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# Manual SIMDEUM Pattern Generator

Tool for water demand and discharge patterns for residential and non-residential buildings

KWR Watercycle Research Institute

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## Tool for water demand and discharge patterns for residential and non-residential buildings

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This manual is not public and is only issued to the clients of the contract research project and to members of the tool within Watershare®.

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# Summary

Understanding the expected water demand is essential for many elements in the water cycle: for the design of distribution networks to supply enough water at a desired pressure to the customers, for the allocation of water demand in hydraulic models to study the water quantity and quality during distribution, for design of installation in houses and non-residential buildings, for design of stage tanks in grey water recycling and rain water harvesting systems, for the analysis of discharge characteristics, etc.

The SIMDEUM Pattern Generator is developed within the Joint Research Programme of the Dutch Water companies and is now also available as Water-Use Info, a tool within Watershare®. This generator is based on SIMDEUM®, an end-use model to simulate residential and non-residential cold and hot water demand patterns. The generator simulates residential demand patterns and generates demand patterns for various non-residential buildings, that can be used in various applications.

This manual describes how to work with the SIMDEUM Pattern Generator, to obtain the demand patterns you need for your area and application. The manual is divided into three parts:

PART I: How to get started with SIMDEUM Pattern Generator.

PART II: SIMDEUM Pattern Generator for residential buildings.

PART III: SIMDEUM Pattern Generator for non- residential buildings.

The tool (and manual) is provided along with some demo files, that assists the user in understanding the tool.

# Contents

# 1 Introduction

## 1.1 Demand and discharge patterns

Understanding the expected water demand is essential for many purposes. Water companies need this information for the design of distribution networks to supply enough water at a desired pressure to the customers. They also need this information in their hydraulic models to study the water quantity and quality during distribution. You can think of relevant quality aspects, as water age, water flows, flow direction reversals and sediment or contaminant propagation.

For the design of drinking water installations in houses and buildings, estimations of the maximum required cold and hot water are required. Also for the selection of the type and capacity of heating systems a reliable estimate of hot water use is essential, for a hygienic and economic design.

Climate changes, future perspectives on economic growth, demographic changes, legislation, sustainability issues can change the behaviour of humans with respect to water use. Moreover, they influence the use of luxurious applications, water-saving appliances, or different sanitation concepts, that also lead to differences in water use. Scenario studies are essential components in design and decision/policy. These studies are based on the expected water demands in each scenario.

Knowledge of discharge patterns is essential in the design of sewerage systems. But also for the design of grey water recycling systems, you need to know the amount of wastewater from the shower and bath (light grey water (LGW)). When the temperature of the wastewater is known and the amount of nutrients, thermal energy and nutrients can potentially be harvested. The harvesting process will be more efficient with a good understanding of the quantity and the location and time of the various discharge flows.

These applications require insight into the cold and hot water demand of a building or a district or in the characteristics of the drainage loads. SIMDEUM®, an end-use model to simulate residential and non-residential cold and hot water demand patterns, can provide this information.

## 1.2 Background SIMDEUM®: simulating demand and discharge patterns

SIMDEUM stands for "SIMulation of water Demand, an End-Use Model." It is a stochastic model based on statistical information of end uses, including statistical data on water appliances and users (Blokker et al., 2010). SIMDEUM's philosophy is that people's behaviour regarding water use is modelled, taking into account the differences in installation and water-using appliances. This means that in each building, whether it is residential, like a house or apartment building, or non-residential, like an office, hotel or nursing home, the characteristics of the installed water-using appliances and taps are considered as well as the water-using behaviour of the occupants.

For each person, the presence is modelled and when they use water and for which reason. The characteristics of each appliance are defined, like the flow rate, duration of use, frequency of use and the desired temperature. The duration and frequency may vary depending on the users: a teenager showers more frequently and longer than an elderly person. Moreover, the duration, frequency and the desired temperature of an appliance depends on the type of appliance (e.g. particular type of washing machine) and the particular application. For example, a kitchen tap can be used for filling a glass (15 s, 0.167 l/s, 10°C) or for washing dishes (45 s, 0.25 l/s, 55°C).

SIMDEUM calculates for each appliance at what time it is used, by whom and for which purpose. This results in a demand pattern for cold and hot water at each appliance. By the addition of the demand patterns of all appliances, the demand pattern of a house, office, hotel or nursing home is obtained. The characteristics of the users and the appliances are different for each type of building and are extensively described in Blokker et al. (2010 and 2011). Measurements of cold and hot water patterns on a per second base in different types of buildings show that SIMDEUM renders a reliable prediction of both cold and hot water demand (Pieterse-Quirijns et al., 2013).

SIMDEUM's basis gives insight into the reason for which the water is used and at what temperature this water needs to be. Therefore, it also provides information of the wastewater quantity, temperature and quality that will leave the building through the sewage system (e.g. shower water at 35°C with soap residue, or toilet water at 15°C with medicines, hormones and nitrates). This information is applied to transform SIMDEUM from a demand model into a discharge model (Hofman et al., 2014; Bloemendal et al., 2014).

SIMDEUM simulates the cold and hot water demand patterns, based on the water using behaviour of the occupants and on the characteristics of the appliances in the building.

SIMDEUM's information can be used for discharge characteristics, as quantity, temperature and quality of wastewater.

## 1.3 Tool for demand patterns for residential and non-residential buildings: SIMDEUM Pattern Generator

### 1.3.1 SIMDEUM Pattern Generator for residential buildings

The SIMDEUM Pattern Generator (SPG) for residential buildings simulates demand patterns based on knowledge of the occupants and appliances. This knowledge is a required input to the SPG. The SPG for residential buildings is flexible for the input of own, country specific data. It is no problem if only average frequencies of use are known, the probability functions are already given in the SPG.

The SPG simulates the water demand with the given data of a specific area or scenario. The outcome of the SPG is simulated demand patterns on one second base for 5 weekdays and 2 weekenddays. The outcome can be used for several purposes:

- Patterns of cold water for hydraulic models
- Patterns of cold and hot water for design purposes:
  - Design of pipelines for water supply
  - Design of hot water systems

  - Design of alternative sanitation: grey water systems or rainwaterharvesting. Patterns of cold and hot water demand at each tap.
- Scenario studies: patterns to investigate the consequences in water demand for different scenario's.

### 1.3.2 SIMDEUM Pattern Generator for non-residential buildings

The SIMDEUM Pattern Generator (SPG) for non-residential buildings generates demand patterns based on a demand pattern library for a number of non-residential users. The demand pattern library is deterministic in nature. This makes the SPG for non-residential buildings not flexible for other input data on users or appliances. When you want a flexible input, you can contact KWR, to apply SIMDEUM for your specific wishes for a non-residential building.

The demand pattern library is developed using SIMDEUM in combination with measured water demands of specific building categories. The library consists of normalised patterns for several categories of non-residential users on a time basis of 5 minutes, 15 minutes and 1 hour. The categories in the library are offices, hotels, nursing homes, schools/education, dining rooms, shops, recreation, sports facilities and swimming pools. Within some of these categories a subdivision is created for specific users. Combining multiplier patterns available in the library, with measured yearly water use for the user, a specific demand pattern for that non-residential building is created.

The demand pattern library is validated for three districts with variable characteristics: a rural district, a residential area with a promenade and a city with a wide variety of non-residential users. For all districts a demand pattern for a weekday and a weekend day was composed with the normalised patterns available in the library, together with measured yearly water use for each user. The predicted demand patterns fall within the variation of the measured demand pattern of the three districts (Pieterse-Quirijns and Van de Roer, 2013).

In the SPG for non-residential buildings, the user can select the typical category and insert the yearly measured water use. The SPG then generates a demand pattern for that specific user during a weekday and during a weekendday. The outcome can be used for several purposes:

- Patterns of cold water for hydraulic models.
- Patterns of cold water for design purposes: design of pipelines for water supply.

## 1.4 Discharge patterns

SIMDEUM calculates for each appliance at what time it is used, by whom and for which purpose. This determines the applied flow rate, desired temperature and duration of use. The insight into water demand at the detailed level of an appliance, also gives information on the quantity and characteristics of the water that is discharged by that appliance.

When we only look to the discharge quantity, we know that in some cases the discharge intensity and duration is different from the demand. The discharges that are equal to the demand are for the end uses at the bathroom tap, kitchen tap (except for "doing dishes") and shower. The discharge from WC, bath, washing machine, dishwasher and water for manual dish washing are different; the outside tap does not discharge to the residential sewer.

The frequency of discharge is equal to the frequency of the demand. The time of discharge is not always equal to the time of the demand. The bath tub can be emptied 10 minutes to 1 hour after it is being filled. The intake and discharge of washing machine, dishwasher and emptying the sink after doing the dishes also shows a shift in time.

On a very small time scale, the discharge pattern will be significantly different from the demand pattern. However, for a time scale of 15 minutes or larger, the discharge patterns will be similar to the demand patterns. This means that the patterns generated with the SIMDEUM pattern generator can be used as discharge patters for a timescale of 15 minutes.

For smaller timescales and when you are interested in temperature and quality of the discharged water, you need another version of SIMDEUM: SIMDEUM for discharged water patterns, SIMSEM. Discharge patterns with these properties can be generated by KWR.

## 1.5 Manual for SIMDEUM Pattern Generator: reading guide

The SIMDEUM Pattern Generator is different for residential and non-residential buildings. Therefore this manual is divided into different parts:

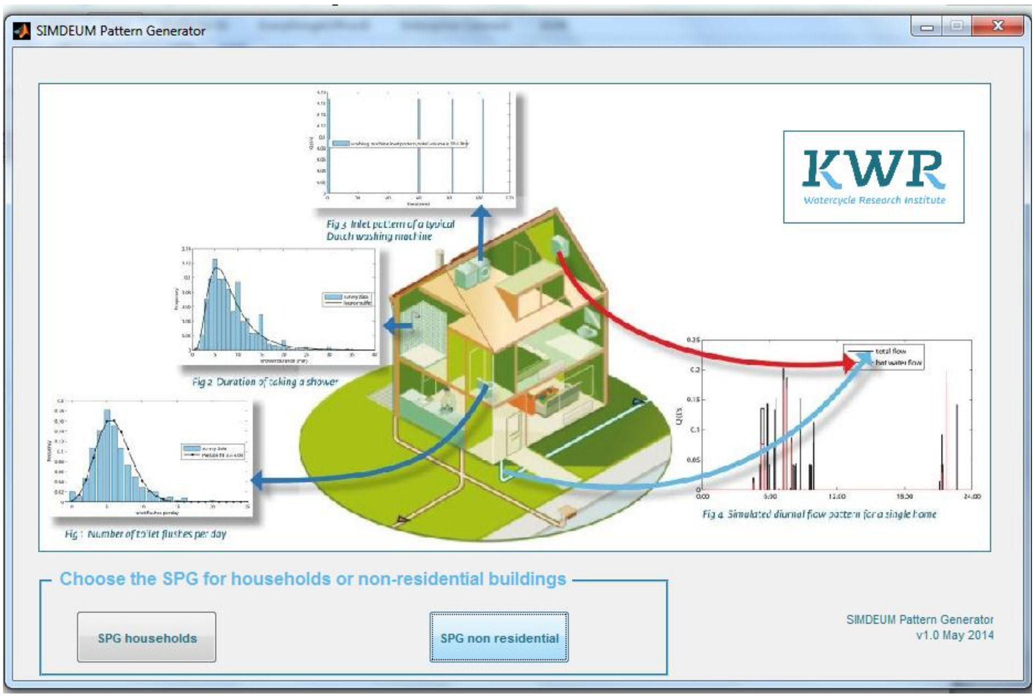
PART I: How to get started with SIMDEUM Pattern Generator.

PART II: SIMDEUM Pattern Generator for residential buildings (chapter 3 to 8).

PART III: SIMDEUM Pattern Generator for non- residential buildings (chapter 9 to 11).

The manual is enclosed with a chapter of possible applications of the SIMDEUM Pattern Generator (chapter12) and a list of references and background information is presented in chapter 13.

# PART I: How to get started with SIMDEUM Pattern Generator



# 2 Installation and start of SIMDEUM Pattern Generator

## 2.1 Installation

SIMDEUM Pattern Generator (SPG) gives information on the water demand and water discharge, in quantity as well as in quality. In Watershare, SPG forms a part of the tool called Water-Use Info. Through the website of Watershare, the software tool for Water-Use Info can be started (http://www.watershare.eu/). You need an account to login to the Watershare website. You can sign in at the right top corner of the screen.

After login, select "Water-Use Info: Understanding water demand and discharge". You enter an environment with information on the Water-Use Info tool, for example a movie, the manual, training possibilities, references with background information and cases describing the application of the tool in practice.

To start working with the tool you choose the "launch" button. You enter the home screen of Water-Use Info, consisting of two parts (Figure 2-1). The first part ❶ is a tool that facilitates the generation of a spg-file, that contains the import data for the residential version of the SPG. This part is described in section 5.3. The second part (❷) is the button Download SPG to download the SPG for both residential and non-residential water use. After saving the zip-file, you can install the SPG by running the executable named "SimdeumPatternGenerator.exe".

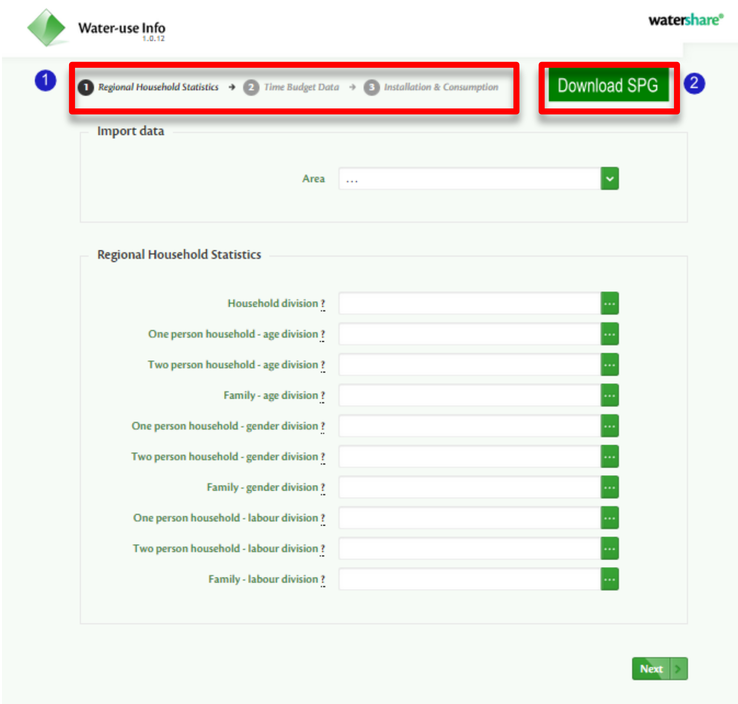



*Figure 2-1 Home screen of Water-Use Info, consisting of a tool to generate a spg-file for residential water use and a button to install the SIMDEUM Pattern Generator.*

## 2.2 Start SIMDEUM Pattern Generator

To start the SPG for residential and non-residential water use, run the executable "SimdeumPatternGenerator.exe". The working/functional SPG appears on the screen ( Figure 2-2). With the buttons at the bottom of the SPG you can choose for the SPG for households (chapter 3 to 8) or for the SPG for non-residential buildings (chapter 9 to 11).

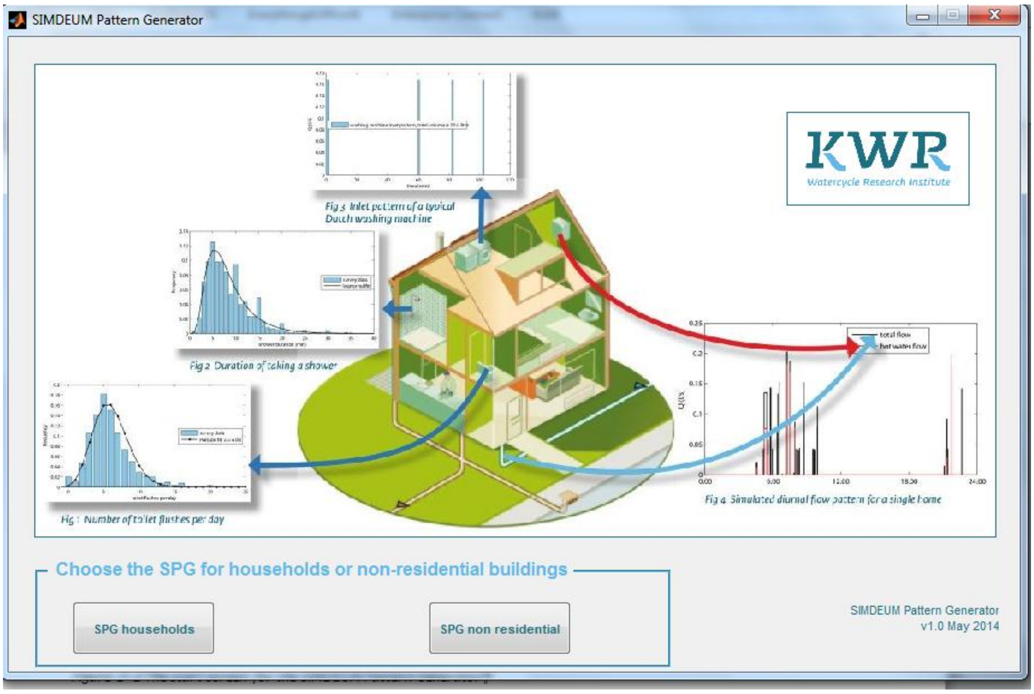
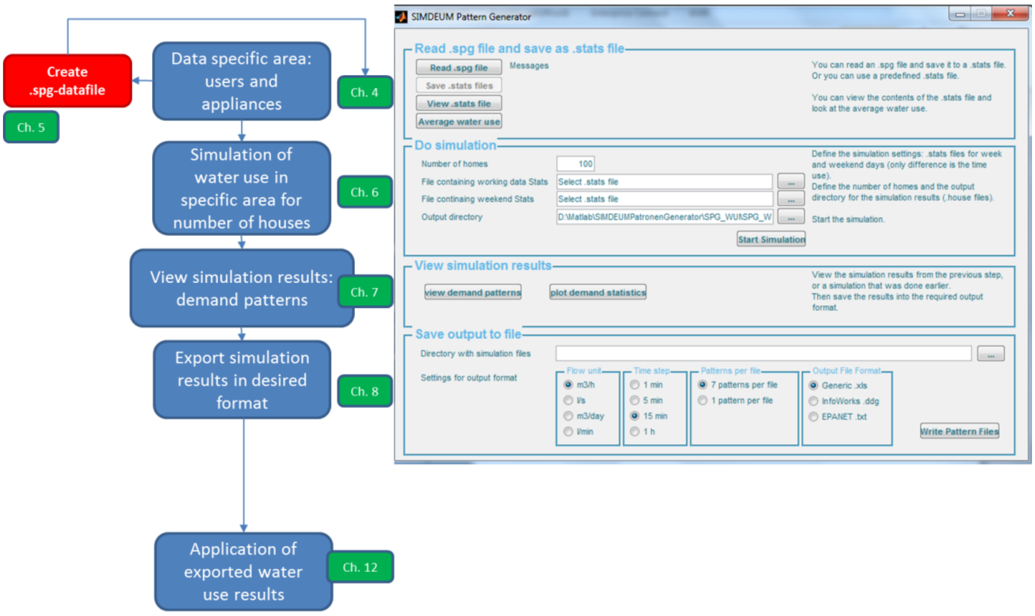



*Figure 2-2 The home screen for the SIMDEUM Pattern Generator.*

# PART II: SIMDEUM Pattern Generator for residential buildings



# 3 Structure of SIMDEUM Pattern Generator for residential buildings

Figure 3-1 shows the structure of the SIMDEUM pattern generator (SPG) for residential buildings, when you choose “SPG Households” in the home screen of the SPG (Figure 2-2). It follows the logical steps you have to make to obtain the demand patterns that you need for a certain purpose:

1. First you define (and collect) the characteristics of the users and the appliances, that are present in the specific area under consideration. How you can do this and which data you need are described in chapter 4 and chapter 5.
2. When you have collected your data and saved them in the required format, you can perform a simulation. This is described in chapter 6.
3. You can view the results of the performed simulation in the following step, described in chapter 7.
4. You can export the simulation results to a format, that suits the desired application of the demand patterns. In chapter 8 you can find the information how to do this.
5. Finally, you can apply the exported results in your application. Some application examples are described in chapter 12.

The SPG is constructed in such a way, that you can carry out each step independently. This means that you can execute step 4, with stored simulation results. You don’t have to start from scratch.

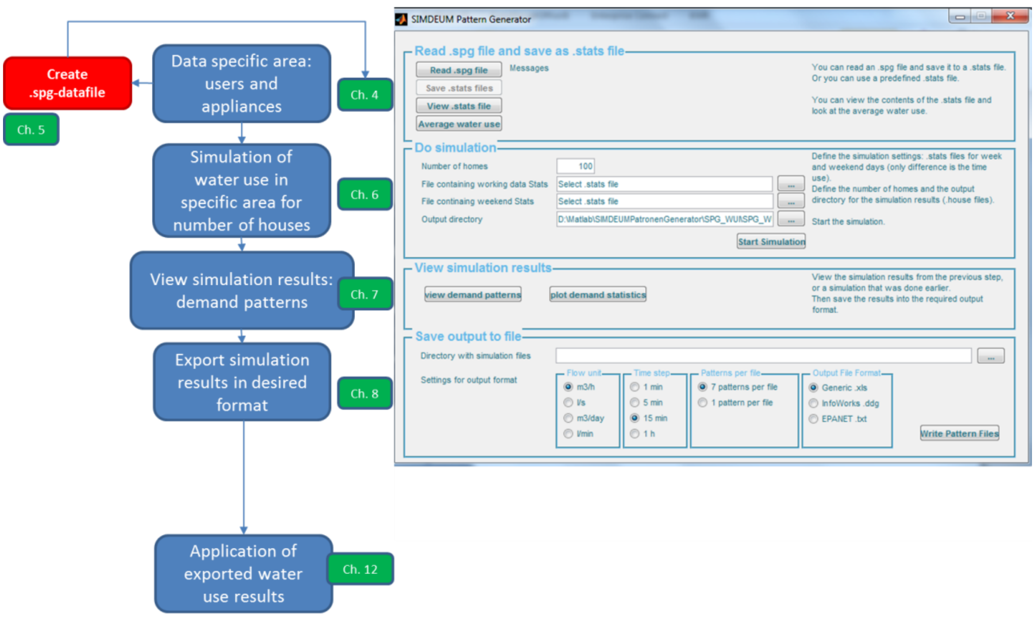



*Figure 3-1 Structure of the SIMDEUM Pattern Generator for residential buildings and the corresponding chapters of this manual.*

# 4 Create area specific stats-file

## 4.1 Introduction

SIMDEUM calculates the cold and hot water demand patterns in a residential building, based on the water using behaviour of the occupants and on the characteristics of the appliances in the building. So, when you want to use the SPG to simulate demand patterns for a certain building or area, knowledge of the occupants and the expected or installed appliances is essential. The input datafile for the SPG contains information on both the users and the appliances in a fixed format, the so-called .spg-datafile.

The data on users and appliances for residential buildings follow the stream as is shown in the top of the SPG “read .spg and save as .stats file” (Figure 4-1). The .spg files contain the data on users and appliances in a certain format. The SPG saves the data in two stats-files: a week.stats-file and a weekend.stats-file, that are used in the simulation procedure. You can view the contents in the stats-file and the average water use can be generated.

The read .spg and save as .stats file screen is divided into three sections:

1. Buttons to execute an action.
2. Messages: this part of the screen gives messages on the execution of the action, whether the action is performed without errors or it gives an error-message.
3. Section with explanations.

In this chapter, we first describe which information and data are required as input for the SPG. Then, we describe how to create a stats.file from the spg.file, that is used in the simulation procedure.

In the next chapter, we describe how the data can be organised in the required format for the SPG. We also include some .spg-files for standard or special houses or situations/scenarios.

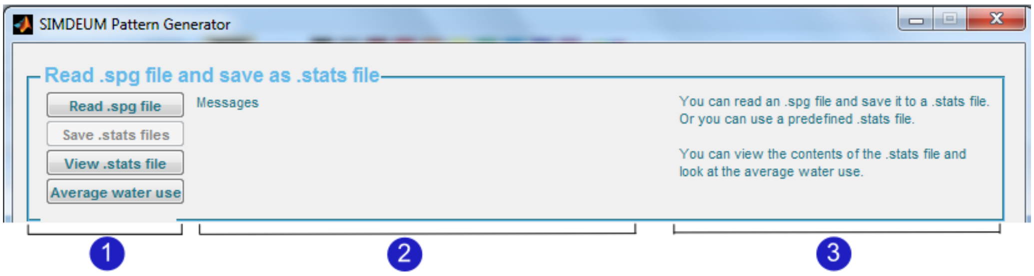



*Figure 4-1 Data on users and appliances as input for simulation of demand patterns: Read .spg file and save as .stats file in the SIMDEUM Pattern Generator.*

## 4.2 Required information on users and appliances in residential buildings for SPG

The SPG is equipped with a number of demo-files, that have been downloaded during installation of the SPG. For the illustration of the required information on users and appliances, we use the file: “demo_house_manual_week.stats”.

### 4.2.1 View the required information on users and appliances through View stats file

Select the button “View .stats file” in the SPG (Figure 4-1) and select the stats-file: “demo_house_manual_week.stats”. The stats-viewer with the information on users (❶), taps (❷) and hot water (❸) then appears on the screen (Figure 4-2).

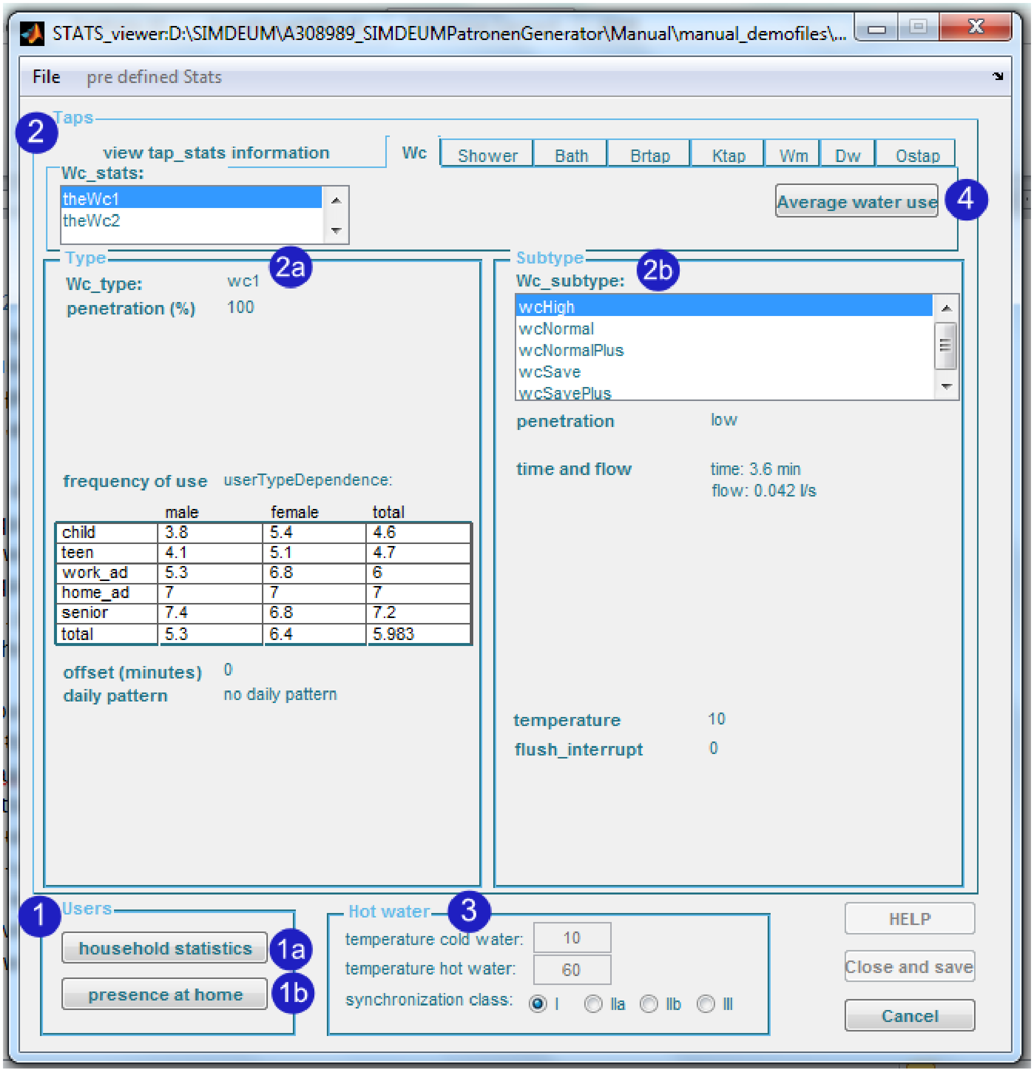



*Figure 4-2 View .stats-file with data on users (1), taps (2) and hot water (3) for residential building, and the average water use (4).*

### 4.2.2 Information on users in SPG (❶ in Figure 4-2)

To simulate the water demand in a household, SIMDEUM needs to have information on the people that are present in the house (“household statistics”) and their time schedule, that gives information on the time the persons are at home (“presence at home”). When people are at home, they can use water. When they are sleeping or when they are away, they cannot use any water.

a) Household statistics

Required information on household statistics

Select the button "household statistics" in the SPG and Figure 4-3 appears. In this figure, you see the household statistics of the house defined in the "demo_house_manual_week.stats".

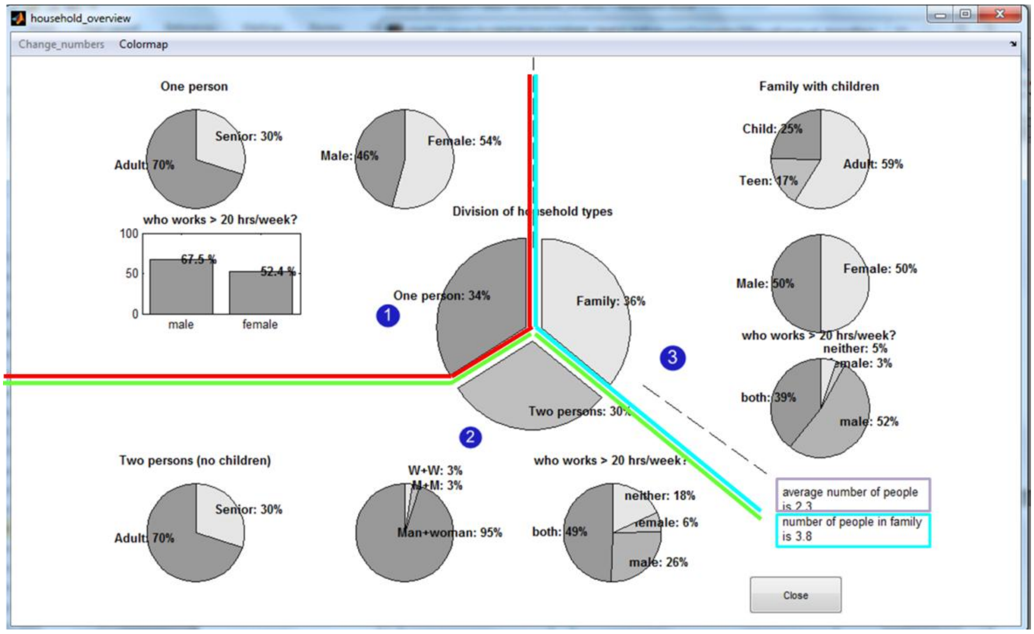



*Figure 4-3 Household statistics of the demo_house_manual_week.stats.*

Within the SPG three types of households are defined: one person households, two person (no children) households and families with children. In the centre you see that, in the example, 34% of the houses is a one person household (❶), 30% is a two person household (❷) and 36% is a family (❸). The average number of people in the households is 2.3 (in purple).

In the other parts of the figure, the statistics of the amount of people, the age, the gender and their occupation, are presented for each household. Four categories exist for age: children (0-12 years), teenagers (13-18 years), adults (19-64 years) and seniors (> 65 years). The information present in Figure 4-3 is summarised in Table 4-1. The colours correspond with the parts/sections in the figure. This information is required since the frequency and the duration of the use of an appliance can depend on the age of the persons. Teenagers for example shower longer and more frequently than a senior.

*Table 4-1 Household statistics of the demo_house_manual_week.stats.*

| | | One person households | Two person households | Families with children |
|---|---|---|---|---|
| Number of people per household | | 1 | 2 | 3.8 (on average) |
| Number of households (%) | | 34 | 30 | 36 |
| Gender division: male/female (%) | | 46/54 | 50/50 in 95% in 5%: 3% male-male and 3 % female-female | 50/50 |
| Age division (%) | Children (0-12 years old) | 0 | 0 | 25 |
| | Teens (13-18 years old) | 0 | 0 | 17 |
| | Adults (19-64 years old) | 70 | 70 | 59 |
| | Subdivision: % of adults with out-of-home job | Male: 67.5<br>Female: 52.4 | Both persons: 49<br>Only male: 26<br>Only female: 6<br>Neither person: 18 | Both parents: 39<br>Only father: 52<br>Only mother: 3<br>Neither parent: 5 |
| | Seniors (> 65 years old) | 30 | 30 | 0 |

In the SPG, the maximum (average) size of households in a family is 5. This corresponds with the Dutch situation, where larger families are rare. When necessary, KWR can make adjustments on request for other situations (larger household size).

### How to obtain the required information on household statistics

Household data differ for each region and for each country. In the Netherlands, CBS has a database with the required information for each city, and even for districts within a city. You can freely use this database through: http://www.cbsinuwbuurt.nl/#pageLocation=index. Statistics Netherlands (CBS) gives information on the number of households per area and the number of people, and their ages, within a household. CBS also gives information on gender and percentage occupation in the district. Also information on other characteristics of a district that can influence water use, can be obtained from CBS, like the number of immigrants, homeless people and people without income.

Most countries have national statistics or even statistics per city. For example in the Netherlands, Amsterdam has its own statistical information on http://www.os.amsterdam.nl/. For countries in the Europian Union the following website links to national statistic offices: ec.europa.eu/Eurostat.

b) Presence at home or time budget data

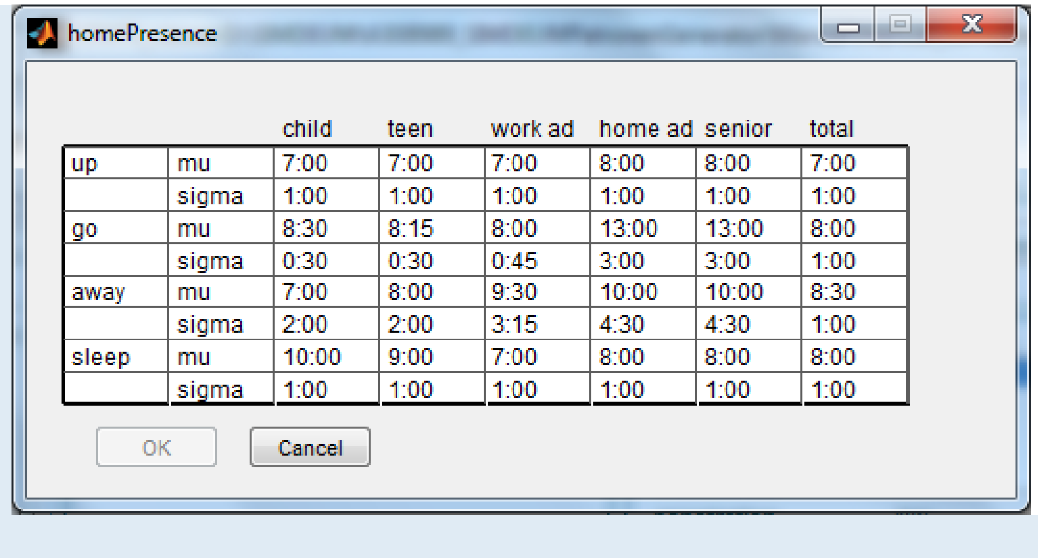
Required information on time budget data

Select the button "presence at home" in the SPG and Figure 4-4 appears. The figure shows for every age category (child, teen, adult and senior) and for different categories in occupation of the adults (work_ad and home_ad), characteristics of their time presence in the "demo_house_manual_week.stats":

- Up: time the person gets up
- Go: time of leaving the house
- Away: the duration of being away (in hours)
- Sleep: sleep duration (in hours)

In this figure 'mu' stands for average and 'sigma' for the standard deviation.

For example, in general, a teenager gets up at 7:00 during a weekday, leaves the house by 8:15 and stays away for 8 hours. On average they sleep for 9 hours.




| | | child | teen | work ad | home ad | senior | total |
|---|---|---|---|---|---|---|---|
| up | mu | 7:00 | 7:00 | 7:00 | 8:00 | 8:00 | 7:00 |
| | sigma | 1:00 | 1:00 | 1:00 | 1:00 | 1:00 | 1:00 |
| go | mu | 8:30 | 8:15 | 8:00 | 13:00 | 13:00 | 8:00 |
| | sigma | 0:30 | 0:30 | 0:45 | 3:00 | 3:00 | 1:00 |
| away | mu | 7:00 | 8:00 | 9:30 | 10:00 | 10:00 | 8:30 |
| | sigma | 2:00 | 2:00 | 3:15 | 4:30 | 4:30 | 1:00 |
| sleep | mu | 10:00 | 9:00 | 7:00 | 8:00 | 8:00 | 8:00 |
| | sigma | 1:00 | 1:00 | 1:00 | 1:00 | 1:00 | 1:00 |

*Figure 4-4 The statistics of presence at home for demo_house_manual_week.stats.*

Human behaviour is predictable. It appears that the probability of water use is related to the sleep-wake rhythm and being at home. For weekdays, this pattern is strongly related to people's ages and occupation. For a weekend day this correlation is not very strong. You can see this in the demo_house_manual_weekend.stats.

The probability of water use is related to the fact that human behaviour is predictable:

- During sleeping hours, the total volume of water use is estimated at 1.5% of the total daily demand. This is based on Dutch water use measurements between 1:00 and 5:00 AM.
- During absence, the probability of water use is zero.
- During the half hour after getting up and returning home and the half hour before leaving the house and going to bed, peak hours are assumed. People shower or flush the toilet at these moments.

How to obtain required information on time budget data

In the Netherlands, the Netherlands Institute for Social Research (SCP) conducts a five-year time-budget survey since 1975. General information on age, occupation, house and household are asked In this survey. Moreover, during one week, people write down in an diary what their main activity was (from a list of predefined activities) at every quarter of an hour of the day and whether they were at home or elsewhere. From the time-budget survey, the duration of sleep and being away, and the time of getting up and leaving home can be derived.

Information on time use data for several countries can be found on www.timeuse.org.

### 4.2.3 Information on taps or water-using appliances in SPG (❷ in Figure 4-2)

Required information on taps or water using appliances

The water demand in a household depends on the number of water-using appliances in the house, for example two toilets, a shower, a washing machine, etc. and the characteristics of the installed water-using appliances and taps, like the flow rate, duration of use, frequency of use and the desired temperature.

The duration and frequency may vary depending on the users: a child bathes more frequently than a senior, while a senior flushes the toilet more frequently. A teenager showers more frequently and longer than an elderly person. Moreover, the duration, frequency and the desired temperature of an appliance can depend on the type of appliance (e.g. particular type of washing machine) and the particular application. For example, a bathroom tap can be used for brushing teeth (cold water) or for shaving (hot water).

At position ❷ in Figure 4-2, the characteristics of the water-using appliances is presented. At the top you see different tabs, with the various water-using appliances, i.e. Wc, Shower, Bath, Brtap (bathroomtap), Ktap (kitchen tap), Wm (washing machine), Dw (Dishwasher) and Ostap (outside tap). At ***tap_stats*** (in this figure it is Wc_stats), you see the number of taps of the tap under consideration. For each tap, you need to enter specific information on the type of end-use (at a) and information on the subtype (at b). The subtype can be a special type of tap (for example a water saving shower) or a special application (for example brushing teeth or shaving). First we list the required information for each appliance in Table 4-2, then we will show some examples.

*Table 4-2 Types of water-using appliances in households and the required information for each type of appliance and each subtype.*

| Type of taps (code in SPG) | Information for each type (2a in Figure 4-2) | Information for each subtype (2b in Figure 4-2) |
|---|---|---|
| Toilet (Wc) | *Penetration*: percentage that this type of water-using appliance is present in the households | *Penetration*: low/average/high chance this subtype of water-using appliance is present in the households/penetration rate within end use |
| Shower (Shower) | | |
| Bath (Bath) | | |
| Bathroomtap (Brtap) | *Frequency of use*[a]: how often this water-using appliance is used per day | *Time and flow*: Duration of use and the flow rate |
| Kitchen tap (Ktap) | | |
| Washing machine (Wm) | *Offset* (minutes): time between two subsequent uses | *Temperature*: desired temperature of this subtype |
| Dishwasher (Dw) | | |
| Outside tap (Ostap) | *Daily pattern*: probability of use varies over the day | *Flush_interrupt* (only with Wc): percentage of using the water-saving option of the toilet flush |

[a]Frequency of use is expressed per person. Except for the kitchen tap, there the frequency of use is expressed per household.

We will illustrate the various possibilities of information/data for a number of water-using appliances in the demo_house_manual_week.stats:

**Example 1: Wc**

Wc-type

*Penetration*

In all households there is one toilet: penetration is 100% for theWc1.
In 50% of the households, there is a second toilet: penetration is 50% for theWc2.

*Frequency of use*

The frequency of use depends on the age and gender of the person:

**frequency of use** userTypeDependence:

| | male | female | total |
|---|---|---|---|
| child | 3.8 | 5.4 | 4.6 |
| teen | 4.1 | 5.1 | 4.7 |
| work_ad | 5.3 | 6.8 | 6 |
| home_ad | 7 | 7 | 7 |
| senior | 7.4 | 6.8 | 7.2 |
| total | 5.3 | 6.4 | 5.9 |

A teenager flushes at home the toilet 4.7 times a day, a teenage boy 4.1 times a day, a teenage girl 5.1 times.
When there are two toilets in the house, the frequency of use will be divided over the two toilets during simulation.

*Offset*

0 minutes
You can directly use the toilet flush again.
When it would take 5 minutes for the cistern to fill again, the offset is 5.

*Daily pattern*

there is no specific daily pattern for toilet use

Wc subtype

A number of Wc subtypes exist, which mostly differ in their water saving character. Water saving can be a consequence of the water volume that is flushed (combination of flow and duration) and the presence of a water-saving option. We will illustrate two subtypes

*Wc_subtype: wcHigh*

*Penetration*

Low:
the toilet in the households is not often of type wcHigh

*Time and flow*

duration is 3.6 minutes with a flowrate of 0.042 l/s. So wcHigh is a toilet with a 9 litre reservoir.

*Temperature*

10°C

*Flush_interrupt*

0:
This toilet subtype does not have a water-saving option or the water-saving option is never used.

*Wc_subtype: wcSavePlus*

*Penetration*

High:
the toilet in the households is often of type wcSavePlus

*Time and flow*

duration is 2.4 minutes with a flowrate of 0.042 l/s. So wcHigh is a toilet with a 6 litre reservoir

*Temperature*

10°C

*Flush_interrupt*

0.8:
In 80% of the flushes, the water-saving option is used (half of the volume: 3 litre), in 20% of the flushes 6 litre flush.

The information for the shower is presented in Figure 4-5.

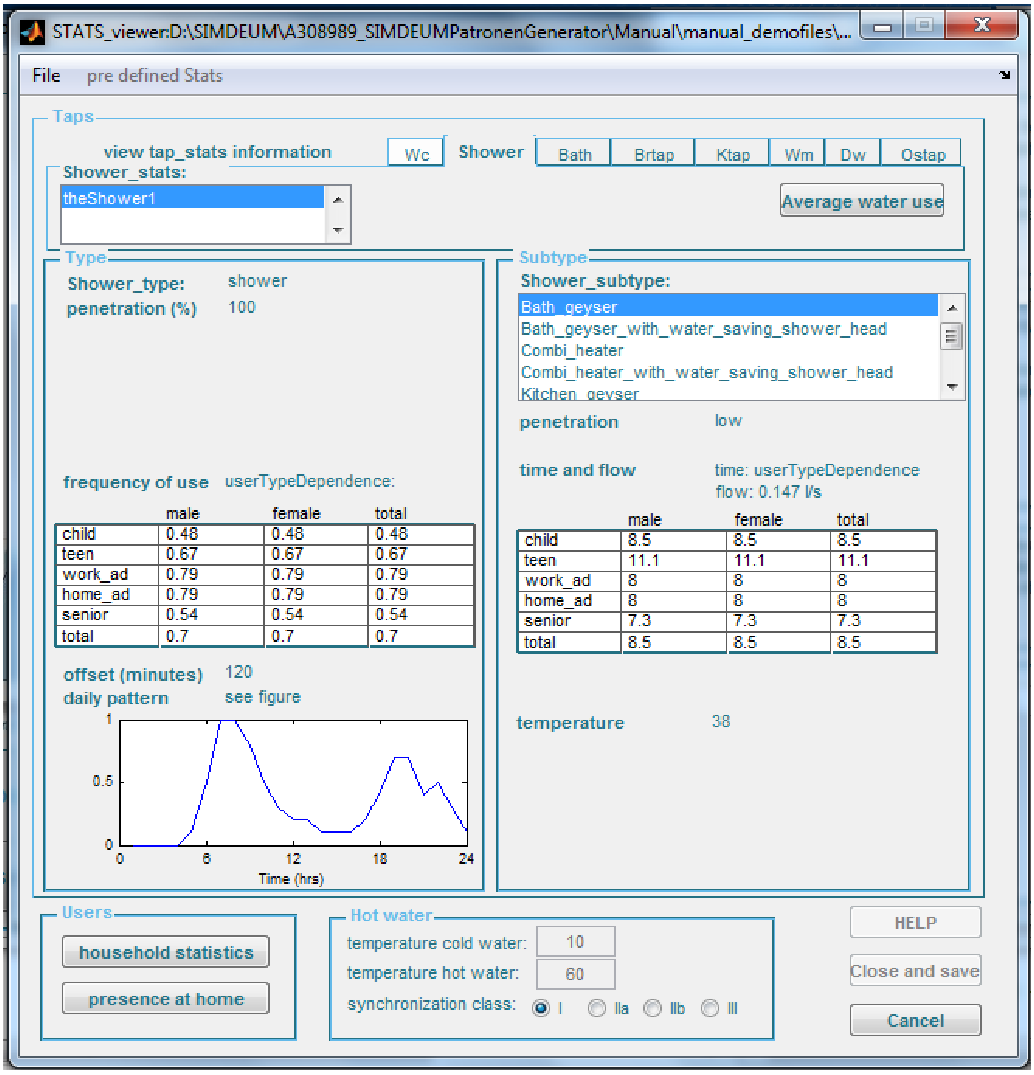



*Figure 4-5 View .stats-file with data for shower in demo_house_manual_week.stats.*

### Example 2: Shower

Shower-type

*Penetration*

In all households there is one shower: penetration is 100% for theShower1. No household has two showers.

*Frequency of use*

The frequency of use of the shower depends on age: a senior showers less frequent (0.54 times a day, so ones in two days) than an adult (0.8 times a day). The frequency is given per person.

| | male | female | total |
|---|---|---|---|
| child | 0.48 | 0.48 | 0.48 |
| teen | 0.67 | 0.67 | 0.67 |
| work_ad | 0.79 | 0.79 | 0.79 |
| home_ad | 0.79 | 0.79 | 0.79 |
| senior | 0.54 | 0.54 | 0.54 |
| total | 0.7 | 0.7 | 0.7 |

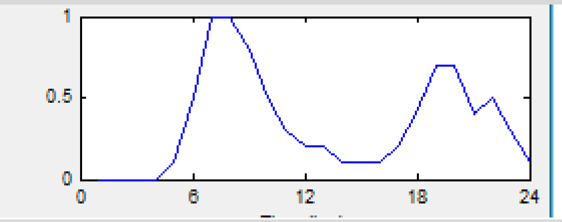
*Offset*

120 minutes

There is at least 120 minutes between two shower turns by one person.

*Daily pattern*

In this shower type, the probability of taking a shower varies during the day:




In this daily demand, it is assumed that people mainly shower after they wake up or before going to sleep, but not after midnight.

Shower subtype

A large number of Shower subtypes exist. They mainly differ in the efficiency of heating water and the resulting flow rate. We will illustrate one subtype: the shower type which often occurs in households

*shower_subtype: combi_heater*

*Penetration*

High:

This type of shower is often present in the defined households.

SPG weighs the penetration by numbers: low = ‘1’, average = ‘2’, high =’3’

Dependent on the number of subtypes the penetration is determined. In this example, there are eight subtypes with penetration low, low, high, high, low, low, low and low; the weights are 1,1, 3,3,1,1,1,1 and the penetrations will be 1/12, 1/12, 3/12, 3/12, 1/12, 1/12, 1/12 and 1/12..

*Time and flow*

The flow rate is 0.142 l/s. When you chose the combi_heater_with_water_savind_shower_head, the flow rate is 0.123 l/s.

The duration of the shower depends on the age of the user:

| | male | female | total |
|---|---|---|---|
| child | 8.5 | 8.5 | 8.5 |
| teen | 11.1 | 11.1 | 11.1 |
| work_ad | 8 | 8 | 8 |
| home_ad | 8 | 8 | 8 |
| senior | 7.3 | 7.3 | 7.3 |
| total | 8.5 | 8.5 | 8.5 |

Teenagers shower the longest.

*Temperature*

38°C

The characteristics of the kitchen tap are shown in Figure 4-6.

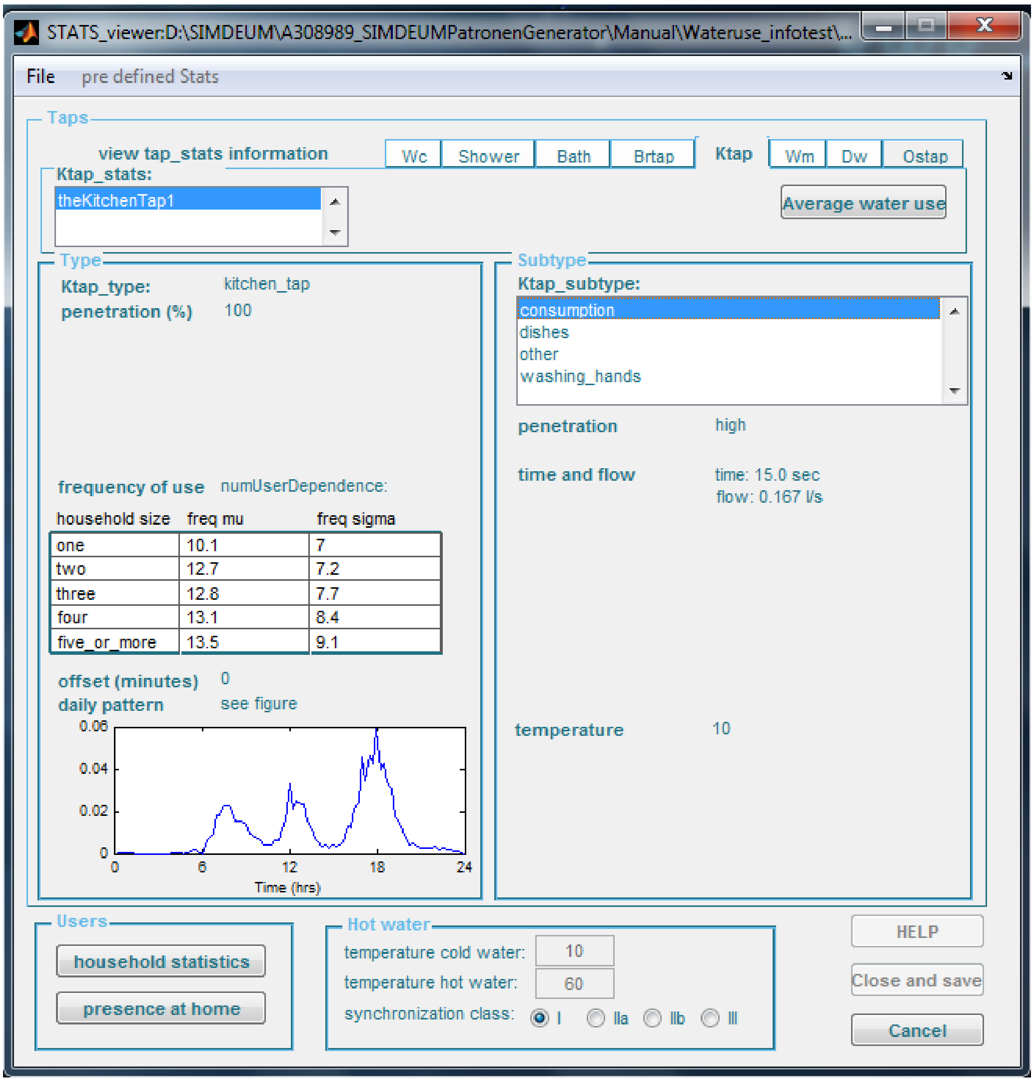



*Figure 4-6 View .stats-file with data for kitchen tap in demo_house_manual_week.stats.*

Example 3: Kitchen tap

Ktap-type

*Penetration*

In all households there is a kitchen tap: penetration is 100% for theKitchenTap1.

*Frequency of use*

The frequency of use of the kitchen tap depends on the size of the family or household:

| household size | freq mu | freq sigma |
|---|---|---|
| one | 10.1 | 7 |
| two | 12.7 | 7.2 |
| three | 12.8 | 7.7 |
| four | 13.1 | 8.4 |
| five_or_more | 13.5 | 9.1 |

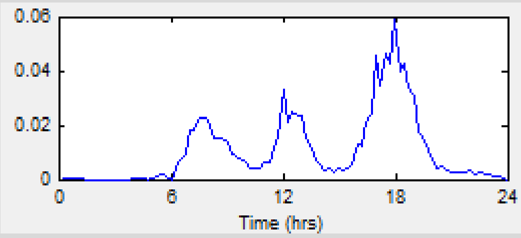
The larger the household, the more frequent the kitchen tap is used.
The frequency is given per household.

*Offset*

0 minutes
After use you can directly use the kitchen tap again.

*Daily pattern*

The daily pattern for a kitchen tap is




This means that the probability of use is higher during breakfast, lunch and the highest around 18:00, when people are preparing dinner. This is characteristic for Dutch households, but can be different for other countries with other cultures.

Ktap subtype

The subtypes for the kitchen tap are related to other applications or use of the tap. Water used for consumption has another temperature, another duration and flow than water used for washing the dishes:

*Ktap_subtype: consumption*

*Penetration*

High:
The water from kitchen tap is often used for consumption.

*Time and flow*

Average duration is 15 seconds with a maximum flowrate of 0.167 l/s

*Temperature*

10°C

*Ktap_subtype: dishes*

*Penetration*

Average:
The water from kitchen tap is used for washing the dishes, but less often than for consumption.

*Time and flow*

Average duration is 45 seconds with a maximum flowrate of 0.250 l/s
When washing the dishes, you turn the valve more and longer open than for consumption.

*Temperature*

55°C

The characteristics of the dishwasher as defined in demo_house_manual_week.stats are shown in Figure 4-7.

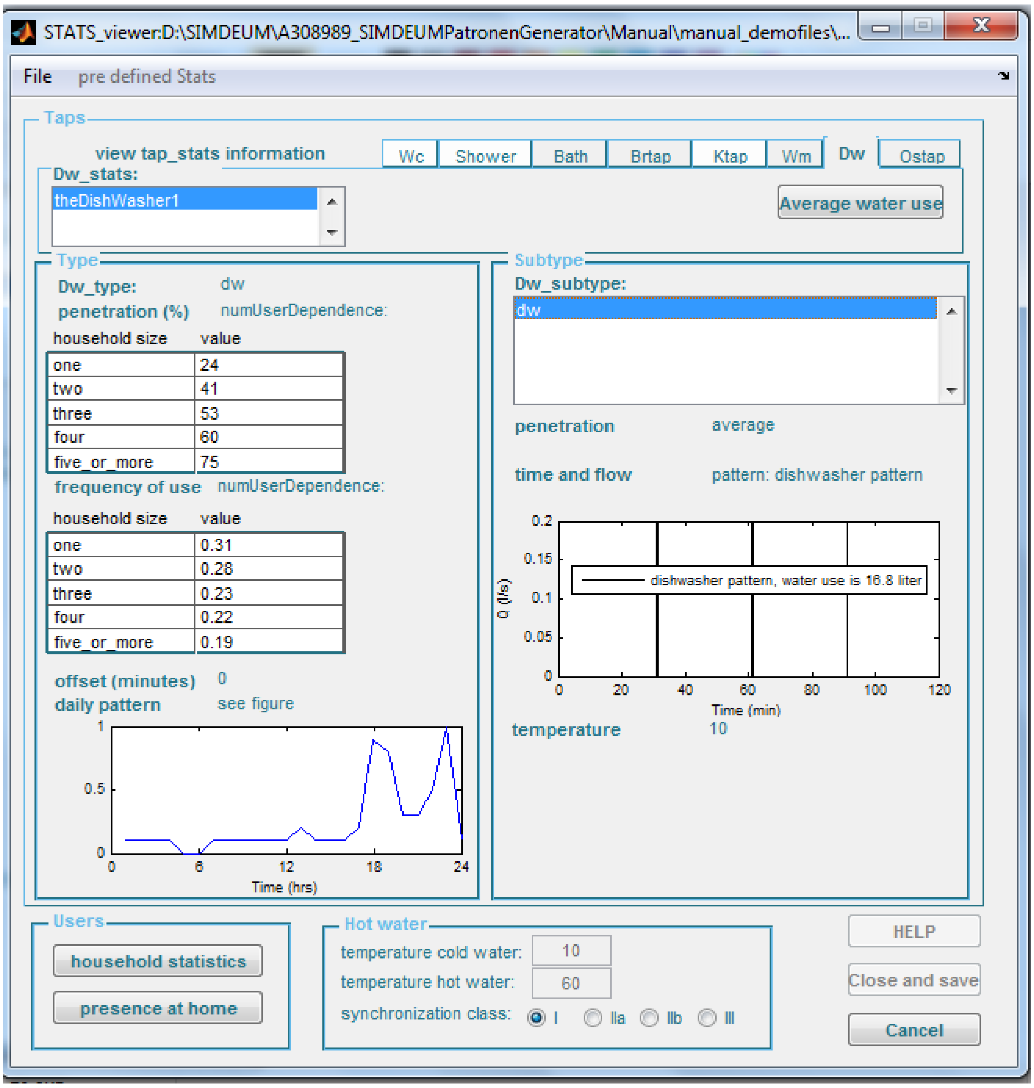



*Figure 4-7 View .stats-file with data for dishwasher in demo_house_manual_week.stats.*

Example 4: Dishwasher

Dw-type

*Penetration*

The presence of a dishwasher in a household depends on the size of the family or household:

| | |
|---|---|
| one | 24 |
| two | 41 |
| three | 53 |
| four | 60 |
| five_or_more | 75 |

The larger the household, the higher the chance that a dishwasher is present. In a household of four persons, there will be a dishwasher in 60% of the houses.

*Frequency of use*

The frequency of use of the dishwasher also depends on the size of the family or household:

| household size | value |
|---|---|
| one | 0.31 |
| two | 0.28 |
| three | 0.23 |
| four | 0.22 |
| five_or_more | 0.19 |

This frequency is expressed per person. So in a four person household, the frequency is 0.22 per person, which corresponds with a total use of 0.8 times per day.

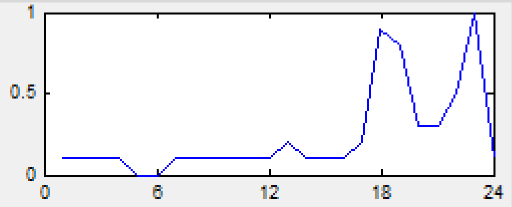
*Offset*

0 minutes

After use you can directly use the dishwasher again.

*Daily pattern*

The daily pattern for a dishwasher is




This pattern shows that the dishwasher is mainly switched on after dinner or at late evening.

Dw subtype

The subtypes for the dishwasher is related to the label of the dishwasher. The manufacturer can provide the required data.

*Dw_subtype: dw*

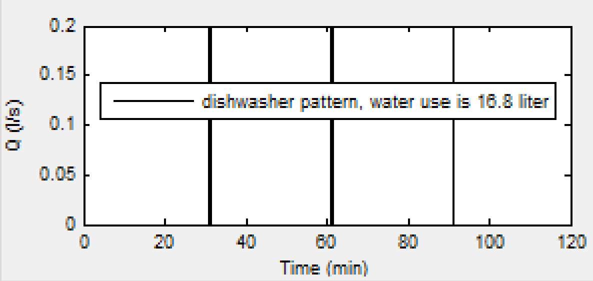
*Penetration*

Average:

Since only one dishwasher is defined, the penetration does not matter. In case of more than one dishwasher, see the explanation of the definition of penetration for the shower.

*Time and flow*

The dishwasher, as well as the washing machine, has a characteristic pattern of flow and duration, due to the taking in of water during time periods:

| | |
|---|---|
| | <br>The total water use is 16.8 litre. |
| *Temperature* | 10°C<br>Dishwashers take in cold water and heat the water in the dishwasher. |

How to obtain required information on taps or water using appliances

The required information on the taps can be divided in:

a) *Technical specifications, like flowrate*
Suppliers can provide technical specifications of taps or appliances. For different brands and types of machines the required characteristics like flow rate, duration of flow or flow patterns can be requested from the supplier.
For example, a toilet can be an old-fashioned toilet with a large cistern (9 litre) or a new one of only 6 litres with a water-saving option of flushing only 3 litres. When the flow rate of the flushing is known from the supplier (0.042 l/s), the duration can be determined for each flush.
For washing machines and dishwashers, the water inlet patterns are specified by the supplier.

b) *Specifications determined by type of household, application or user behaviour*
In the described examples of some appliances it is shown that the penetration of appliances can depend on the household size (like the washing machine), the frequency of use can depend on the age or gender of the user (toilet, shower) or size of household (washing machine), the time, flow and temperature can depend on the user (shower) or application (kitchen tap). Moreover, the probability of use can vary during the day (shower, washing machine, dish washer). These specifications can be different for different cultures and countries.
Information on these specifications can be derived from research on water using behaviour or time-budget data. In the Netherlands, two types of surveys assist in deriving this information:
    1. Survey on residential water use carried out every three years for the Dutch water companies.
    The respondents in the survey answer questions on their household (number of people, age and gender, and ownership of appliances) and fixtures (flow during normal operation, measured with stopwatch and bucket). During one week, they filled a diary on their water use at home, like how often they took a shower, flushed the toilet, opened the kitchen tap and for what purpose, washed at the sink, took a bath, etc.

This survey gives information on the penetration of appliances in each household, the frequency of use of appliances by different groups, the duration of using an appliance by different groups and for different purposes.

2. Time-budget survey by SCP (see p. 23).
   This survey gives information on the time on the day that an appliance is used by different persons.

In case no information is available for your country you may reuse data from The Netherlands or other countries. KWR can help you with some default values. You can also use the demo-files given in 5.4.

### 4.2.4 Information on hot water in SPG (❸ in Figure 4-2)

For each appliance the desired temperature, for different applications, and the desired flowrate and duration are known and defined in the former section (4.2.3). The required hot water amount for each purpose, is calculated by mixing cold water with hot water from the heater so that the desired temperature at a certain flowrate is achieved. Therefore, for the simulation of the hot water demand during the day by SPG, the temperature of cold water and the temperature of hot water from the heater at the tap need to be specified.

In Figure 4-2, the temperatures for incoming cold water and hot water at the tap are presented at position ❸. The synchronization class is an indication of the possibility of simultaneous use of taps using warm water. Synchronization class I means that only one tap can use warm water. Suppose one wants to use two hot water taps at the same time, then this is not possible within synchronization class I. The following prioritization is applied, first the shower is used, then the kitchen faucet and finally the bathroom faucet. Within synchronization class II, two hot water taps can be used simultaneously, i.e. the kitchen and shower faucet or kitchen and bath tap. In synchronization class III there is no limitation in simultaneous use: the hot water taps can be used simultaneously.

For design purposes we take 10°C for cold water and 60°C for hot water.

### 4.2.5 Information on average water use (❹ in Figure 4-2)

In the former sections, the information is described on the components that determine the water use in a building: the type of household and the water using behaviour of the occupants and the characteristics of the installed appliances in the building. With the button "Average water use", a figure is created that show a table with the average water use in the defined building and the average water use per appliance per person per day. Moreover, it shows a pie chart, that illustrates the division of the used water quantity over the appliances. It directly shows the appliances responsible for the highest water use.

When you press the button Average water use, the figures for average water use of demo_house_manual_week.stats appear (Figure 4-8). The pie chart shows that 34% of the total water use is caused by the use of the shower, which corresponds with 45.9 litre per person per day (shown in the table).

| tap | liter pppd |
|---|---|
| Bath | 3.5 |
| Brtap | 4.0 |
| Dw | 1.9 |
| Ktap | 14.6 |
| Ostap | 13.4 |
| Shower | 45.9 |
| Wc | 35.9 |
| Wm | 17.1 |
| sum | 136.2 |

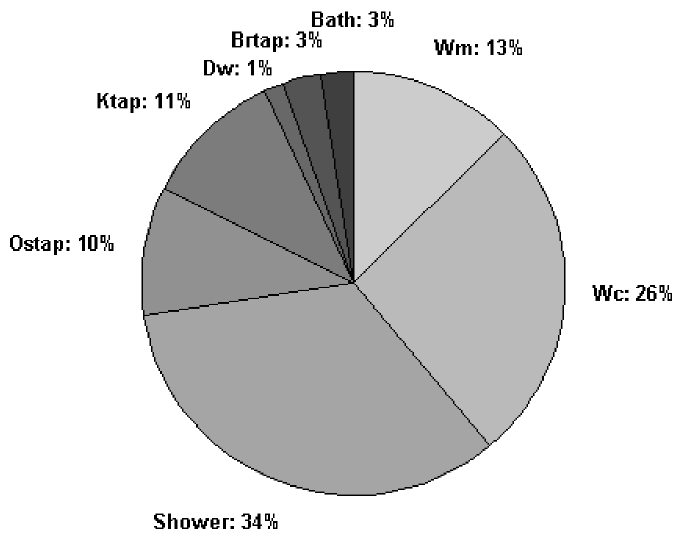



*Figure 4-8 Average water use of the building/household defined in demo_house_manual_week.stats.*

This function is useful to get an impression of the water use in a building and the dominance of certain appliances in water use. It can assist in proposing new appliances for saving water use and also to have a quick glance on the effect of using other sanitation concepts, as for example a water saving shower head or another type of washing machine.

## 4.3 Creating stats.files for the simulation procedure in the SPG

The input datafile for the SPG contains the described information on both the users and the appliances in a fixed format, the so-called .spg-datafile. How you can create a spg-file, forms the core of next chapter, chapter 5.

The created spg-files contain all relevant data for users and appliances in the households, that are required to simulate the cold and hot water demand with SIMDEUM in the SPG. However, the simulation procedure is using a stats-file. Therefore, the next step is to convert the final version of the spg-file into a stats-file.

In the top of the SPG "read .spg and save as .stats file" (Figure 4-1), you first read the spg-file by pressing Read .spg file. You can browse to the location of the required spg-file. And select the spg-file. After the message appears that the spg-file was read without errors, you can save it as a .stats-file by pressing Save .stats files. You select the desired location and the SPG creates automatically two stats-files from the data in the spg-file:

a) a stats-file for a weekday: namefile_week.stats.
b) a stats-file for a weekend day: namefile_weekend.stats.
   At the moment the weekend day differs only for the time budget data or the presence at home data.
   Of course, it is possible that the use of appliances also differs in weekends. For example, the daily pattern of the shower may be different on a weekend day. In a future version, also different daily patterns for shower and washing machine during week or weekend day may be included.

# 5 Create area specific spg-datafile

## 5.1 Introduction

The spg-file with all the data on users and appliances is a plain text file, with extension .spg. The format of the file is shown in Appendix I and covers all components described in the sequence of section 4.2.2 and 4.2.3. The terminology corresponds with the names and terms described in these sections. To illustrate a filled spg-file, the spg-file belonging to the demo_house_manual_week.stats is given in Appendix II. By comparing the spg-file with the figure obtained after pushing the button "View .stats file" (Figure 4-2) helps you to interpret the spg-file.

You can create a spg-file for your specific situation or area in two ways (Figure 5-1):

a) by creating a spg-file or adjusting an existing spg-file as a text-file in the required format (Figure 5-1a). This is described in section 5.2.
b) by creating a spg-file or adjusting an existing spg-file with the Watershare tool Water-Use Info (Figure 5-1b). This is described in section 5.3.

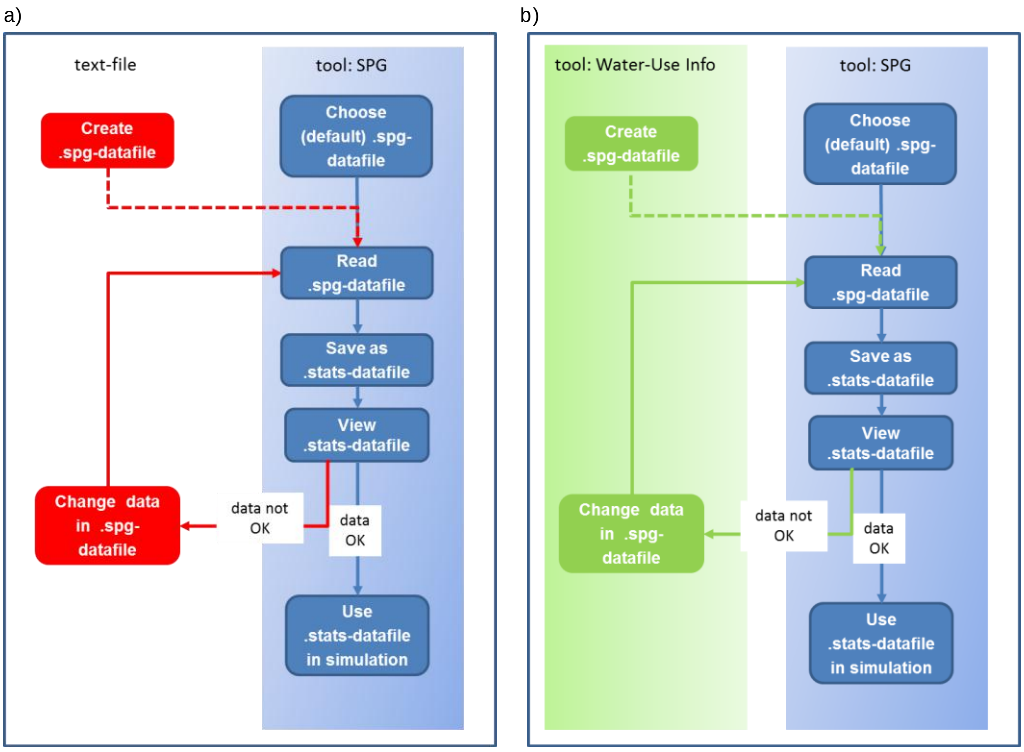



*Figure 5-1 Procedure to create a spg-file starting from a default or demo spg-file or default stats-file: a) using a text-file and b) using Water-Use Info in Watershare®.*

## 5.2 Creating the .spg-datafile for residential buildings as text-file

### 5.2.1 Creating a –spg-datafile for residential buildings in text-file
With the format shown in Appendix I, you can create a text-file in the required format, with the data you have collected for the users and the appliances. Subsequently, you save it as .spg. However, it is quite a lot of work and time consuming.

The easiest way to create a spg-file for your area, is to start with a demo spg-file. The SPG is equipped with a number of demo-files, that have been downloaded during installation of the SPG. The characteristics of each demo-file are described in section 5.4. From the list with demo-files, you first choose a suitable file.

Then you follow the procedure, as shown in Figure 5-1a. You start with an existing spg-file. In the SPG (Figure 4-1), you read the spg-file, save it as a stats-file and view the contents of the data on users and appliances. When the data are okay, you use the stats-file in the simulations. When you need to adjust some data, you change the corresponding data in the text file and save it as .spg. In most cases, the change of the parameter values is straightforward. However, it is quite complicated to adjust or create new patterns, for example the daily patterns of the shower (Figure 4-5) or the kitchen tap (Figure 4-6) or the inlet patterns of the washing machine or dishwasher (Figure 4-7). This is described in 5.2.2. After you have saved the adjustments in the spg-file, you read the new spg-file in the SPG and follow the circle until the data are correct.

### 5.2.2 Creating daily patterns and machine inlet patterns in the text-file
Two types of patterns are present in the calculation of water demand: daily patterns that describe the probability of use of the appliance during the day and inlet patterns of some machines. You can find examples in Figure 4-5 to Figure 4-7.

The most difficult information in the spg-file are these patterns, for example for the shower and the inlet flow patterns for the cycles in a washing machine and dishwasher. In Appendix I, you see the required syntax of the patterns. It consists of a time vector with all timesteps ($t_1$, $t_2$, …., $t_n$), followed by the values for the patterns (value at $t_1$, value at $t_2$, …., value at $t_n$). The timestep in the timevector is free. So you can make a vector with data every hour, but also every 15 minutes or every minute etc. In the demo-house-manual_week.spg in Appendix II, you see various examples of daily patterns: the daily patterns for shower, kitchen tap, washing machine and dishwasher. The daily patterns give the probability of use of the appliance over the day. Appendix II also gives the inlet patterns belonging to the washing cycles of a type of washing machine and of a dishwasher.

You are free to create your own daily patterns or inlet patterns, that correspond with your culture or with the technical specifications from the supplier. However, although this format is very flexible, the examples in Appendix II show that creating these patterns can be very complicated, especially for a small timescale. Together with the installation of the SPG, you received a large number of demo-files (section 5.4). In several demo-files, different patterns are available. We advise you to select the suitable or desired patterns from the demo-files, and combine them in your spg-file. With the procedure of Figure 5-1a, you can view and change the patterns as you wish.

## 5.3 Creating a –spg-datafile for residential buildings with Water-Use Info

Water-Use Info is a helpful tool within Watershare® to create a spg-file. In Figure 2-1 you see the start screen of Water-Use Info. The first part ❶ forms a tool that facilitates the generation of a spg-file.

In this section we describe the structure of the Water-Use Info tool and the use of the tool in three situations: when you don't have a spg-file and have to start from scratch (subsection 5.3.2), when you start with a default or existing .spg-file (subsection 5.3.3) or when you use earlier defined areas (subsection 5.3.4). As is described in the former section, it is quite complicated to adjust or create new patterns, for example the daily patterns of the shower (Figure 4-5) or the kitchen tap (Figure 4-6) or the inlet patterns of the washing machine or dishwasher (Figure 4-7). Therefore, each subsection ends with special attention for the patterns.

Finally, this section describes how to export the filled Water-Use Info fields to a .spg-file in subsection 5.3.5.

### 5.3.1 The structure of Water-Use Info: definition of area

The Water-Use Info tool to create a spg-file (❶ in Figure 2-1) shows three steps to fill information on the users and the appliances, as described in the former chapter (Figure 5-2):

❶ *Regional Household Statistics* corresponds with Household statistics in section 4.2.2.

❷ *Time Budget data* corresponds with Presence at home or time budget data in section 4.2.2.

❸ *Installation & consumption* corresponds with taps or water-using appliances in section 4.2.3.

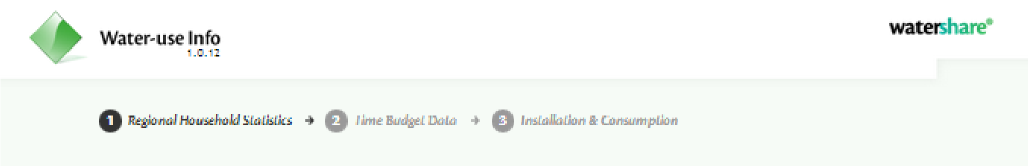



*Figure 5-2 Three steps in Water-Use Info to generate a spg-file.*

*The meaning of* area *in Water-Use Info*

Below the three steps in Water-Use Info to generate a spg-file, you find the field of import data (Figure 5-3). In this field, you can define or choose areas as will be explained in the next sections. The definition of areas has a number of advantages:

a. The area remains in the Water-Use Info tool. In this way you create a database with information for specific areas or scenarios.

b. In future, the database assists in the exchange of data between different users. It facilitates data exchange between different users of Water-Use Info
c. This database assists you in making new spg-files for other purposes. You don't have to import the spg-file of the area anymore.
d. You can combine different areas with each other (for example the household characteristics of Belgium, with the time budget data of Germany and the appliances of The Netherlands).

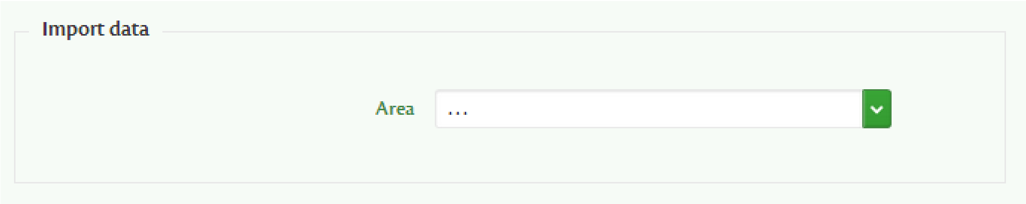



*Figure 5-3 The field 'import data' in Water-Use Info to create or use a specific area.*

### 5.3.2 How to use Water-Use Info **from scratch/when you don't have a spg**-file

Water-Use Info helps you to import the required information and it creates a corresponding spg-file, in the required format. In each component ❶, ❷ and ❸ of the tool, you can define a name for the area. For this reason, you select 'new area' after Area in Figure 5-3 and enter the desired name after AreaName in the rule that appears after selecting 'new area' (see also Figure 5-14).

To fill the required information, you click on . Then an input screen/pop-up form appears, that you need to fill. As an example, you see the form for the first rule in ❶ 'Regional household statistics' in Figure 5-4: Household division. In this way, you can walk through the Water-Use Info tool and fill all the requested information.

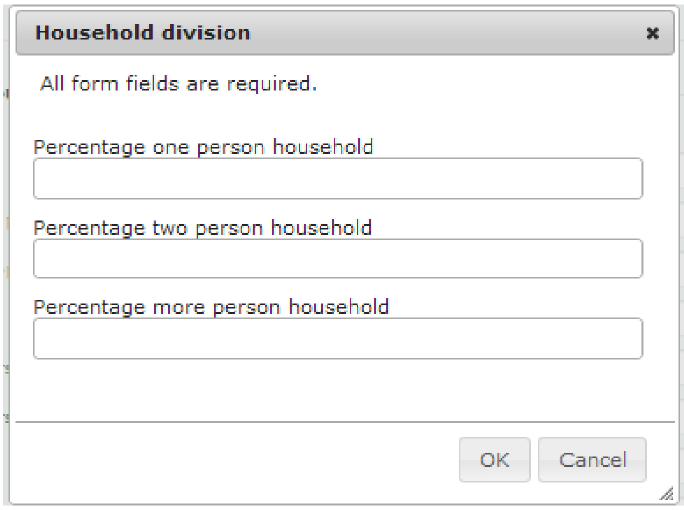



*Figure 5-4 The form for Household division in Water-Use Info*

Step ❶ and ❷ in Water-Use Info are straightforward to fill. For the third step ❸ *Installation & consumption*, you have to give the information as presented in Table 4-2. We will illustrate step ❸ for the toilet of Figure 4-2.

First select the installation type 'toilet' (Figure 5-5). Then you enter the desired installation name. According to Figure 4-2, the name of the wc-type is 'theWc1' (Figure 5-6). Then press Add. A tab appears, called Toilet-theWc1, where you can fill the desired information of this wc-type (second column in Table 4-2). We filled the form with the same information as in Figure 4-2. You see the result in Figure 5-7. Figure 4-2 refers to the Wc_subtype 'wcHigh'. So we have to add this subtype at the position after Name. After pressing Add, the tab appears for filling the information belonging to the subtype wcHigh, as presented in the third column of Table 4-2. You can see the filled form for wcHigh, with the same data as in Figure 4-2, in Figure 5-8. Figure 4-2 shows that more Wc_subtypes are present, like wcNormal, wcNormalPlus, wcSave, wcSavePlus. You can add these subtypes in the same way: fill the subtype after Name, press Add and fill the characteristics of the subtype.

In the same way, you can add all the appliances or taps, that are present in the households.

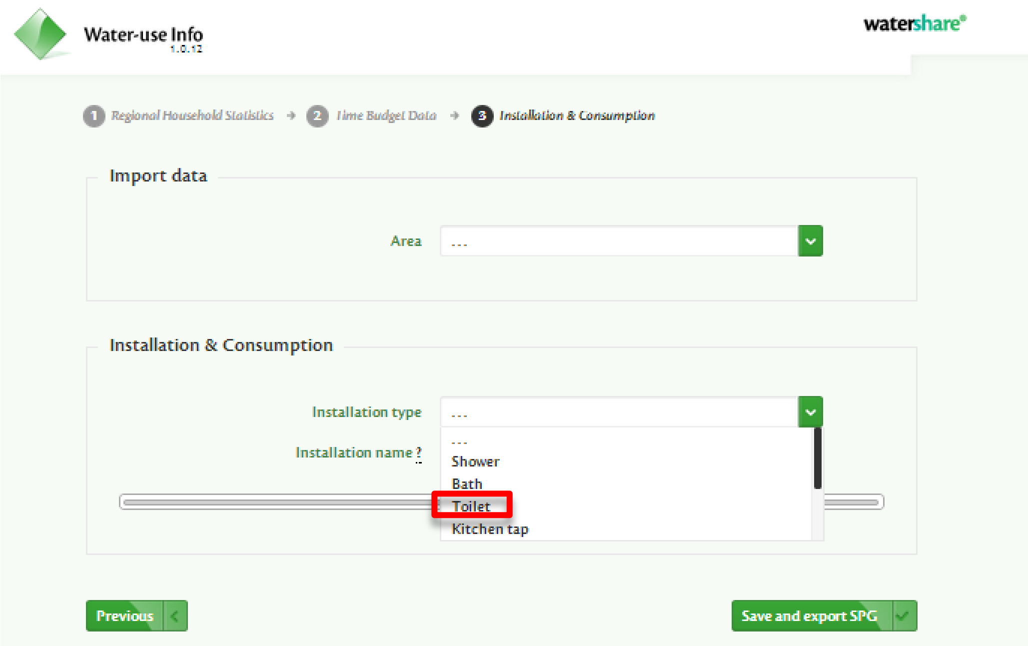



*Figure 5-5 Input of toilet characteristics in Water-Use Info (following the data in Figure 4-2): select installation type.*

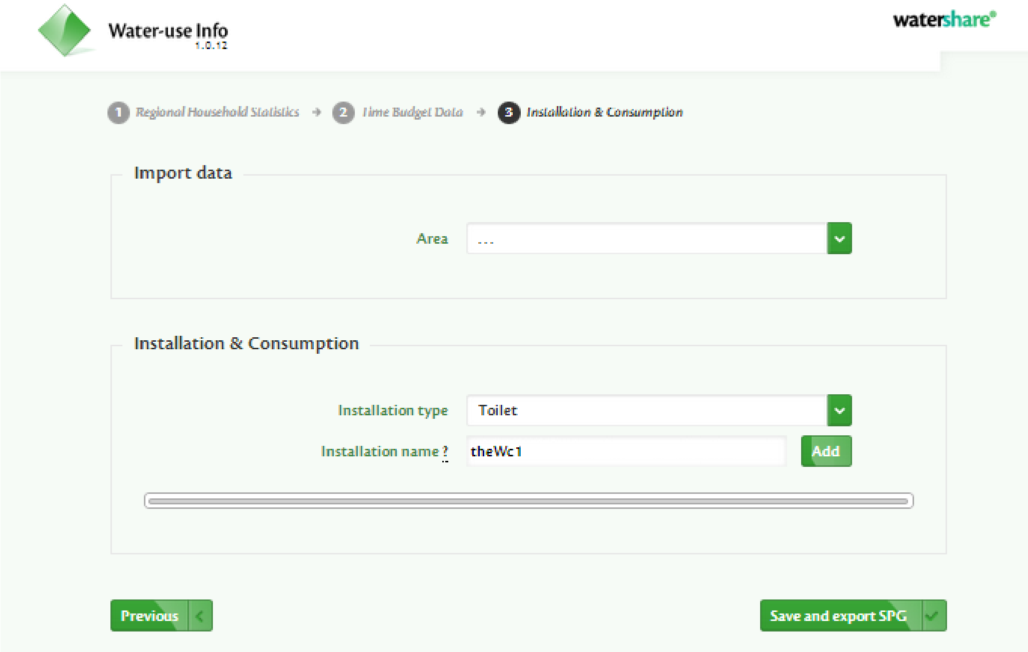



*Figure 5-6 Input of toilet characteristics in Water-Use Info (following the data in Figure 4-2): choose installation name.*

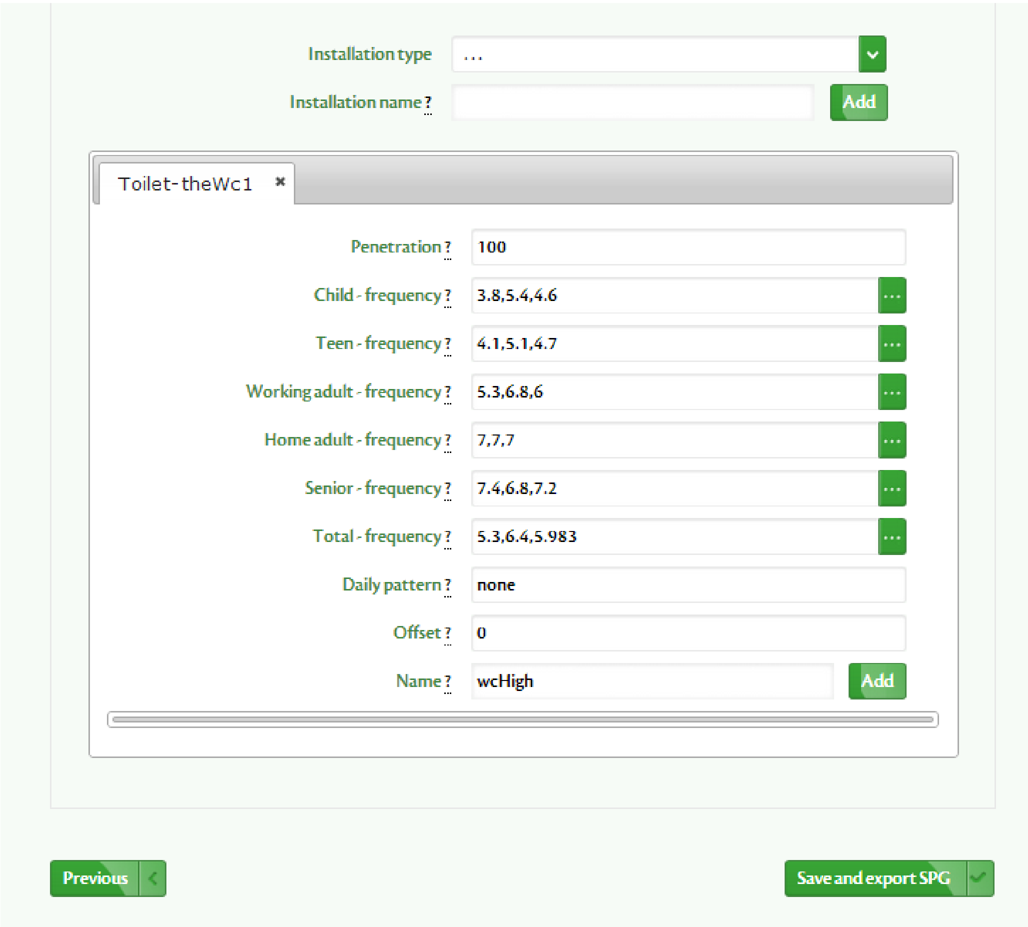



*Figure 5-7 Input of toilet characteristics in Water-Use Info (following the data in Figure 4-2): fill information on wc-type.*

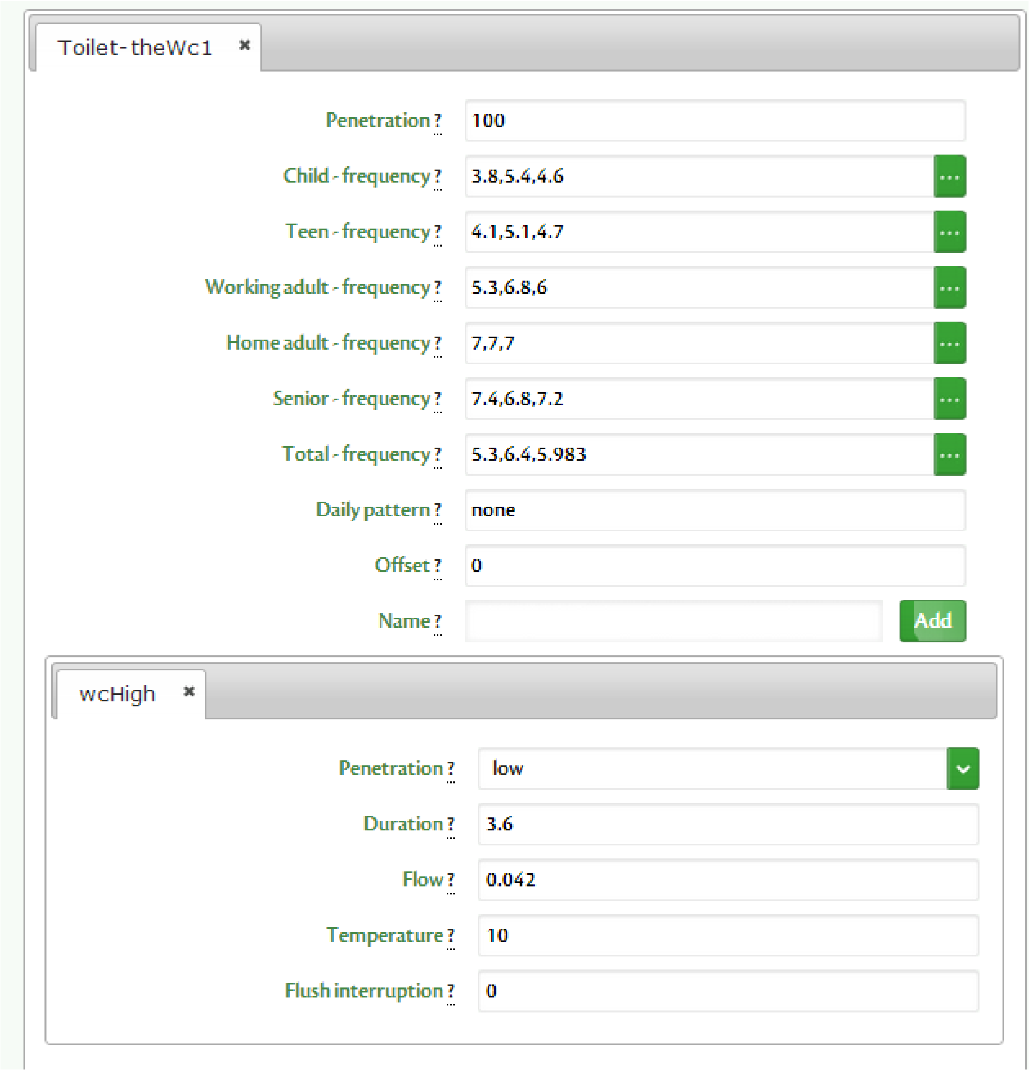



*Figure 5-8 Input of toilet characteristics in Water-Use Info (following the data in Figure 4-2): fill information on wc-subtype.*

*How to create patterns in Water-Use Info?*

Water-Use Info has some pre-defined patterns: daily patterns for kitchen tap, washing machine, dishwasher and shower and inlet patterns for a dishwasher with total water use of 14 liter and a washing machine with total water use of 50 liter.

In Water-Use Info, it is not possible to create new daily patterns or inlet patterns for appliances. This is in contrast with the generation of spg-files as text-file, as is described in the former section (5.2.1). So, when you need to be flexible in the definition of patterns, Water-Use Info is not complete and you need to follow the procedure of section 5.2.1.

As an example, we show you how to create the patterns for the dishwasher of Figure 4-7. First, we select 'dishwasher' at the installation type (Figure 5-9). Then you enter the desired installation name, which is according to Figure 4-7 the DishWasher1 (Figure 5-10). Then press . A tab appears, called Dishwasher-theDishWasher1, where you can fill the desired information of this dishwasher-type (Table 4-2). We filled the form with the same information as in Figure 4-7. At 'daily pattern' you can choose at  between different options: <NONE>, pat_dw_week and pat_dw_weekend (Figure 5-11). These options represent no daily pattern, a pattern for use during a weekday and a pattern for use during a weekendday.

Then we have to fill the characteristics of the subtype. Figure 4-7 refers to the Dw_subtype 'dw'. So we have to add this subtype at the position after Name. After pressing , the tab appears for filling the information belonging to the subtype 'dw', as presented in the third column of Table 4-2. You can see the filled form for 'dw', with the same data as in Figure 4-7, in Figure 5-12. For the inlet pattern of flow and time, you can choose at  between different options: <NONE> and pat_dw, where the latter is a standard inlet pattern for a dishwasher with total water use of 14 liter.

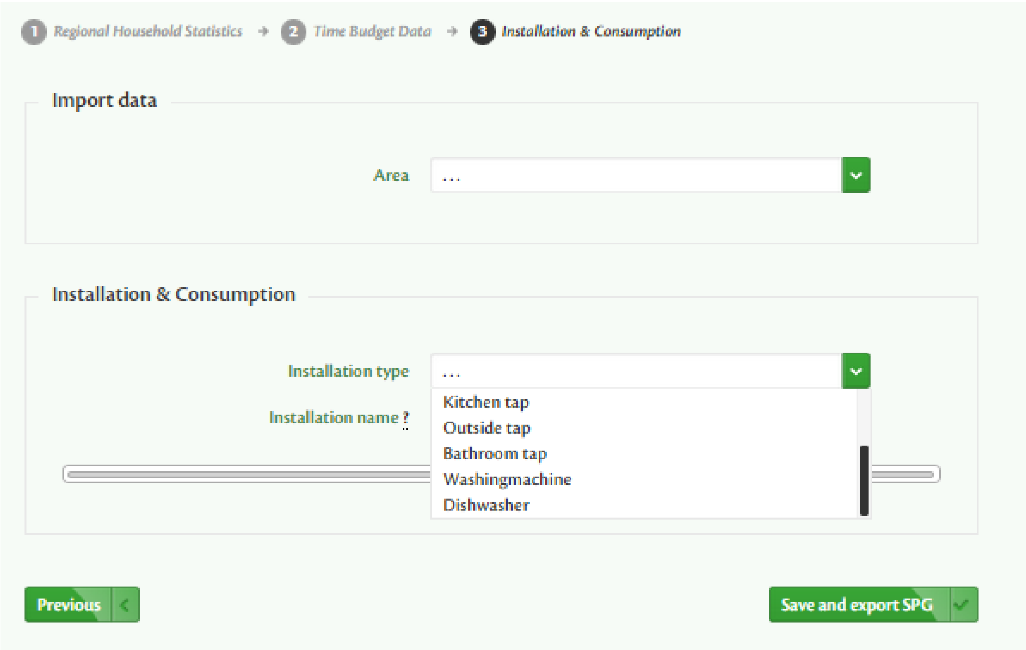



*Figure 5-9 Create patterns in Water-Use Info: dishwasher as example (following the data in Figure 4-7). Step 1: choose installation type.*

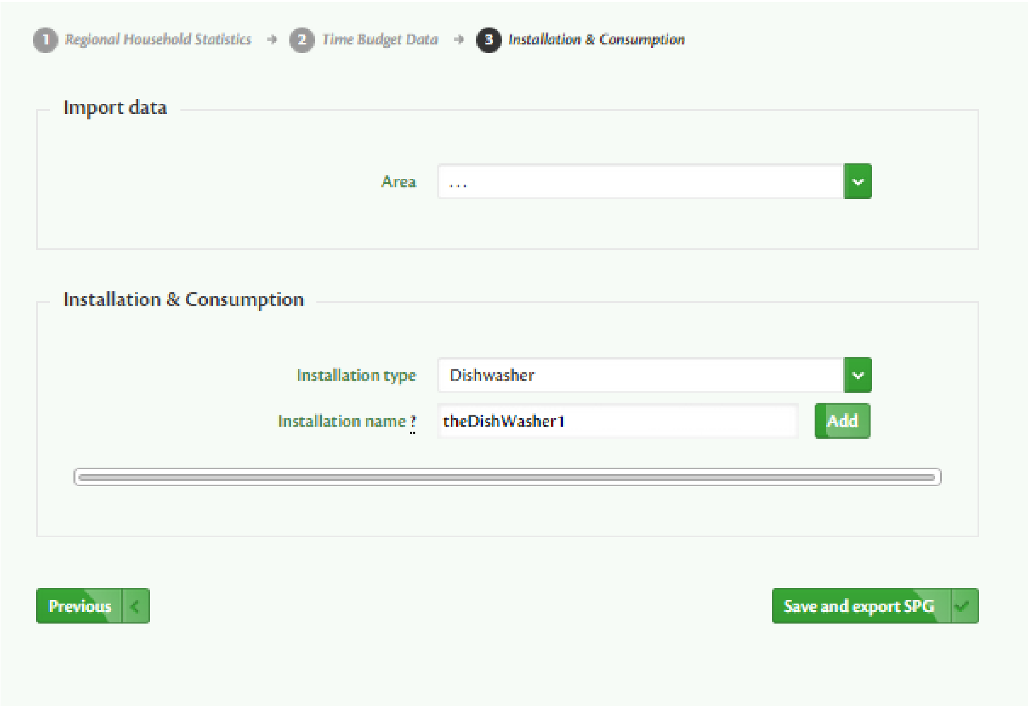



*Figure 5-10 Create patterns in Water-Use Info: dishwasher as example (following the data in Figure 4-7). Step 2: choose installation name.*

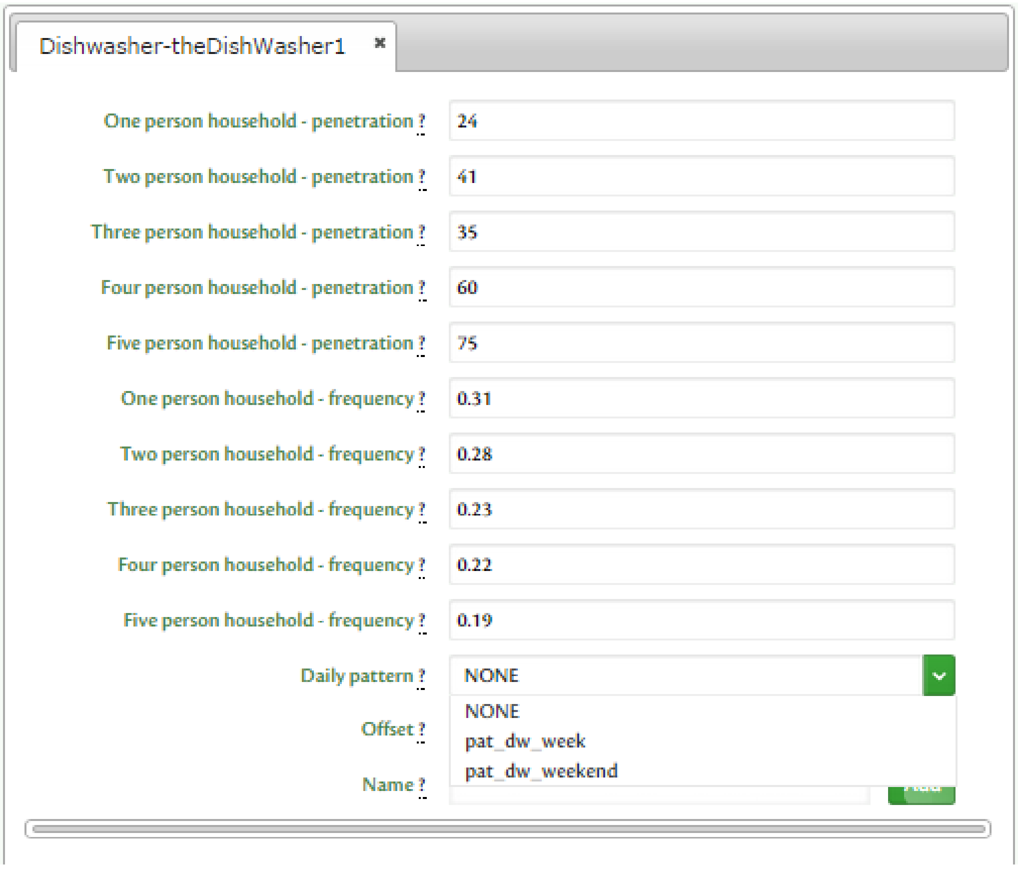



*Figure 5-11 Create patterns in Water-Use Info: dishwasher as example (following the data in Figure 4-7). Step 3: fill data on penetration and frequency of use and select daily pattern.*

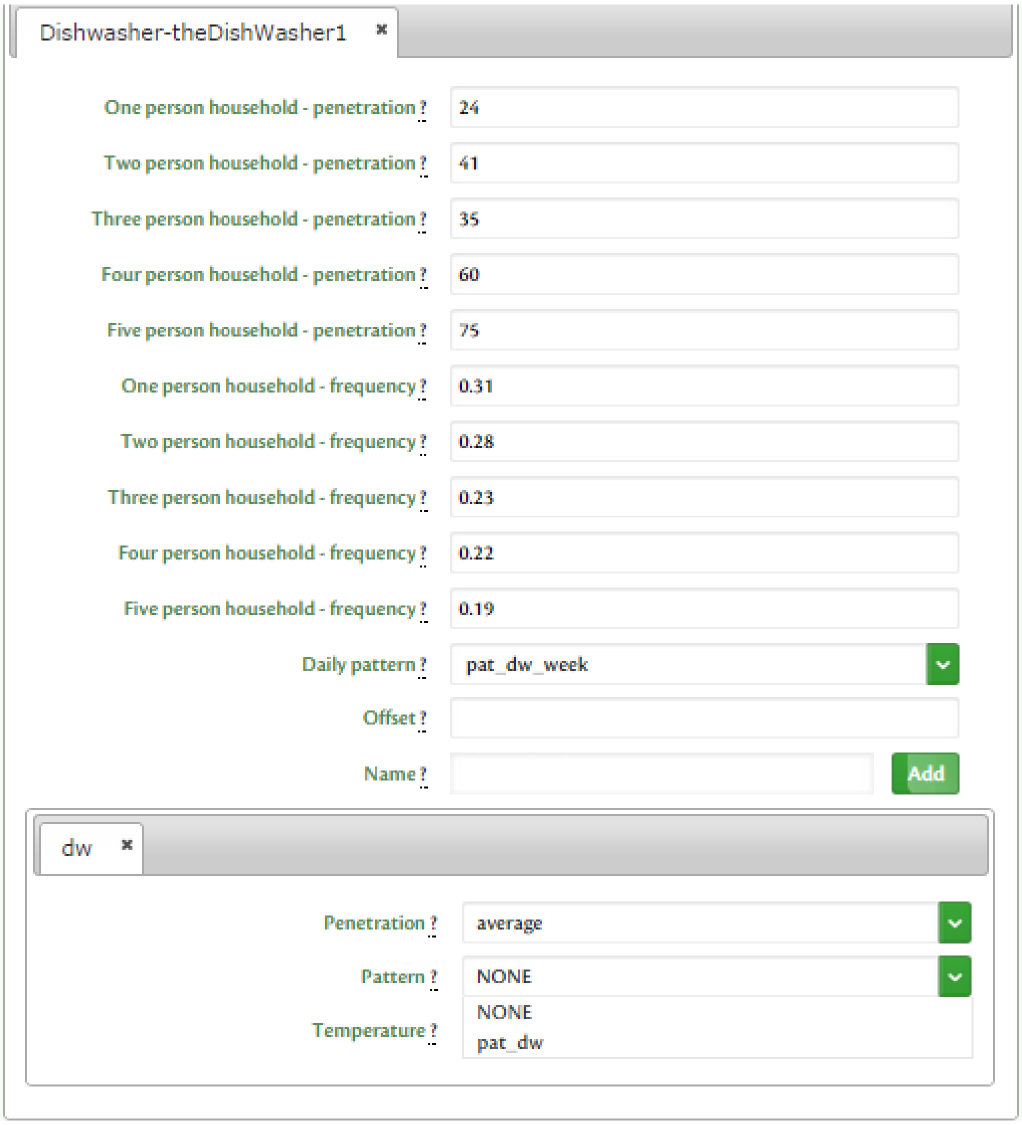



*Figure 5-12 Create patterns in Water-Use Info: dishwasher as example (following the data in Figure 4-7). Step 4: add subtype and its characteristics as penetration, inlet pattern and temperature.*

### 5.3.3 How to use Water-Use Info with a default or an existing spg-file?

The easiest way to use Water-Use Info to create a spg-file for your area, is to start with a demo spg-file. It need to be emphasised that this procedure only works when you don't use daily patterns or inlet patterns, or when you use patterns that correspond with the defined patterns in Water-Use Info. When in the demo-file another pattern is described, it disappears/is lost when uploading it in Water-Use Info.

The SPG is equipped with a number of demo-files, that have been downloaded during installation of the SPG. The characteristics of each demo-file are described in section 5.4. From the list with demo-files, you first choose a suitable file. Then you follow the steps:

Step 1: In Water-Use Info, you select 'new area' in the section Import data (Figure 5-13).

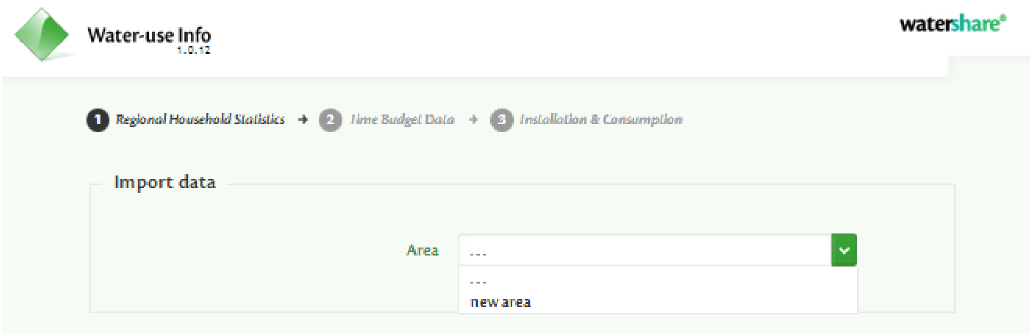



*Figure 5-13 Import a default spg-file in Water-Use Info: step 1.*

Step 2: Fill a name for the new area after AreaName (Figure 5-14). This area remains in the Water-Use Info tool. Next time you use Water-Use Info and select the area name, the data belonging to this area directly appear.

Step 3: Press Select File after File name (Figure 5-14), then a menu appears to select the desired default spg-file. After that, press Import SPG.

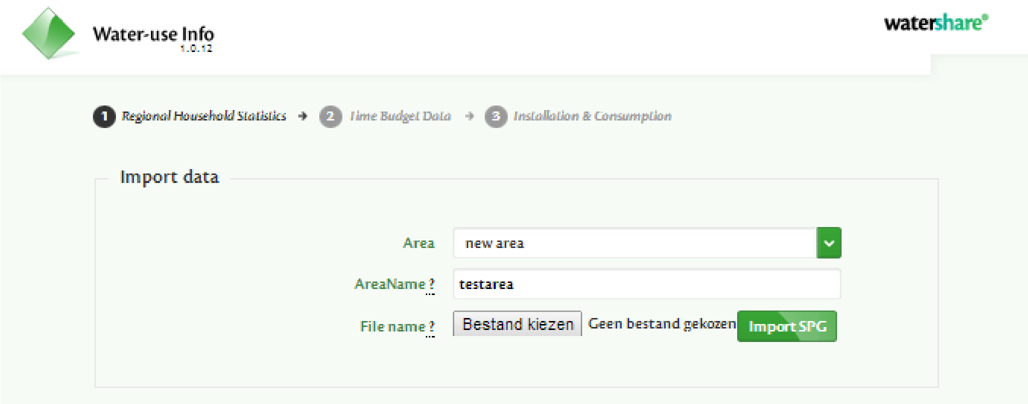



*Figure 5-14 Import a default spg-file in Water-Use Info: step 2 en step 3.*

You follow these three steps for all components of Water-Use Info: ❶ *Regional Household Statistics*, ❷ *Time Budget data* and ❸ *Installation & consumption*. When you have finished this and adjusted the data if necessary, you can export the data into a .spg-file (section 5.3.5).

Some points of attention:

a) You can use different existing spg-files in the three components ❶ *Regional Household Statistics*, ❷ *Time Budget data* and ❸ *Installation & consumption* and create a new area.
b) The defined areas remain in the Water-Use Info tool. Next time, you use the tool, you can select an area in each component ❶, ❷ and ❸. The data belonging to the area directly appear in the fields. This combination results in a new spg-file.

When you want to have an area with the data of this last spg-file, be aware, that you have to create a new area by following step 1 to 3 for each component ❶, ❷ and ❸ with the new spg-file as importfile.

c) In each component ❶, ❷ and ❸, you can choose to use the data from an already defined area or create a new area for this component with an existing spg-file. For example, when you create an area 'dinky' for component ❶ with the demo-file dinky_app.spg (section 5.4), then only the household statistics from the dinky_app.spg is included in the Water-Use Info tool.

*How to create patterns in Water-Use Info when using an existing spg-file?*

Water-Use Info has some pre-defined patterns: daily patterns for kitchen tap, washing machine, dishwasher and shower and inlet patterns for a dishwasher with total water use of 14 liter and a washing machine with total water use of 50 liter.

When you start Water-Use Info with an existing spg-file, only patterns, both daily patterns and inlet patterns, that correspond with the fixed patterns of Water-Use Info survive this procedure. Freely defined patterns in the spg-file, that do not correspond with the predefined patterns, will be overwritten by <NONE> and disappear from the spg-file.

### 5.3.4 How to use Water-Use Info with earlier defined areas?

You can also create a spg-file, based on specific information of already defined areas. In each component of Water-Use Info, ❶ *Regional Household Statistics*, ❷ *Time Budget data* and ❸ *Installation & consumption,* you select the area from which you want to use the data on users and appliances.

In Water-Use Info, you select the desired area in the section Import data (Figure 5-15). When you are in the field of ❶ *Regional Household Statistics*, only the information on household statistics in this area will be used in the new spg-file. Then you select an area for component ❷ and finally for component ❸. In this way you can built your spg-file with data from different selected areas. In the example of Figure 5-15, you can use the data from demo-housetest for household statistics, the time budget data from the testarea and the appliances from dinky.

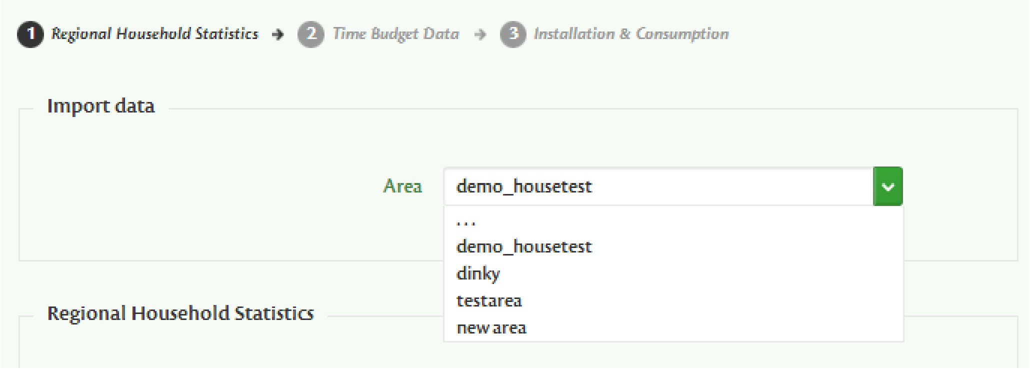



*Figure 5-15 Select an area with information on household statistics to create a new spg-file.*

### 5.3.5 Export of filled Water-Use Info fields to a .spg-file

When you have filled all elements in the Water-Use Info fields, you push 

in the screen ❸ *Installation & consumption* and the desired spg-file is created. The spg-file appears at the left bottom of the screen and in your personal downloads. Save the spg-file with the desired name on the desired location. You can check and adapt the contents of the spg-file by following the cycle of Figure 5-1, when you want to make changes in a text-file follow Figure 5-1a or when you want to make changes using Water-Use Info follow Figure 5-1b.

## 5.4 Demo-files: Spg-files for different households and scenarios

The SPG is equipped with a number of spg-files that assists you in understanding the SPG and in creating new spg-files, that meet your needs. Table 5-1 gives the names of the files and a description of their characteristics. A short description is given in the table. For more details you can open the spg-files, save them as stats-file and view the characteristic data in the stats-viewer.

*Table 5-1 Description of spg-files for characteristic households and various scenarios, installed together with SPG.*

| Name spg-file | description |
|---|---|
| | Standard and specific Dutch households |
| Demo_house_manual.spg | .spg-file corresponding to the stats-file used in section 4.2. Household statistics and time budget data corresponding to average Dutch situation: average number of people in the households is 2.3. Various possible appliances. |
| Demo_2014.spg | Household statistics and time budget data corresponding to average Dutch situation: average number of people in the households is 2.3.<br>Various possible appliances and user behaviour regarding water demand corresponding to Dutch culture, based on data of 2014 |
| Dinky_app.spg | double-income-no-kids apartment:<br>Household statistics refer to apartments with 1 or 2 persons (1.7 on average), without children, time budget data, appliances and user behaviour regarding water demand correspond with Dutch situation. No outside tap is present. |
| Sen_app.spg | Senior apartment:<br>Household statistics refer to apartments with 1 or 2 persons (1.5 on average), mainly seniors. time budget data, appliances and user behaviour regarding water demand correspond with Dutch situation. No outside tap is present |
| Fam_house.spg | Family house:<br>Household statistics refer to houses with bigger families. Average number of persons in family household is 3.9. Average number of people in all households is 2.9.<br>time budget data, appliances and user behaviour regarding water demand correspond with Dutch situation. |
| New_demo_house.spg | Standard conditions for Dutch households (as in demo_house) but with characteristics for a newly build house, like water saving appliances. |
| SIMDEUM_maxday.spg | Average Dutch household during a warm summer day: increased use of shower, washing machine and outside tap |

| Scenarios (Agudelo-Vera and Blokker, 2014 ; Blokker et al., 2012) | |
|---|---|
| Scen_RC.spg | Regional Communities:<br>per capita demand declined because the economic downfall results in (water) saving behaviour (like grey water and alternative sanitation, washing machine), coupled with decreasing population. The average age of the population increases. |
| Scen_SE.spg | Strong Europe:<br>Despite low economic growth, mobility increases due to open borders. Personal hygiene habits have changed with an increase in shower frequency. Water pricing based on real cost drives alternative water resources to be adapted on a larger scale; e.g. rain water tanks for watering the garden. |
| Scen_TM.spg | Transatlantic Market:<br>Population growth causes increases in drinking water demand. Innovations aim at luxury and wellness products. Water saving concepts of toilets, like grey water and alternative sanitation. |
| Scen_GE.spg | Global Economy:<br>Economic growth causes increases in consumption. Innovations are aimed at luxury and wellness, people shower longer and water their garden more frequently to diminish the effects of climate change. |
| Scen_dual.spg | House with dual system for water supply<br>Toilet, laundry machine and outside tap are not supplied by DWDS |
| Scen_ECOplus.spg | Adoption of innovative sanitation concepts (100% adoption of 1 L flushing toilets) plus highly water use efficient showers, washing machines and dishwashers |

# 6 Simulation

The SIMDEUM Pattern Generator (SPG) simulates the cold and hot water demand patterns based on characteristics of users and appliances. These data are defined in a stats-file, that contains the data in a suitable format for simulation with SPG. In the previous chapter, the way to generate a stats-file is described.

In this chapter, we describe how you can start a simulation with the SPG. In Figure 6-1 you see the Do simulation field, where you can enter the input for the desired simulation:

❶: here you enter the number of houses, for which you want to simulate the water demand patterns. For each house, a house-file is created with 7 demand patterns, i.e. 5 demand patterns for workdays and 2 demand patterns for weekenddays. In Figure 6-1, for 100 houses demand patterns will be simulated with a time step of 1 second, based on the information on users and appliances in the selected stats-files (❷ and ❸).

❷: here you select the desired stats-file with data for weekdays. By pressing ..., you can browse to the desired location and select the stats-file for a weekday: namefile_week.stats.

❸: here you select the desired stats-file with data for weekend days. By pressing ..., you can browse to the desired location and select the stats-file for a weekendday: namefile_weekend.stats.

❹: here you select the desired output directory. In this directory, the house files with the simulation results will be stored. By pressing ..., you can browse to the desired location. When you want to store them in a new directory, you first need to externally create the new directory.

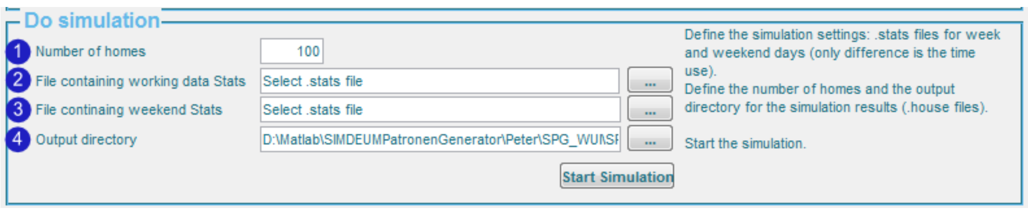



*Figure 6-1 Field with information to execute a simulation with the SIMDEUM Pattern Generator.*

When all fields in Do simulation are filled, you can start the simulation by pressing Start Simulation. A progress bar (Figure 6-2) appears on the screen, that illustrates the progress of the simulation. For each house, from which the total number XX is given at ❶ in Figure 6-1, a house-file appears in the given output directory. The name of the house-files correspond with the name of the stats-file, extended with week1.house until weekXX.house.

The name refers to patterns for all days in a *week* for house 1 to house XX. The house-files are structured arrays in Matlab format on a one second base. When you are used to work with Matlab, you can process the data for your specific application.

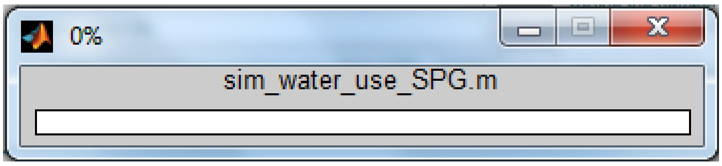



*Figure 6-2 Progress bar for simulation of water use after choosing 'Start Simulation' in SPG.*

# 7 View simulation results

## 7.1 Introduction

The SIMDEUM Pattern Generator (SPG) simulates the cold and hot water demand patterns for 5 weekdays and 2 weekend days and saves them as house.files for each house that is simulated. The time step in the simulations is 1 second. Without exporting the results, you can view the simulation results in two ways. First, you can view the separate demand patterns in each house through 'view demand patterns' (section 7.2). Secondly, you can view the average patterns of all the simulated houses through 'plot demand statistics' (section 7.3). In Figure 7-1, the field View simulation results in the SPG is shown, in which you can choose to view the results of any saved simulation.

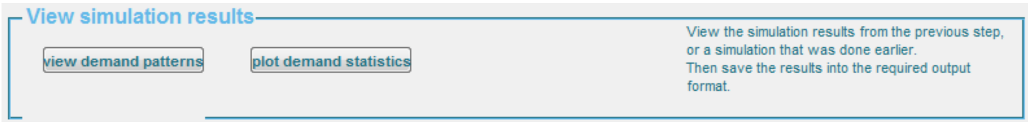



*Figure 7-1 Field in the SIMDEUM Pattern Generator to view the simulation results as demand patterns of each simulated house or as average demand pattern for all simulated houses.*

## 7.2 View demand patterns

When you want to view the individual week and weekend demand patterns of each simulated house, you choose 

in Figure 7-1. Then, a screen appears where you can browse to the desired directory with the house-files. This means that you can select any directory: the simulation results of the previous step in chapter 6 or simulations done earlier. After selecting the directory, the demand viewer from SPG appears, as is shown in Figure 7-2.

The graph in the figure shows you the total water demand (in black) and the hot water demand (in red) during the day. You have the following options to choose:

❶: file

In this field you can choose the specific house, from which you want to view the cold and hot water demand patterns. You can see that the number of .house-files correspond with the number of houses chosen as input for the simulation.

❷: pattern

In this field you see seven demand patterns. The first five correspond to the demand patterns during a week or working day (see also the title of the graph), the last two correspond with weekend days.

❸: tap

In this field you can also select a tap. This means that you can view the demand pattern of cold and hot water at a specific tap, for example the shower or the sum of the toilets.

When you select total, you see the demand pattern of the whole house, that is obtained after summation of the demand patterns of all taps.

❹: user

In this field you can only see (not select) the occupants in the house when you select ‘Total’ at ❸. Each house corresponds to the criteria or household statistics given in Figure 4-2 and Figure 4-3. This means that in a house one or more users can be present. When you select a house at ❶, this field shows you how many users are present in that house.

When you select a certain tap at ❸, that is used per person (like toilet, shower and bath), you can study the users here. Selecting a user shows the use of the tap by that specific user during that specific day (selected at ❷).

❺: time base

In this field you can select the time base for your results. In Figure 7-2 you see the demand patterns on a second base. By chosing a larger time base, the demand pattern will be more smooth. A larger time scale, averages the demands during that time.

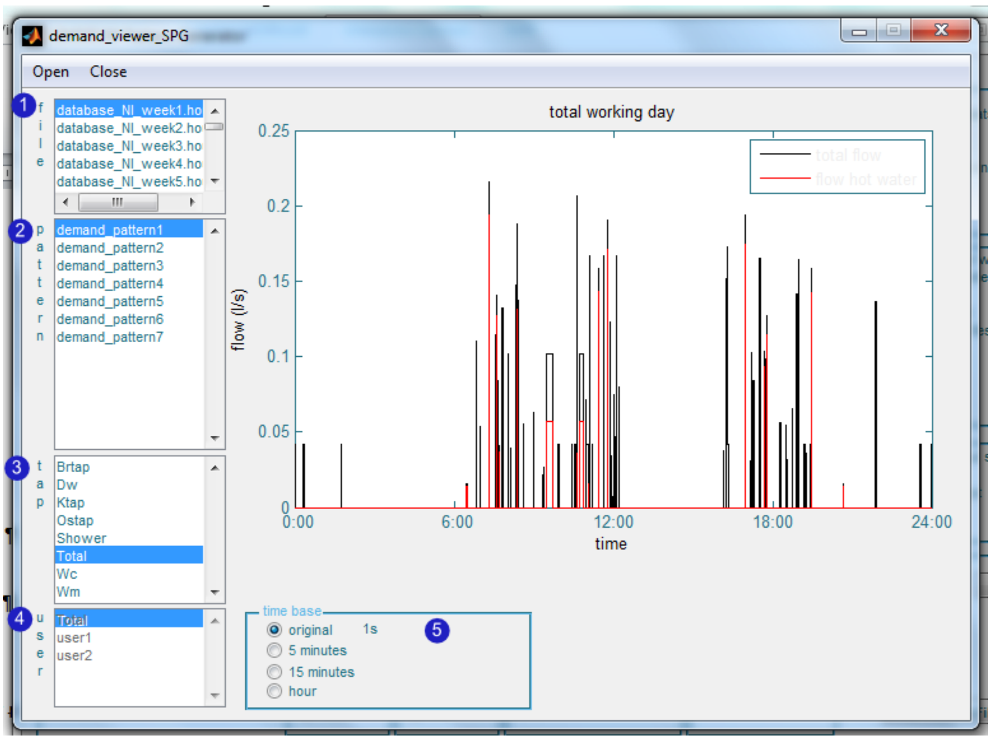


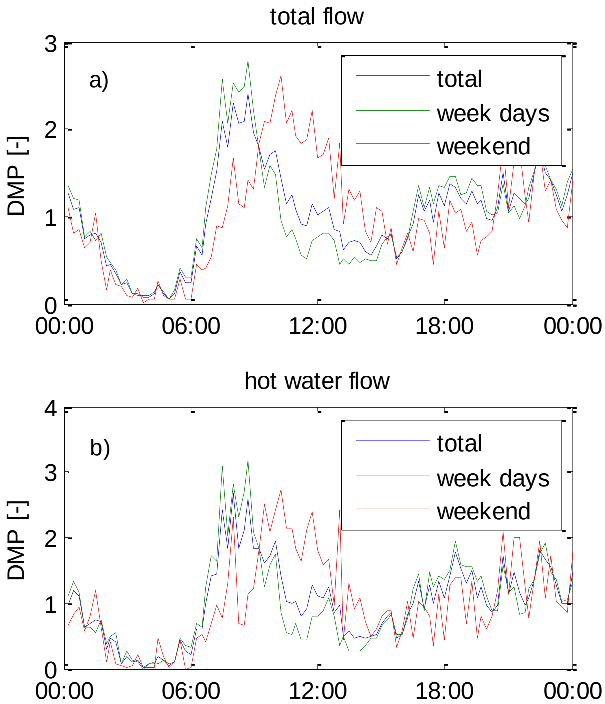

*Figure 7-2 The demand viewer of SIMDEUM Pattern Generator, that shows the demand patterns of cold and hot water in different houses during different days.*

## 7.3 Plot demand statistics

When you want to have an impression of the average water demand in a street or district with the chosen number of houses, you press **plot demand statistics** in Figure 7-1. This button opens a screen, where you can browse to the directory with the desired house-files. After selecting the folder, a progress bar appears on the screen to show that the SPG is calculating the average demand patterns for all house-files, that are present in the folder.

In Figure 7-3, you see an example of the results. One figure shows the normalised average flow of the total of cold and hot ('total') water during the day and one shows the normalised average hot water flow. DMP means the demand multiplier pattern, that has an average of 1. Each graph also distinguishes between the demand on a week day and on a weekend day. The example of Figure 7-3, shows that during a weekend day the peak in the water demand takes place later during the day and the peak is wider.

The table next to the figures, gives the average water use per house (l/h). Multiplying the graphs with these factors and the number of houses, results in the actual average water demand of the area.




| | l/h |
|---|---|
| total | 13.1 |
| w eek | 13.1 |
| w eekend | 13.0 |

| | l/h |
|---|---|
| total | 3.5 |
| w eek | 3.5 |
| w eekend | 3.6 |

*Figure 7-3 Average normalised demand patterns for total number of houses, for all days (blue), during week days (green) and during weekend days (red): a) for total (cold and hot water) flow and b) for hot water flow. The tables give the average water use per house in [l/h].*

# 8 Export simulation results

## 8.1 Introduction

The simulated water demand patterns can be used in many applications. Each application sets its own requirements for time scale and format. Before exporting the simulation results, you first need to consider the desired application and the corresponding requirements. This chapter describes how you can export the simulation results and which choices you can make in the exported format.

## 8.2 Settings for saving the simulation results

In Figure 8-1, the field Save output to file in the SPG is shown. Here you can select the simulation results you want to save and in which format:

❶: here you select the directory with the simulation results, that you want to save. By pressing , you can browse to the desired location.

❷: here you can choose the settings for the desired format of the exported simulation results.

a. Flow unit
You can chose four units for the flow: $m^3$/h, l/s, $m^3$/day and l/min. The choice you make depends on your application.

b. Time step
The simulated results in the house-files, have a time step of 1 second. In the SPG, you can choose four time steps: 1 minute, 5 minutes, 15 minutes and one hour. When you want a smaller time step than 1 minute, you can contact KWR. The choice you make, depends on the application of the demand patterns and may differ per company:

- For the allocation of demand patterns in the transport trunk, peak demands per minute will be less relevant, but per hour might be too coarse.
- For the reticulation network, minute scale is relevant.
- For the prediction of water age with a hydraulic model a time scale of 15 minutes is too long to see enough variation, a time step of 5 minutes is okay.
- When you want to base the designs on the water demand patterns, you may need demands on a second base, since you want to know the actual maximum flow rate. For this application you can use the house-files (contact KWR) or design rules based on SIMDEUM (Blokker, 2007; ISSO 2013).

  When you use larger time steps than one second, the peak demand value will decrease. Using a timestep of 1 minute, the peak demand value in the demand patterns is only approximately 80% of the maximum flow rate with 1 second time step. Using a timestep of 5 minutes, the peak demand is only 65% of the maximum flow rate. You can use these values as rules of thumb, when you wan to use the simulated results for design purposes (Pieterse-Quirijns, 2012).

c. Patterns per file
Each house file contains 7 demand patterns, 5 demand patterns for a week day and 2 demand patterns for a weekendday. In this field you can choose whether you want the 7 patterns in one file or whether you want the 7 patterns separately.

d. Output File Format
The demand patterns can be used in various hydraulic models or applications/calculations. In this field you can choose the desired format:

- Excel file
- Infoworks format: ddg (Demand Diagram Group).
- Epanet format as txt file.

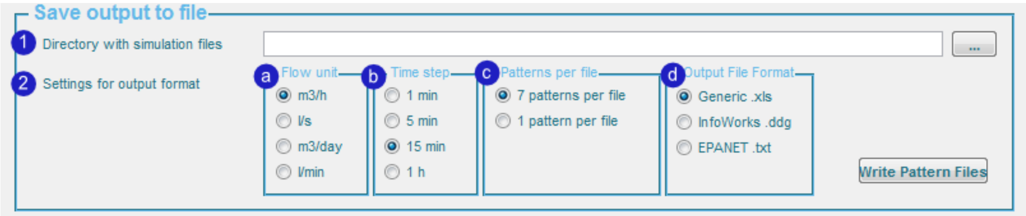



*Figure 8-1 Field in SIMDEUM Pattern Generator to save the simulation results in a desired format.*

## 8.3 Exported pattern files

By pressing Write Pattern Files, the simulated house-files in the given directory at ❶, are exported with the desired settings (❷). The procedure and results differ for each Output File Format.

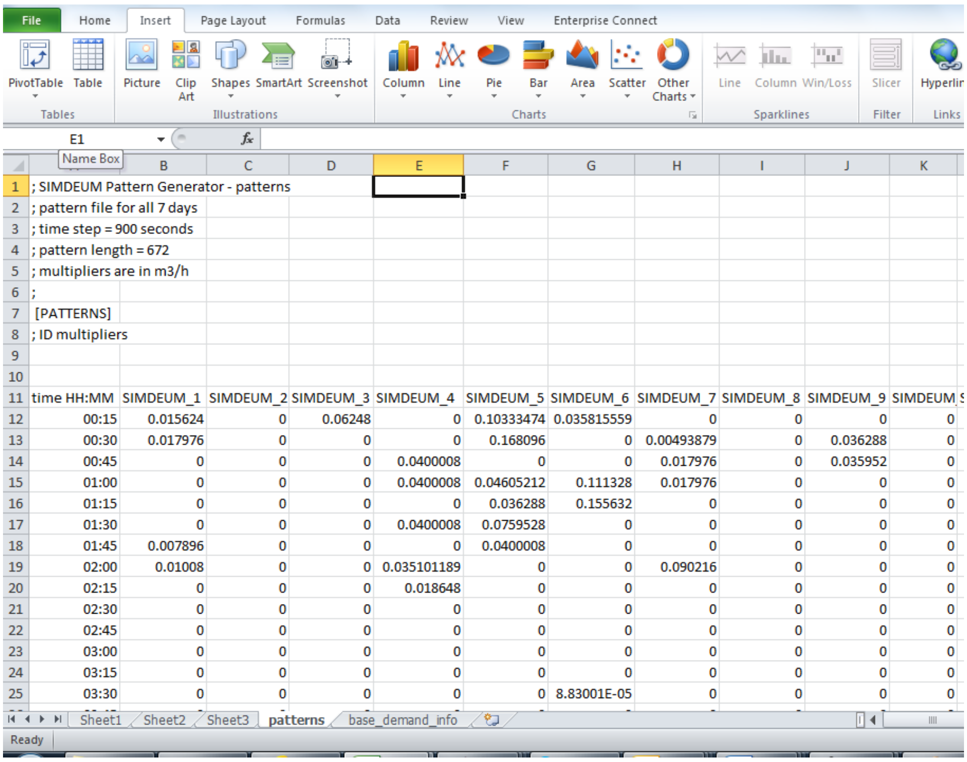
### 8.3.1 Exported pattern files as Generic.xls

When exporting the data as an Excel file, Write Pattern Files requests a name for the resulting xls-file and yields one Excel-file in the same directory as the simulation results. There are two possibilities:

- 7 patterns per file (see Figure 8-2a): in one worksheet all the demand patterns are listed. Each column is a house, and the demand patterns of all seven days (5 weekdays and 2 weekend days) are listed underneath each other in the same column in the worksheet called ‘patterns’.
- 1 pattern per file (see Figure 8-2b): each worksheet represents the demand patterns on one day. Each column is a house and the demand pattern of only one day is given. This results in a worksheet for each day called ‘patterns_day1’ to ‘patterns_day7’. Pattern_day1 to day 5 represent the demand patterns on weekdays, pattern_day 6 and day 7 represent the weekend days.

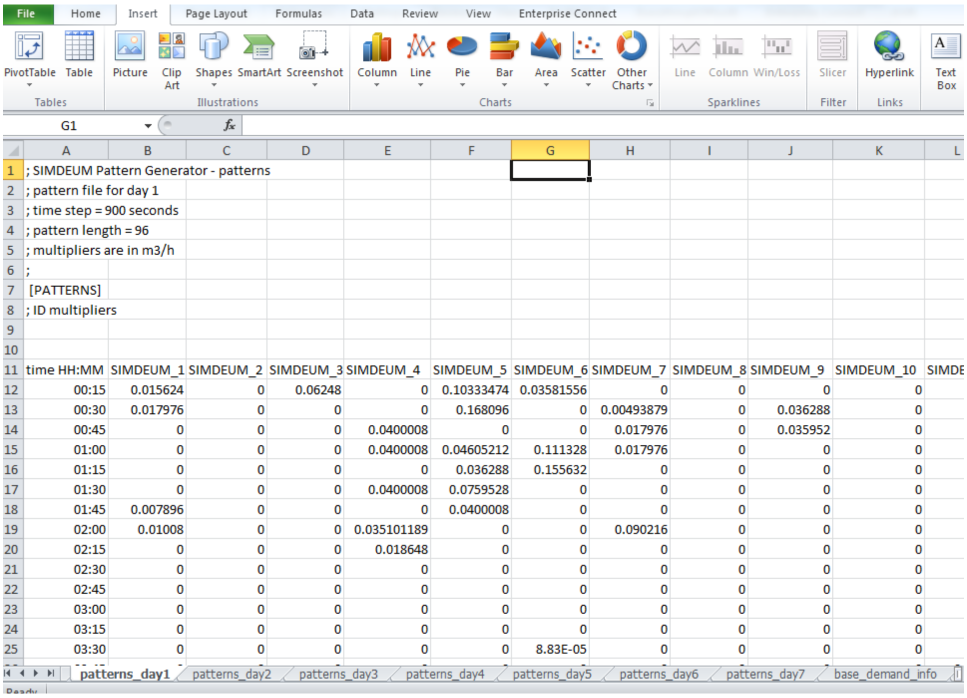
In the first cells of each worksheet, you see the settings used for the export: the time step (900 seconds in this case) and the flow unit ($m^3$/h in this example). When you make a figure of the demand pattern of one house, you obtain a graph with flow rate in $m^3$/h with every 15 minutes a datapoint. In Figure 8-3, you see an example of the demand pattern of the first three houses (SIMDEUM_1 to SIMDEUM_3).

a)




| | A | B | C | D | E | F | G | H | I | J | K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ; SIMDEUM Pattern Generator - patterns | | | | | | | | | | |
| 2 | ; pattern file for all 7 days | | | | | | | | | | |
| 3 | ; time step = 900 seconds | | | | | | | | | | |
| 4 | ; pattern length = 672 | | | | | | | | | | |
| 5 | ; multipliers are in m3/h | | | | | | | | | | |
| 6 | ; | | | | | | | | | | |
| 7 | [PATTERNS] | | | | | | | | | | |
| 8 | ; ID multipliers | | | | | | | | | | |
| 9 | | | | | | | | | | | |
| 10 | | | | | | | | | | | |
| 11 | time HH:MM | SIMDEUM_1 | SIMDEUM_2 | SIMDEUM_3 | SIMDEUM_4 | SIMDEUM_5 | SIMDEUM_6 | SIMDEUM_7 | SIMDEUM_8 | SIMDEUM_9 | SIMDEUM_10 |
| 12 | 00:15 | 0.015624 | 0 | 0.06248 | 0 | 0.10333474 | 0.035815559 | 0 | 0 | 0 | 0 |
| 13 | 00:30 | 0.017976 | 0 | 0 | 0 | 0.168096 | 0 | 0.00493879 | 0 | 0.036288 | 0 |
| 14 | 00:45 | 0 | 0 | 0 | 0.0400008 | 0 | 0 | 0.017976 | 0 | 0.035952 | 0 |
| 15 | 01:00 | 0 | 0 | 0 | 0.0400008 | 0.04605212 | 0.111328 | 0.017976 | 0 | 0 | 0 |
| 16 | 01:15 | 0 | 0 | 0 | 0 | 0.036288 | 0.155632 | 0 | 0 | 0 | 0 |
| 17 | 01:30 | 0 | 0 | 0 | 0.0400008 | 0.0759528 | 0 | 0 | 0 | 0 | 0 |
| 18 | 01:45 | 0.007896 | 0 | 0 | 0 | 0.0400008 | 0 | 0 | 0 | 0 | 0 |
| 19 | 02:00 | 0.01008 | 0 | 0 | 0.035101189 | 0 | 0 | 0.090216 | 0 | 0 | 0 |
| 20 | 02:15 | 0 | 0 | 0 | 0.018648 | 0 | 0 | 0 | 0 | 0 | 0 |
| 21 | 02:30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 22 | 02:45 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 23 | 03:00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 24 | 03:15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 25 | 03:30 | 0 | 0 | 0 | 0 | 0 | 8.83001E-05 | 0 | 0 | 0 | 0 |

b)




| | A | B | C | D | E | F | G | H | I | J | K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ; SIMDEUM Pattern Generator - patterns | | | | | | | | | | |
| 2 | ; pattern file for day 1 | | | | | | | | | | |
| 3 | ; time step = 900 seconds | | | | | | | | | | |
| 4 | ; pattern length = 96 | | | | | | | | | | |
| 5 | ; multipliers are in m3/h | | | | | | | | | | |
| 6 | ; | | | | | | | | | | |
| 7 | [PATTERNS] | | | | | | | | | | |
| 8 | ; ID multipliers | | | | | | | | | | |
| 9 | | | | | | | | | | | |
| 10 | | | | | | | | | | | |
| 11 | time HH:MM | SIMDEUM_1 | SIMDEUM_2 | SIMDEUM_3 | SIMDEUM_4 | SIMDEUM_5 | SIMDEUM_6 | SIMDEUM_7 | SIMDEUM_8 | SIMDEUM_9 | SIMDEUM_10 |
| 12 | 00:15 | 0.015624 | 0 | 0.06248 | 0 | 0.10333474 | 0.03581556 | 0 | 0 | 0 | 0 |
| 13 | 00:30 | 0.017976 | 0 | 0 | 0 | 0.168096 | 0 | 0.00493879 | 0 | 0.036288 | 0 |
| 14 | 00:45 | 0 | 0 | 0 | 0.0400008 | 0 | 0 | 0.017976 | 0 | 0.035952 | 0 |
| 15 | 01:00 | 0 | 0 | 0 | 0.0400008 | 0.04605212 | 0.111328 | 0.017976 | 0 | 0 | 0 |
| 16 | 01:15 | 0 | 0 | 0 | 0 | 0.036288 | 0.155632 | 0 | 0 | 0 | 0 |
| 17 | 01:30 | 0 | 0 | 0 | 0.0400008 | 0.0759528 | 0 | 0 | 0 | 0 | 0 |
| 18 | 01:45 | 0.007896 | 0 | 0 | 0 | 0.0400008 | 0 | 0 | 0 | 0 | 0 |
| 19 | 02:00 | 0.01008 | 0 | 0 | 0.035101189 | 0 | 0 | 0.090216 | 0 | 0 | 0 |
| 20 | 02:15 | 0 | 0 | 0 | 0.018648 | 0 | 0 | 0 | 0 | 0 | 0 |
| 21 | 02:30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 22 | 02:45 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 23 | 03:00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 24 | 03:15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 25 | 03:30 | 0 | 0 | 0 | 0 | 0 | 8.83E-05 | 0 | 0 | 0 | 0 |

*Figure 8-2 Exported simulation results as Excel file: a) after choosing 7 patterns per file and b) after choosing 1 pattern per file.*

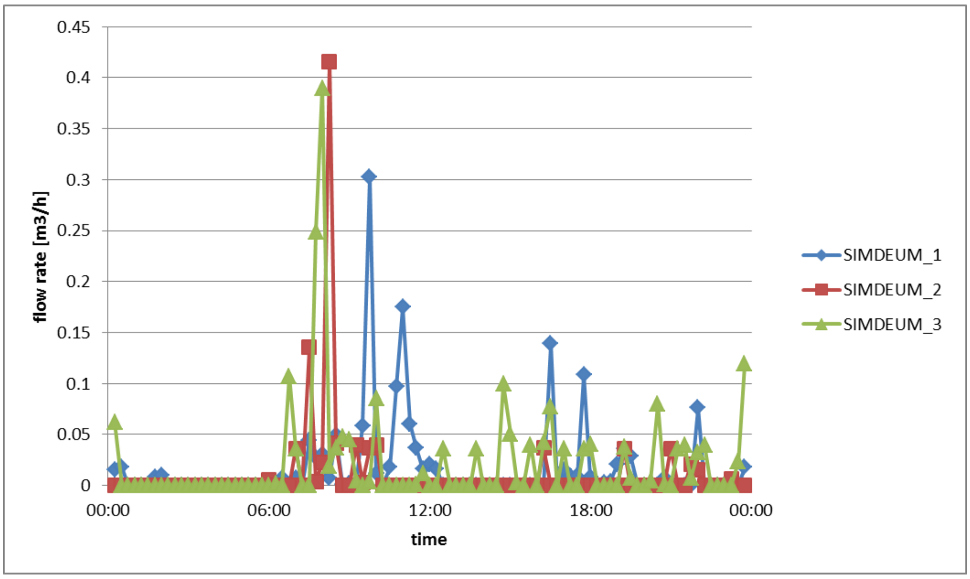



*Figure 8-3 Example of demand patterns for three houses in Excel file, time step is 900 seconds and flow rate unit is m³/h.*

The last worksheet gives the 'base_demand_info' (Figure 8-4). The base demand represents the average demand of the house on annual basis expressed in the chosen unit for the flow rate, in this example m³/h. You don't have to use this information, since the demand patterns in the former worksheets represent the real demand. This base demand is just for your information and helps you to select the small and big households.

In the household statistics the percentages are defined of one person household, two person household and of family. Each house fulfills these statistics, so can consist of one person, two persons or a family. The demand patterns itself do not automatically show the size of the household, due to the stochatic character. However, the average consumption helps you to determine what household size corresponds to the simulated house.

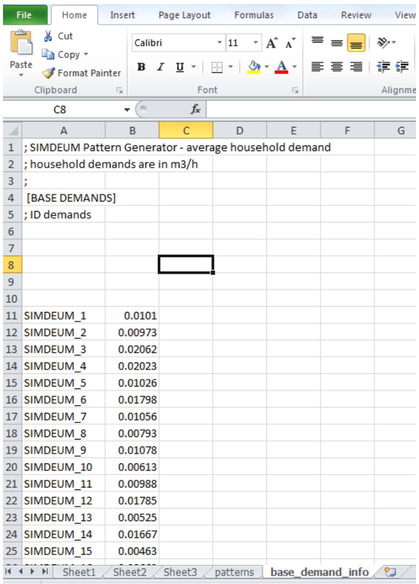



*Figure 8-4 Example of the base_demand_info of simulation results belonging to export as Generic.xls. It represents the daily average demand of each house on annual basis in m³/h.*

### 8.3.2 Exported pattern files as InfoWorks.ddg

When exporting the data as an Infoworks file, 

opens a screen where you can select a folder as destination for the exported ddg. There are two possibilities:

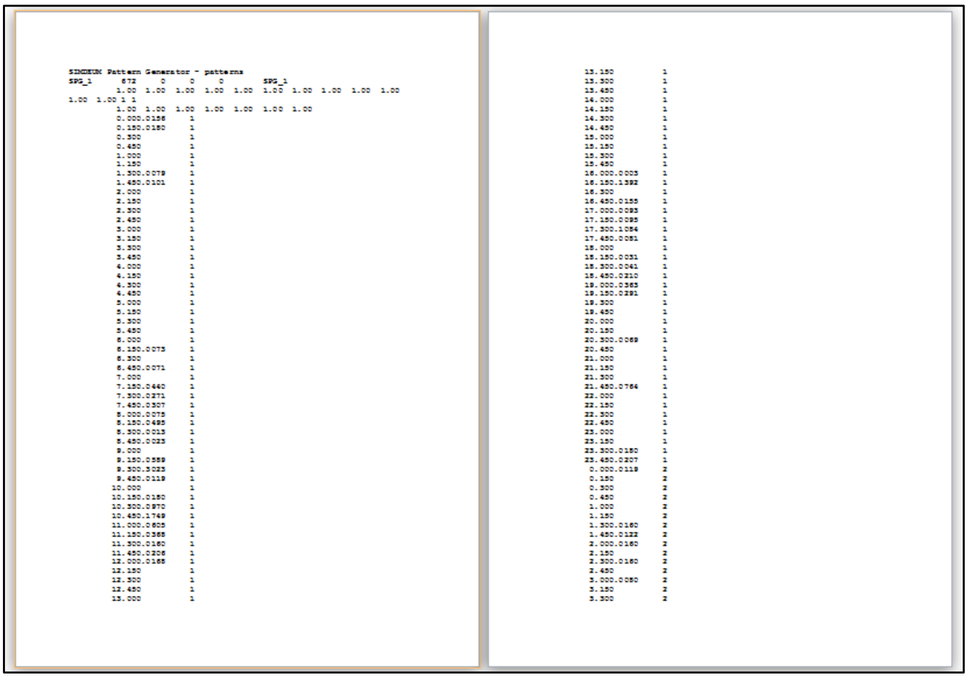
- 7 patterns per file (see Figure 8-5a): ‘write pattern files’ yields one ddg file named SIMDEUM pattern_file.ddg and a txt-file with base_demand_info. SIMDEUM pattern_file.ddg contains the seven demand patterns of all houses, from Monday to Sunday (5 weekdays and 2 weekenddays). First all seven patterns of house 1 are listed: SPG_1 with the time and flow on day 1, then the time and flow on day 2, etc. The day is displayed as a number after the flow (Figure 8-5a). Then all seven patterns of house 2 are listed: SPG_2, etc.
- 1 pattern per file (Figure 8-5b): ‘write pattern files’ yields seven ddg files, for each day one ddg-file with the demand patterns for all houses, named SIMDEUM pattern_file1.ddg to SIMDEUM pattern_file7.ddg and a txt-file with base_demand_info. SIMDEUM pattern_file1 to file5 represent the demand patterns on weekdays, SIMDEUM pattern_file6 and file7 are weekend days. The ddg file lists first the time and flow for house 1, called SPG_1, then the time and flow for house 2, called SPG_2, etc (Figure 8-5b).

The chosen time step follows from the time vector in the ddg.file. The chosen flow unit is given in the corresponding base_demand_info.txt (Figure 8-6). The base_demand_info.txt contains the same information as in Figure 8-4. The base demand represents the average demand of the house on annual basis expressed in the chosen unit for the flow rate, in this example $m^3$/h and is explained in the former section 8.3.1.

The SIMDEUM pattern_file.ddg can be imported in InfoWorks through:

- Step 1: Import-Item from Wesnetfile.
- Step 2: Assign the pattern to a demand node (use “1 [$m^3$/h]” as base demand).

a)



b)

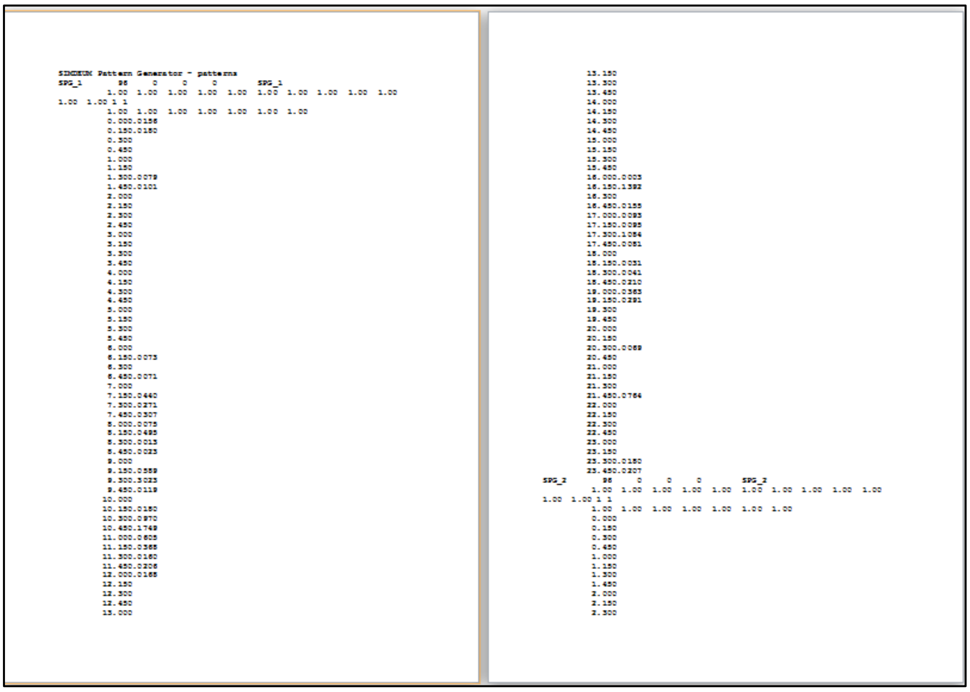


*Figure 8-5 Exported simulation results as Infoworks.ddg file: a) after choosing 7 patterns per file and b) after choosing 1 pattern per file.*

```
; SIMDEUM Pattern Generator - average household demand
; household demands are in m3/h
;

 [BASE DEMANDS]
; ID demands
SPG_1 0.0101
SPG_2 0.0097
SPG_3 0.0206
SPG_4 0.0202
SPG_5 0.0103
SPG_6 0.0180
SPG_7 0.0106
SPG_8 0.0079
SPG_9 0.0108
SPG_10 0.0061
SPG_11 0.0099
SPG_12 0.0178
SPG_13 0.0052
SPG_14 0.0167
SPG_15 0.0046
SPG_16 0.0067
SPG_17 0.0052
SPG_18 0.0101
SPG_19 0.0155
SPG_20 0.0160
SPG_21 0.0071
SPG_22 0.0163
SPG_23 0.0046
SPG_24 0.0063
SPG_25 0.0166
SPG_26 0.0046
SPG_27 0.0169
SPG_28 0.0180
SPG_29 0.0118
SPG_30 0.0065
SPG_31 0.0044
SPG_32 0.0112
SPG_33 0.0100
SPG_34 0.0101
SPG_35 0.0156
SPG_36 0.0101
SPG_37 0.0122
```

*Figure 8-6 Example of the base_demand_info of simulation results belonging to export as Infoworks.ddg and as EPANET.txt. It represents the daily average demand of each house on annual basis in m³/h.*

### 8.3.3 Exported pattern files as EPANET.txt

When exporting the data as an EPANET file, **Write Pattern Files** opens a screen where you can select a folder, as destination for the exported txt-files. There are two possibilities:

- 7 patterns per file(see Figure 8-7a): 'write pattern files' yields one txt- file named SIMDEUM pattern_file.txt and a txt-file with base_demand_info. SIMDEUM pattern_file.txt contains the seven demand patterns of all houses, from Monday to Sunday (5 weekdays and 2 weekenddays). First, all seven patterns of house 1 are listed after SIMDEUM_1, then all seven patterns of house 2 are listed after SIMDEUM_2, etc.
- 1 pattern per file (see Figure 8-7b): 'write pattern files' yields seven txt files, for each day one txt-file with the demand patterns for all houses, named SIMDEUM pattern_file1.txt to SIMDEUM pattern_file7.txt and a txt-file with base_demand_info. SIMDEUM pattern_file1 to file5 represent the demand patterns on weekdays, file 6 and file 7 represent weekenddays. The EPANET.txt file first lists the pattern on that day for house 1, SIMDEUM_1, then for house 2, SIMDEUM_2, etc.

In the first cells of each EPANET.txt file, you see the settings used for the export: the time step (900 seconds in this case) and the flow unit ($m^3/h$ in this example).

The base_demand_info.txt is the same as for the Infoworks export (Figure 8-6). The base demand represents the average demand of the house on annual basis expressed in the chosen unit for the flow rate, in this example $m^3/h$ and is explained in section 8.3.1.

The SIMDEUM pattern_file.txt can be imported in EPANET hydraulic model through:

- Step 1: Copy and paste the txt-file into [PATTERNS] section of .inp file.
- Step 2: Assign the pattern to a demand node (use “1 [$m^3$/h]” as base demand).

a)

```
; SIMDEUM Pattern Generator - patterns
; pattern file for all 7 days
; time step = 900 seconds
; pattern length = 672
; multipliers are in m3/h
;

 [PATTERNS]
; ID multipliers
SIMDEUM_1 0.01562 0.01798 0.00000 0.00000 0.00000 0.00000 0.00790 0.01008 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00734 0.00000 0.00705 0.00000
0.04398 0.02706 0.03066 0.00751 0.04947 0.00132 0.00226 0.00000 0.05885 0.30233 0.01193 0.00000 0.01798 0.09696 0.17488
0.06049 0.03680 0.01600 0.02059 0.01679 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
0.00000 0.00000 0.00000 0.00000 0.00000 0.00030 0.13919 0.00000 0.01548 0.00935 0.00945 0.10836 0.00814 0.00000 0.00314
0.00413 0.02101 0.03629 0.02911 0.00000 0.00000 0.00000 0.00000 0.00693 0.00000 0.00000 0.00000 0.00000 0.07644 0.00000
0.00000 0.00000 0.00000 0.00000 0.00000 0.01798 0.02066 0.01193 0.00000 0.00000 0.00000 0.00000 0.00000 0.01600 0.01217
0.01600 0.00000 0.01600 0.00000 0.00800 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.03371 0.00000 0.13301 0.00000 0.06347 0.18541 0.03909 0.02793 0.00000
0.01600 0.00000 0.03219 0.01798 0.01583 0.01798 0.01600 0.00000 0.01600 0.00000 0.01600 0.01244 0.00800 0.00000 0.00000
0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.02419 0.03259 0.00137 0.00000
0.01600 0.00119 0.01600 0.00000 0.05971 0.00000 0.05143 0.00346 0.00000 0.01186 0.00000 0.00000 0.00000 0.00118 0.00000
0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.01193 0.00000 0.00000 0.00000 0.02990 0.12846 0.00000 0.00000
0.00000 0.04000 0.00000 0.04000 0.04000 0.10730 0.14282 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00375 0.00000 0.00000
0.00001 0.17763 0.00000 0.00000 0.01193 0.00000 0.00000 0.00000 0.00000 0.00282 0.03398 0.00000 0.11514 0.00000 0.01600
0.00000 0.06598 0.05835 0.04000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
0.00000 0.00000 0.01193 0.01798 0.02962 0.09600 0.00260 0.01752 0.00042 0.07497 0.04235 0.00800 0.04000 0.00133 0.00039
0.01309 0.00118 0.00000 0.00021 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.03629 0.00000 0.02419 0.00000 0.00000
0.00000 0.00000 0.02974 0.10436 0.00000 0.01193 0.00000 0.00000 0.00000 0.00000 0.00196 0.03595 0.00000 0.00000 0.00000
0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.06074 0.01798 0.00969 0.01877 0.00000 0.01600 0.00035 0.01268
0.00000 0.02814 0.00000 0.07535 0.00000 0.02167 0.00000 0.03330 0.30263 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.01798 0.00000 0.00000 0.00000 0.00000 0.00000
0.00000 0.00000 0.00625 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.03629 0.00000 0.00000 0.00000
0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.01798
0.00000 0.00037 0.00753 0.02906 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00532 0.00000 0.00000 0.00411 0.00000 0.21878 0.02517
0.03629 0.00000 0.00323 0.00000 0.00000 0.00000 0.01798 0.00023 0.01112 0.04551 0.02312 0.00000 0.02990 0.00000 0.00000
0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
0.00000 0.00000 0.00837 0.01196 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00043 0.00093 0.00000 0.00000
0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.04639 0.00539 0.00000 0.00000 0.00000
0.03612 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
0.00246 0.01051 0.00000 0.00329 0.00000 0.00086 0.02990 0.02272 0.02755 0.00000 0.11465 0.09100 0.05705 0.01902 0.00372
0.02049 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
0.00000 0.00000 0.00000 0.00000 0.04549 0.21992 0.04291 0.00000 0.00000 0.00000 0.00000 0.00000 0.00453 0.01819 0.00000
0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
0.00000 0.00000 0.00000 0.00000 0.00621 0.00024 0.00248 0.00288 0.01678 0.00049 0.01574 0.02032 0.02048 0.03759 0.00609
0.00000 0.00815 0.04011 0.03924 0.05512 0.03031 0.01600 0.00000 0.01600 0.00000 0.00800 0.00000 0.00000 0.00000 0.00000
0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00324 0.12166 0.32172 0.00562 0.00799
0.00000 0.00000 0.00000 0.00360 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
SIMDEUM_2 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00525 0.00000 0.00000 0.00000 0.03629 0.00000
```

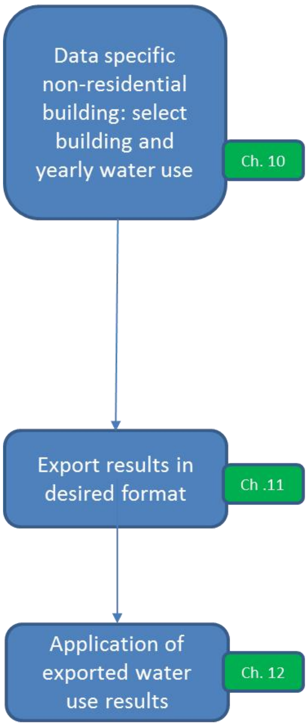
b)

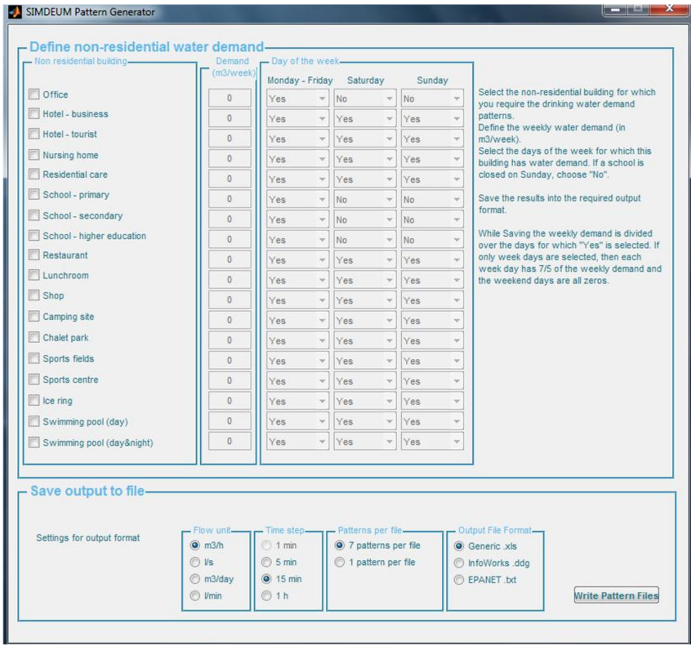
```
; SIMDEUM Pattern Generator - patterns
; pattern file for day 1
; time step = 900 seconds
; pattern length = 96
; multipliers are in m3/h
;

 [PATTERNS]
; ID multipliers
SIMDEUM_1 0.01562 0.01798 0.00000 0.00000 0.00000 0.00000 0.00790 0.01008 0.00000 0.00000
0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
0.00000 0.00000 0.00000 0.00000 0.00734 0.00000 0.00705 0.00000 0.04398 0.02706 0.03066
0.00751 0.04947 0.00132 0.00226 0.00000 0.05885 0.30233 0.01193 0.00000 0.01798 0.09696
0.17488 0.06049 0.03680 0.01600 0.02059 0.01679 0.00000 0.00000 0.00000 0.00000 0.00000
0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00030
0.13919 0.00000 0.01548 0.00935 0.00945 0.10836 0.00814 0.00000 0.00314 0.00413 0.02101
0.03629 0.02911 0.00000 0.00000 0.00000 0.00000 0.00693 0.00000 0.00000 0.00000 0.00000
0.07644 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.01798 0.02066
SIMDEUM_2 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
0.00000 0.00000 0.00525 0.00000 0.00000 0.00000 0.03629 0.00000 0.13534 0.00391 0.02227
0.41579 0.04129 0.00000 0.00000 0.04000 0.00333 0.03667 0.04000 0.00000 0.00000 0.00000
0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.03686
0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
0.03629 0.00000 0.00000 0.00000 0.00000 0.00000 0.00007 0.03629 0.00000 0.00000 0.02050
0.01588 0.00000 0.00000 0.00000 0.00000 0.00623 0.00000 0.00000 0.00000
SIMDEUM_3 0.06248 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
0.00000 0.00000 0.00000 0.00193 0.00002 0.10718 0.03629 0.00000 0.00041 0.24878 0.38976
0.01866 0.03736 0.04783 0.04519 0.00499 0.00000 0.00341 0.08520 0.00000 0.00000 0.00000
0.00033 0.00000 0.00148 0.01200 0.00000 0.00000 0.03629 0.00000 0.00000 0.00000 0.00000
0.03629 0.00000 0.00000 0.00032 0.09949 0.05085 0.00252 0.00000 0.04000 0.00000 0.04267
0.07766 0.00000 0.03629 0.00000 0.00000 0.03629 0.04069 0.00000 0.00000 0.00000 0.00000
0.03792 0.00742 0.00000 0.00000 0.00511 0.08000 0.00146 0.00000 0.03629 0.04000 0.00733
0.03267 0.04000 0.00000 0.00000 0.00000 0.00000 0.02332 0.11955 0.54749
SIMDEUM_4 0.00000 0.00000 0.04000 0.04000 0.00000 0.04000 0.00000 0.03510 0.01865 0.00000
0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00510 0.00000 0.00000 0.00000 0.01814
0.02288 0.24321 0.01193 0.02461 0.00299 0.00000 0.03629 0.00000 0.00000 0.03629 0.00000
0.00000 0.03659 0.00000 0.00714 0.00000 0.00000 0.00000 0.04133 0.00000 0.00000 0.00000
0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.02897 0.47939 0.00013 0.00000 0.00000
0.00000 0.00000 0.00629 0.01193 0.18517 0.08846 0.00000 0.05290 0.01053 0.00013 0.21548
```

*Figure 8-7 Exported simulation results as EPANET.txt file: a) after choosing 7 patterns per file and b) after choosing 1 pattern per file.*

# PART III: SIMDEUM Pattern Generator for non-residential buildings



# 9 Structure of SIMDEUM Pattern Generator for non-residential buildings

Figure 9-1 shows the structure of the SIMDEUM pattern generator (SPG) for non-residential buildings, when you choose "SPG non-residential" in the home screen of the SPG (Figure 2-2). It follows the logical steps you have to make to obtain the demand patterns that you need for a certain purpose:

1. First you select the non-residential buildings that are present in the specific area under consideration. How you can do this and which data you need are described in chapter 10.
2. When you have entered the required choices and data, the SPG generates the demand patterns and exports them in a format, that suits the desired application of the demand patterns. This is described in chapter 11.
3. Finally, you can apply the exported results in your application. Some application examples are described in chapter 12.


*Figure 9-1 Structure of the SIMDEUM Pattern Generator for non-residential buildings and the corresponding chapters of this manual.*

# 10 Data for specific non-residential building

## 10.1 Introduction

The SIMDEUM Pattern Generator (SPG) for non-residential buildings generates demand patterns based on a demand pattern library for a number of non-residential users. The library consists of normalised patterns for several categories of non-residential users on a time basis of 5 minutes, 15 minutes and 1 hour. This means that the SPG for non-residential buildings does not simulate the demand patterns. It combines normalised patterns available in the library, with measured water use for the user, and creates in such a way a specific demand pattern for that non-residential building. In this chapter, we describe how you can define the non-residential water demand, required for a certain purpose.

SIMDEUM itself, can simulate demand patterns of any non-residential building. When you want stochastic demand patterns for cold and hot water demand for a non-residential building, you can contact KWR.

## 10.2 Define non-residential water demand

In the field Define non-residential water demand in the SPG for non-residential buildings (Figure 10-1), the user can select the typical category, insert the weekly measured water use and chose the days on which water is used during the week. The SPG then generates a demand pattern for that specific user during a weekday and during a weekend day.

The required information for the SPG is given in three fields:

❶: non-residential building

Here you select the categories of non-residential buildings, from which you want demand patterns. You can choose any number of non-residential building by selecting the check-box in front of the category. When you select the building type, the data in field ❷ and ❸ can be entered.

There are 18 categories of non-residential buildings, varying from office, school, to hotel, nursing home and recreation. When your specific building is not present in the list, you can select a category from which you expect to have a similar demand pattern during the day. In practice it appears, that it is mainly important to know whether there is only day consumption ('office' pattern), only evening consumption ('restaurant' pattern), or both day and night usage (‘sports centre’- or 'ice ring' pattern).

❷: demand ($m^3$/week)

The SPG is based on the demand pattern library, that consists of normalised demand patterns. To adjust the normalised pattern to the actual demand pattern of a specific non-residential building, the measured water use is required. For this purpose, you need to fill the weekly water demand in m³ in field ❷.

❸: day of the week

Some buildings are not open every day. Therefore, the entered weekly water use needs to be divided over the days that water is consumed in the building. In this field you select the days of the week for which this building has water demand. Defaults are set, but you can alter them.

The same pattern is used for the week and weekend days, unless "no" is selected. Then an all zeros pattern is used for that day of the week.

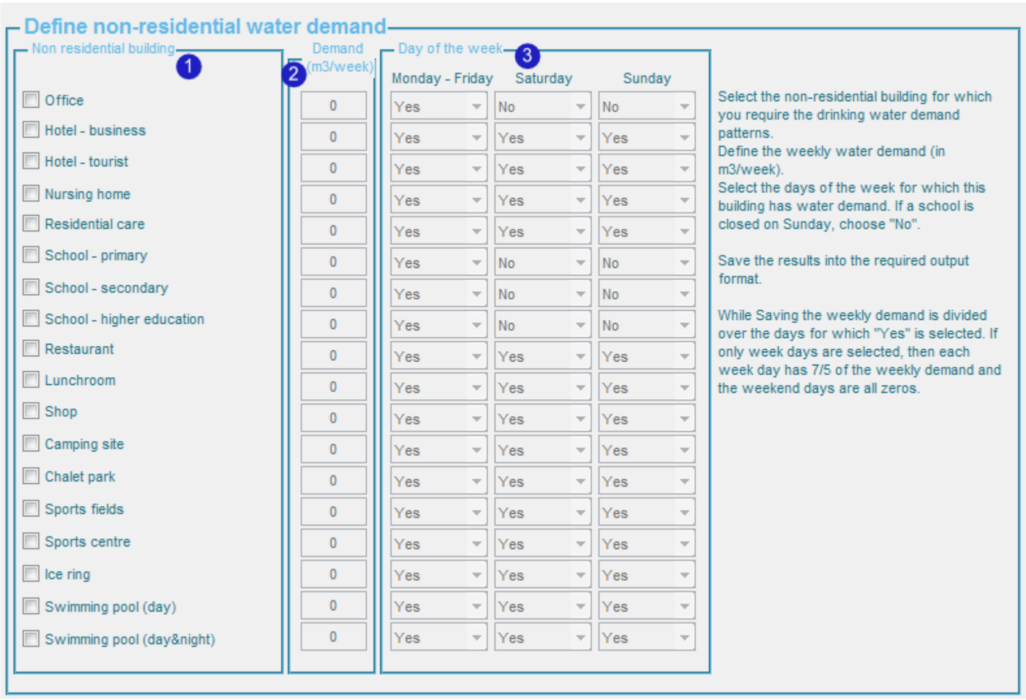



*Figure 10-1 Field in SIMDEUM Pattern Generator to define the characteristics for the non-residential water demand.*

In the example of this manual, we want to generate a demand pattern for a business hotel with a weekly demand of 100 m³/week, a secondary school with a weekly demand of 50 m³/week and sports fields with a weekly demand of 75 m³/week. The business hotel and sports field are open all days, the secondary school only on week days.

# 11 Export generated demand patterns

## 11.1 Introduction

The generated demand patterns for non-residential buildings can be used in many applications. Each application sets its own requirements for time scale and format. Before exporting the simulation results, you first need to consider the desired application and the corresponding requirements. This chapter describes how you can export the generated patterns and which choices you can make in the exported format.

## 11.2 Settings for saving the generated demand patterns

In Figure 11-1, the field Save output to file in the SPG is shown. Here you select the settings for the export of the generated demand patterns of the non-residential buildings and their characteristics, that you have defined in the top screen of the SPG (Figure 10-1):

a. Flow unit
   You can chose four units for the flow: $m^3$/h, l/s, $m^3$/day and l/min. The choice you make depends on your application.
b. Time step
   The generated demand patterns for non-residential buildings are based on the normalised patterns of the library, which are on a time basis of 5 minutes, 15 minutes or 1 hour. Therefore, you can export the patterns with three time steps: 5 minutes, 15 minutes and one hour. When you want a smaller timestep, you can contact KWR.
   The choice you make, depends on the application of the demand patterns and may differ per company:
   - For the allocation of demand patterns in the transport trunk, peak demands per minute will be less relevant, but per hour might be too coarse.
   - For the reticulation network, minute scale is relevant.
   - For the prediction of water age with a hydraulic model a time scale of 15 minutes is too long to see enough variation, a time step of 5 minutes is okay.
   - When you want to base the designs on the water demand patterns, you may need demands on a second base, since you want to know the actual maximum flow rate. For this application you ask KWR for stochastic simulation results of the desired building or you use design rules based on SIMDEUM (ISSO, 2013).
     When you use larger time steps than one second, the peak demand value will decrease. Using a timestep of 1 minute, the peak demand value in the demand patterns is only approximately 80% of the maximum flow rate with 1 second time step. Using a timestep of 5 minutes, the peak demand is only 65% of the maximum flow rate. You can use these values as rules of thumb, when you wan to use the simulated results for design purposes (Pieterse-Quirijns, 2012).

c. Patterns per file
Each generated demand pattern contains 7 demand patterns, 5 demand patterns for a week day and 2 demand patterns for a weekendday. In this field you can choose whether you want the 7 patterns in one file or whether you want the 7 patterns separately.

d. Output File Format
The demand patterns can be used in various hydraulic models or applications/calculations. In this field you can choose the desired format:
- Excel file
- Infoworks format: ddg (Demand Diagram Group).
- Epanet format as txt file.

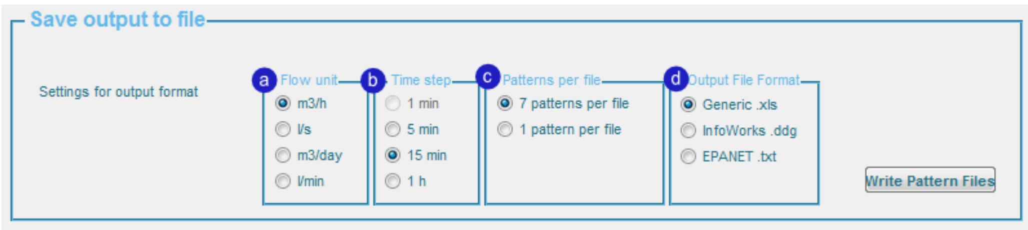



*Figure 11-1 Field in SIMDEUM Pattern Generator to save the generated demand patterns for non-residential buildings in a desired format.*

## 11.3 Exported pattern files

By pressing Write Pattern Files, the generated demand patterns will be exported with the desired settings of Figure 11-1. The procedure and results differ for each Output File Format.

### 11.3.1 Exported pattern files as Generic.xls

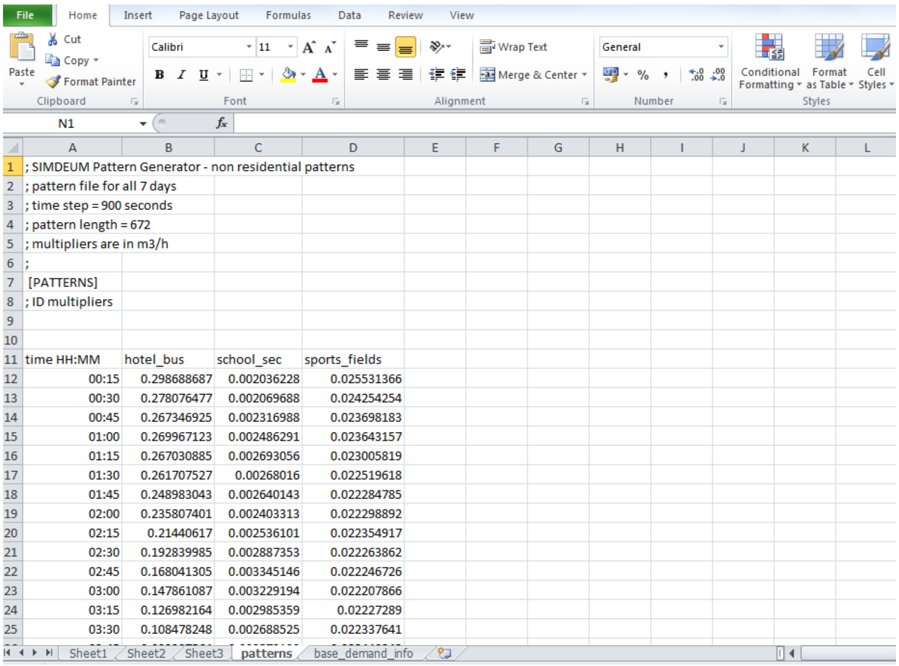
When exporting the data as an Excel file, Write Pattern Files requests a name for the resulting xls-file and the desired location. It yields one Excel-file.

There are two possibilities:

- 7 patterns per file (see Figure 11-2a): in one worksheet all the demand patterns are listed. Each column is a non-residential building, and the demand patterns of all seven days (5 weekdays and 2 weekend days) are listed under each other in the same row in the worksheet called 'patterns'. The title in of the columns refer to the selected category of non-residential buildings. In this example, you see the demand patterns of a business hotel, a secondary school and sports field.
- 1 pattern per file (see Figure 11-2b): each worksheet represents the demand patterns on one day. Each column is a non-residential building and the demand pattern of only one day is given. This results in a worksheet for each day called 'patterns_day1' to 'patterns_day7'. Pattern_day1 to day 5 represent the demand patterns on weekdays, pattern_day 6 and day 7 represent the weekend days.

In the first cells of each worksheet, you see the settings used for the export: the time step (900 seconds in this case) and the flow unit (m³/h in this example). When you make a figure of the demand pattern of one non-residential, you obtain a graph with flow rate in m³/h with every 15 minutes a datapoint. In Figure 11-3, you see an example of the demand pattern of the three non-residential buildings with a arbitrarily chosen weekly demand.

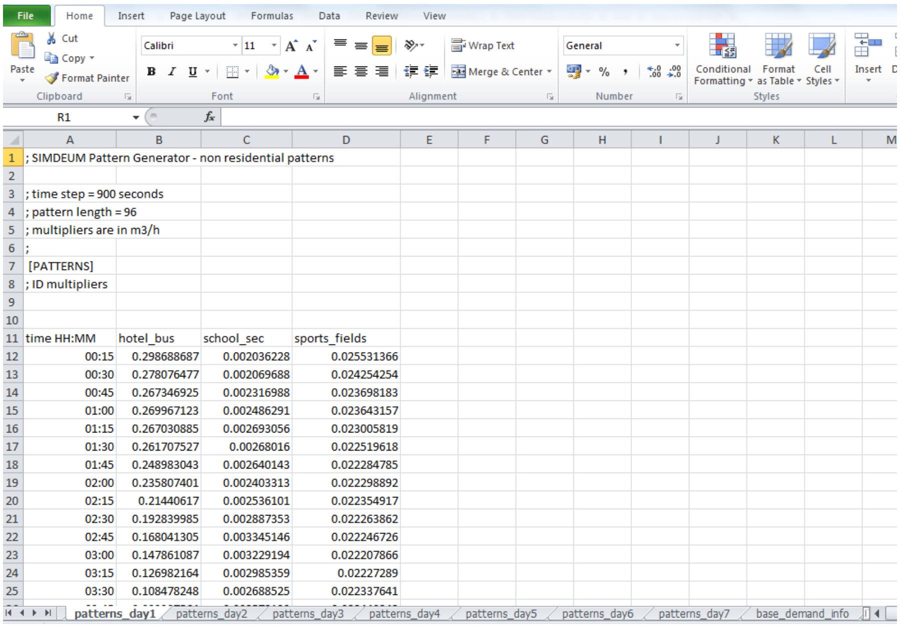
a)



| | A | B | C | D |
|---|---|---|---|---|
| 1 | ; SIMDEUM Pattern Generator - non residential patterns | | | |
| 2 | ; pattern file for all 7 days | | | |
| 3 | ; time step = 900 seconds | | | |
| 4 | ; pattern length = 672 | | | |
| 5 | ; multipliers are in m3/h | | | |
| 6 | ; | | | |
| 7 | [PATTERNS] | | | |
| 8 | ; ID multipliers | | | |
| 9 | | | | |
| 10 | | | | |
| 11 | time HH:MM | hotel_bus | school_sec | sports_fields |
| 12 | 00:15 | 0.298688687 | 0.002036228 | 0.025531366 |
| 13 | 00:30 | 0.278076477 | 0.002069688 | 0.024254254 |
| 14 | 00:45 | 0.267346925 | 0.002316988 | 0.023698183 |
| 15 | 01:00 | 0.269967123 | 0.002486291 | 0.023643157 |
| 16 | 01:15 | 0.267030885 | 0.002693056 | 0.023005819 |
| 17 | 01:30 | 0.261707527 | 0.00268016 | 0.022519618 |
| 18 | 01:45 | 0.248983043 | 0.002640143 | 0.022284785 |
| 19 | 02:00 | 0.235807401 | 0.002403313 | 0.022298892 |
| 20 | 02:15 | 0.21440617 | 0.002536101 | 0.022354917 |
| 21 | 02:30 | 0.192839985 | 0.002887353 | 0.022263862 |
| 22 | 02:45 | 0.168041305 | 0.003345146 | 0.022246726 |
| 23 | 03:00 | 0.147861087 | 0.003229194 | 0.022207866 |
| 24 | 03:15 | 0.126982164 | 0.002985359 | 0.02227289 |
| 25 | 03:30 | 0.108478248 | 0.002688525 | 0.022337641 |



b)



| | A | B | C | D |
|---|---|---|---|---|
| 1 | ; SIMDEUM Pattern Generator - non residential patterns | | | |
| 2 | | | | |
| 3 | ; time step = 900 seconds | | | |
| 4 | ; pattern length = 96 | | | |
| 5 | ; multipliers are in m3/h | | | |
| 6 | ; | | | |
| 7 | [PATTERNS] | | | |
| 8 | ; ID multipliers | | | |
| 9 | | | | |
| 10 | | | | |
| 11 | time HH:MM | hotel_bus | school_sec | sports_fields |
| 12 | 00:15 | 0.298688687 | 0.002036228 | 0.025531366 |
| 13 | 00:30 | 0.278076477 | 0.002069688 | 0.024254254 |
| 14 | 00:45 | 0.267346925 | 0.002316988 | 0.023698183 |
| 15 | 01:00 | 0.269967123 | 0.002486291 | 0.023643157 |
| 16 | 01:15 | 0.267030885 | 0.002693056 | 0.023005819 |
| 17 | 01:30 | 0.261707527 | 0.00268016 | 0.022519618 |
| 18 | 01:45 | 0.248983043 | 0.002640143 | 0.022284785 |
| 19 | 02:00 | 0.235807401 | 0.002403313 | 0.022298892 |
| 20 | 02:15 | 0.21440617 | 0.002536101 | 0.022354917 |
| 21 | 02:30 | 0.192839985 | 0.002887353 | 0.022263862 |
| 22 | 02:45 | 0.168041305 | 0.003345146 | 0.022246726 |
| 23 | 03:00 | 0.147861087 | 0.003229194 | 0.022207866 |
| 24 | 03:15 | 0.126982164 | 0.002985359 | 0.02227289 |
| 25 | 03:30 | 0.108478248 | 0.002688525 | 0.022337641 |



*Figure 11-2 Exported non-residential demand patterns as Excel file: a) after choosing 7 patterns per file and b) after choosing 1 pattern per file.*

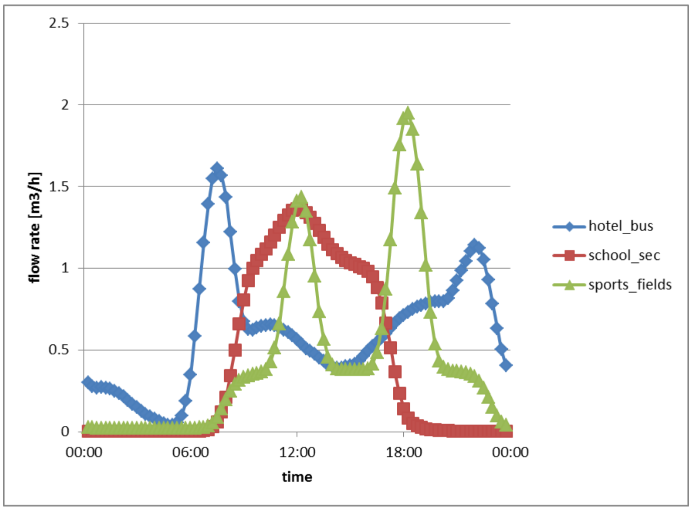



*Figure 11-3 Example of demand patterns of three non-residential buildings, a business hotel, a secondary school and sports fields in Excel file, time step is 900 seconds and flow rate unit is m³/h.*

The last worksheet gives the 'base_demand_info' of each non-residential building for which a demand pattern is generated (Figure 11-4). The base demand represents the average demand of the building on annual basis expressed in the chosen unit for the flow rate, in this example m³/h. You don't have to use this information, since the demand patterns in the former worksheets represent the real demand. This base demand is just for your information and directly shows the building with the highest water demand.

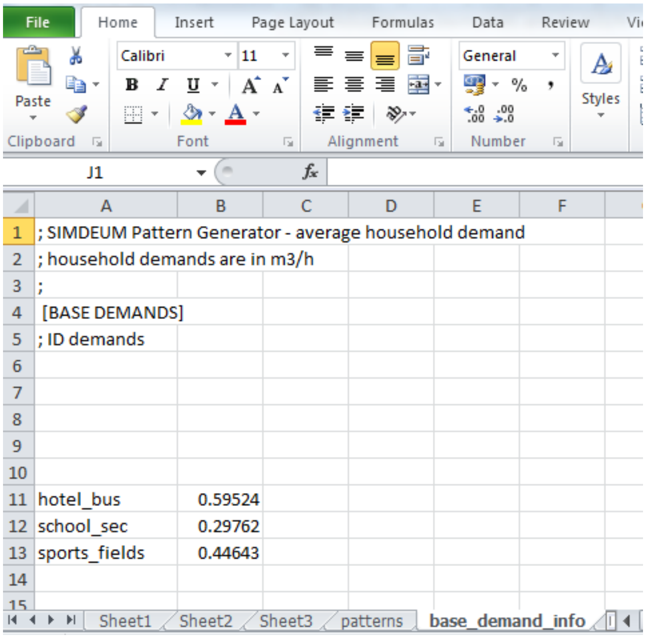



*Figure 11-4 Example of the base_demand_info of the generated demand patterns for three non-residential buildings, a business hotel, a secondary school and sports fields, exported in Excel. It represents the average demand of each non-residential building on annual basis in m³/h.*

### 11.3.2 Exported pattern files as InfoWorks.ddg

When exporting the data as an Infoworks file, 

opens a screen where you can select a folder as destination for the exported ddg. There are two possibilities:

- 7 patterns per file (see Figure 11-5a): 'write pattern files' yields one ddg file named SPG_NonRes_pattern_file.ddg and a txt-file with base_demand_info (SPG_NonRes_base_demand_file.txt). SPG_NonRes_pattern_file.ddg contains the seven demand patterns for the selected non-residential buildings. In this example, first all seven patterns of the business hotel are listed: S_hotel_bus with the time and flow on day 1, then the time and flow on day 2, etc. The day is displayed as a number after the flow (Figure 11-5a). Then all seven patterns of the secondary school are listed: S_school_sec, followed by the seven patterns of thhe sports fields, S_sports_fields.
- 1 pattern per file (see Figure 11-5b): 'write pattern files' yields seven ddg files, for each day one ddg-file with the demand patterns for the selected non-residential buildings, named SPG_NonRes_pattern_file1.ddg to SPG_NonRes_pattern_file7.ddg and a txt-file with base_demand_info. SPG_NonRes_pattern_file1 to file5 represent the demand patterns on weekdays, SPG_NonRes_pattern_file6 and file7 are weekend days. The ddg file lists first the time and flow for the business hotel, called S_hotel_bus, then the time and flow for the secondary school called S_school_sec, and finally for the sports fields, called S_sports_fields.

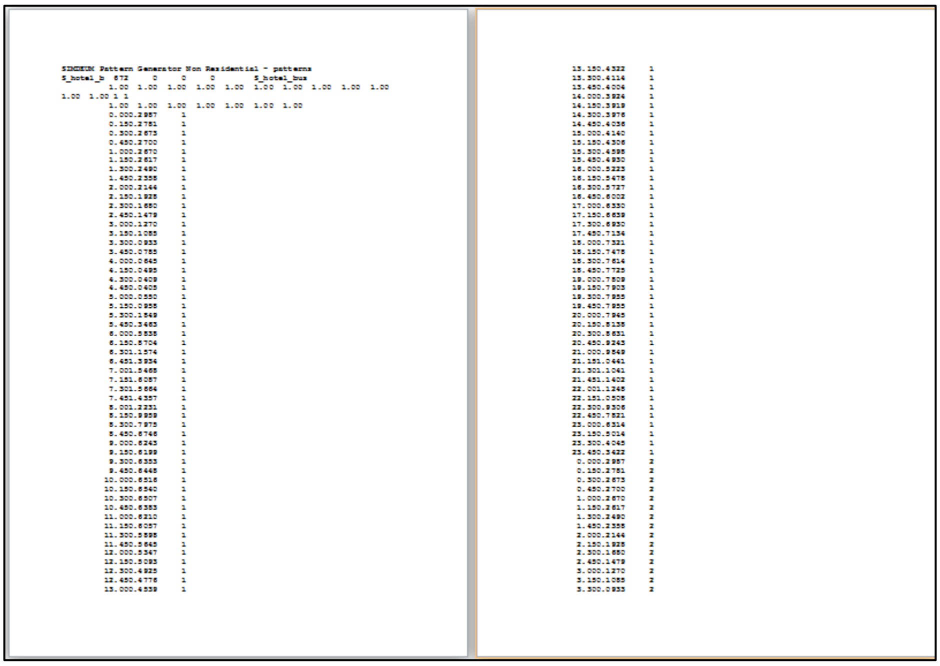
The chosen time step follows from the time vector in the ddg.file. The chosen flow unit is given in the corresponding base_demand_info.txt (Figure 11-6).

The SPG_NonRes_base_demand_file.txt contains the same information as in Figure 11-4. The base demand represents the average demand of the non-residential building on annual basis expressed in the chosen unit for the flow rate, in this example $m^3$/h and is explained in the former section 11.3.1.

The SPG_NonRes_pattern_file.ddg can be imported in InfoWorks through:

- Step 1: Import-Item from Wesnetfile.
- Step 2: Assign the pattern to a demand node (use "1 [$m^3$/h]" as base demand).

a)



b)

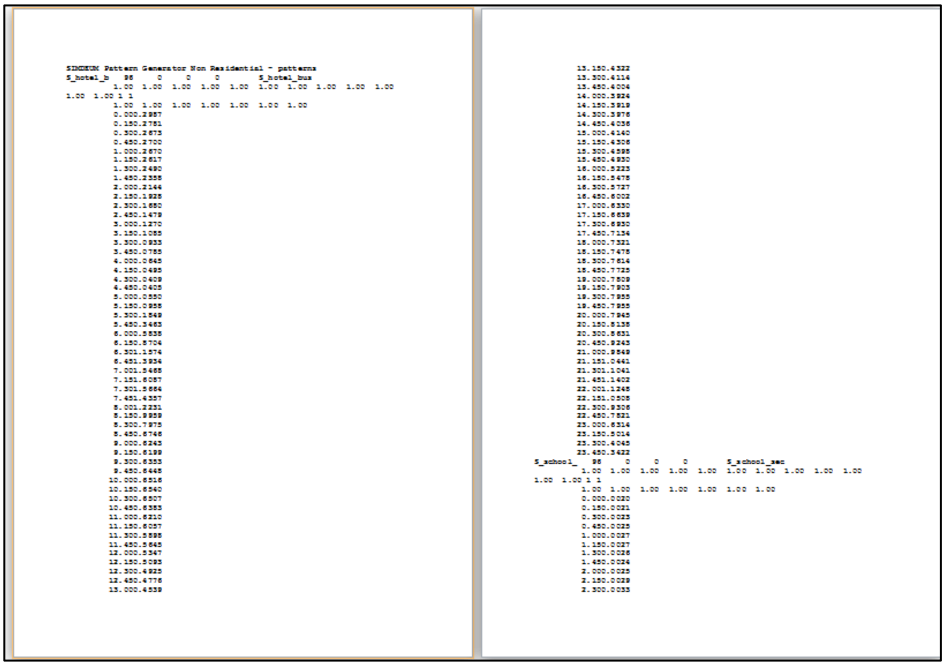


*Figure 11-5 Exported non-residential demand patterns as Infoworks.ddg file: a) after choosing 7 patterns per file and b) after choosing 1 pattern per file*

```
; SIMDEUM Pattern Generator Non Residential - average household demand
; non residential demands are in m3/h
;

 [BASE DEMANDS]
; ID demands
SPG_hotel_bus 0.5952
SPG_school_sec 0.2976
SPG_sports_fields 0.4464
```

*Figure 11-6 Example of the base_demand_info of of the generated demand patterns for three non-residential buildings, a business hotel, a secondary school and sports fields exported as Infoworks.ddg and as EPANET.txt. It represents the average demand of each non-residential building on annual basis in m³/h.*

### 11.3.3 Exported pattern files as EPANET.txt

When exporting the data as an EPANET file, Write Pattern Files opens a screen where you can select a folder, as destination for the exported txt-files. There are two possibilities:

- 7 patterns per file (see Figure 11-7a): 'write pattern files' yields one txt- file named SPG_NonRes_pattern_file.txt and a txt-file with base_demand_info. SPG_NonRes_pattern_file.txt contains the seven demand patterns for the selected non-residential buildings. In this example, first all seven patterns of the business hotel are listed after SIMDEUM_hotel_bus, then all seven patterns of the secondary school are listed after SIMDEUM_school_sec and finally the seven patterns of the sports fields after SIMDEUM_sports_fields.
- 1 pattern per file (see Figure 11-7b): 'write pattern files' yields seven txt files, for each day one txt-file with the demand patterns for the selected non-residential buildings, named SPG_NonRes_pattern_file1.txt to SPG_NonRes_pattern_file7.txt and a txt-file with base_demand_info. SPG_NonRes_pattern_file1 to file5 represent the demand patterns on weekdays, file 6 and file 7 represent weekenddays. The EPANET.txt file first lists the pattern on that day for the business hotel, SIMDEUM_hotel_bus, then for the secondary school, SIMDEUM_school_sec and finally for the sports fields, SIMDEUM_sports_fields.

In the first cells of each EPANET.txt file, you see the settings used for the export: the time step (900 seconds in this case) and the flow unit ($m^3/h$ in this example).

The SPG_NonRes_base_demand_file.txt is the same as for the Infoworks export (Figure 11-6). The base demand represents the average demand of non-residential on annual basis expressed in the chosen unit for the flow rate, in this example $m^3/h$ and is explained in section 11.3.1.

The SIMDEUM pattern_file.txt can be imported in EPANET hydraulic model through:

- Step 1: Copy and paste the txt-file into [PATTERNS] section of .inp file.
- Step 2: Assign the pattern to a demand node (use "1 [$m^3/h$]" as base demand).

a)

```
; SIMDEUM Pattern Generator Non Residential - patterns
; pattern file for all 7 days
; time step = 900 seconds
; pattern length = 672
; multipliers are in m3/h
;

 [PATTERNS]
; ID multipliers
SIMDEUM_hotel_bus 0.29869 0.27808 0.26735 0.26997 0.26703 0.26171 0.24898 0.23581 0.21441
0.19284 0.16804 0.14786 0.12698 0.10848 0.09331 0.07854 0.06453 0.04946 0.04086 0.04047
0.05495 0.09584 0.18494 0.34627 0.58378 0.87045 1.15742 1.39336 1.54682 1.60866 1.56636
1.43573 1.22310 0.99586 0.79750 0.67464 0.62432 0.61994 0.63529 0.64479 0.65158 0.65398
0.65071 0.63832 0.62097 0.60567 0.58981 0.56452 0.53468 0.50931 0.49252 0.47762 0.45388
0.43219 0.41142 0.40041 0.39236 0.39189 0.39758 0.40363 0.41396 0.43060 0.45980 0.49295
0.52226 0.54781 0.57270 0.60016 0.63301 0.66389 0.69303 0.71339 0.73210 0.74782 0.76144
0.77252 0.78093 0.79030 0.79550 0.79546 0.79451 0.81378 0.86314 0.92431 0.98490 1.04405
1.10412 1.14017 1.12485 1.05077 0.93062 0.78213 0.63138 0.50138 0.40449 0.34217 0.29869
0.27808 0.26735 0.26997 0.26703 0.26171 0.24898 0.23581 0.21441 0.19284 0.16804 0.14786
0.12698 0.10848 0.09331 0.07854 0.06453 0.04946 0.04086 0.04047 0.05495 0.09584 0.18494
0.34627 0.58378 0.87045 1.15742 1.39336 1.54682 1.60866 1.56636 1.43573 1.22310 0.99586
0.79750 0.67464 0.62432 0.61994 0.63529 0.64479 0.65158 0.65398 0.65071 0.63832 0.62097
0.60567 0.58981 0.56452 0.53468 0.50931 0.49252 0.47762 0.45388 0.43219 0.41142 0.40041
0.39236 0.39189 0.39758 0.40363 0.41396 0.43060 0.45980 0.49295 0.52226 0.54781 0.57270
0.60016 0.63301 0.66389 0.69303 0.71339 0.73210 0.74782 0.76144 0.77252 0.78093 0.79030
0.79550 0.79546 0.79451 0.81378 0.86314 0.92431 0.98490 1.04405 1.10412 1.14017 1.12485
1.05077 0.93062 0.78213 0.63138 0.50138 0.40449 0.34217 0.29869 0.27808 0.26735 0.26997
0.26703 0.26171 0.24898 0.23581 0.21441 0.19284 0.16804 0.14786 0.12698 0.10848 0.09331
0.07854 0.06453 0.04946 0.04086 0.04047 0.05495 0.09584 0.18494 0.34627 0.58378 0.87045
1.15742 1.39336 1.54682 1.60866 1.56636 1.43573 1.22310 0.99586 0.79750 0.67464 0.62432
0.61994 0.63529 0.64479 0.65158 0.65398 0.65071 0.63832 0.62097 0.60567 0.58981 0.56452
0.53468 0.50931 0.49252 0.47762 0.45388 0.43219 0.41142 0.40041 0.39236 0.39189 0.39758
0.40363 0.41396 0.43060 0.45980 0.49295 0.52226 0.54781 0.57270 0.60016 0.63301 0.66389
0.69303 0.71339 0.73210 0.74782 0.76144 0.77252 0.78093 0.79030 0.79550 0.79546 0.79451
0.81378 0.86314 0.92431 0.98490 1.04405 1.10412 1.14017 1.12485 1.05077 0.93062 0.78213
0.63138 0.50138 0.40449 0.34217 0.29869 0.27808 0.26735 0.26997 0.26703 0.26171 0.24898
0.23581 0.21441 0.19284 0.16804 0.14786 0.12698 0.10848 0.09331 0.07854 0.06453 0.04946
0.04086 0.04047 0.05495 0.09584 0.18494 0.34627 0.58378 0.87045 1.15742 1.39336 1.54682
1.60866 1.56636 1.43573 1.22310 0.99586 0.79750 0.67464 0.62432 0.61994 0.63529 0.64479
0.65158 0.65398 0.65071 0.63832 0.62097 0.60567 0.58981 0.56452 0.53468 0.50931 0.49252
0.47762 0.45388 0.43219 0.41142 0.40041 0.39236 0.39189 0.39758 0.40363 0.41396 0.43060
0.45980 0.49295 0.52226 0.54781 0.57270 0.60016 0.63301 0.66389 0.69303 0.71339 0.73210
0.74782 0.76144 0.77252 0.78093 0.79030 0.79550 0.79546 0.79451 0.81378 0.86314 0.92431
```

b)

```
; SIMDEUM Pattern Generator Non Residential - patterns
; pattern file for day 1
; time step = 900 seconds
; pattern length = 96
; multipliers are in m3/h
;

 [PATTERNS]
; ID multipliers
SIMDEUM_hotel_bus 0.29869 0.27808 0.26735 0.26997 0.26703 0.26171 0.24898 0.23581 0.21441
0.19284 0.16804 0.14786 0.12698 0.10848 0.09331 0.07854 0.06453 0.04946 0.04086 0.04047
0.05495 0.09584 0.18494 0.34627 0.58378 0.87045 1.15742 1.39336 1.54682 1.60866 1.56636
1.43573 1.22310 0.99586 0.79750 0.67464 0.62432 0.61994 0.63529 0.64479 0.65158 0.65398
0.65071 0.63832 0.62097 0.60567 0.58981 0.56452 0.53468 0.50931 0.49252 0.47762 0.45388
0.43219 0.41142 0.40041 0.39236 0.39189 0.39758 0.40363 0.41396 0.43060 0.45980 0.49295
0.52226 0.54781 0.57270 0.60016 0.63301 0.66389 0.69303 0.71339 0.73210 0.74782 0.76144
0.77252 0.78093 0.79030 0.79550 0.79546 0.79451 0.81378 0.86314 0.92431 0.98490 1.04405
1.10412 1.14017 1.12485 1.05077 0.93062 0.78213 0.63138 0.50138 0.40449 0.34217
SIMDEUM_school_sec 0.00204 0.00207 0.00232 0.00249 0.00269 0.00268 0.00264 0.00240 0.00254
0.00289 0.00335 0.00323 0.00299 0.00269 0.00257 0.00243 0.00250 0.00275 0.00313 0.00323
0.00324 0.00300 0.00296 0.00309 0.00360 0.00463 0.00729 0.01377 0.02916 0.06060 0.11868
0.21155 0.34094 0.49732 0.66044 0.80771 0.92222 0.99983 1.04921 1.08474 1.11961 1.16036
1.20393 1.24892 1.29071 1.32772 1.35366 1.36334 1.35837 1.33974 1.31200 1.27512 1.23171
1.18733 1.14709 1.11464 1.08887 1.06685 1.04943 1.03424 1.02245 1.01158 1.00040 0.98146
0.94628 0.88324 0.78910 0.66211 0.51478 0.36482 0.23474 0.14092 0.08217 0.05142 0.03439
0.02518 0.01869 0.01412 0.01085 0.00851 0.00669 0.00513 0.00398 0.00321 0.00271 0.00263
0.00283 0.00331 0.00334 0.00321 0.00287 0.00258 0.00237 0.00226 0.00225 0.00214
SIMDEUM_sports_fields 0.02553 0.02425 0.02370 0.02364 0.02301 0.02252 0.02228 0.02230 0.02235
0.02226 0.02225 0.02221 0.02227 0.02234 0.02244 0.02251 0.02259 0.02272 0.02296 0.02309
0.02319 0.02318 0.02336 0.02346 0.02381 0.02475 0.02792 0.03636 0.05528 0.08969 0.13842
0.19527 0.24768 0.28950 0.31680 0.33428 0.34499 0.35237 0.35764 0.36501 0.38250 0.42619
0.51233 0.66090 0.86050 1.08679 1.28282 1.41044 1.43422 1.35173 1.17681 0.95485 0.73492
0.56599 0.45869 0.40737 0.38575 0.37972 0.37866 0.37991 0.38096 0.38143 0.38187 0.38767
0.41193 0.48362 0.63321 0.87235 1.17678 1.49086 1.75517 1.91576 1.94917 1.85096 1.63918
1.34248 1.01831 0.73177 0.53782 0.43445 0.39416 0.37874 0.37235 0.36926 0.36668 0.36319
0.35374 0.33717 0.30809 0.26556 0.21000 0.15087 0.09857 0.06161 0.04005 0.03003
```

*Figure 11-7 Exported non-residential demand patterns as EPANET.txt file: a) after choosing 7 patterns per file and b) after choosing 1 pattern per file.*

# 12 Application

## 12.1 Introduction

The SIMDEUM Pattern Generator (SPG), as described in chapter 3 to 8 for residential buildings and in chapter 9 to 11 for non-residential buildings, can be applied to generate demand patterns for a wide range of buildings. For the residential buildings, it simulates the demand patterns for freely defined houses in a stochastic way. The SPG is flexible for input data of a specific country, district, culture, etc. For non-residential buildings, it generates demand patterns for a large number of non-residential buildings, based on a demand pattern library. This means that the SPG for non-residential buildings is deterministic in nature and not flexible for other input data on users or appliances. When you want a flexible input, you can contact KWR, to apply SIMDEUM for your specific wishes for a non-residential building.

The demand patterns exported from the SPG can be used in many applications in the water cylce. In this chapter, we shortly illustrate some applications and refer to corresponding references.

## 12.2 Hydraulic models

To study the flowing behaviour of drinking water in the distribution network, water demand needs to be allocated at each node in the hydraulic model. With the hydraulic model, it can be investigated whether water is supplied with enough pressure to the customers. Moreover, the hydraulic model is essential to study relevant quality aspects, as water age, water flows, flow direction reversals and sediment or contaminant propagation.

The application of stochastic residential demand patterns and deterministic non-residential demand patterns in a hydraulic model is described in Blokker et al. (2010 and 2011) and in Pieterse-Quirijns and Van de Roer (2013). The use of user specific demand patterns, instead of the conventional top-down approach, in which the demand multiplier pattern from the pumping station is allocated to all nodes, results in different prediction of water flows through the pipes. This leads to differences in predicted water age, time of maximum flow, flow direction reversals, routes of water flow, in backtracing, in the way of sediment/contaminant propagation. A better insight into water quality is obtained with user specific demand patterns (for example from the SPG).

## 12.3 Scenario Studies

Due to the physical basis of SIMDEUM and therefore also of SPG, all parameters have a physical meaning. This makes the residential version of the SPG suitable for scenario studies. Consequences of future development, demographic changes, technical developments on water demand can be investigated, but also legislative measures, for example to save water, can be studied. With the SPG it is possible to make a statement about the best way to achieve water-saving; is it more effective to change the water-using behaviour of the people or is it more effective to install water-saving appliances or devices.

With the SPG, the influence of several changes in users and appliances on water demand can be studied. But also the consequences for water demand related subjects can be investigated. For example, are the present distribution networks robust for the expected changes in water demand, following different future scenarios.

Examples of scenario studies with demand patterns from SPG are described in Agudelo-Vera et al. (2014) and Blokker et al. (2012).

## 12.4 Design of installations

For a reliable design of indoor installations and heater capacity, understanding of the expected water demand is crucial. Since SIMDEUM renders a realistic cold and hot water diurnal demand pattern of both residential and non-residential buildings, design rules for indoor installations are developed based on SIMDEUM. The new design-demand-equations lead to reliable and improved designs of building installations and water heater capacity, resulting in more hygienic and economical installations (Pieterse-Quirijns et al., 2010 and 2013; Blokker and Van der Schee, 2006).

They are published in the standard handbook for indoor plumbers in the Netherlands (ISSO, 2013).

## 12.5 Alternative concepts

Energy costs and climate change challenge the water industry to promote sustainability. Sustainability issues for a building's water system are saving of water, materials and energy in the supply of water to a building, reuse of wastewater and rainwater harvesting, heat and resources recovery from wastewater. These applications require insight in the cold and hot water demand of a building or in the characteristics of the drainage loads. SIMDEUM can provide this information.

In Pieterse-Quirijns et al. (2012) some examples for sustainability in water supply and drainage are illustrated. An example is the proper choice of storage capacities in grey water recycling and rainwater harvesting systems based on SIMDEUM. This supports minimising urban $CO_2$ footprint. In another example, SIMDEUM is used to study possibilities to recover energy and resources from wastewater.

In Hofman et al. (2014) and Bloemendal et al. (2014), the possibilities and opportunities for heat recovery from sewage are investigated.

# 13 References

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# Appendix I Format spg-file

The input datafile for the SPG contains information on both the users and the appliances in a fixed format, the so-called .spg-datafile. This appendix describes the required format of the .spg-file.

## Format of spg-file for SIMDEUM Pattern Generator for residential water demand

In the format for the spg-file the following typographical conventions are used:

- mandatory values are indicated between <>
- optional values are indicated between []

Header

| *rule* | *contains* | *comment* |
|---|---|---|
| 1 | SIMDEUM pattern generator input file | required identification string |
| 2 | version=<version number> | version number of definition import – the current document has version 1 |
| 3 | date=<date> | date of creating the inputfile, format yyyy-mm-dd |

Parameters and patterns

The header is followed by a parameter block, in which model parameters are set, or one or more pattern definition blocks, in which for example the water demand pattern of a washing machine during a wash cycle is specified.

A parameter block represents a sub-area of the entire area to simulate or (a part of) an area from a set of areas to simulate.
The definition of a parameter block is started as follows:
PARAMETERS[:block description]

A pattern definition block is started as follows:
PATTERN:< unique pattern name >[: description]

## Definition of input parameters

<parameter> : tag or value to be filled
(comment) : explanation, does not come in input file

household

household=DEFAULT

household size=DEFAULT
household size=<percentage one person households>,<percentage two person households>,<percentage more person households>
household size=<percentage one person households>,<percentage two person households>,<percentage more person households>,<average household size>

```
        household age oneperson=DEFAULT
        household age oneperson=<percentage adults>,<percentage seniors>
        household age twoperson=DEFAULT
        household age twoperson=<percentage adults>,<percentage seniors>
        household age family=DEFAULT
        household age family=<percentage childrend>,<percentage teenagers>,<percentage
                    adults>

        household sex oneperson=DEFAULT
        household sex oneperson=<percentage male>, <percentage female>
        household sex twoperson=DEFAULT
        household sex twoperson=<percentage m+f>, <percenage m+m>, <percentage f+f>
        household sex family=DEFAULT
        household sex family=<percentage male>, <percentage female>

        household work oneperson=DEFAULT
        household work oneperson=<percentage of males working>,<percentage of females
                    working>
        household work twoperson=DEFAULT
        household work twoperson=<percentage of households in which both male and female
                    work fulltime>, < percentage of households in which male works fulltime
                    and female not>, < percentage of households in which female works full
                    time and male not>, < percentage of households in which neither works full
                    time>  (full time is more than 20 hours per week)
        household work family=DEFAULT
        household work family=<percentage of households in which both male and female work
                    fulltime>, < percentage of households in which male works fulltime and
                    female not>, < percentage of households in which female works full time
                    and male not>, < percentage of households in which neither works full
                    time>


homepresence
        homepresence=DEFAULT
        homepresence <period>=DEFAULT
        homepresence <period> <group>=<up mu>, <up sigma>, <go mu>, <go sigma>, <away
                    mu>, <away sigma>, <sleep mu>, sleep<sigma>

        allowed period options: week, weekend
        allowed group options: child, teen, workad, homead, senior, total

shower
        shower=DEFAULT
        shower name=<name>
        shower penetration=<degree of penetration (percentage)>
        shower dailypattern=NONE / Pattern name
        shower offset=<minimum time between subsequent uses (minutes)>
        shower frequency <group>=<frequency for males (per day)>, <frequency for females (per
                    day)>, <frequency for all (per day)>
        shower <subtype> name=<name>
        shower <subtype> penetration=<degree of penetration (low/average/high)>
```

```
        shower <subtype> flow=<flow (l/s)>
        shower <subtype> temperature=<water temperature (ºC)>
        shower <subtype> duration <group>=<duration for males (minutes)>, <duration for
                    females (minutes)>, <duration for all (minutes)>

        allowed group options: child, teen, workad, homead, senior, total
        allowed subtypes: combiheater,combiheaterwithwatersavinghead

ktap
        ktap=DEFAULT
        ktap name=<name>
        ktap penetration=<degree of penetration (percentage)>
        ktap frequency <household size>=<mean frequency of use for this household size (per
                    day)>, <standard deviation of frequency of use for this household size (per
                    day)>
        ktap dailypattern=NONE / Pattern name
        ktap offset=<minimum time between subsequent uses (minutes)>
        ktap <usetype> name=<name>
        ktap <usetype> penetration=<degree of penetration (low/average/high)>
        ktap <usetype> duration=<duration of water use (s)>
        ktap <usetype> flow =<flow (l/s)>
        ktap <usetype> temperature=<water temperature (ºC)>

        allowed household size options: one, two, three, four, five_or_more
        allowed usetypes: consumption, dishes , washinghands , other


bath
        bath=DEFAULT
        bath name=<name>
        bath penetration <household size>=<degree of penetration for this household size
                    (percentage )>
        bath frequency <group>=<frequency of use (per day)>
        bath dailypattern=NONE / Pattern name
        bath offset=<minimum time between subsequent uses (minutes)>
        bath <subtype> name=<name>
        bath <subtype> penetration=<degree of penetration (low/average/high)>
        bath <subtype> duration=<duration of water use (minutes)>
        bath <subtype> flow =<flow (l/s)>
        bath <subtype> temperature=<water temperature (ºC)>

        allowed household size options: one, two, three, four, five_or_more
        allowed group options: child, teen, workad, homead, senior, total
        allowed subtypes: bath


brtap
        brtap=DEFAULT
        brtap name=<name>
        brtap penetration=<degree of penetration (low/average/high)>
        brtap frequency=<frequency of use (per day)>
        brtap dailypattern=NONE / Pattern name
```

```
        brtap offset=<minimum time between subsequent uses (minutes)>
        brtap <usetype> name=<name>
        brtap <usetype> penetration=<degree of penetration (low/average/high)>
        brtap <usetype> duration=<duration of water use (s)>
        brtap <usetype> flow =<flow (l/s)>
        brtap <usetype> temperature=<water temperature (ºC)>

        allowed usetypes: washingshaving,brushingteeth

washingmachine
        washingmachine=DEFAULT
        washingmachine name=<name>
        washingmachine penetration <household size>=<degree of penetration for this
                        household size (percentage)>
        washingmachine frequency <household size>=<frequency of use for this household size
                        (per day)>
        washingmachine dailypattern=NONE / Pattern name
        washingmachine offset=<minimum time between subsequent uses (minutes)>
        washingmachine <subtype> name=<name>
        washingmachine <subtype> penetration=<degree of penetration (low/average/high)>
        washingmachine <subtype> pattern=NONE / Pattern name
        washingmachine <subtype> temperature=<input water temperature (ºC)>

        allowed household size options: one, two, three, four, five_or_more
        allowed subtypes: wm

dishwasher
        dishwasher=DEFAULT
        dishwasher name=<name>
        dishwasher penetration <household size>=<degree of penetration for this household size
                        (percentage)>
        dishwasher frequency <household size>=<frequency of use for this household size (per
                        day)>
        dishwasher dailypattern=NONE / Pattern name
        dishwasher offset=<minimum time between subsequent uses (minutes)>
        dishwasher <subtype> name=<name>
        dishwasher <subtype> penetration=<degree of penetration (low/average/high)>
        dishwasher <subtype> pattern=NONE / Pattern name
        dishwasher <subtype> temperature=<input water temperature (ºC)>

        allowed household size options: one, two, three, four, five_or_more
        allowed subtypes: dw

wc
        wc=DEFAULT
        wc name=<name>
        wc penetration=<degree of penetration  (percentage )>
        wc frequency <group>=<male frequency of use (per day)>, <female frequency of use (per
                        day)>, <total frequency of use (per day)>
        wc dailypattern=NONE / Pattern name
        wc offset=<minimum time between subsequent uses (minutes)>
        wc <subtype> name=<name>
```

wc <subtype> penetration=<degree of penetration (low/medium/high)>

wc <subtype> duration=<duration of water use (minutes)>

wc <subtype> flow=<flow (l/s)>

wc <subtype> temperature=<water temperature (°C)>

wc <subtype> flushinterruption=<fraction of cases in which only half of the flushing volume is used>

allowed group options: child, teen, workad, homead, senior, total

ostap

ostap=DEFAULT

ostap name=<name>

ostap penetration=<degree of penetration (fraction)>

ostap frequency=<frequency of use (per day)>

ostap dailypattern=NONE / Pattern name

ostap offset=<minimum time between subsequent uses (minutes)>

ostap <usetype> name=<name>

ostap <usetype> penetration=<degree of penetration (low/medium/high)>

ostap <usetype> duration=<duration of water use (s)>

ostap <usetype> flow=<flow (l/s)>

ostap <usetype> temperature=<water temperature (°C)>

allowed usetype options: garden, other

Patroondefinitie

PATTERN:<name>[:description]

**<time 1>, <time 2>, ..., <time n>**

**<value 1>, <value 2>, ..., <value n>**

# Appendix II spg-file for demo_house_manual_week.stats

This appendix shows the spg-file, that belongs to the demo_house_manual_week.stats: demo_house_manual.spg. The patterns at the end of the spg-file are not included in the manual, because they take many pages to complete. They can be found in the demo spg-file: demo_house_manual.spg.

```
SIMDEUM pattern generator input file
version=1
date=2014-04-25


PARAMETERS:demo_house.stats


household size=34.0,30.0,36.0,2.3
household age oneperson=70.0,30.0
household sex oneperson=46.0,54.0
household work oneperson=67.5,52.4
household age twoperson=70.0,30.0
household sex twoperson=95.0,2.5,2.5
household work twoperson=49.4,26.0,6.3,18.3
household age family=25.0,16.5,58.5
household sex family=50.0,50.0
household work family=39.4,52.3,3.1,5.2


homepresence week child=7:00,1:00,8:30,0:30,7:00,2:00,10:00,1:00
homepresence week teen=7:00,1:00,8:15,0:30,8:00,2:00,9:00,1:00
homepresence week workad=7:00,1:00,8:00,0:45,9:30,3:15,7:00,1:00
homepresence week homead=8:00,1:00,13:00,3:00,10:00,4:30,8:00,1:00
homepresence week senior=8:00,1:00,13:00,3:00,10:00,4:30,8:00,1:00
homepresence week total=7:00,1:00,8:00,1:00,8:30,1:00,8:00,1:00


homepresence weekend child=7:00,1:00,8:00,1:00,8:30,1:00,8:00,1:00
homepresence weekend teen=7:00,1:00,8:00,1:00,8:30,1:00,8:00,1:00
homepresence weekend workad=7:00,1:00,8:00,1:00,8:30,1:00,8:00,1:00
homepresence weekend homead=7:00,1:00,8:00,1:00,8:30,1:00,8:00,1:00
homepresence weekend senior=7:00,1:00,8:00,1:00,8:30,1:00,8:00,1:00
homepresence weekend total=7:00,1:00,8:00,1:00,8:30,1:00,8:00,1:00


% shower
shower name=shower
shower penetration=100.0
```

```
shower frequency child=0.480,0.480,0.480
shower frequency teen=0.670,0.670,0.670
shower frequency homead=0.790,0.790,0.790
shower frequency workad=0.790,0.790,0.790
shower frequency senior=0.540,0.540,0.540
shower frequency total=0.700,0.700,0.700
shower offset=120.0
shower dailypattern=pat_shower


shower Kitchen_geyser name=Kitchen_geyser
shower Kitchen_geyser penetration=low
shower Kitchen_geyser duration child=8.5,8.5,8.5
shower Kitchen_geyser duration teen=11.1,11.1,11.1
shower Kitchen_geyser duration homead=8.0,8.0,8.0
shower Kitchen_geyser duration workad=8.0,8.0,8.0
shower Kitchen_geyser duration senior=7.3,7.3,7.3
shower Kitchen_geyser duration total=8.5,8.5,8.5
shower Kitchen_geyser flow=0.102
shower Kitchen_geyser temperature=38.0


shower Kitchen_geyser_with_water_saving_shower_head
name=Kitchen_geyser_with_water_saving_shower_head
shower Kitchen_geyser_with_water_saving_shower_head penetration=low
shower Kitchen_geyser_with_water_saving_shower_head duration child=8.5,8.5,8.5
shower Kitchen_geyser_with_water_saving_shower_head duration teen=11.1,11.1,11.1
shower Kitchen_geyser_with_water_saving_shower_head duration homead=8.0,8.0,8.0
shower Kitchen_geyser_with_water_saving_shower_head duration workad=8.0,8.0,8.0
shower Kitchen_geyser_with_water_saving_shower_head duration senior=7.3,7.3,7.3
shower Kitchen_geyser_with_water_saving_shower_head duration total=8.5,8.5,8.5
shower Kitchen_geyser_with_water_saving_shower_head flow=0.097
shower Kitchen_geyser_with_water_saving_shower_head temperature=38.0


shower Bath_geyser name=Bath_geyser
shower Bath_geyser penetration=low
shower Bath_geyser duration child=8.5,8.5,8.5
shower Bath_geyser duration teen=11.1,11.1,11.1
shower Bath_geyser duration homead=8.0,8.0,8.0
shower Bath_geyser duration workad=8.0,8.0,8.0
shower Bath_geyser duration senior=7.3,7.3,7.3
shower Bath_geyser duration total=8.5,8.5,8.5
shower Bath_geyser flow=0.147
shower Bath_geyser temperature=38.0


shower Bath_geyser_with_water_saving_shower_head
name=Bath_geyser_with_water_saving_shower_head
shower Bath_geyser_with_water_saving_shower_head penetration=low
shower Bath_geyser_with_water_saving_shower_head duration child=8.5,8.5,8.5
shower Bath_geyser_with_water_saving_shower_head duration teen=11.1,11.1,11.1
```

```
shower Bath_geyser_with_water_saving_shower_head duration homead=8.0,8.0,8.0
shower Bath_geyser_with_water_saving_shower_head duration workad=8.0,8.0,8.0
shower Bath_geyser_with_water_saving_shower_head duration senior=7.3,7.3,7.3
shower Bath_geyser_with_water_saving_shower_head duration total=8.5,8.5,8.5
shower Bath_geyser_with_water_saving_shower_head flow=0.135
shower Bath_geyser_with_water_saving_shower_head temperature=38.0


shower Mini_boiler name=Mini_boiler
shower Mini_boiler penetration=low
shower Mini_boiler duration child=8.5,8.5,8.5
shower Mini_boiler duration teen=11.1,11.1,11.1
shower Mini_boiler duration homead=8.0,8.0,8.0
shower Mini_boiler duration workad=8.0,8.0,8.0
shower Mini_boiler duration senior=7.3,7.3,7.3
shower Mini_boiler duration total=8.5,8.5,8.5
shower Mini_boiler flow=0.138
shower Mini_boiler temperature=38.0


shower Mini_boiler_with_water_saving_shower_head
name=Mini_boiler_with_water_saving_shower_head
shower Mini_boiler_with_water_saving_shower_head penetration=low
shower Mini_boiler_with_water_saving_shower_head duration child=8.5,8.5,8.5
shower Mini_boiler_with_water_saving_shower_head duration teen=11.1,11.1,11.1
shower Mini_boiler_with_water_saving_shower_head duration homead=8.0,8.0,8.0
shower Mini_boiler_with_water_saving_shower_head duration workad=8.0,8.0,8.0
shower Mini_boiler_with_water_saving_shower_head duration senior=7.3,7.3,7.3
shower Mini_boiler_with_water_saving_shower_head duration total=8.5,8.5,8.5
shower Mini_boiler_with_water_saving_shower_head flow=0.130
shower Mini_boiler_with_water_saving_shower_head temperature=38.0


shower Combi_heater name=Combi_heater
shower Combi_heater penetration=high
shower Combi_heater duration child=8.5,8.5,8.5
shower Combi_heater duration teen=11.1,11.1,11.1
shower Combi_heater duration homead=8.0,8.0,8.0
shower Combi_heater duration workad=8.0,8.0,8.0
shower Combi_heater duration senior=7.3,7.3,7.3
shower Combi_heater duration total=8.5,8.5,8.5
shower Combi_heater flow=0.142
shower Combi_heater temperature=38.0


shower Combi_heater_with_water_saving_shower_head
name=Combi_heater_with_water_saving_shower_head
shower Combi_heater_with_water_saving_shower_head penetration=high
shower Combi_heater_with_water_saving_shower_head duration child=8.5,8.5,8.5
shower Combi_heater_with_water_saving_shower_head duration teen=11.1,11.1,11.1
shower Combi_heater_with_water_saving_shower_head duration homead=8.0,8.0,8.0
shower Combi_heater_with_water_saving_shower_head duration workad=8.0,8.0,8.0
```

```
shower Combi_heater_with_water_saving_shower_head duration senior=7.3,7.3,7.3
shower Combi_heater_with_water_saving_shower_head duration total=8.5,8.5,8.5
shower Combi_heater_with_water_saving_shower_head flow=0.123
shower Combi_heater_with_water_saving_shower_head temperature=38.0


% ktap
ktap name=kitchen_tap
ktap penetration=100.0
ktap frequency one=10.100, 7.000
ktap frequency two=12.700, 7.200
ktap frequency three=12.800, 7.700
ktap frequency four=13.100, 8.400
ktap frequency five_or_more=13.500, 9.100
ktap offset=0.0
ktap dailypattern=pat_ktap


ktap consumption name=consumption
ktap consumption penetration=high
ktap consumption duration=15.0
ktap consumption flow=0.167
ktap consumption temperature=10.0


ktap dishes name=dishes
ktap dishes penetration=average
ktap dishes duration=45.0
ktap dishes flow=0.250
ktap dishes temperature=55.0


ktap washing_hands name=washing_hands
ktap washing_hands penetration=average
ktap washing_hands duration=13.0
ktap washing_hands flow=0.167
ktap washing_hands temperature=10.0


ktap other name=other
ktap other penetration=low
ktap other duration=48.0
ktap other flow=0.167
ktap other temperature=10.0


% bath
bath name=bath
bath penetration one=28.0
bath penetration two=45.0
bath penetration three=53.0
bath penetration four=54.0
```

```
bath penetration five_or_more=63.0
bath frequency child=0.086,0.086,0.086
bath frequency teen=0.051,0.051,0.051
bath frequency homead=0.044,0.044,0.044
bath frequency workad=0.044,0.044,0.044
bath frequency senior=0.040,0.040,0.040
bath frequency total=0.064,0.064,0.064
bath offset=0.0
bath dailypattern=NONE


bath bath name=bath
bath bath penetration=average
bath bath duration=10.0
bath bath flow=0.200
bath bath temperature=40.0


% brtap
brtap name=bathroom_tap
brtap penetration=100.0
brtap frequency=4.100
brtap offset=0.0
brtap dailypattern=NONE


brtap washing_shaving name=washing_shaving
brtap washing_shaving penetration=low
brtap washing_shaving duration=40.0
brtap washing_shaving flow=0.083
brtap washing_shaving temperature=38.0


brtap brushing_teeth name=brushing_teeth
brtap brushing_teeth penetration=average
brtap brushing_teeth duration=15.0
brtap brushing_teeth flow=0.083
brtap brushing_teeth temperature=10.0


% washingmachine
washingmachine name=wm
washingmachine penetration one=92.0
washingmachine penetration two=98.0
washingmachine penetration three=98.0
washingmachine penetration four=98.0
washingmachine penetration five_or_more=98.0
washingmachine frequency one=0.320
washingmachine frequency two=0.290
washingmachine frequency three=0.290
washingmachine frequency four=0.270
washingmachine frequency five_or_more=0.290
```

```
washingmachine offset=0.0
washingmachine dailypattern=pat_washingmachine


washingmachine wm name=wm
washingmachine wm penetration=average
washingmachine wm pattern=washing machine pattern
washingmachine wm temperature=10.0



% dishwasher
dishwasher name=dw
dishwasher penetration one=24.0
dishwasher penetration two=41.0
dishwasher penetration three=53.0
dishwasher penetration four=60.0
dishwasher penetration five_or_more=75.0
dishwasher frequency one=0.310
dishwasher frequency two=0.280
dishwasher frequency three=0.230
dishwasher frequency four=0.220
dishwasher frequency five_or_more=0.190
dishwasher offset=0.0
dishwasher dailypattern=pat_dishwasher


dishwasher dw name=dw
dishwasher dw penetration=average
dishwasher dw pattern=dishwasher pattern
dishwasher dw temperature=10.0


% wc
wc name=wc1
wc penetration=100.0
wc frequency child=3.800,5.400,4.600
wc frequency teen=4.100,5.100,4.700
wc frequency homead=7.000,7.000,7.000
wc frequency workad=5.300,6.800,6.000
wc frequency senior=7.400,6.800,7.200
wc frequency total=5.3,6.4,5.983
wc offset=0.0
wc dailypattern=NONE


wc wcHigh name=wcHigh
wc wcHigh penetration=low
wc wcHigh duration=3.6
wc wcHigh flow=0.042
wc wcHigh temperature=10.0
wc wcHigh flushinterruption=0
```

```
wc wcNormalPlus name=wcNormalPlus
wc wcNormalPlus penetration=average
wc wcNormalPlus duration=3.6
wc wcNormalPlus flow=0.042
wc wcNormalPlus temperature=10.0
wc wcNormalPlus flushinterruption=0.8

wc wcNormal name=wcNormal
wc wcNormal penetration=average
wc wcNormal duration=3.6
wc wcNormal flow=0.042
wc wcNormal temperature=10.0
wc wcNormal flushinterruption=0

wc wcSavePlus name=wcSavePlus
wc wcSavePlus penetration=high
wc wcSavePlus duration=2.4
wc wcSavePlus flow=0.042
wc wcSavePlus temperature=10.0
wc wcSavePlus flushinterruption=0.8

wc wcSave name=wcSave
wc wcSave penetration=low
wc wcSave duration=2.4
wc wcSave flow=0.042
wc wcSave temperature=10.0
wc wcSave flushinterruption=0


wc name=wc2
wc penetration=50.0
wc frequency child=3.800,5.400,4.600
wc frequency teen=4.100,5.100,4.700
wc frequency homead=7.000,7.000,7.000
wc frequency workad=5.300,6.800,6.000
wc frequency senior=7.400,6.800,7.200
wc frequency total=5.3,6.4,5.983
wc offset=0.0
wc dailypattern=NONE


wc wcNormalPlus name=wcNormalPlus
wc wcNormalPlus penetration=average
wc wcNormalPlus duration=3.6
wc wcNormalPlus flow=0.042
wc wcNormalPlus temperature=10.0
wc wcNormalPlus flushinterruption=0.8

wc wcNormal name=wcNormal
wc wcNormal penetration=average
wc wcNormal duration=3.6
```

```
wc wcNormal flow=0.042
wc wcNormal temperature=10.0
wc wcNormal flushinterruption=0

wc wcSavePlus name=wcSavePlus
wc wcSavePlus penetration=high
wc wcSavePlus duration=2.4
wc wcSavePlus flow=0.042
wc wcSavePlus temperature=10.0
wc wcSavePlus flushinterruption=0.8

wc wcSave name=wcSave
wc wcSave penetration=low
wc wcSave duration=2.4
wc wcSave flow=0.042
wc wcSave temperature=10.0
wc wcSave flushinterruption=0


% ostap
ostap name=outside_tap
ostap penetration=58.0
ostap frequency=0.440
ostap offset=0.0
ostap dailypattern=NONE


ostap garden name=garden
ostap garden penetration=high
ostap garden duration=600.0
ostap garden flow=0.200
ostap garden temperature=10.0


ostap other name=other
ostap other penetration=low
ostap other duration=300.0
ostap other flow=0.200
ostap other temperature=10.0


PATTERN:pat_shower:daily_pattern shower (see demo_house_manual.spg)

PATTERN:pat_ktap:daily_pattern ktap (see demo_house_manual.spg)

PATTERN:pat_washingmachine:daily_pattern washingmachine (see demo_house_manual.spg)

PATTERN:washing machine pattern:washingmachine pattern (see demo_house_manual.spg)

PATTERN:pat_dishwasher:daily_pattern dishwasher (see demo_house_manual.spg)

PATTERN:dishwasher pattern:dishwasher pattern (see demo_house_manual.spg)
```