MANUAL FOR ESKOM DISTRIBUTION PROFILE MIXER TOOL (DPM)

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1 ABOUT ESKOM DISTRIBUTION PROFILE MIXER TOOL

The Distribution Profile Mixer Tool is a software application for estimating the aggregate hourly load profile for consumers from different domestic consumer classes.

This software provides analysis of the impact of summated loads at given consumption levels, and using load models which have been derived from extensive research by the authors, using data collected during the course of the NRS Load Research Project since1995.

Typical use cases would be:

- Total residential load on a feeder
- Total residential load in an area
- What-if scenarios for load planning

All these use cases assume that the consumers are in the same geographical area and the application does not allow mixture of consumers from different geographical areas.

Boundaries of operation

At this time, the application has the following boundaries:
Average householder consumption 0- 1200 kwh/mth.
Geographical boundaries: The tool is only designed to operate inside the boundaries of South Africa.

Period of validity

The current version of the application is designed to auto-update itself whenever there is new data or models available, over the internet. Typically data and profile models are reviewed every 3-4 years.

Please use the contacts given in the “about” page if you have any queries.

2 SYSTEM REQUIREMENTS

Operating system: Windows XP, Vista and Windows 7.
Processor: Intel Pentium 4 or later
Free disk space: 577 MB (typical)
Ram: 512 MB

This application uses HTML5.0 technology.

A small chrome browser is installed on the client, with all necessary program code (Java), lookup data (ie load profiles) and GIS Map data.

The code and data is kept updated via internet link whenever newer versions are available or more detailed map data is requested when the user zooms beyond the level of the local cache. Such updates only happen at run-time, if there is network connectivity.

Network connectivity is otherwise not essential for software to operate

3 WORKING WITH THE SOFTWARE

3.1 Installation

The Distribution Profie Mixer computer program is distributed as a download from https://di.enerweb.co.za/dpm/installers/

The install file is roughly 80 MB in size.

Use the normal installation procedure for Windows applications should be followed to install the program.

3.2 Overview: Parts of the application

The application contains the following parts:

- **Consumption histogram:** Handles capture of a mixed load scenario. *Save* and *Load* of the scenario are supported.

- **Profile:** Produces hourly profiles and Load/time views, Applied filters and modes, and an energy matrix by filtered types. Results of scenarios may be saved as either images or values.

- **TOU setup:** Supports setup for a complete TOU scenario for a year. *Save* and *Load* of the TOU scenario are supported.

- **About:** Acknowledgments and contacts (in case you have any problems).

3.3 How to generate a scenario

Profile mixer scenarios are driven by Consumption class mixes, and Geographical location (Location contains East-west effects and climatic response).

The following steps should be followed:

- Capture numbers of consumers in each consumer-class on the **Consumption histogram** page.
- Indicate the approximate position of the site on the map in **Consumption histogram** page (fine accuracy is not essential).
- Navigate to the **Profile** page, and press *Calculate*.
- View the resulting profile, and apply filters as necessary.

<u>Profile view</u>

The following filters may be applied in profile mode:

- Day type (ie weekday or Saturday/Sunday)
- Season (Month of year or TOU season)

Resulting profiles may be displayed as gross hourly load, or load per consumer.

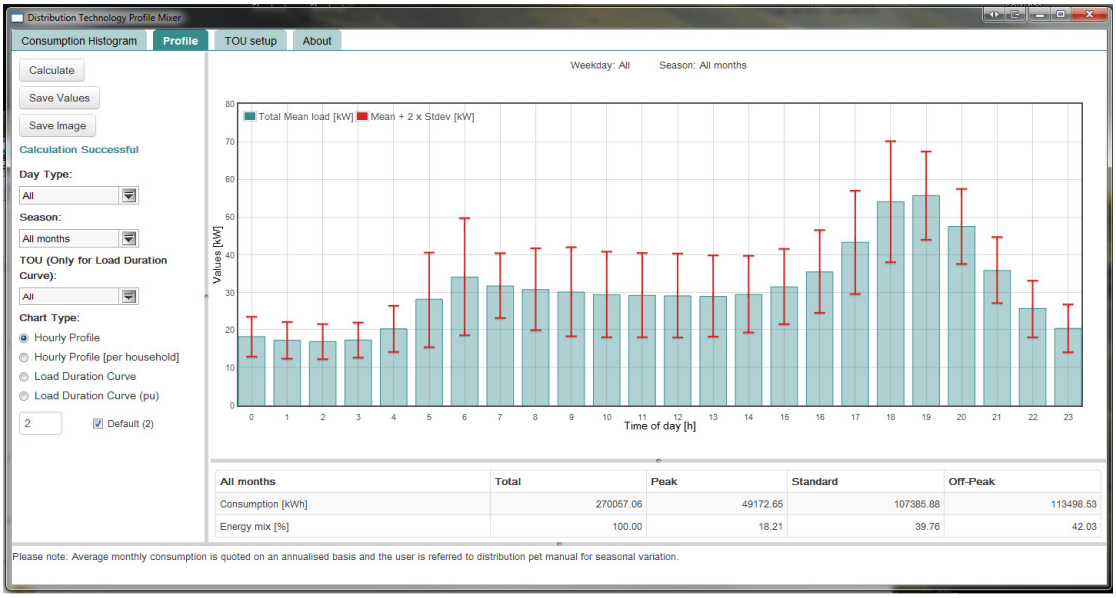

Figure 1 Load profile shown for 100 consumers, all day types and all months of the year.

<u>Load-duration view:</u>

The following filters may be applied in the load/duration view:

- Day type (ie weekday or Saturday/Sunday)
- Season (Month of year or TOU season)
- TOU period (peak std or off peak)

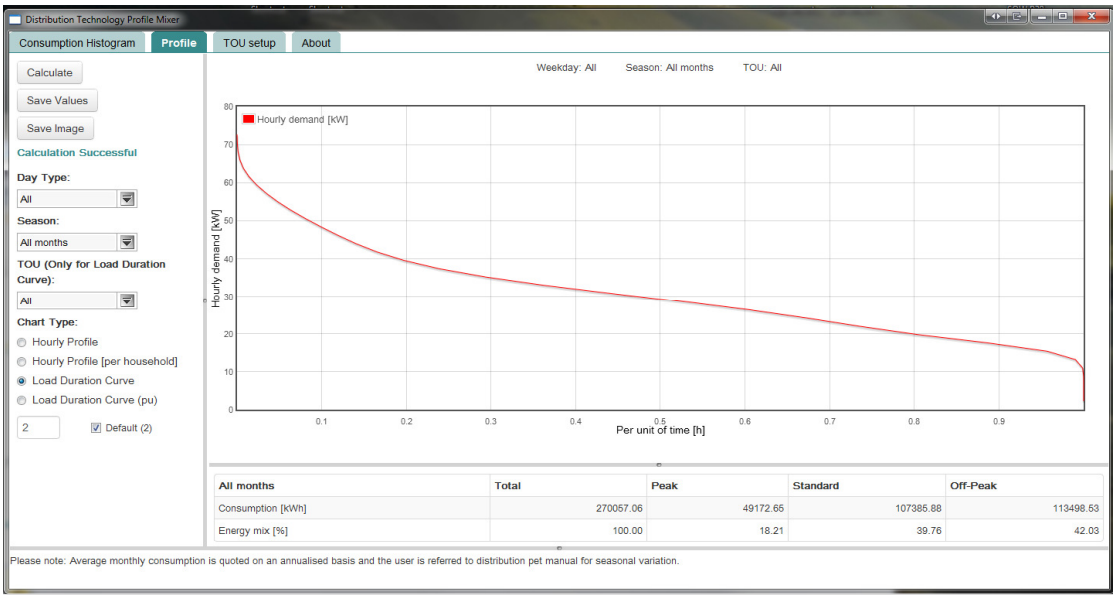

Figure 2 Load duration curve shown for 100 consumers, all day types and all months of the year.

Load–duration view can be expressed as either gross hourly Load over the available hours (if there is filtering), or as %Load vs %Time.

A data grid under the graph shows how sub-totals of the consumptions per TOU period (for the filtered day-type and season).

4 CONSUMER CLASSES AND THE PROFILE LIBRARY

4.1 Consumer classes

The consumer classes (C) are based on average monthly consumption ranges as follows:

- 0 – 150 kWh
- 150 – 200 kWh
- 200 – 250 kWh
- 250 – 300 kWh
- 300 – 400 kWh
- 400 – 500 kWh
- 500 – 600 kWh
- 600 – 700 kWh
- 700 – 800 kWh
- Greater than 800 kWh

The user can specify the number of consumers per class, N_c.

The consumption referred to in a class is average monthly consumption per connection. The consumption is the real value (i.e. includes theft).

4.2 Profile library

For each consumer class, a profile was estimated using DPET profile models[1].

The estimated profile has the following components:

- Hourly mean and standard deviation values
- Aggregated per weekday, Saturday and Sunday
- Aggregated per month

For example the following figure show the hourly average weekday mean and standard deviation values for 100 customers (N_c = 100) in consumption class (C) 200-250kWh/household/month for the month of May.

[1] The maintenance and derivation of these load profile models and their reliability is published by the authors at local conferences in South Africa.

The mean load profile ($M_{c,h,w,s}$) for a particular class(C), hour (h), weekday type (w) and season (s) is calculated as

$$M_{c,h,w,s} = N_c.P_{c,h,w,s} \qquad (1)$$

Where
N_c is the number of consumers for class C
$P_{c,h,w,s}$ is the normalized profile for class C, hour h, weekday type w and season s

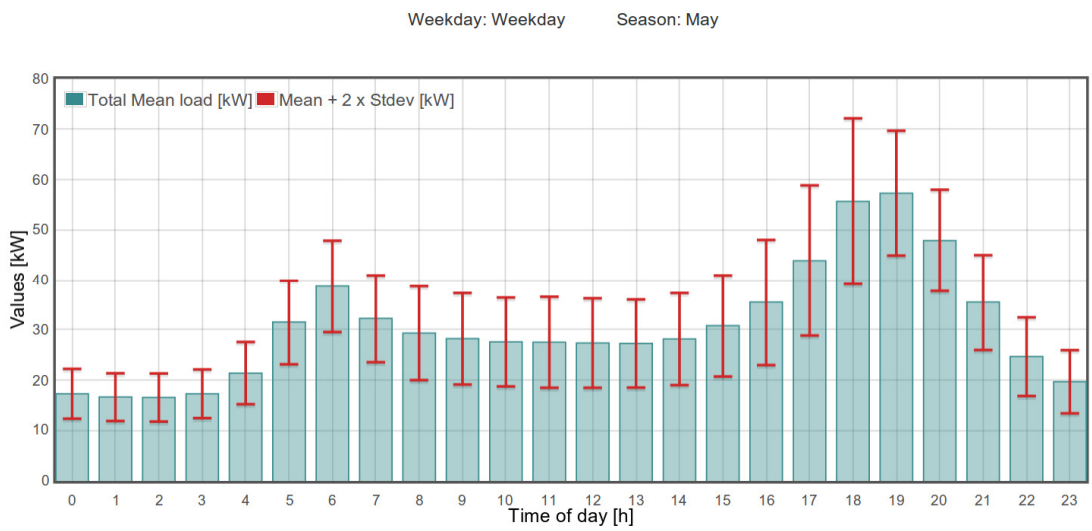

Figure 2 Average weekday profile for 100 consumers (N_c) in consumption class 200-250kWh / consumer for the month of May – showing mean and mean+2standard deviation of load.

The standard deviation is shown as an error bar around the mean and the length of the bar is two standard deviations up and two standard deviations down, i.e. four in total. Assuming a standard normal distribution, this equates to about 95% confidence interval and 98% (one-tail) confidence level.

The standard deviation does not include the differences between consumers and only reflects the "repeatability" of the total load within a particular hour, for a weekday type and season type. **For small numbers of consumers (<30), this significantly understates the load uncertainty and should be avoided.**

5 PROFILE AGGREGATION ALGORITHM

5.1 Aggregation of mean load profile

The aim of the aggregation algorithm is to calculate the aggregate mean and standard deviation load profile for a mixture of consumer classes. For each class (C) the number of consumers (N_c) is specified and then aggregation proceeds as follows:

$$M_{hws} = \sum_c N_c P_{chws} \qquad (1)$$

Where

M_{hws} is the aggregated scaled mean profile for hour h, weekday type w and season s

N_c is the number of consumers for class c

P_{chws} is the normalized mean load profile for class c for hour h, weekday type w and season s

The aggregate mean load profile is therefore a weighted sum of the load profiles for the individual load classes.

The calculation of the aggregate load profile standard deviation requires some assumption about the correlation within and between load classes.

A "load class" is conveniently defined as a group of customers of similar load behavior who react to external stimuli in a similar manner (ie they consume similar amounts and have significantly more correlation than adjacent load classes which are of dissimilar load behavior and far less correlated).

These assumptions simplify the estimation of resulting standard deviation significantly[2].

5.2 Aggregation of standard deviation (within same class)

The standard deviation load profile ($S_{c,w,h,s}$) for consumption class C, hour h, weekday type w and season s is calculated as

$$S_{c,w,h,s} = N_c . R_{c,h,w,s} \qquad (2)$$

Where

$S_{c,w,h,s}$ is the standard deviation load profile for consumption class c, hour h, weekday type w and season s

N_c is the number of consumers in consumption class c

$R_{c,h,w,s}$ is the normalized standard deviation load profile for consumption class c, hour h, weekday type w and season s

This scaling implies perfect correlation between the consumers of class c and is a consequence of the definition of the standard deviation.

Because perfect correlation is optimistic, this assumption leads to an over-estimation of the total standard deviation.

[2] The assumptions applied here are the same as those used in Geo-based Load Forecasting (GLF) currently: Within subclasses, correlation = 1, between subclasses correlation = 0.

5.3 Aggregation of standard deviation (between classes)

A correlation of zero is assumed between different load classes. Under this assumption, the following aggregation formula for the aggregate standard deviation is applicable:

$$S_{hws} = \sqrt{\sum_c {N_c}^2 {R_{chws}}^2} \qquad (3)$$

Where

$S_{w,h,s}$ is the aggregate load profile standard deviation for hour h, weekday type w and season s

N_c is the number of consumers in consumption class c

$R_{c,h,w,s}$ is the normalized standard deviation load profile for consumption class c, hour h, weekday type w and season s

This assumption is pessimistic and leads to an under-estimation of the total standard deviation.

<u>Because of these combined effects, scenarios with mixed consumption classes do approximate the expected diversity/coincidence for hourly loads.</u>