Deliverable D5.1

GREEN DATA CENTRE LIBRARY.

User guide

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Data Centre

Data Centre APC tool

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Schneider

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Transient simulation software

Trnsys17

Type

Studio

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Wave Power Plant

Weather file

Wire

LIST OF ABBREVIATIONS

Abbreviations

CPU	Computer Processing Unit
GCDC	Green Cooling for Data Centre
GE	Generator
IREC	Institut de Recerca en Energia de Catalunya
IT	Information Technology
LGT	Lighting
MISC	Miscellanea
PDU	Power Distribution Unit
PSU	Power Supply Unit
SWG	Switch Gear
TR	Transformer
TRNSYS	Transient Simulation Software
TUC	Technische Universität Chemnitz
UPS	Uninterruptible Power Supply
WVP	Wave Power Plant

1 PURPOSE AND STRUCTURE OF THE DOCUMENT

The document is prepared with the aim of understanding, at a basic level:

- Which modelling tools have been used to model the Data Centre scenarios and why.
- The new features of the modelling tools that have been developed in this project.
- How these new features have been packaged to be installed as libraries and be ready for using them in other projects.

This document briefly introduces the Green Data Centre Library document, which deeply explains all tools developed in this project. Moreover, a file library compatible with TRNSYS will embody all the new tools. This file library will be included as a prototype of an executable file that could be added to existing user's libraries.

2 MODELLING TOOL: TRNSYS17

2.1 GENERAL INTRODUCTION TO TRNSYS17

The main software used to develop the energy models in RenewIT is TRNSYS17. TRNSYS17 has been chosen because is a transient simulation software that allows the user to model any imaginable energy system, like a building, a HVAC system, a pool, or a whole Data Centre.

TRNSYS 17

Figure 2.1 TRNSYS 17 logo

The main value of TRNSYS17 is that it uses a calculation engine that allows the simulation of the energy system along a determined time (usually a year). Using a synthetic weather file it is possible to model a system whose performance is variable along the time steps in which the simulation have been divided. It means that the previous conditions of the system are taken into account in every time step. It allows a more realistic approach than static calculations.

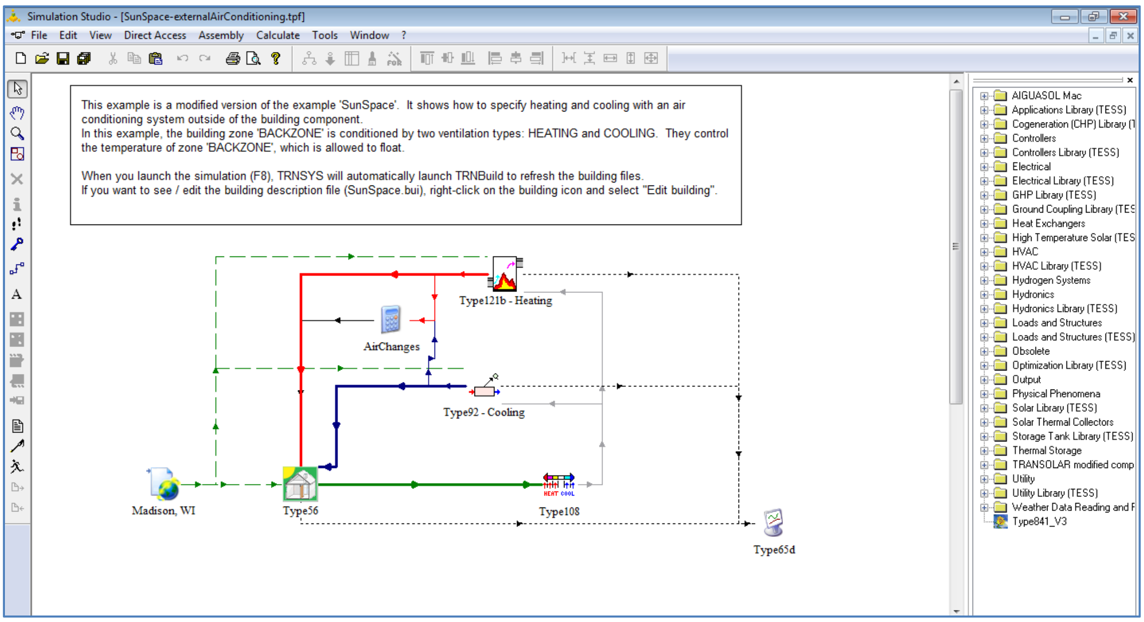

Figure 2.2 TRNSYS 17 Studio

RenewIT

Another important reason for using TRNSYS17 is that it works by modules interconnections. As it can be seen in the picture above, TRNSYS17 connects different components, known as types, that reproduce a physical phenomenon in its inside. Types are interconnected via inputs and outputs that can be also modified by the user.

However, one of the main reason for using TRNSYS17 in the Data Centre models development is the possibility to create new types if these do not exist in the provided library. Anyone, with the needed knowledge, can write the mathematical description of the physical phenomena and convert it into a type that can be used in a greater model.

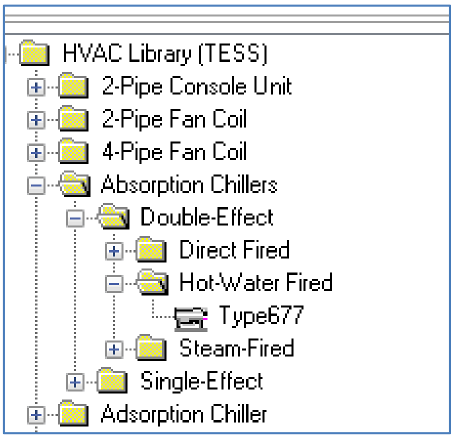

Figure 2.3 TRNSYS 17-Existing Library

The figure above shows a part of the existing library of TRNSYS17. In this particular case, Type 677 models an absorption chiller of double effect fired with hot water.

Types can be grouped also by “Macros” in order to simplify the Studio plan, as it is done also with mechanical drawings.

2.2 Brief introduction to types

Types are described as a group of equations , which represents the physical phenomena of the related energy system.

Types consist of:

- Icon
- Proforma
- Source Code
- Mathematical description

In the view of illustrating these structures, Type 700 is shown.

Icon

Types are represented in TRNSYS17 as icons that can be moved from the library and placed into the Studio, or in other words, included into the energy system. In this case, Type 700 is a boiler that uses the efficiency ratio as an input.

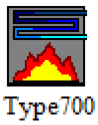

Figure 2.4 Type 700 Icon

Proforma

the proforma opens Whenever the user double clicks on any type,. The proforma is the interface of the type that allows the user to set parameters and inputs.

Parameters are values that define the type and they are constant.

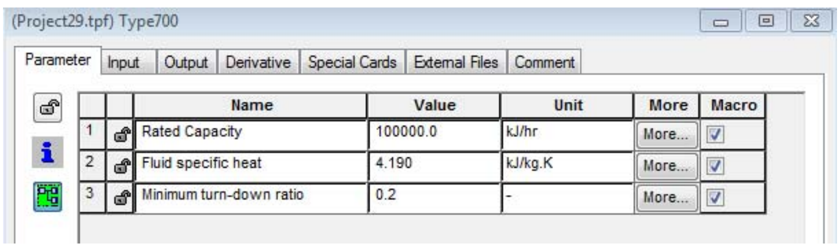

Figure 2.5 Type 700 Parameters in the proforma

Inputs are values not necessary constant. Actually, it is possible to link the inputs to other types or data in order to acquire new value at each time step.

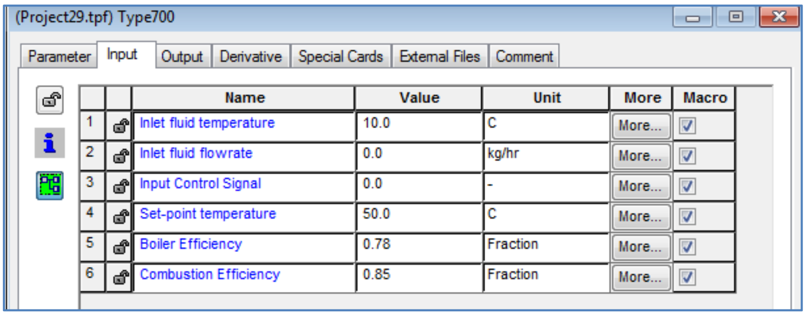

Figure 2.6 Type 700 Inputs in the proforma

Set of equations inside types provides output at every time step.

Source Code

The source code comprises all the equations related to the types.

Mathematical description

At every type corresponds a mathematical description. This document helps the user to understand the type behaviour and its description in the source code). Usually, a mathematical description refers to all the equations and it explains the links between inputs and outputs.. The mathematical description of the new developed types has been included in a specific Manual for the RENEWIT project: *Green Data Centre Library*.

3 Overview of Green Data Centre library

TRNSYS17 library is not wide enough to cover all the needed types for the different Data Centre scenarios. Innovations in the concept of an energy source for Data Centre have made that many types are not commercially available and needed to be developed from scratch.

The new developed type can be classified in:

- Electrical Components: these types refer to Data Centre electrical equipment and to electrical devices used in the energy production and management to supply the Data Centre
- IT Loads: this type is used mainly to manage the loads from the Information Technology equipment.
- Electrical generation: a wave energy converter is used to calculate the power generated by the ocean waves.

For each type, all the subcomponents of the type, as icons, proforma, source code and mathematical description have been developed.

The family of electrical components types has been divided into 2 big groups with slight differences. Mainly, the purpose of the types is the same, but different approaches have been considered.

3.1 IT Loads

3.1.1 IT Loads Type4000

IT load is a model for the IT equipment that embodies mainly servers, storage and network. This type transforms an IT load curve into a power consumption curve, by considering the effects of non-linear power-consumption increasing power consumption at higher temperatures and Green Algorithms.

3.2 Electrical Components

As it was mentioned above, electrical components have been developed into two big groups:

Electrical Components whose performances are based on quadratic dependence on load factor

These types use experimental coefficients from Schneider manufacturer. The co-efficients and the equations used are identical to the ones utilized by Schneider in Data Center APC tool.

Electrical Components whose performances are based on manufacturers properties

These types use also experimental coefficients but these are not specifically from Schneider but from any manufacturer. The purpose of these types is to be able to set loss coefficients in the types equations through the related manufacturer da-tabase .

As it can be noted, inside the electrical components family some types have been developed in both options (APC tool database or manufacturer's database) and this enables the user to choose the option that fits better their purpose. In the follow-ing chapters, electrical components types will be grouped for families but peculi-arities will be specified for each type:

- Uninterruptible Power Supply Unit (UPS)
- Losses UPS

    Type 4001 based on load factor dependence

    Type 4011 based on manufacturer properties
- Detailed UPS

    Type 4015
- Power Distribution Unit (PDU)

    Type 4002 based on load factor dependence
- Wire

    Type 4003 based on load factor dependence

    Type 4010 based on manufacturer properties
- Switchgear unit (SWG)

Type 4004 based on load factor dependence

Type 4009 based on manufacturer properties

- Standby losses of a Generator (GE)

Type 4005 based on reference power

- Lighting consumption (LGT)

Type 4006 based on reference power

Type 4013 based on area

- Miscellaneous consumption (MISC)

Type 4007 based on reference power

- Transformer (TR)

Type 4008 based on manufacturer properties

- Power Supply Unit (PSU)

Type 4012 based on manufacturer properties

3.2.1 Uninterruptible Power Supply Unit. Type 4001, Type 4011 & Type 4015.

Uninterruptible Power Supply is a combination of power converters, switches and energy storage media, e.g. batteries. Such a power supply system guarantees ongoing supply to the load also in case of a supply voltage failure. At the same time, voltage and frequency do not exceed static and dynamic limits defined for the load. The international product standard IEC 62040-3 puts UPS into classes 1, 2 or 3 depending on these limits.

An uninterruptible power supply units (UPS) is a combination of power converters, switches and energy storage media, e.g. batteries that allows the building to continue operation even in the presence of temporary loss-of-power instances. It requires that the distribution architecture contain additional conversion stages to convert from the input AC-DC at the batteries, back to AC at traditional levels for local distribution. At the same time, UPS must ensure that the voltage and frequency remain within the static and dynamic limits defined for the load. The international product standard IEC 62040-3 classifies UPS into classes 1, 2 or 3 depending on the load limits.

Several types have been developed with different levels of complexity:

- Type 4001 describes the losses performance of a UPS based on load factor dependence.

- Type 4011 describes the losses performance of a UPS based on manufacturer properties.
- Type 4015 describes from a higher level of detail the performance of a UPS unit that works with two battery models: Lead-Acid and Li-Ion. This type is based on Tremblay, O. et al [2] work, where the same assumptions and model limitations have been made. In order to adapt the Tremblay models to an UPS model, a couple of functions and internal controllers are added. These functions and controllers introduce the behaviour of converters inside the UPS, such as generation of losses or current limitations.

3.2.2 Power distribution unit. Type 4002.

The Power Distribution Unit is a device fitted with multiple outputs designed to distribute electric power. This unit includes main breakers, individual breakers and power monitoring panels to show and ensure the proper energy distribution to each of the electrical devices connected to the PDU.

3.2.3 Wire. Type 4003 & Type 4010.

Wires carry electrical currents from the power source to the load consumption, such as lighting or electrical machines. The losses of wires depend on the operating current, the size and the length of them. A Data Centre hosts hundreds or even thousands of different wires, and the losses of each wire must be added to compute the total loss. A common design value for wire losses is 1% of the load power at full load.

Type 4003 describes the performance of a wire based on load factor dependence and Type 4010 it's based on manufacturer properties.

3.2.4 Switchgear Unit. Type 4004 & Type 4009.

Switchgear is used to control protect and isolate electrical equipment by connecting and disconnecting it from the electrical source in case of power failures or inappropriate electrical power supply conditions. Therefore, these kinds of units are directly linked to the reliability of the electricity supply.

Type 4004 describes the performance of switchgear based on load factor dependence and Type 4009 it is based on manufacturer properties.

3.2.5 Generator. Type 4005.

Generator is a device that converts mechanical energy to electrical energy. Depending on the size and the final use of generator, this device can be used as primary energy source or as backup energy source in case of failure. Usually these devices spend most of their operational time in a standby mode, while they wait to start to supply power and generate power losses.

3.2.6 Lighting. Type 4006 & Type 4013.

Lighting is the deliberate use of light to achieve a practical or aesthetic effect. Numerous lighting devices are available nowadays in the market, where the trend is to ensure high lighting conditions at the minimum energy consumption. Proper lighting is beneficial, indeed it , improves appearance of an area, it has positive psychological effects on occupants.

Type 4006 describes the power consumption of lights based on a reference power and Type 4013 it's based on a the area to be illuminated.

3.2.7 Miscellaneous. Type 4007.

Type 4007 is an empirical model that considers auxiliary or miscellaneous electrical consumptions. The model uses a mathematical equation based on empirical coefficients in order to describe electrical consumption of auxiliary devices such as emergency lights or small fans and pumps. It is worth notice that these devices have small impact in the total electrical consumption of a Data Centre.

3.2.8 Transformer. Type 4008.

A transformer is an electrical device that transfers energy between two or more circuits through electromagnetic induction. A wide range of transformer designs has been developed for electronic and electric power applications.

Type 4008 is a mathematical model for a transformer unit. The model uses a mathematical equation based on empirical coefficients in order to describe the operational losses of a TR system.

3.2.9 Power supply unit. Type 4012.

Power supply unit is a device in charge of properly supply power to servers by correcting voltage disturbances and avoiding overloaded current capacities. Moreover, the power supply can provide continuously energy and this actuates and prevents power shutdowns.

3.3 Wave energy converter (WEC). Type4014

Type 4014 is a simplified model for analyse the potential wave energy in a certain location. The wave energy is approximated by the main wave height and period by the formula developed by D. Vicinanza et al. Moreover, the type approximates power generation based on capture length value of the WEC (Wave Energy Converter) system. The WEC systems available are: Wave Dragon, AquabuOY and Pelamis.

4 Examples of developed types

For a fully comprehension of the developed types, some examples have been provided. It is possible to take a look on to the examples to see how the types are connected. The provided examples are located in the "*Examples*" folder of Trnsys and are listed below:

1. Detailed UPS
2. Electrical Components
3. IT Power
4. Wave Energy Converter

As it can be seen on the figure, example is detailed with a brief explanation and works independently to allow the users to check the different functionalities of the types.

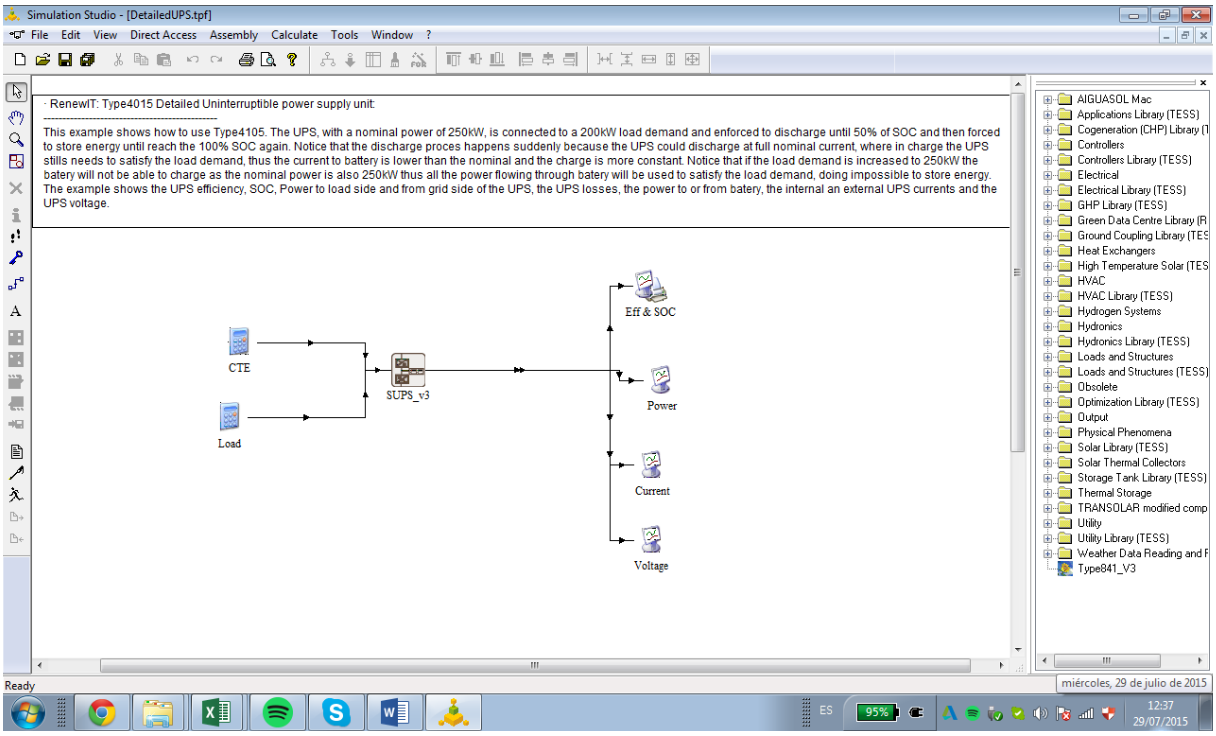

Figure 4.1 Example of detailed UPS

5 INSTALLATION OF GREEN DATA CENTRE LIBRARY

The Green Data Centre Library will be prepared for an easy installation in the TRNSYS directories. Consequently, all TRNSYS users are able to use the developed types in the RENEWIT for their own purposes. A brief description of the installation procedure is shown below:

- Download the setup file from *http://www.renewit-project.eu/green-data-centre-library/*
- Open the setup file and follow the instructions
- Users can also refer to the Green Data Centre Manual, once installed the setup file or downloading it separately. The manual embodies all the mathematical description of each type in the view of fully understanding the corresponding physical phenomena.

6 REFERENCES

D. Vicinanza, P. Contestiable and V. Ferrante, “Wave energy potential in the north-west of Sardinia”, Renewable Energy (ELSEVIER),vol. 50, pp. 506-521, 2013.