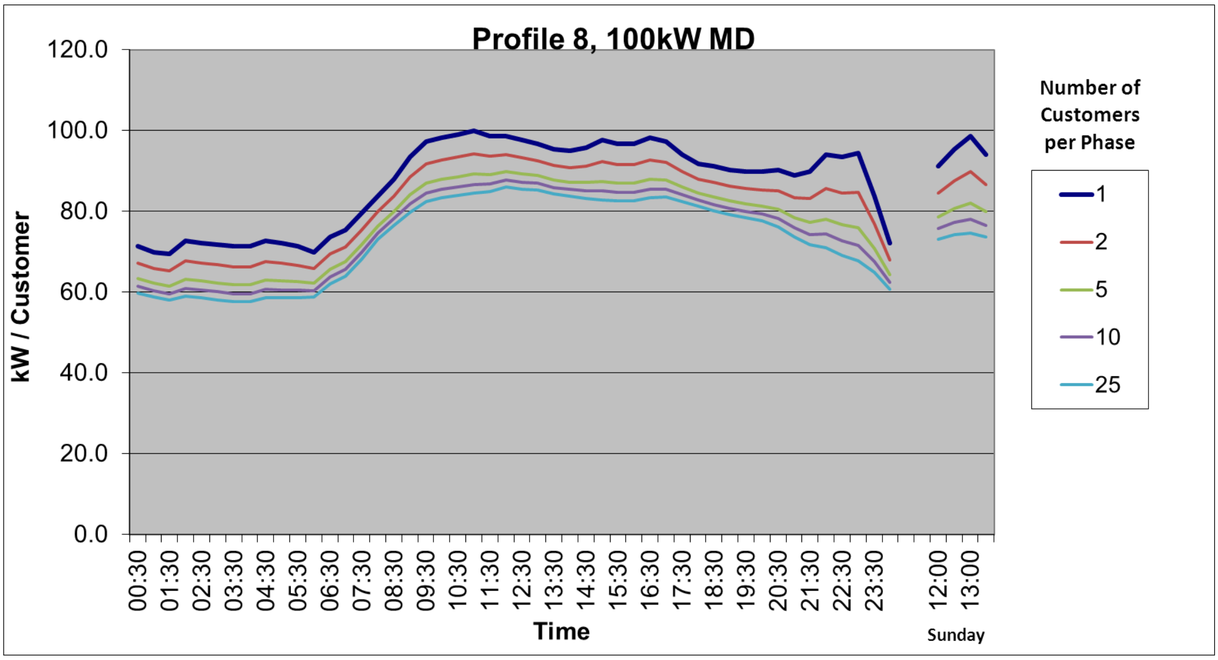
Profile 6



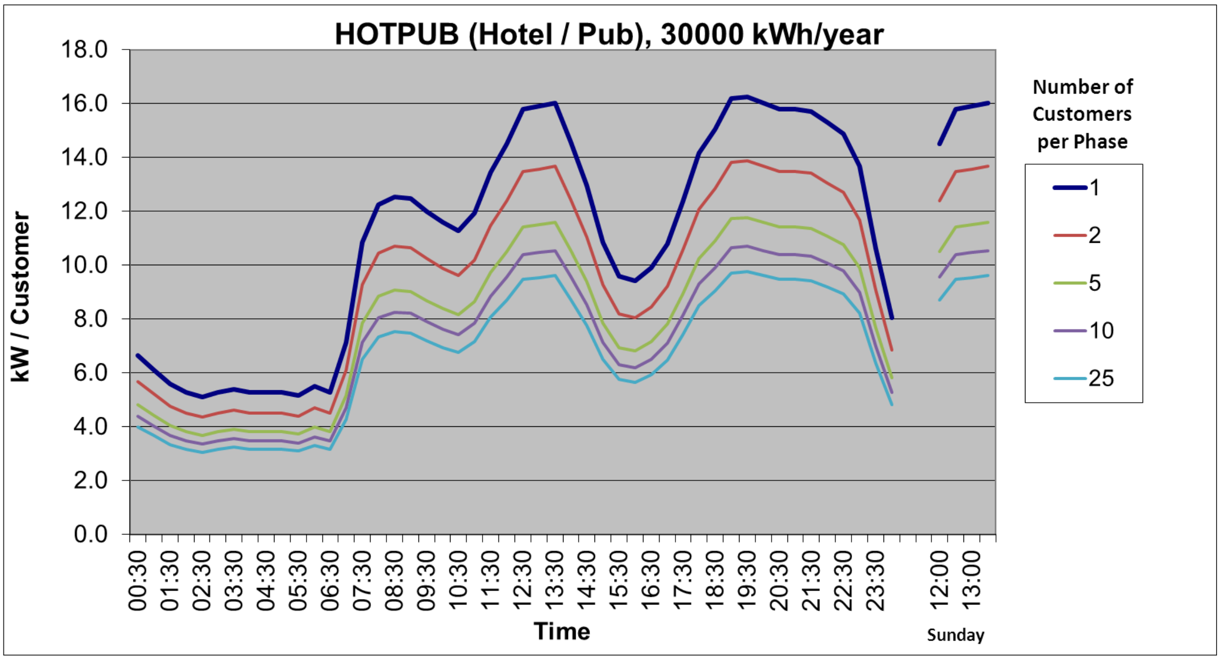
Profile 7



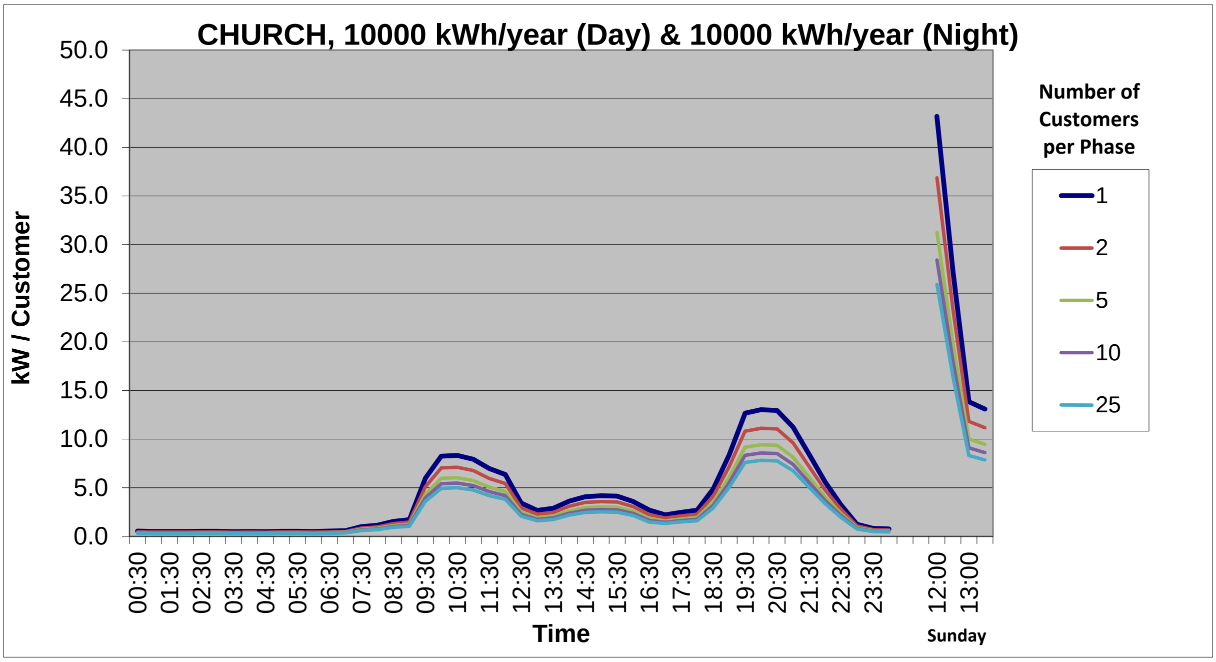
Profile 8



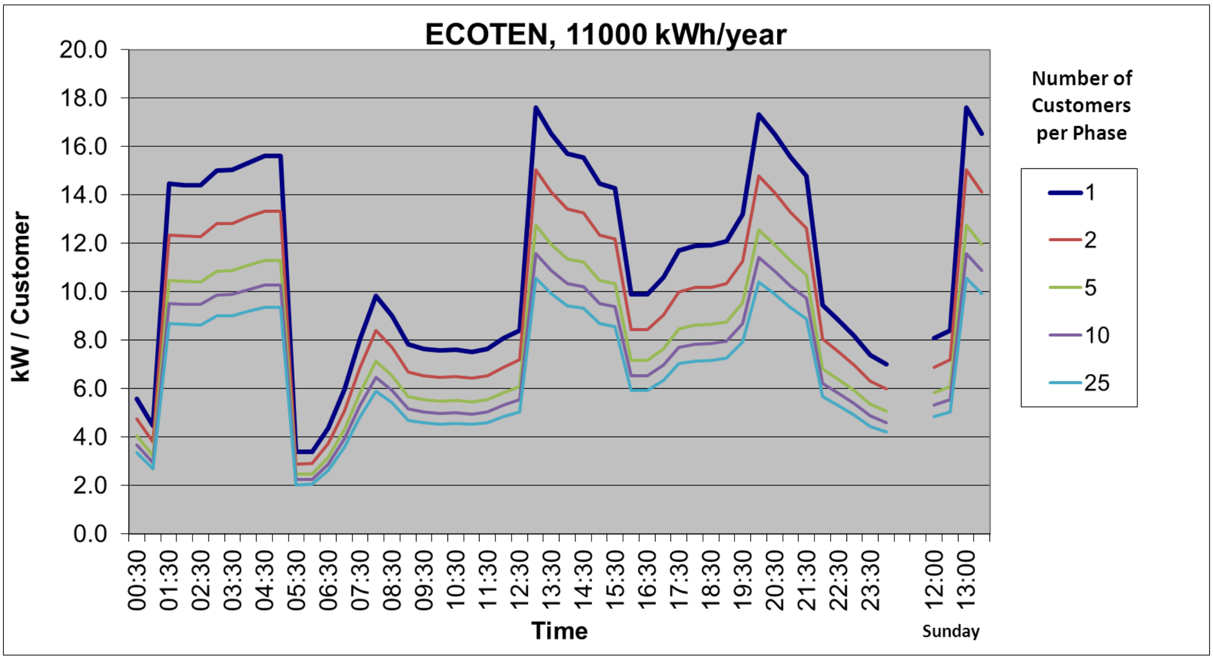
Profile HOTPUB



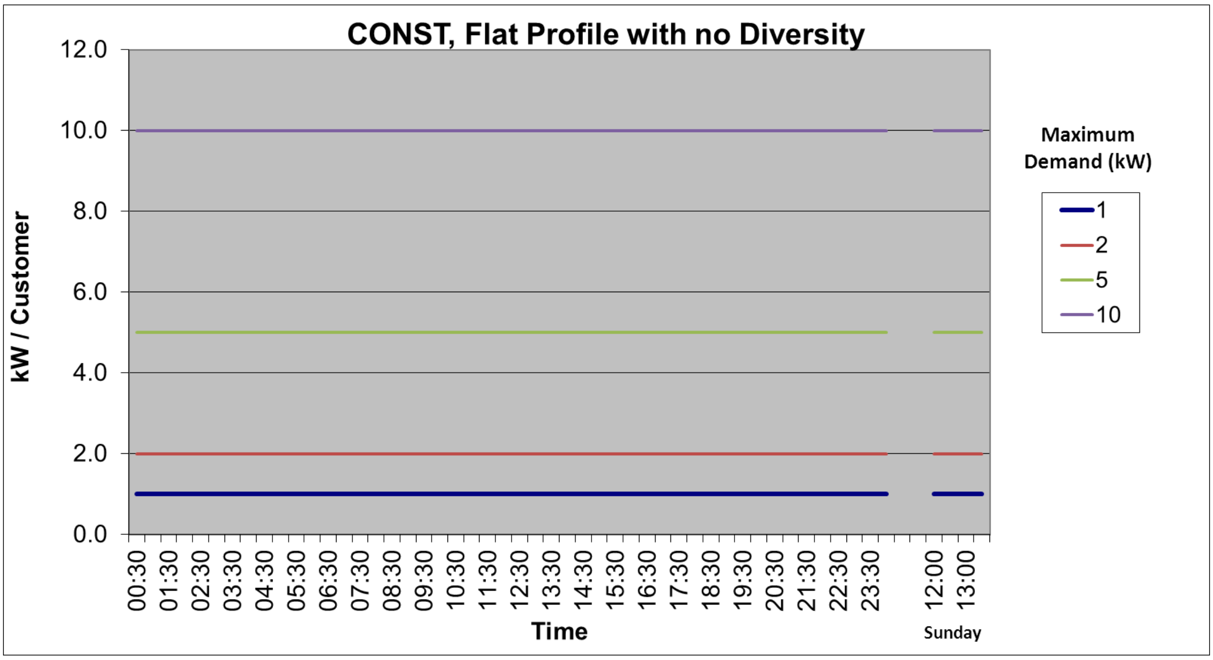
Profile CHURCH



Profile ECOTEN

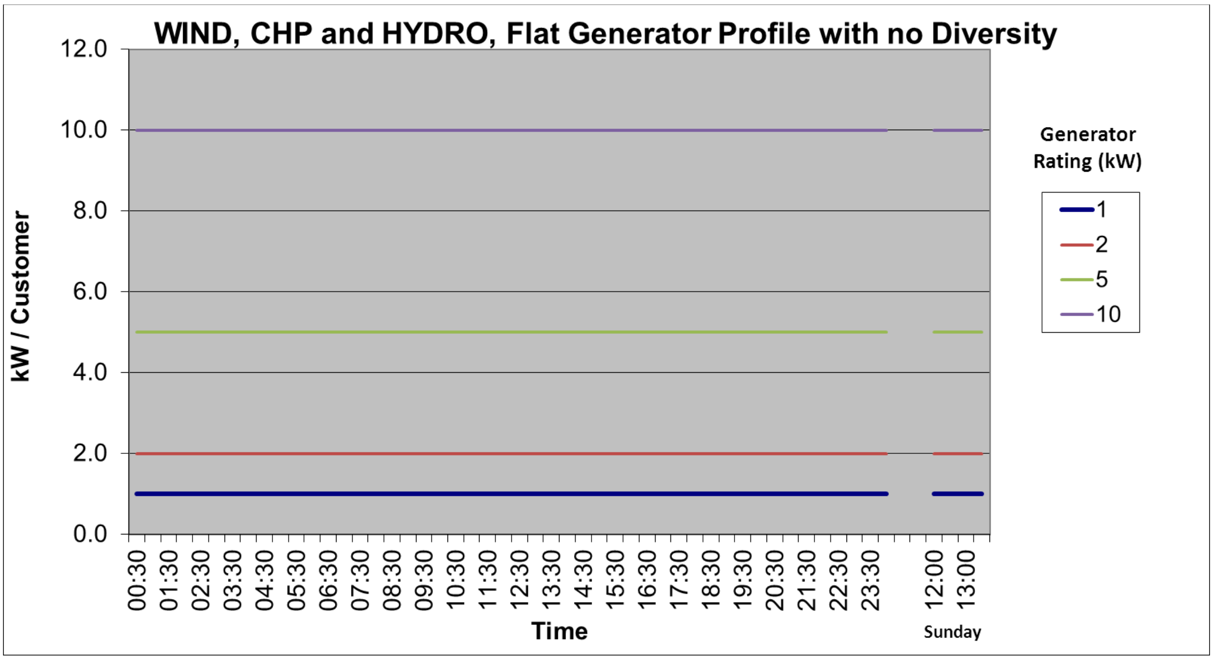


Profile CONST

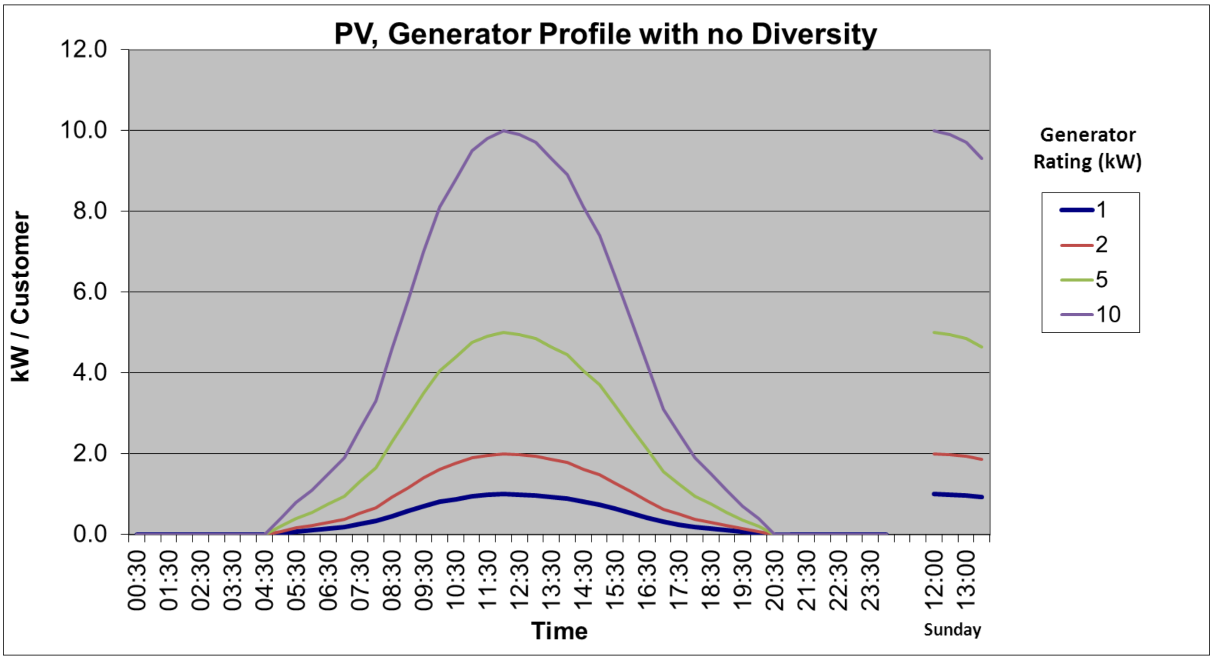


GENERATOR PROFILES

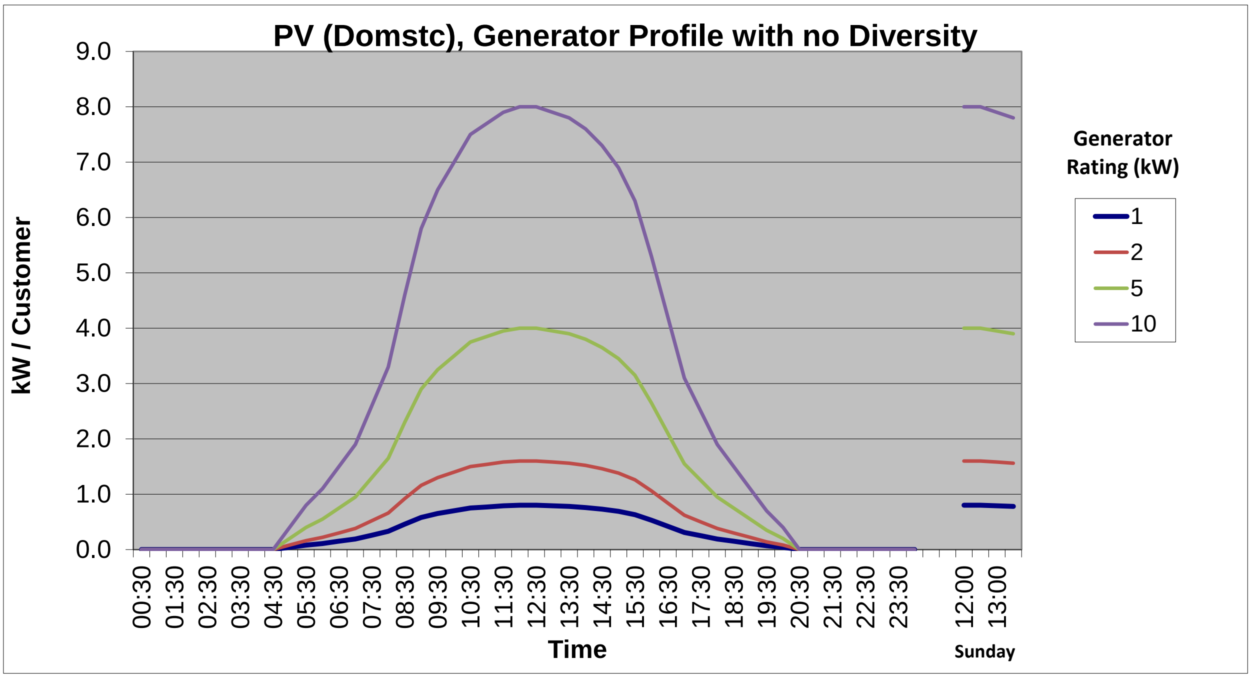
Profile: Wind, CHP and Hydro Generators



Profile: PV Generator – For Commercial Installations



Profile: PV Generator (Domstc) – For Domestic Installations



SERVICE VOLTAGE DROP

C1 Service Voltage Drop - Single Phase Load

Service Reference	Service Voltage Drop (% of 240V) for a 10m service – Single Phase Load								
	1 kW	2kW	3kW	4kW	5kW	7.5kW	10kW	15kW	20kW
Single Phase Services									
AL 0.007	0.228%	0.456%	0.684%	0.913%	1.141%	1.711%	2.281%	-	-
AL 0.0145	0.109%	0.218%	0.328%	0.437%	0.546%	0.819%	1.092%	1.638%	-
AL 0.0225	0.072%	0.144%	0.217%	0.289%	0.361%	0.542%	0.722%	1.083%	1.444%
AL 0.04	0.040%	0.081%	0.121%	0.161%	0.201%	0.302%	0.403%	0.604%	0.806%
AL 25	0.042%	0.083%	0.125%	0.167%	0.208%	0.313%	0.417%	0.625%	0.833%
AL 35	0.030%	0.060%	0.090%	0.121%	0.151%	0.226%	0.301%	0.452%	0.603%
CC 16	0.041%	0.082%	0.122%	0.163%	0.204%	0.306%	0.408%	0.612%	0.816%
CC 25	0.026%	0.052%	0.077%	0.103%	0.129%	0.194%	0.258%	0.387%	0.516%
CC 35	0.017%	0.033%	0.050%	0.067%	0.084%	0.125%	0.167%	0.251%	0.334%
CU 0.007	0.138%	0.276%	0.414%	0.551%	0.689%	1.034%	1.378%	-	-
CU 0.0145	0.066%	0.132%	0.198%	0.264%	0.330%	0.495%	0.660%	0.991%	1.321%
CU 0.0225	0.044%	0.088%	0.131%	0.175%	0.219%	0.328%	0.438%	0.656%	0.875%
CU 0.025	0.044%	0.089%	0.133%	0.178%	0.222%	0.333%	0.444%	0.667%	0.889%
CU 0.04	0.024%	0.049%	0.073%	0.098%	0.122%	0.183%	0.244%	0.366%	0.488%
CU 0.05	0.019%	0.038%	0.057%	0.075%	0.094%	0.141%	0.189%	0.283%	0.377%
CU 16	0.040%	0.080%	0.120%	0.160%	0.200%	0.299%	0.399%	0.599%	0.799%
CU 25	0.023%	0.047%	0.070%	0.093%	0.117%	0.175%	0.234%	0.351%	0.467%
CU 35	0.018%	0.036%	0.055%	0.073%	0.091%	0.136%	0.182%	0.273%	0.364%
HY 25	0.042%	0.083%	0.125%	0.167%	0.208%	0.313%	0.417%	0.625%	0.833%
HY 35	0.028%	0.057%	0.085%	0.113%	0.141%	0.212%	0.283%	0.424%	0.565%
SCC 16	0.041%	0.082%	0.122%	0.163%	0.204%	0.306%	0.408%	0.612%	0.816%
SCC 25	0.026%	0.052%	0.077%	0.103%	0.129%	0.194%	0.258%	0.387%	0.516%
SCC 35	0.017%	0.035%	0.052%	0.070%	0.087%	0.131%	0.174%	0.261%	0.349%

C2 Service Voltage Drop - Three Phase Load*

Service	Service Voltage Drop (% of 240V) for a 10m service - 3 Phase Load								
	3kW	5kW	10kW	20kW	30kW	40kW	50kW	60kW	70kW
Three Phase Services									
AL 0.007	0.171%	0.285%	0.570%	1.141%	1.711%	-	-	-	-
AL 0.0145	0.082%	0.136%	0.273%	0.546%	0.819%	1.092%	1.365%	-	-
AL 0.0225	0.054%	0.090%	0.181%	0.361%	0.542%	0.722%	0.903%	1.083%	1.264%
AL 0.04	0.030%	0.050%	0.101%	0.201%	0.302%	0.403%	0.503%	0.604%	0.705%
AL 25	0.031%	0.052%	0.104%	0.208%	0.313%	0.417%	0.521%	0.625%	0.729%
AL 35	0.023%	0.038%	0.075%	0.151%	0.226%	0.301%	0.377%	0.452%	0.527%
CCT 16	0.030%	0.051%	0.101%	0.203%	0.304%	0.405%	0.506%	0.608%	0.709%
CCT 25	0.019%	0.032%	0.064%	0.128%	0.192%	0.256%	0.320%	0.384%	0.448%
CCT 35	0.013%	0.022%	0.044%	0.088%	0.132%	0.176%	0.220%	0.264%	0.308%
CU 0.007	0.103%	0.172%	0.345%	0.689%	1.034%	1.378%	-	-	-
CU 0.0145	0.050%	0.083%	0.165%	0.330%	0.495%	0.660%	0.826%	0.991%	-
CU 0.0225	0.033%	0.055%	0.109%	0.219%	0.328%	0.438%	0.547%	0.656%	0.766%
CU 0.025	0.033%	0.055%	0.109%	0.219%	0.328%	0.437%	0.546%	0.656%	0.765%
CU 0.04	0.018%	0.030%	0.061%	0.122%	0.183%	0.244%	0.305%	0.366%	0.427%
CU 0.05	0.015%	0.025%	0.049%	0.099%	0.148%	0.198%	0.247%	0.297%	0.346%
CU 16	0.030%	0.050%	0.100%	0.200%	0.299%	0.399%	0.499%	0.599%	0.699%
CU 25	0.018%	0.029%	0.058%	0.117%	0.175%	0.234%	0.292%	0.351%	0.409%
CU 35	0.014%	0.023%	0.045%	0.091%	0.136%	0.182%	0.227%	0.273%	0.318%
HYT 25	0.031%	0.052%	0.104%	0.208%	0.313%	0.417%	0.521%	0.625%	0.729%
HYT 35	0.022%	0.036%	0.072%	0.144%	0.217%	0.289%	0.361%	0.433%	0.506%
SCCT 25	0.019%	0.032%	0.064%	0.128%	0.192%	0.256%	0.320%	0.384%	0.448%
SCCT 35	0.013%	0.022%	0.044%	0.088%	0.132%	0.176%	0.220%	0.264%	0.308%

* *Note: 25% load unbalance is assumed, where load unbalance = 100 x Neutral Current / (Sum of the 3 phase currents).*

C3 Service Voltage Drop – Split Phase Load*

Service	Service Voltage Drop (% of 240V) for a 10m service – Split Phase Load								
	3kW	5kW	10kW	20kW	30kW	40kW	50kW	60kW	70kW
Three Phase Services									
AL 0.007	0.171%	0.285%	0.570%	1.141%	1.711%	-	-	-	-
AL 0.0145	0.082%	0.136%	0.273%	0.546%	0.819%	1.092%	1.365%	-	-
AL 0.0225	0.054%	0.090%	0.181%	0.361%	0.542%	0.722%	0.903%	1.083%	1.264%
AL 0.04	0.030%	0.050%	0.101%	0.201%	0.302%	0.403%	0.503%	0.604%	0.705%
AL 25	0.031%	0.052%	0.104%	0.208%	0.313%	0.417%	0.521%	0.625%	0.729%
AL 35	0.023%	0.038%	0.075%	0.151%	0.226%	0.301%	0.377%	0.452%	0.527%
CCT 16	0.030%	0.051%	0.101%	0.203%	0.304%	0.405%	0.506%	0.608%	0.709%
CCT 25	0.019%	0.032%	0.064%	0.128%	0.192%	0.256%	0.320%	0.384%	0.448%
CCT 35	0.013%	0.022%	0.044%	0.088%	0.132%	0.176%	0.220%	0.264%	0.308%
CU 0.007	0.103%	0.172%	0.345%	0.689%	1.034%	1.378%	-	-	-
CU 0.0145	0.050%	0.083%	0.165%	0.330%	0.495%	0.660%	0.826%	0.991%	-
CU 0.0225	0.033%	0.055%	0.109%	0.219%	0.328%	0.438%	0.547%	0.656%	0.766%
CU 0.025	0.033%	0.055%	0.109%	0.219%	0.328%	0.437%	0.546%	0.656%	0.765%
CU 0.04	0.018%	0.030%	0.061%	0.122%	0.183%	0.244%	0.305%	0.366%	0.427%
CU 0.05	0.015%	0.025%	0.049%	0.099%	0.148%	0.198%	0.247%	0.297%	0.346%
CU 16	0.030%	0.050%	0.100%	0.200%	0.299%	0.399%	0.499%	0.599%	0.699%
CU 25	0.018%	0.029%	0.058%	0.117%	0.175%	0.234%	0.292%	0.351%	0.409%
CU 35	0.014%	0.023%	0.045%	0.091%	0.136%	0.182%	0.227%	0.273%	0.318%
HYT 25	0.031%	0.052%	0.104%	0.208%	0.313%	0.417%	0.521%	0.625%	0.729%
HYT 35	0.022%	0.036%	0.072%	0.144%	0.217%	0.289%	0.361%	0.433%	0.506%
SCCT 25	0.019%	0.032%	0.064%	0.128%	0.192%	0.256%	0.320%	0.384%	0.448%
SCCT 35	0.013%	0.022%	0.044%	0.088%	0.132%	0.176%	0.220%	0.264%	0.308%

* *Note: It is assumed that the neutral conductor is bunched with the spare phase conductor and the load unbalance is 33%, where load unbalance = 100 x Neutral Current / (Sum of the 2 phase currents).*

CABLE / OVERHEAD LINE DATA

D1 WinDebut Cable / Overhead Line Current Rating and Impedance Data can be found in ST:SD7A.

S:\Acrobat\MA\Sd\SD007\SD007A\SD7A_7.pdf

D2 Cable and Overhead Line Fusing and Minimum Short Circuit Current

WinDebut Code	Size (mm^2 or in^2)	Maximum Fuse Rating	Minimum Short Circuit Current (for each fuse rating)								
			100A	160A	200A	250A	315A	355A	400A	500A	630A
Mains Cables and Overhead lines											
ABC	50	500	298	517	719	1099	1710	2270	3164	6939	-
ABC	95	630	298	517	661	848	1032	1437	1877	3132	5510
ABC	120	630	298	517	661	848	1032	1255	1577	2622	3416
AL	0.1	630	298	517	661	954	1416	1907	2539	4658	7870
AL	0.15	630	298	517	661	848	1032	1431	1871	3151	5577
AL	0.2	630	298	517	661	848	1032	1255	1526	2501	3461
AL	0.25	630	298	517	661	848	1032	1255	1454	2087	3358
AL	0.3	630	298	517	661	848	1032	1255	1454	1903	2901
AL	0.4	630	298	517	661	848	1032	1255	1454	1903	2446
AL	0.5	630	298	517	661	848	1032	1255	1454	1903	2446
AL	50	500	298	517	745	1117	1765	2354	3284	7214	-
AL	70	630	298	517	661	909	1322	1806	2442	4330	7626
AL	95	630	298	517	661	848	1032	1454	1924	3229	5659
AL	120	630	298	517	661	848	1032	1255	1637	2683	3436
AL	185	630	298	517	661	848	1032	1255	1454	1903	3149
AL	300	630	298	517	661	848	1032	1255	1454	1903	2446
AO	0.025	400	298	638	944	1470	2342	3238	4450	-	-
AO	0.05	630	298	517	661	944	1357	1800	2388	4158	7406
AO	0.06	630	298	517	661	872	1180	1628	2090	3476	5976
AO	0.075	630	298	517	661	848	1032	1416	1814	2945	4625
AO	0.1	630	298	517	661	848	1032	1255	1511	2388	3484
AO	0.15	630	298	517	661	848	1032	1255	1454	1903	2748
AO	25	400	298	638	944	1470	2342	3238	4450	-	-
AO	50	630	298	517	661	944	1357	1800	2388	4158	7406
AO	100	630	298	517	661	848	1032	1255	1511	2388	3484
AO	150	630	298	517	661	848	1032	1255	1454	1903	2748
CO	0.007	100	298	-	-	-	-	-	-	-	-
CO	0.0225	400	298	687	1014	1604	2596	3671	5016	-	-
CO	0.025	400	298	641	959	1478	2364	3254	4533	-	-
CO	0.05	630	298	517	661	965	1365	1824	2413	4180	7477
CO	0.058	630	298	517	661	863	1188	1638	2115	3492	5916
CO	0.06	630	298	517	661	863	1188	1638	2115	3492	5916
CO	0.1	630	298	517	661	848	1032	1255	1526	2394	3486

WinDebut Code	Size (mm² or in²)	Maximum Fuse Rating	Minimum Short Circuit Current (for each fuse rating)								
			100A	160A	200A	250A	315A	355A	400A	500A	630A
CO	0.15	630	298	517	661	848	1032	1255	1454	1903	2804
CO	16	400	298	647	964	1493	2412	3339	4572	-	-
CO	25	630	298	517	750	1100	1678	2224	3012	6092	-
CO	32	630	298	517	661	960	1408	1852	2438	4295	7626
CO	70	630	298	517	661	848	1032	1255	1454	2286	3492
CO	100	630	298	517	661	848	1032	1255	1454	1903	2772
CS	70	630	298	517	661	906	1322	1806	2422	4330	7626
CS	95	630	298	517	661	848	1032	1454	1924	3229	5659
CS	120	630	298	517	661	848	1032	1255	1637	2683	3436
CS	150	630	298	517	661	848	1032	1255	1454	2188	3401
CS	185	630	298	517	661	848	1032	1255	1454	1903	3149
CS	240	630	298	517	661	848	1032	1255	1454	1903	2446
CS	300	630	298	517	661	848	1032	1255	1454	1903	2446
CU	0.06	630	298	517	661	1005	1532	2054	2774	5464	9426
CU	0.1	630	298	517	661	848	1032	1431	1874	3136	5529
CU	0.15	630	298	517	661	848	1032	1255	1454	2264	3505
CU	0.2	630	298	517	661	848	1032	1255	1454	1903	2882
CU	0.25	630	298	517	661	848	1032	1255	1454	1903	2446
CU	0.3	630	298	517	661	848	1032	1255	1454	1903	2446
CU	0.4	630	298	517	661	848	1032	1255	1454	1903	2446
CU	0.5	630	298	517	661	848	1032	1255	1454	1903	2446
CU	0.6	630	298	517	661	848	1032	1255	1454	1903	2446
CU	0.75	630	298	517	661	848	1032	1255	1454	1903	2446
CU	70	630	298	517	661	848	1032	1375	1772	2987	5049
CU	95	630	298	517	661	848	1032	1255	1454	2325	3497
CU	120	630	298	517	661	848	1032	1255	1454	1955	2189
CU	185	630	298	517	661	848	1032	1255	1454	1903	2446
CU	300	630	298	517	661	848	1032	1255	1454	1903	2446
CU	400	630	298	517	661	848	1032	1255	1454	1903	2446
SA	480	630	298	517	661	848	1032	1255	1454	1903	2446
SA	600	630	298	517	661	848	1032	1255	1454	1903	2446
SA	740	630	298	517	661	848	1032	1255	1454	1903	2446
SA	960	630	298	517	661	848	1032	1255	1454	1903	2446
SA	1480	630	298	517	661	848	1032	1255	1454	1903	2446
SA	1800	630	298	517	661	848	1032	1255	1454	1903	2446
SA	2220	630	298	517	661	848	1032	1255	1454	1903	2446
TR	70	630	298	517	661	848	1032	1405	1863	3203	5729
TR	95	630	298	517	661	848	1032	1255	1454	2474	3461
TR	120	630	298	517	661	848	1032	1255	1454	2921	3358
TR	150	630	298	517	661	848	1032	1255	1454	1903	2446
TR	185	630	298	517	661	848	1032	1255	1454	1903	2446
TR	240	630	298	517	661	848	1032	1255	1454	1903	2446
TR	300	630	298	517	661	848	1032	1255	1454	1903	2446

WinDebut Code	Size (mm² or in²)	Maximum Fuse Rating	Minimum Short Circuit Current (for each fuse rating)								
			100A	160A	200A	250A	315A	355A	400A	500A	630A
WC	95	630	298	517	661	848	1032	1255	1510	2587	3413
WC	185	630	298	517	661	848	1032	1255	1454	1903	2446
WC	300	630	298	517	661	848	1032	1255	1454	1903	2446
Service Cables											
AL	0.007	630	186	290	369	470	575	667	776	981	1244
AL	0.0145	630	186	290	369	470	575	667	776	981	1244
AL	0.0225	630	186	290	369	470	575	667	776	981	1244
AL	0.04	630	186	290	369	470	575	667	776	981	1244
AL	0.06	630	186	290	369	470	575	667	776	981	1244
AL	25	630	186	290	369	470	575	667	776	981	1244
AL	35	630	186	290	369	470	575	667	776	981	1244
CC	16	630	186	290	369	470	575	667	776	981	1244
CC	25	630	186	290	369	470	575	667	776	981	1244
CC	35	630	186	290	369	470	575	667	776	981	1244
CCT	16	630	186	290	369	470	575	667	776	981	1244
CCT	25	630	186	290	369	470	575	667	776	981	1244
CCT	35	630	186	290	369	470	575	667	776	981	1244
CU	0.007	630	186	290	369	470	575	667	776	981	1244
CU	0.0145	630	186	290	369	470	575	667	776	981	1244
CU	0.0225	630	186	290	369	470	575	667	776	981	1244
CU	0.025	630	186	290	369	470	575	667	776	981	1244
CU	0.04	630	186	290	369	470	575	667	776	981	1244
CU	0.05	630	186	290	369	470	575	667	776	981	1244
CU	16	630	186	290	369	470	575	667	776	981	1244
CU	25	630	186	290	369	470	575	667	776	981	1244
CU	35	630	186	290	369	470	575	667	776	981	1244
HY	25	630	186	290	369	470	575	667	776	981	1244
HY	35	630	186	290	369	470	575	667	776	981	1244
HYT	25	630	186	290	369	470	575	667	776	981	1244
HYT	35	630	186	290	369	470	575	667	776	981	1244
SCC	16	630	186	290	369	470	575	667	776	981	1244
SCC	25	630	186	290	369	470	575	667	776	981	1244
SCC	35	630	186	290	369	470	575	667	776	981	1244
SCCT	25	630	186	290	369	470	575	667	776	981	1244
SCCT	35	630	186	290	369	470	575	667	776	981	1244
WC	35	630	186	290	369	470	575	667	776	981	1244

APPENDIX E

TRANSFORMER DATA

WinDebut Code	Transformer Rating (kVA)	Resistance (Ohms)	Reactance (Ohms)	Iron losses (Watts)	Full Load Copper Losses (Watts)
GMT	1000	0.00219	0.00863	1283	10708
GMT	800	0.00291	0.01070	1120	8870
GMT	750	0.00313	0.01150	1000	6300
GMT	500	0.00509	0.01710	755	6211
GMT	315	0.00901	0.02680	600	4146
GMT	300	0.00948	0.02810	520	3000
GMT	200	0.01580	0.04060	417	3091
PMTTRP	315	0.00900	0.02680	600	4146
PMTTRP	200	0.01580	0.04060	417	3091
PMTTRP	100	0.03710	0.08100	243	1818
PMTTRP	50	0.08760	0.14400	113	1073
PMTTRP	25	0.20800	0.26600	70	636
PMTSIN	100	0.01113	0.025500	243	1636
PMTSIN	50	0.02660	0.049600	113	973
PMTSIN	25	0.06120	0.094400	65	559
PMTSIN	16	0.10800	0.13900	48	405
PMTSIN	15	0.11800	0.14600	73	430
PMTSIN	10	0.19100	0.20600	57	310
PMTSIN	5	0.43000	0.36200	39	175
SPLT	1000	0.00220	0.00860	1283	7139
SPLT	800	0.00291	0.01070	1120	5913
SPLT	750	0.00313	0.01150	1000	4200
SPLT	500	0.00509	0.01710	755	4141
SPLT	315	0.00901	0.02680	600	2764
SPLT	300	0.00948	0.02810	520	2000
SPLT	200	0.01580	0.04060	417	2061
SPLT	100	0.02225	0.05100	243	1636
SPLT	50	0.05320	0.09920	113	973
SPLT	25	0.11240	0.18880	65	559

UNBALANCED LOAD EXAMPLE

F1 Where 3 phase consumers are modelled it is often necessary to consider a certain amount of un-balance. If un-balance is ignored it is possible that the voltage drop or voltage rise will be understated by WinDebut. This is particularly important when using WinDebut to assess the impact of large maximum demand customers.

F2 The following example, shoes how un-balance can be handled by WinDebut:

- Consumer: Maximum Demand = 180kVA Profile 6.
- Existing Transformer Rating: 500kVA.
- Location 200m from the substation.

F2.1 If the load were balanced this would equate to 60kW (250A) per phase (WinDebut uses 240V for load calculations). To take account of unbalance it is recommended that in this case 60kW is modelled on two of the phases and 30kW is modelled on the third phase. This would give rise to 250A in the heavily loaded phases, 125A in the lightly loaded phase and 125A in the neutral. This is shown in Figure F1.

The % unbalance in this case is determined as follows:

% Unbalance = 100 x Neutral Current / Sum of the Phase Currents

= 100 x 125 / (250+250+125)

= 20%

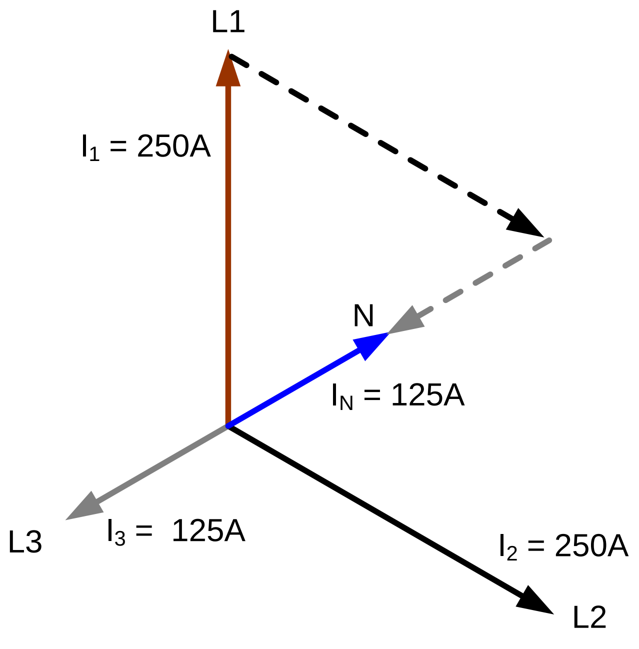


Figure F1 Unbalanced Current Example

F.2.2 In order to replicate this example in WinDebut, set up 3 customers at a Point Load. Consumer 1 is set to 60kW (*Maximum Demand no – q*) and placed on the red phase. Consumer 2 is also set at 60kW and placed on the yellow phase and Consumer 3 is set to 30kW and placed on the blue phase. Note, WinDebut still uses the old phase colours:

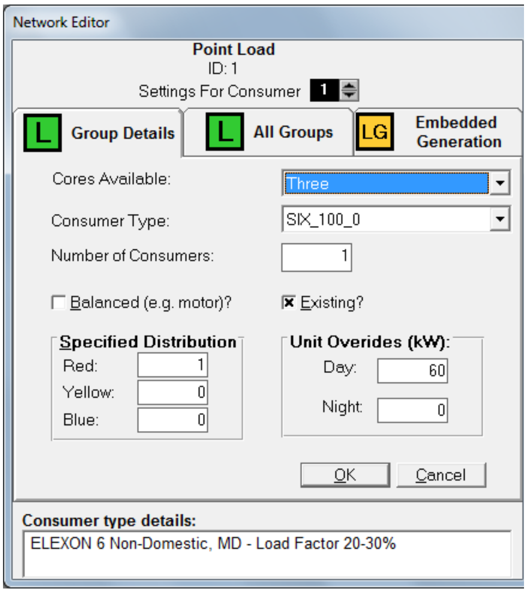


Figure F2 Consumer 1 (60kW red phase)

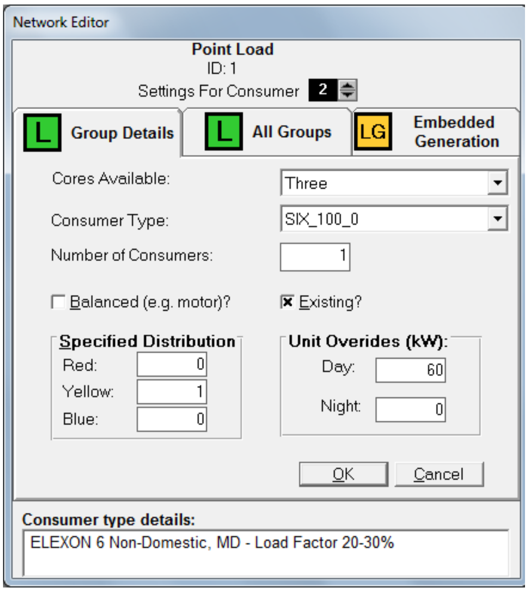


Figure F3 Consumer 2 (60kW yellow phase)

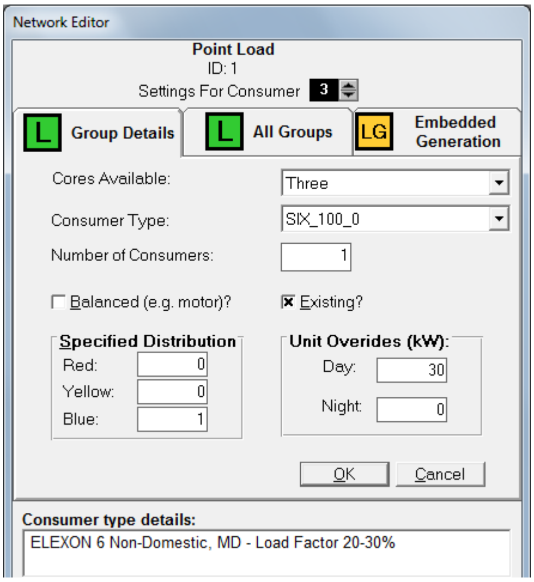


Figure F4 Consumer (30kW blue phase)

F2.3 When the model is run the voltage drop is found to be 4.48% (with 185 wavecon cable along the whole 200m length). This voltage drop is below the maximum acceptable value of 5.75% (for mains and services). Note, as the cable is used as a service then the 5.75% limit may be applied rather than 4.79% value (but WinDebut defaults to 4.79% if no "service" cables are modelled).

F.2.4 By way of comparison, if the load is modelled as a balanced three phase load of 180kW *Maximum demand with no - q* the voltage drop is 3.59%. In this case the voltage drop is lower because there is no current flowing in the neutral.

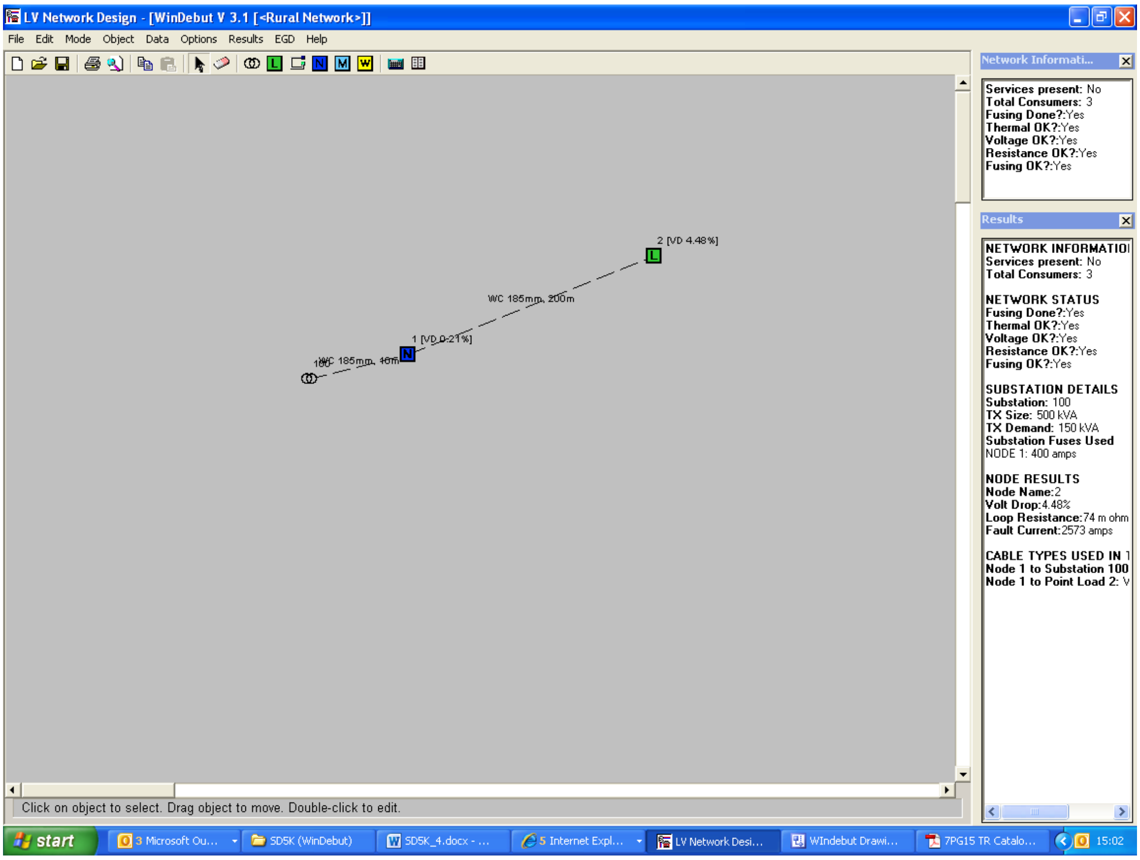


Figure F5 Results for Unbalanced Load Example (60kW in R and Y phase, 30kW in B phase)

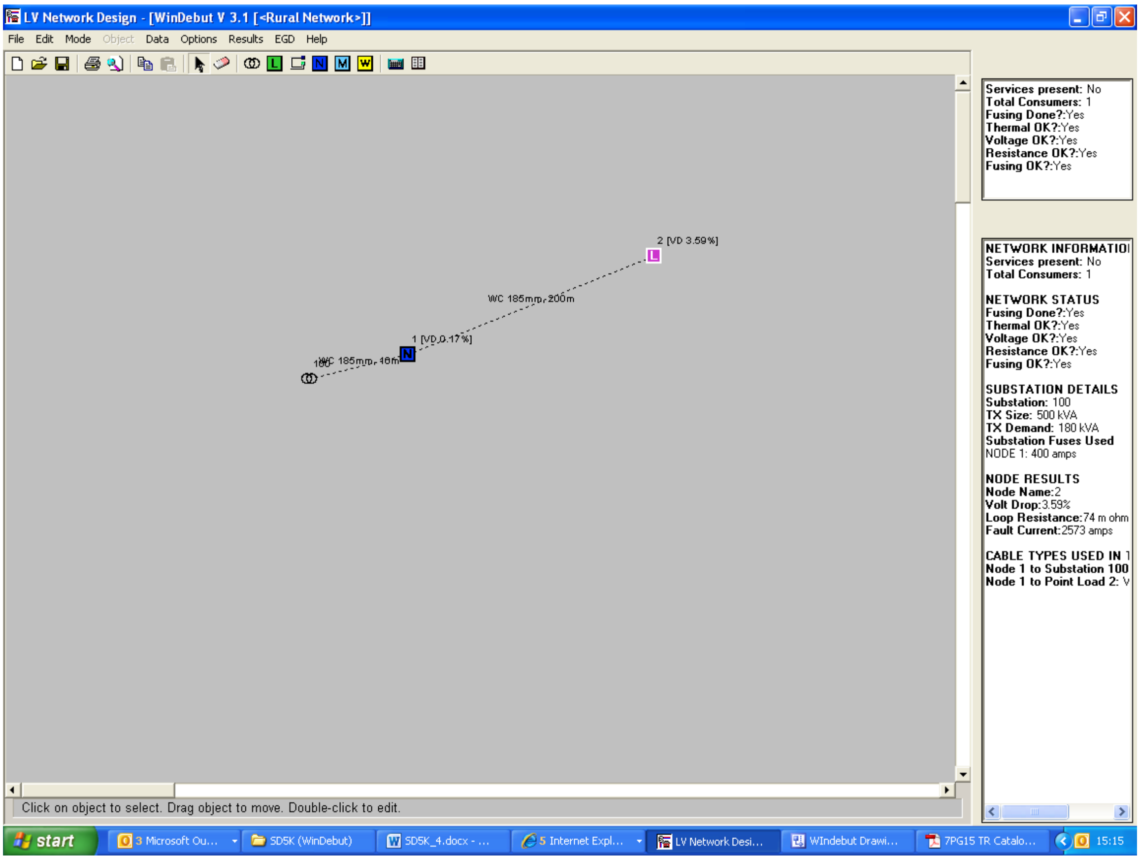


Figure F6 Results for Balanced Load (180kW balance perfectly across 3 phases).

DISCREPENCY WITH MAXIMUM DEMAND CONSUMERS

When MD type consumers are modelled in WinDebut two options are available. The first option, *Maximum Demand (kW)* allows WinDebut to apply diversity between consumers with the same profile connected to the same phase, whilst the second option *Maximum Demand – no Q (kW)* prevents diversity being applied.

When the *Maximum Demand (kW)* option is selected and the *balanced* option is selected then the method used by WinDebut to calculate phase current gives rise to unexpected results. In such cases WinDebut scales down the current by a factor which is dependent on the “p” and “q” values that are used to define the demand for each half hour of the relevant profile. If the “q” values are the same as the “p” values (which is the case for some profiles) the calculated current is 70% of the expected current.

A full explanation of the rationale for this calculation is included in the EA Technology Guide to WinDebut. A summary of the impact of this scaling factor is given in Table F1, below.

Given this discrepancy, it is recommended that the *Maximum Demand – no q (kW)* option is used as this gives the expected values of current, where the Consumer MD is known (i.e. where it is derived from metered values or from the consumers Agreed Supply Capacity).

Profile Type	Single 100kW MD Consumer with Diversity Current Calculated by WinDebut (240V base)		
	Expected Max. Current (A)	Calculated Max. Current (A)	% of Expected value
1	138.9	101.2	72.9%
2	138.9	119.9	86.3%
3	138.9	97.2	70.0%
4	138.9	96.4	69.4%
5	138.9	91.9	66.2%
6	138.9	118.5	85.3%
7	138.9	124.5	89.6%
8	138.9	123.8	89.1%
HOTPUB	138.9	97.2	70.0%
CHURCH	138.9	97.2	70.0%
ECOTEN	138.9	97.2	70.0%

Table G1 Discrepancy in WinDebut Current Calculations for 3 phase MD Consumers when the Maximum Demand (kW) option is selected

APPENDIX H

SUPERSEDED DOCUMENTATION

The document supersedes ST:SD5K/5 dated March 2017 which has now been withdrawn

APPENDIX I

ASSOCIATED DOCUMENTATION

ST: SD5A:	Design of Low Voltage Domestic Connections.
ST: SD5R:	Earth Fault Loop Impedances and Phase to Neutral Loop Impedances at LV Installations
ST: SD8A:	Overhead Line Ratings.
ST: SD8B Part 1:	Underground Cable Ratings (LV).
ST: TP4B:	11KV and 6.6kV Transformer Protection.
ST: OH4H:	Mounting of Auxiliary Equipment on Wood Poles.
ST: SD6F:	Dealing with Potentially Disturbing Electrical Loads/Equipment.
ST: SD6J:	Connection Design - Potentially Disturbing Electrical Equipment Rated <=75A/Phase Subject to Conditional Connection.
ST: SD7A	The Data Sets Used with Windebut Software

APPENDIX J

KEY WORDS

WinDebut, Design, Domestic Connection, Voltage drop, Voltage Rise, Housing Estate, Motor, Welder.