A Probabilistic Domestic Electricity Demand Model for Demand Side Management Studies

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Abstract

This manual provides technical details of a residential load model tool developed for the analysis of smart grid functionalities in low-voltage networks. The model has been developed in MATLAB software. The methodology uses a Markov chain Monte Carlo approach to generate residential demand profiles from user activity patterns. The demand profiles are combined with the electrical characteristics of individual appliance to create detailed time-varying electrical models of residential loads.

An agile software development cycle has been implemented to allow for flexibility and future modifications. This is realised in the modular structure of the software, which consists of a number of interacting functions. The technical description included herein presents the inputs and outputs of the entire software package and each function in turn. Two generic loads types are also defined to allow the user to add to the load types already included in the model. Instructions of this process are also included within the manual.

Source code location: https://github.com/kiprakis/DESIMAX

DESIMAX project website: https://www.desimax.eng.ed.ac.uk/

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1 Introduction

This manual provides an overview of a residential demand model. The model provides active and reactive power demand profiles, and also the corresponding load model coefficients for use in power flow studies.

2 Model overview

The modeling approach developed in this paper is divided into four stages:

1. user activity modeling;
2. generating a set of electrical appliances;
3. conversion of user activities to electrical appliance use;
4. aggregation of the electrical appliances to build household power demand profiles and load models.

3 Directory structure

The software has been developed in a modular fashion, with one single code to act as the upper level and control data flow between submodules. The structure of the software is shown below in Figure 1. Each level of indentation denotes a dependency between two separate modules, e.g. initial_condition.m is called by activity_profile_generation.m. All modules have been given a descriptive name to reflect their functionality.

4 Content of this manual

The modules are described in Section 5. Each module is described in the same way. A brief functional description is provided followed by the input (arguments) and output (returns) of each module.

Configuration data is defined in Section 6.

Output data is discussed in Section 7.

Some guidance on using the software and modifying the data is included in Section 8.

```
desimax/
  LICENSE
  requirements.txt
  version_history.txt
  code/
    desimax.m
      user_defined_load.m
      hh_user_type.m
      round_hh_composition.m
      activity_profile_generation.m
        - initial_condition.m
        - check_device_sharing.m
      appliance_population.m
      activity_to_power.m
        - electric_shower_loads.m
        - cooking_loads.m
        - wet_loads.m
        - clothes_drier.m
        - ce_ict.m
        - lighting_loads.m
        - heating_loads.m
        - electric_vehicles.m
      zip_aggregation.m
  data/
    .xlsx : ce_ict, cold_loads, cooking_loads, ev_loads, general, heating_loads
            lighting_loads, misc_loads, wet_loads
    .mat : DesTemp, IC, irradiancedata, Sharing, TM
  docs/
    manual.pdf
  output/
  examples/
    user_defined_load_type_one.xlsx
    user_defined_load_type_two.xlsx
```

Figure 1: Directory structure.

5 Modules

5.1 desimax.m

This code is the highest hierarchical control level and coordinates data flow between the four main subroutines. It is responsible for loading the configuration data, initializing and controlling data flow between the subroutines and exporting the results.

This iterates over each household and each household occupant of the defined population. Each household occupant is assigned an activity profile in *function* **activity_profile_generation** and each household is assigned a set of appliances in *function* **appliance_population**. These are combined to produce a total household demand profile in *function* **activity_to_power**, with the corresponding household ZIP model calculated in *function* **zip_aggregation**.

5.2 activity_profile_generation.m

5.2.1 Description

This function generates the household occupant activity profiles. This is implemented as a Markov chain process, with initial conditions in *variable* IC and transition probabilities in *variable* TM. The initial state is set in *function* **initial_condition**. This function also creates the total household occupancy profile which carries information of the total number of active occupants for every instance of time.

For multiple occupancy households, there is a probability that certain appliances will be used by more than one occupant at any given time. These probabilities are stored in *variable* Sharing. This functionality is included in the modelling approach by an additional stage after the user activity time series have been synthesized in *function* **check_device_sharing**.

The *variables* Sharing, TM and IC are described in Sections 6.1, 6.2 and 6.3, respectively.

5.2.2 Arguments

The function arguments are shown in Table 1.

5.2.3 Returns

The parameters returned by the function are shown in Table 2.

Table 1: Activity profile generation module: Arguments

Parameter	Structure	Unit	Description
n_occ	int	-	The number of occupants in the household
n_working	int	-	The number of working occupants in the household
day	int	-	Day identifier
agg_size	int	-	The total number of households to be created
TM	cell	-	DataStructure to hold the transition matrix probabilities
IC	cell	-	DataStructure to hold the transition matrix probabilities
Sharing	cell	-	DataStructure to hold the transition matrix probabilities

Table 2: Activity profile generation module: Returns

Parameter	Structure	Unit	Description
profiles	cell	-	DataStructure to hold the user activity profiles. Each user is represented by a 144x17 array
hh_occ	array	-	DataStructure to hold the overall household occupancy data. Each household is represented by a 1x144 array, with the integer value indicating the number of active occupants

5.3 initial_condition.m

5.3.1 Description

This function sets the initial condition of the user. The initial conditions probabilities are converted into a cumulative distribution and the user state is selected by comparison with a randomly generated number. Each household type has a unique distribution.

The *variable* <u>IC</u> is described in Section 6.3.

5.3.2 Arguments

The function arguments are shown in Table 3.

5.3.3 Returns

The parameters returned by the function are shown in Table 4.

Table 3: Initial condition module: Arguments

Parameter	Structure	Unit	Description
IC	array	-	Probability array of initial conditions
r	float	-	A random number

Table 4: Initial condition module: Returns

Parameter	Structure	Unit	Description
stateone	int	-	User initial activity state

5.4 check_device_sharing.m

5.4.1 Description

For multiple occupancy households, there is a probability that certain appliances will be used by more than one occupant at any given time. The algorithm identifies every time period when multiple users have the same activity and uses the device sharing probability from *variable* devicesharing to determine if the activity is shared or not. If the activity is shared then the activity occurrence is removed from the secondary user to avoid double counting of the load use.

The *variable* devicesharing is described in Section 6.1.

5.4.2 Arguments

The function arguments are shown in Table 5.

5.4.3 Returns

The parameters returned by the function are shown in Table 6.

Table 5: Check device sharing module: Arguments

Parameter	Structure	Unit	Description
current	array	-	Activity profile of the household users
n_occ	int	-	The number of occupants in the household
devicesharing	array	pu	Array of probabilities of activity sharing for the given user type

Table 6: Check device sharing module: Returns

Parameter	Structure	Unit	Description
current	array	-	Updated activity profile of the household users

5.5 appliance_population.m

5.5.1 Description

This function populates a household with a set of electrical appliances. Appliances are selected based on the ownership statistics defined in the configuration files defined in Section 6. Each appliance is assigned relevant electrical characteristics, which include: operating power, power factor, standby power and electrical load model. Auxiliary/dependent loads, e.g. computer monitors, are only assigned if the primary load is present. Loads with operating cycles, i.e. wet loads, are given a unique operating cycle to introduce further diversity in the appliance set. The power and duration of each stage of the operating cycle is selected from a uniform distribution from the given input data.

Full details of the characteristics required for each load are discussed in Section 6.

5.5.2 Arguments

The function arguments are shown in Table 7.

5.5.3 Returns

The parameters returned by the function are shown in Table 8.

Table 7: Appliance population module: Arguments

Parameter	Structure	Unit	Description
time_res	int	min	Simulation time step
n_occ	int	-	The number of occupants in the household
tv_stuff	array	-	TV load specification
settop_box	array	-	Set-top box load specification
printer	array	-	Printer load specification
music	array	-	Music player load specification
router	array	-	Router load specification
phone	array	-	Phone load specification
cooking	array	-	Cooking loads specification
iron	array	-	Iron load specification
vacuum	array	-	Vacuum cleaner load specification
shower	array	-	Shower load specification
dishwasher	array	-	Dishwasher load specification
washingmachine	array	-	Washing machine load specification
clothesdrier	array	-	Clothes drier load specification
gamesconsole	array	-	Games console loads specification
computers	array	-	Computer loads specification
monitors	array	-	Monitor loads specification
heating	array	-	Heating loads specification
cold_loads	array	-	Cold loads specification
ev	array	-	EV load specification

Table 8: Appliance population module: Returns

Parameter	Structure	Unit	Description
distr	cell	-	DataStructure to hold the active power characteristics of household appliances
distr_q	cell	-	DataStructure to hold the reactive power characteristics of household appliances
p_zips	cell	-	DataStructure to hold the active power ZIP models for household appliances
q_zips	cell	-	DataStructure to hold the reactive power ZIP models for household appliances

5.6 activity_to_power.m

5.6.1 Description

This functions converts the user activity profile into electrical demand using the household appliance set. Each user activity is converted by a specific subroutine and this function acts as a control to handle the data flow by calling each subroutine in sequence. Each subroutine is discussed further in the following sections: Sectio 5.7: Electric shower loads, Section 5.8: Cooking loads, Section 5.9: Wet loads, Section 5.10: Clothes drier load, Section 5.11: CE and ICT load, Section 5.12: Heating load, Section 5.13: Lighting load and Section 5.14: EV load.

5.6.2 Arguments

The function arguments are shown in Table 9.

5.6.3 Returns

The parameters returned by the function are shown overleaf in Table 10.

Table 9: Activity to power module: Arguments

Parameter	Structure	Unit	Description
time_res	int	min	Simulation time step
Profiles	cell	-	DataStructure to hold the user activity profiles
month	int	-	Month of the year
day	int	-	Type of day; 1 = weekday, 2 = weekend
u_beh	int	-	User behaviour type
lighting_data	array	-	Lighting loads specification
set_temp	array	Degree C	Cumulative probability of temperature set-point
irr	array	W/m^2	Solar irradiance for the given month
hh_occ	array	-	DataStructure to hold the overall household occupancy data
distr	cell	-	DataStructure to hold the active power characteristics of household appliances
distr_q	cell	-	DataStructure to hold the reactive power characteristics of household appliances
n_occ	int	-	The number of occupants in the household

Table 10: Activity to power module: Returns

Parameter	Structure	Unit	Description
APower	cell	W	DataStructure to hold the active power profiles of every household load for every occupant
RePower	cell	var	DataStructure to hold the reactive power profiles of every household load for every occupant
distr	cell	-	DataStructure to hold the active power characteristics of household appliances
light_pzip	array	-	Active power ZIP models for lamps
light_qzip	array	-	Reactive power ZIP models for lamps
light_qs	array	-	Reactive power profiles for lamps
wet_starts	array	min	Start times of wet loads
wet_ends	array	min	End times of wet loads

5.7 electric_shower_loads.m

5.7.1 Description

Three sets of statistics are applied: one to determine if the load is used or not, another to set the start time of the appliance and another to set the duration.

The electric shower load configuration file is described in Section 6.10.

5.7.2 Arguments

The function arguments are shown in Table 11.

Table 11: Electric shower load module: Arguments

Parameter	Structure	Unit	Description
time_res	int	min	Simulation time step
activ	cell	-	DataStructure to hold the user activity profiles
rated_power	float	W	Active power of the load
rated_q_power	float	var	Reactive power of the load
ownership	float	-	Ownership probability

5.7.3 Returns

The parameters returned by the function are shown in Table 12.

Table 12: Electric shower load module: Returns

Parameter	Structure	Unit	Description
p	array	W	Active power profile of the shower load
q	array	var	Reactive power profile of shower load

5.8 cooking_loads.m

5.8.1 Description

Converts the cooking activity into electrical appliance use. Five appliances are defined: oven, hob (plus extractor fan), microwave, kettle and toaster. The use of each load is governed by time varying probabilities. Use is not mutually exclusive and multiple cooking appliances can be used simultaneously.

The cooking load configuration file is described in Section 6.7.

5.8.2 Arguments

The function arguments are shown in Table 13.

5.8.3 Returns

The parameters returned by the function are shown in Table 14.

Table 13: Cooking load module: Arguments

Parameter	Structure	Unit	Description
time_res	int	min	Simulation time step
activ144	cell	-	DataStructure to hold the user activity profiles
month	int	-	Month of year
day	int	-	Type of day; 1 = weekday, 2 = weekend
appliance_p	array	W	Rated active power of cooking appliances
appliance_q	array	var	Rated reactive power of cooking appliances
appliance_use	array	-	Activity profile of cooking appliance use

Table 14: Cooking load module: Returns

Parameter	Structure	Unit	Description
p_cooking	array	W	Active power profile of the cooking loads
q_cooking	array	var	Reactive power profile of the cooking loads
appliance_use	array	-	Activity profile of cooking appliance use

5.9 wet_loads.m

5.9.1 Description

Assign load load cycle to a given instance of use of either the washing machine or dishwasher load. Two sets of statistics are applied to define the clothes drier activity: one to determine if the load is used or not and another to set the start time of the appliance. If the load is used then the cycle defined in *function* **appliance_population** is connected from the locally defined start time.

The clothes drier load configuration file is described in Section 6.11.

5.9.2 Arguments

The function arguments are shown in Table 15.

5.9.3 Returns

The parameters returned by the function are shown in Table 16.

Table 15: Wet load module: Arguments

Parameter	Structure	Unit	Description
time_res	int	min	Simulation time step
activ	array		Activity profile of the load
month	int	-	Month of year
p_cycle	array	W:	Active power cycle of the appliance
q_cycle	array	var	Reactive power cycle of the appliance
type	int	-	Wet load type identifier. Allowed values: 1 = dishwasher, 2 = washingmachine

Table 16: Wet load module: Returns

Parameter	Structure	Unit	Description
p	array	W	Active power profile of load
q	array	var	Reactive power profile of load
start_time	int	min	Start time of load use
end_time	int	min	End time of load use

5.10 clothes_drier.m

5.10.1 Description

Assign load cycle to a given instance of use of the clothes drier load. This function is dependent on a previous use of the washing machine load. If the washing machine load has previously been utilised then two sets of statistics are applied to define the clothes drier activity: one to determine if the load is used or not and another to set the start time of the appliance. If the load is used then the cycle defined in *function* **appliance_population** is connected from the locally defined start time.

The clothes drier load configuration file is described in Section 6.11.

5.10.2 Arguments

The function arguments are shown in Table 17.

5.10.3 Returns

The parameters returned by the function are shown in Table 18.

Table 17: Clothes drier load module: Arguments

Parameter	Structure	Unit	Description
time_res	int	min	Simulation time step
month	int	-	Month of year
wm_end	int	min	End time of washing machine load
p_cycle	array	W	Active power cycle of the appliance
q_cycle	array	var	Reactive power cycle of the appliance

Table 18: Clothes drier load module: Returns

Parameter	Structure	Unit	Description
p	array	W	Active power profile of the clothes drier load
q	array	var	Reactive power profile of the clothes drier load
start_time	int	min	Start time of the load use
end_time	int	min	End time of the load use

5.11 ce_ict.m

5.11.1 Description

Converts user activities into consumer electronics (CE) and ICT loads. This covers pcs, laptops, consoles, tvs and secondary devices and stereos. As these loads are associated with a specific user activity, the activity profile is directly converted into active and reactive power demand using the appliance data. The user standby behaviour defines the power demand in-between active periods.

The CE and ICT load configuration file is described in Section 6.4.

5.11.2 Arguments

The function arguments are shown in Table 19.

5.11.3 Returns

The parameters returned by the function are shown overleaf in Table 20.

Table 19: CE and ICT load module: Arguments

Parameter	Structure	Unit	Description
time_res	int	min	Simulation time step
activ	array	-	Activity profile of the load
distr	cell	-	DataStructure to hold the active power characteristics of household appliances
distr_q	cell	-	DataStructure to hold the reactive power characteristics of household appliances
i	int	-	Household occupant identifier
u_beh	int	-	User behaviour type

Table 20: CE and ICT load module: Returns

Parameter	Structure	Unit	Description
tv_p	array	W	Active power profile of tv load
tv_q	array	var	Reactive power profile of tv load
pc_p	array	W	Active power profile of pc load
pc_q	array	var	Reactive power profile of pc load
monitor_p	array	W	Active power profile of monitor load
monitor_q	array	var	Reactive power profile of monitor load
printer_p	array	W	Active power profile of printer load
printer_q	array	var	Reactive power profile of printer load
music_p	array	W	Active power profile of music player load
music_q	array	var	Reactive power profile of music player load
phone_p	array	W	Active power profile of phone load
phone_q	array	var	Reactive power profile of phone load
console_p	array	W	Active power profile of games console load
console_q	array	var	Reactive power profile of games console load
video_tv_p	array	W	Active power profile of video/dvd load
video_tv_q	array	var	Reactive power profile of video/dvd load

5.12 heating_loads.m

5.12.1 Description

Two types of heating system are included: direct heating and storage heating. For direct heating the power demand is dependent on the presence of people in house and a comparison between the external and required internal temperature conditions. A thermal model of the house is considered to represent the heat transfer between the internal and external environments. For storage heating, a look-up table is consulted to define the storage required for the given month.

The heating load configuration file is described in Section 6.9.

5.12.2 Arguments

The function arguments are shown in Table 21. The function arguments are shown in Table 21.

5.12.3 Returns

The parameters returned by the function are shown in Table 22.

Table 21: Heating load module: Arguments

Parameter	Structure	Unit	Description
time_res	int	min	Simulation time step
distr	cell	-	DataStructure to hold the active power characteristics of household appliances
month	int	-	Month of the year
set_temperature	array	˚C	Cumulative probability of temperature set-point
irradiance	array	W/m^2	Solar irradiance for the given month
hh_occ	array	-	DataStructure to hold the overall household occupancy data

Table 22: Heating load module: Returns

Parameter	Structure	Unit	Description
p	array	W	Active power profile of the heating load

5.13 lighting_loads.m

5.13.1 Description

The lighting power demand is dependent on the presence of people in house and a comparison between the external and required illumination conditions. The external irradiance is compared with a threshold at each time step to determine whether artificial light is needed. When artificial lighting is needed, the code checks the occupancy profile at each time point and if there is at least one active occupant then the possibility of turning on the lights increases. Then, the demand for artificial light is converted into power demand. Additionally, to account for uncertainty, the model provides a fixed probability of turning on any light even when it is not required.

The lighting configuration file is described in Section 6.12.

5.13.2 Arguments

The function arguments are shown in Table 23.

5.13.3 Returns

The parameters returned by the function are shown in Table 24.

Table 23: Lighting load module: Arguments

Parameter	Structure	Unit	Description
time_res	int	min	Simulation time step
irr	array	W/m^2	Solar irradiance for the given month
lighting_data	array	-	Lighting load data
hh_occ	array	-	DataStructure to hold the overall household occupancy data

Table 24: Lighting load module: Returns

Parameter	Structure	Unit	Description
total_power	array	W	Active power profile of the lighting load
total_q_power	array	var	Reactive power profile of the lighting load
bulbsdb	cell	W	Active power profile of each individual lamp
lighting_q	cell	var	Reactive power profile of each individual lamp
lamp_types	array	-	Lamp type of each individual lamp
lamp_p_zip	array	-	Active power ZIP models for each lamp
lamp_q_zip	array	-	Reactive power ZIP models for each lamp

5.14 electric_vehicle_loads.m

5.14.1 Description

This module calculates the household electric vehicle demand. This sets an uncontrolled/unoptimised charging profile, which assumes that the car is charged from the last continuous occupancy period of the day. The required charging duration is calculated from the battery state of charge, the battery capacity and the rating of the charger. It is assumed that the charger will always fully charge unless disconnected.

The EV configuration file is described in Section 6.8.

5.14.2 Arguments

The function arguments are shown in Table 25.

5.14.3 Returns

The parameters returned by the function are shown in Table 26.

Table 25: Electric vehicle load module: Arguments

Parameter	Structure	Unit	Description
time_res	int	min	Simulation time step
distr	cell	-	DataStructure to hold the active power characteristics of household appliances
distr_q	cell	-	DataStructure to hold the reactive power characteristics of household appliances
hh_occ	array	-	DataStructure to hold the overall household occupancy data

Table 26: Electric vehicle load module: Returns

Parameter	Structure	Unit	Description
p	array	W	Active power profile of the EV load
q	array	var	Reactive power profile of the EV load

5.15 user_defined_load.m

5.15.1 Description

Add a user defined load. Two different user definitions are accounted for: 1 - one load profile with power demand defined from uniform distribution and a set penetration level, 2 - multiple individual load profiles. The new loads are randomly allocated within the total population.

The user load configuration files are described in Section 6.13. The file structure is different depending on the type of load defined. User defined loads are also discussed in Section 8, where further details are available.

5.15.2 Arguments

The function arguments are shown in Table 27.

5.15.3 Returns

The parameters returned by the function are shown in Table 28.

Table 27: User defined load module: Arguments

Parameter	Structure	Unit	Description
agg_size	int	-	The total number of households to be created
data_dir	str	-	Path to the data directory
new_load_data	array	-	Overview of the new load electrical data
filename	str	-	Filename of load definition

Table 28: User defined load module: Returns

Parameter	Structure	Unit	Description
new_load_lc	array	-	Household number to which the new load is assigned
new_load	cell	-	DataStructure to carry all new load electrical characteristics

5.16 zip_aggregation.m

5.16.1 Description

The aggregate ZIP is obtained by a weighted summation of all household loads. For all instances of time the load models of the individual components are aggregated by (1) and (2):

$$\left[\ Z_{p_{hh}}, I_{p_{hh}}, P_{p_{hh}}\ \right] = \sum_{a=1}^{A} \frac{P_a}{P_{hh}} \left[\ Z_{p_a}, I_{p_a}, P_{p_a}\ \right] \tag{1}$$

$$\left[\ Z_{q_{hh}}, I_{q_{hh}}, P_{q_{hh}}\ \right] = \sum_{a=1}^{A} tan\left(cos^{-1}\left(PF_{1_a}\right)\right) \frac{P_a}{P_{hh}} \left[\ Z_{q_a}, I_{q_a}, P_{q_a}\ \right] \tag{2}$$

where: $Z_{p_{hh}}$, $I_{p_{hh}}$, $P_{p_{hh}}$, $Z_{q_{hh}}$, $I_{q_{hh}}$ and $P_{q_{hh}}$ are the real and reactive components of the household ZIP model, A is the total number of appliances, a is the appliance index, P_a and P_{hh} are the power demand of appliance a and the total household power demand, Z_{p_a}, I_{p_a}, P_{p_a}, Z_{q_a}, I_{q_a}, P_{q_a} and PF_{1_a} are the real and reactive ZIP model components and displacement power factor of appliance a.

5.16.2 Arguments

The function arguments are shown in Table 29.

5.16.3 Returns

The parameters returned by the function are shown in Table 30.

Table 29: ZIP aggregation load module: Arguments

Parameter	Structure	Unit	Description
p_hh	array	W	Active power demand profile of the household
occ_power	cell	-	DataStructure to hold the power profiles of every household load for every occupant. This can be either active or reactive power demand
hh_zips	cell	-	ZIP models for each household appliance
n_occ	int	-	The number of occupants in the household
lightzip	array	-	ZIP models for lamps
lightload	cell	-	Demand profile of each individual lamp
wet_starts	array	min	Start times of wet loads
wet_ends	array	min	End times of wet loads

Table 30: ZIP aggregation load module: Returns

Parameter	Structure	Unit	Description
agg_zip	array	-	Aggregate ZIP model of the household

6 Configuration files

This section describes the data files required to execute the code. Two file types are utilized - .mat and .xlsx. The default location of these files is in the *../data/* directory. If this is modified then the paths in desimax.m must be updated. For the .xlsx data a standard template has been used where possible. If a data field is not required for a specific load then the data in the .xlsx sheet is blank and the data definition in this section is marked by gray text (not to be confused with table background) and includes only the parameter name.

6.1 Sharing

Type: .mat
This contains the sharing probabilities for the *function* **check_device_sharing.m**. The data definition is as follows:

Sharing{1,n_occ}{1,n_working+1}{1,day}{n_occ, *n_occ*}(15,144)
level0 level1 level2 level3 level4

At level 0, the data is separated into four based on the number of occupants. At level 1, the data is divided by the number of working of occupants. At level2, the data is separated by the type of day. Level3 presents a matrix based on the number of users sharing the same appliance, with time varying probabilities of all activities found at level4.

6.2 TM

Type: .mat
This contains the transition matrices required by the Markov chain in *function* **activity_profile_generation.m**. This MATLAB cell data is structured as follows:

TM{1,n_occ}{n_occ+1,2}{1,143}(16,16)
level0 level1 level2 level3

At level 0, the data is separated into four based on the number of occupants. At level 1, the data is divided by the number of working of occupants (rows) and separated into weekday and weekend (cols) variants. At level2, 143 16x16 transition matrices are found.

6.3 IC

Type: .mat
This MATLAB cell contains the initial condition probabilities required by the *function* **initial_condition.m**. The data definition is as follows:

IC{1,n_occ}{n_occ+1,2}(16,1)
level0 level1 level2

At level 0, the data is separated into four based on the number of occupants. At level 1, the data is divided by the number of working of occupants (rows) and separated into weekday and weekend (cols) variants. At level 2 the probabilities of the 16 user activities are defined.

6.4 ce_ict

Type: .xlsx
This file contains data on all CE and ICT loads, as indicated by the following worksheet names:

- tv
- box
- printer
- music
- router
- phone
- gamesconsole
- computer
- monitor

6.4.1 Sheet: tv

Currently there is space for definition of four different TV technologies. Normal distribution is assumed for the distribution of rated powers (i.e. characterized by mean and standard deviation). A uniform distribution is assumed for standby power (i.e. characterized by minimum and maximum value).

Table 31: Input data: TV

Col	Parameter	Unit	Description
1	Type	-	Load type identifier
2	Probability	pu	Ownership probability, in pu of total population
3	Mean	W	Active power demand mean value
4	Sigma	W	Active power demand standard deviation
5	Min	W	Active power demand minimum value
6	Max	W	Active power demand maximum value
7	PF	-	Fundamental power factor
8	Standby min	W	Active power demand minimum value in standby mode
9	Standby max	W	Active power demand maximum value in standby mode
10	ZIP P Z	-	Active power polynomial load model, z coefficient
11	ZIP P I	-	Active power polynomial load model, i coefficient
12	ZIP P P	-	Active power polynomial load model, p coefficient
13	ZIP Q Z	-	Reactive power polynomial load model, z coefficient
14	ZIP Q I	-	Reactive power polynomial load model, i coefficient
15	ZIP Q P	-	Reactive power polynomial load model, p coefficient

6.4.2 Sheet: box

Currently there is space for definition of only one set-top box technology. A uniform distribution is assumed for both on and standby power (i.e. characterized by minimum and maximum value). As such the values in column three and four and not considered.

Table 32: Input data: Set-top box

Col	Parameter	Unit	Description
1	Type	-	Load type identifier
2	Probability	pu	Ownership probability, in pu of total population
3	Mean		
4	Sigma		
5	Min	W	Active power demand minimum value
6	Max	W	Active power demand maximum value
7	PF	-	Fundamental power factor
8	Standby min	W	Active power demand minimum value in standby mode
9	Standby max	W	Active power demand maximum value in standby mode
10	ZIP P Z	-	Active power polynomial load model, z coefficient
11	ZIP P I	-	Active power polynomial load model, i coefficient
12	ZIP P P	-	Active power polynomial load model, p coefficient
13	ZIP Q Z	-	Reactive power polynomial load model, z coefficient
14	ZIP Q I	-	Reactive power polynomial load model, i coefficient
15	ZIP Q P	-	Reactive power polynomial load model, p coefficient

6.4.3 Sheet: printer

Currently there is space for definition of only one printer technology. A uniform distribution is assumed for both on and standby power (i.e. characterized by minimum and maximum value). As such the values in column three and four and not considered.

Table 33: Input data: Printer

Col	Parameter	Unit	Description
1	Type	-	Load type identifier
2	Probability	pu	Ownership probability, in pu of total population
3	Mean		
4	Sigma		
5	Min	W	Active power demand minimum value
6	Max	W	Active power demand maximum value
7	PF	-	Fundamental power factor
8	Standby min	W	Active power demand minimum value in standby mode
9	Standby max	W	Active power demand maximum value in standby mode
10	ZIP P Z	-	Active power polynomial load model, z coefficient
11	ZIP P I	-	Active power polynomial load model, i coefficient
12	ZIP P P	-	Active power polynomial load model, p coefficient
13	ZIP Q Z	-	Reactive power polynomial load model, z coefficient
14	ZIP Q I	-	Reactive power polynomial load model, i coefficient
15	ZIP Q P	-	Reactive power polynomial load model, p coefficient

6.4.4 Sheet: music

Currently there is space for definition of only one music player technology. Normal distribution is assumed for the distribution of rated powers (i.e. characterized by mean and standard deviation). A uniform distribution is assumed for standby power (i.e. characterized by minimum and maximum value).

Table 34: Input data: Music player

Col	Parameter	Unit	Description
1	Type	-	Load type identifier
2	Probability	pu	Ownership probability, in pu of total population
3	Mean	W	Active power demand mean value
4	Sigma	W	Active power demand standard deviation
5	Min	W	Active power demand minimum value
6	Max	W	Active power demand maximum value
7	PF	-	Fundamental power factor
8	Standby min	W	Active power demand minimum value in standby mode
9	Standby max	W	Active power demand maximum value in standby mode
10	ZIP P Z	-	Active power polynomial load model, z coefficient
11	ZIP P I	-	Active power polynomial load model, i coefficient
12	ZIP P P	-	Active power polynomial load model, p coefficient
13	ZIP Q Z	-	Reactive power polynomial load model, z coefficient
14	ZIP Q I	-	Reactive power polynomial load model, i coefficient
15	ZIP Q P	-	Reactive power polynomial load model, p coefficient

6.4.5 Sheet: router

Currently there is space for definition of only one router technology. Normal distribution is assumed for the distribution of rated powers (i.e. characterized by mean and standard deviation). A uniform distribution is assumed for standby power (i.e. characterized by minimum and maximum value).

Table 35: Input data: Router

Col	Parameter	Unit	Description
1	Type	-	Load type identifier
2	Probability	pu	Ownership probability, in pu of total population
3	Mean	W	Active power demand mean value
4	Sigma	W	Active power demand standard deviation
5	Min	W	Active power demand minimum value
6	Max	W	Active power demand maximum value
7	PF	-	Fundamental power factor
8	Standby min	W	Active power demand minimum value in standby mode
9	Standby max	W	Active power demand maximum value in standby mode
10	ZIP P Z	-	Active power polynomial load model, z coefficient
11	ZIP P I	-	Active power polynomial load model, i coefficient
12	ZIP P P	-	Active power polynomial load model, p coefficient
13	ZIP Q Z	-	Reactive power polynomial load model, z coefficient
14	ZIP Q I	-	Reactive power polynomial load model, i coefficient
15	ZIP Q P	-	Reactive power polynomial load model, p coefficient

6.4.6 Sheet: phone

Currently there is space for definition of only one phone technology. A uniform distribution is assumed for both on and standby power (i.e. characterized by minimum and maximum value). As such the values in column three and four and not considered.

Table 36: Input data: Phone

Col	Parameter	Unit	Description
1	Type	-	Load type identifier
2	Probability	pu	Ownership probability, in pu of total population
3	Mean		
4	Sigma		
5	Min	W	Active power demand minimum value
6	Max	W	Active power demand maximum value
7	PF	-	Fundamental power factor
8	Standby min	W	Active power demand minimum value in standby mode
9	Standby max	W	Active power demand maximum value in standby mode
10	ZIP P Z	-	Active power polynomial load model, z coefficient
11	ZIP P I	-	Active power polynomial load model, i coefficient
12	ZIP P P	-	Active power polynomial load model, p coefficient
13	ZIP Q Z	-	Reactive power polynomial load model, z coefficient
14	ZIP Q I	-	Reactive power polynomial load model, i coefficient
15	ZIP Q P	-	Reactive power polynomial load model, p coefficient

6.4.7 Sheet: gamesconsole

Currently there is space for definition of three console technologies. The on power is set directly in column three, A uniform distribution is assumed for the standby power (i.e. characterized by minimum and maximum value).

Table 37: Input data: Games consoles

Col	Parameter	Unit	Description
1	Type	-	Load type identifier
2	Probability	pu	Ownership probability, in pu of total population
3	power	W	Active power demand value
4	Sigma		
5	Min	W	Active power demand minimum value
6	Max	W	Active power demand maximum value
7	PF	-	Fundamental power factor
8	Standby min	W	Active power demand minimum value in standby mode
9	Standby max	W	Active power demand maximum value in standby mode
10	ZIP P Z	-	Active power polynomial load model, z coefficient
11	ZIP P I	-	Active power polynomial load model, i coefficient
12	ZIP P P	-	Active power polynomial load model, p coefficient
13	ZIP Q Z	-	Reactive power polynomial load model, z coefficient
14	ZIP Q I	-	Reactive power polynomial load model, i coefficient
15	ZIP Q P	-	Reactive power polynomial load model, p coefficient

6.4.8 Sheet: computer

Currently there is space for definition of four computer technologies. Computer Type 1 is a desktop and Type 2-4 are laptops, and are not used with a monitor. A uniform distribution is assumed for the standby power (i.e. characterized by minimum and maximum value). Additional fields are included in columns 16-19 which reflect that the power consumption of this load type exhibits variations based on the task being performed.

Table 38: Input data: Computer

Col	Parameter	Unit	Description
1	Type	-	Load type identifier
2	Probability	pu	Ownership probability, in pu of total population
3	Mean	W	Active power demand mean value
4	Sigma	W	Active power demand standard deviation
5	Min	W	Active power demand minimum value
6	Max	W	Active power demand maximum value
7	PF	-	Fundamental power factor
8	Standby min	W	Active power demand minimum value in standby mode
9	Standby max	W	Active power demand maximum value in standby mode
10	ZIP P Z	-	Active power polynomial load model, z coefficient
11	ZIP P I	-	Active power polynomial load model, i coefficient
12	ZIP P P	-	Active power polynomial load model, p coefficient
13	ZIP Q Z	-	Reactive power polynomial load model, z coefficient
14	ZIP Q I	-	Reactive power polynomial load model, i coefficient
15	ZIP Q P	-	Reactive power polynomial load model, p coefficient
16	load_mean	%	Computer loading mean value, as percentage of rated power.
17	load_sigma	%	Computer loading standard deviation, as percentage of rated power.
18	load_min	%	Computer loading minimum allowed value, as percentage of rated power.
19	load_max	%	Computer loading maximum allowed value, as percentage of rated power.

6.4.9 Sheet: monitor

Currently there is space for definition of two monitor technologies. Normal distribution is assumed for the distribution of rated powers (i.e. characterized by mean and standard deviation). A uniform distribution is assumed for standby power (i.e. characterized by minimum and maximum value).

Table 39: Input data: Monitor

Col	Parameter	Unit	Description
1	Type	-	Load type identifier
2	Probability	pu	Ownership probability, in pu of total population
3	Mean	W	Active power demand mean value
4	Sigma	W	Active power demand standard deviation
5	Min	W	Active power demand minimum value
6	Max	W	Active power demand maximum value
7	PF	-	Fundamental power factor
8	Standby min	W	Active power demand minimum value in standby mode
9	Standby max	W	Active power demand maximum value in standby mode
10	ZIP P Z	-	Active power polynomial load model, z coefficient
11	ZIP P I	-	Active power polynomial load model, i coefficient
12	ZIP P P	-	Active power polynomial load model, p coefficient
13	ZIP Q Z	-	Reactive power polynomial load model, z coefficient
14	ZIP Q I	-	Reactive power polynomial load model, i coefficient
15	ZIP Q P	-	Reactive power polynomial load model, p coefficient

6.5 general

Type: .xlsx
The file groups together discrete configuration parameters in a single location.

Worksheet names:

- general
- composition
- user_behaviour

6.5.1 general

Values to define the type of day to be analysed, the month of year to be analysed and the number of households in the aggregate population.

Table 40: Input data: General

Col	Parameter	Unit	Description
1	day	-	Day of week. Allowed values: 1, 2. Weekday = 1, Weekend = 2
2	month	-	Month of year. Allowed values: 1..12. Jan = 1, Feb = 2...Dec = 12
3	size	-	Aggregate size - integer

6.5.2 composition

This specifies the composition of the aggregate population. The values are given in per unit and should sum to one. The form of this is m x n matrix and size is 4x5 where m is the hhsize and n is the number of working occupants+1, e.g. (1,1) is hhsize 1 with 0 working occupant, (1,2) is hhsize 1 with 1 working occupant etc.

6.5.3 user_behaviour

In addition to the activity profiles, users can be allocated a behaviour type based a preference to appliance standby mode, where:

- Type 0: no 'standby' mode (always off)
- Type 1: 'standby' mode between first and last use
- Type 2: 'standby' mode all day (except when used)

In this worksheet, the proportion of each user type is defined. These are randomly allocated within the aggregate population.

6.6 Cold

Type: .xlsx
Currently there is space for definition of three different types of cold load. A normal distribution is assumed for the power rating (i.e. characterized by minimum and maximum value).

Table 41: Input data: Cold loads

Col	Parameter	Unit	Description
1	Type	-	Load type identifier
2	Probability	pu	Ownership probability, in pu of total population
3	Mean	W	Active power demand mean value
4	Sigma	W	Active power demand standard deviation
5	Min	W	Active power demand minimum value
6	Max	W	Active power demand maximum value
7	PF	-	Fundamental power factor
8	Standby min		
9	Standby max		
10	ZIP P Z	-	Active power polynomial load model, z coefficient
11	ZIP P I	-	Active power polynomial load model, i coefficient
12	ZIP P P	-	Active power polynomial load model, p coefficient
13	ZIP Q Z	-	Reactive power polynomial load model, z coefficient
14	ZIP Q I	-	Reactive power polynomial load model, i coefficient

6.7 cooking_loads

Type: .xlsx

Currently there is space for definition of up to seven cooking technologies. Unlike other loads, cooking technology types are defined by name. Normal distribution is assumed for the distribution of rated powers (i.e. characterized by mean and standard deviation). No standby powers are defined.

Table 42: Input data: Cooking loads

Col	Parameter	Unit	Description
1	Type	-	Load type identifier. Allowed values: Oven, Hob, Hood, Microwave, Kettle, Toaster, Food processor.
2	Probability	pu	Ownership probability, in pu of total population
3	Mean	W	Active power demand mean value, assumes a normal distribution
4	Sigma	W	Active power demand standard deviation, assumes a normal distribution
5	Min	W	Active power demand minimum value
6	Max	W	Active power demand maximum value
7	PF	-	Fundamental power factor
8	Standby min		
9	Standby max		
10	ZIP P Z	-	Active power polynomial load model, z coefficient
11	ZIP P I	-	Active power polynomial load model, i coefficient
12	ZIP P P	-	Active power polynomial load model, p coefficient
13	ZIP Q Z	-	Reactive power polynomial load model, z coefficient
14	ZIP Q I	-	Reactive power polynomial load model, i coefficient
15	ZIP Q P	-	Reactive power polynomial load model, p coefficient

6.8 EV

Type: .xlsx
Currently there is space for definition of one EV charger. Uniform distribution is assumed for the distribution of rated powers (i.e. characterized by minimum and maximum values). No standby powers are defined. Columns 16 - 21 specify the charger efficiency (uniform distribution), battery state of charge (normal distribution) and battery capacity (uniform distribution).

Table 43: Input data: Electric loads

Col	Parameter	Unit	Description
1	Type	-	Load type identifier
2	Probability	pu	Ownership probability, in pu of total population
3	Mean		
4	Sigma		
5	Min	W	Active power demand minimum value
6	Max	W	Active power demand maximum value
7	PF	-	Fundamental power factor
8	Standby min		
9	Standby max		
10	ZIP P Z	-	Active power polynomial load model, z coefficient
11	ZIP P I	-	Active power polynomial load model, i coefficient
12	ZIP P P	-	Active power polynomial load model, p coefficient
13	ZIP Q Z	-	Reactive power polynomial load model, z coefficient
14	ZIP Q I	-	Reactive power polynomial load model, i coefficient
15	ZIP Q P	-	Reactive power polynomial load model, p coefficient
16	charger_eff_min	pu	Minimum considered EV charger efficiency value
17	charger_eff_max	pu	Maximum considered EV charger efficiency value
18	battery_soc_mean	pu	Mean value considered for EV state of charge
19	battery_soc_sigma	pu	Standard deviation value considered for EV state of charge
20	battery_capacity_min	Wh	Minimum considered EV battery capacity value
21	battery_capacity_max	Wh	Maximum considered EV battery capacity value

6.9 heating

Type: .xlsx
Currently there is space for definition of two heating types: Type 1 is direct electrical heating and Type 2 is storage electrical heating. Uniform distribution is assumed for the distribution of rated powers (i.e. characterized by minimum and maximum values). No standby powers are defined.

Table 44: Input data: Heating loads

Col	Parameter	Unit	Description
1	Type	-	Load type identifier
2	Probability	pu	Ownership probability, in pu of total population
3	Mean	W	Active power demand mean value
4	Sigma	W	Active power demand standard deviation
5	Min	W	Active power demand minimum value
6	Max	W	Active power demand maximum value
7	PF	-	Fundamental power factor
8	Standby min		
9	Standby max		
10	ZIP P Z	-	Active power polynomial load model, z coefficient
11	ZIP P I	-	Active power polynomial load model, i coefficient
12	ZIP P P	-	Active power polynomial load model, p coefficient
13	ZIP Q Z	-	Reactive power polynomial load model, z coefficient
14	ZIP Q I	-	Reactive power polynomial load model, i coefficient
15	ZIP Q P	-	Reactive power polynomial load model, p coefficient

6.10 Misc

Type: .xlsx
The file groups together miscellaneous load type configuration parameters in a single location. All of these loads have space for a single definition.

Worksheet names:

- iron
- vacuum
- shower

Table 45: Input data: Iron load

Col	Parameter	Unit	Description
1	Type	-	Load type identifier
2	Probability		
3	Mean	W	Active power demand mean value
4	Sigma	W	Active power demand standard deviation
5	Min	W	Active power demand minimum value
6	Max	W	Active power demand maximum value
7	PF	-	Fundamental power factor
8	Standby min		
9	Standby max		
10	ZIP P Z	-	Active power polynomial load model, z coefficient
11	ZIP P I	-	Active power polynomial load model, i coefficient
12	ZIP P P	-	Active power polynomial load model, p coefficient
13	ZIP Q Z	-	Reactive power polynomial load model, z coefficient
14	ZIP Q I	-	Reactive power polynomial load model, i coefficient
15	ZIP Q P	-	Reactive power polynomial load model, p coefficient

Table 46: Input data: Vacuum cleaner load

Col	Parameter	Unit	Description
1	Type	-	Load type identifier
2	Probability	pu	Ownership probability, in pu of total population
3	Mean	W	Active power demand mean value
4	Sigma	W	Active power demand standard deviation
5	Min	W	Active power demand minimum value
6	Max	W	Active power demand maximum value
7	PF	-	Fundamental power factor
8	Standby min		
9	Standby max		
10	ZIP P Z	-	Active power polynomial load model, z coefficient
11	ZIP P I	-	Active power polynomial load model, i coefficient
12	ZIP P P	-	Active power polynomial load model, p coefficient
13	ZIP Q Z	-	Reactive power polynomial load model, z coefficient
14	ZIP Q I	-	Reactive power polynomial load model, i coefficient
15	ZIP Q P	-	Reactive power polynomial load model, p coefficient

Table 47: Input data: Electric shower load

Col	Parameter	Unit	Description
1	Type	-	Load type identifier
2	Probability	pu	Ownership probability, in pu of total population
3	Mean	W	Active power demand mean value
4	Sigma	W	Active power demand standard deviation
5	Min	W	Active power demand minimum value
6	Max	W	Active power demand maximum value
7	PF	-	Fundamental power factor
8	Standby min		
9	Standby max		
10	ZIP P Z	-	Active power polynomial load model, z coefficient
11	ZIP P I	-	Active power polynomial load model, i coefficient
12	ZIP P P	-	Active power polynomial load model, p coefficient
13	ZIP Q Z	-	Reactive power polynomial load model, z coefficient
14	ZIP Q I	-	Reactive power polynomial load model, i coefficient
15	ZIP Q P	-	Reactive power polynomial load model, p coefficient

6.11 Wet load

Type: .xlsx
The file groups together the wet load type configuration parameters in a single location. All of these loads have space for a single definition.

Worksheet names:

- dishwasher
- washingmachine
- clothesdrier

As the data parameters are identical for all three, only one data definition is given below.

Table 48: Input data: Wet load configuration data

Col	Parameter	Unit	Description
1	stage	-	Number of discrete stages included in the cycle
2	power_min	W	Active power demand minimum value for each stage
3	power_max	W	Active power demand maximum value for each stage
4	duration_min	min	Minimum duration for each stage
5	duration_max	min	Maximum duration for each stage
6	pf	W	Fundamental power factor for each stage
7	ZIP P Z	-	Active power polynomial load model, z coefficient, for each stage
8	ZIP P I	-	Active power polynomial load model, i coefficient, for each stage
9	ZIP P P	-	Active power polynomial load model, p coefficient, for each stage
10	ZIP Q Z	-	Reactive power polynomial load model, z coefficient, for each stage
11	ZIP Q I	-	Reactive power polynomial load model, i coefficient, for each stage
12	ZIP Q P	-	Reactive power polynomial load model, p coefficient, for each stage

6.12 lighting

Type: .xlsx
Currently there is space for definition of seven different types of lamp. A uniform distribution is assumed for the power rating (i.e. characterized by minimum and maximum value).

Table 49: Input data: Lighting loads

Col	Parameter	Unit	Description
1	Type	-	Load type identifier
2	Probability	pu	Ownership probability, in pu of total population
3	Mean		
4	Sigma		
5	Min	W	Active power demand minimum value
6	Max	W	Active power demand maximum value
7	PF	-	Fundamental power factor
8	Standby min		
9	Standby max		
10	ZIP P Z	-	Active power polynomial load model, z coefficient
11	ZIP P I	-	Active power polynomial load model, i coefficient
12	ZIP P P	-	Active power polynomial load model, p coefficient
13	ZIP Q Z	-	Reactive power polynomial load model, z coefficient
14	ZIP Q I	-	Reactive power polynomial load model, i coefficient
15	ZIP Q P	-	Reactive power polynomial load model, p coefficient

6.13 User defined load

6.13.1 User defined load: Type 1

Type: .xlsx

Worksheet names:

- statistics
- electrical

For this user load type, only one electrical worksheet is allowed.

Table 50: Input data: User defined load: Type 1 electrical worksheet

Col	Parameter	Unit	Description
1	t	min	Time stamp of the load profile. This must be set to equal the time resolution, i.e. 1440
2	p	W	Active power demand of the load
3	q	var	Reactive power demand of the load
4	ZIP P Z	-	Active power polynomial load model, z coefficient
5	ZIP P I	-	Active power polynomial load model, i coefficient
6	ZIP P P	-	Active power polynomial load model, p coefficient
7	ZIP Q Z	-	Reactive power polynomial load model, z coefficient
8	ZIP Q I	-	Reactive power polynomial load model, i coefficient
9	ZIP Q P	-	Reactive power polynomial load model, p coefficient

Table 51: Input data: User defined load: Type 1 statistics worksheet

Col	Parameter	Unit	Description
1	type	-	Type of user defined load. Must be set to 1 for this type
2	penetration	pu	The penetration of the load, in pu of the total population
3	p_var_min	pu	Lower boundary for the active power load scale factor
4	p_var_max	pu	Upper boundary for the active load scale factor
5	q_var_min	pu	Lower boundary for the reactive power load scale factor
6	q_var_max	pu	Upper boundary for the reactive load scale factor

6.13.2 User defined load: Type 2

Type: .xlsx

Worksheet names:

- statistics
- electrical1
- ...
- electricalN

For this user load type, multiple electrical worksheets are allowed. The number of electrical worksheets is equal to the number of loads to be included in the aggregate population.

Table 52: Input data: User defined load: Type 2 electrical worksheets

Col	Parameter	Unit	Description
1	t	min	Time stamp of the load profile. This must be set to equal the time resolution, i.e. 1440.
2	p	W	Active power demand of the load
3	q	var	Reactive power demand of the load
4	ZIP P Z	-	Active power polynomial load model, z coefficient
5	ZIP P I	-	Active power polynomial load model, i coefficient
6	ZIP P P	-	Active power polynomial load model, p coefficient
7	ZIP Q Z	-	Reactive power polynomial load model, z coefficient
8	ZIP Q I	-	Reactive power polynomial load model, i coefficient
9	ZIP Q P	-	Reactive power polynomial load model, p coefficient

Table 53: Input data: User defined load: Type 2 statistics worksheet

Col	Parameter	Unit	Description
1	type	-	Type of user defined load. Must be set to 2 for this type
2	penetration		
3	p_var_min		
4	p_var_max		
5	q_var_min		
6	q_var_max		

7 Outputs

Four outputs are produced for each household: active and reactive power demand profiles and the corresponding active and reactive zip model. These are defined in Table 54. These are saved in the path specified by *save_dir*. By default this is set to the *../output/* directory. The time resolution is equal to *time_res*.

Table 54: Output data

Filename	Structure	Unit	Description
active_power_profiles.mat	array	W	Active power demand profile of each household
reactive_power_profiles.mat	array	var	Reactive power demand profile of each household
active_power_load_models.mat	cell	-	Active power zip models of each household
reactive_power_load_models.mat	cell	-	Reactive power zip models of each household

8 Using the software

8.1 Running the code

The tool is run directly from desimax.m The paths stated at the top of this file can be modified but must point to the location of the configuration files. On completion the output data are stored in the location specified by *save_dir* (by default this is a sub-directory of the main directory).

8.2 Modifying the data

The penetration of different technologies can be directly adjusted using the configuration files. Similarly, the electrical characteristics - rated power, power factors, ZIP model coefficients etc - of these predefined loads can be adjusted by modifying the data in the configuration files.

Two means to add new loads have also been included. The template for these are available in *../examples/* in the files *user_defined_load_type_one.xlsx* and *user_defined_load_type_two.xlsx*. If a new load is to be added then the modified template must be placed in the *data* directory and the filename at the top of desimax.m should be corrected to the matched the given filename. Note that an empty file is included in the *data* directory and can be overwritten by a customised file.

The template in *user_defined_load_type_one.xlsx* defines one load profile. The penetration of the load is defined as percentage of the aggregate population.The active and reactive power load profiles are multiplied by a scale factor, selected from a uniform distribution (Table 51.). Therefore, a diverse population of new loads can be simply achieved. Alternatively, setting the minimum and maximum value of the scale factor to the same value will return multiple instances of an identical load profile. Conversely, the template in *user_defined_load_type_two.xlsx* allows for multiple unique load profiles to directly defined for use with the tool.

9 Benchmarking

To characterise the performance of the developed code, the simulation time was assessed. This anaysis considered aggregates of homogeneous household types for aggregate sizes of 10, 100 and 1,000 thousand households. Each test point was divided into two: one to assess only "base" loads (i.e. without heating, EV and user defined loads) and one with these present at all households. The average results of 50 simulations are shown in Fig. 2. The results contain only the time required for the model to run the simulation and output the data. As the input data files are currently in .xlsx format reading these files is laborious; this process takes approximately 25s. All tests were permed using MATLAB R2014b run on a Windows 10 Pro PC with Processor Intel(R) Core(TM) i7-2620M CPU @ 2.70GHz and 8.00 GB of RAM.

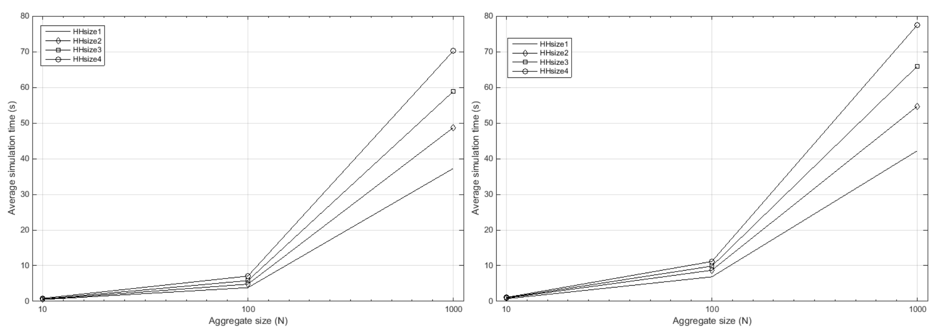

Figure 2: Benchmarking results (a) base load set (b) all loads.

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11 Further reading

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12 Contact

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