The EnRiMa Project

The aim of the project Energy Efficiency and Risk Management in Public Buildings (EnRiMa) is to develop a Decision-Support System (DSS) to enable operators to control energy flows in energy-efficient buildings and areas of public use.

The project consists of nine partners of a consortium of: Stockholm University, University College London, International Institute for Applied Systems Analysis, Universidad Rey Juan Carlos, Center for Energy and Innovative Technologies, Minerva Consulting & Communication, SINTEF Group, Tecnalia Research and Innovation, EDP HC Energía.

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Sustainable Energy Europe

EnRiMa
Energy Efficiency and Risk Management in Public Buildings

EnRiMa DSS Quick Start Guide

www.enrima-project.eu

The EnRiMa DSS

The EnRiMa Decision Support Systems (DSS) allows you to lower the energy use of a building by making the best use of the installed building equipment. The system also supports you when making long-term decisions, such as making investments in new building equipment and selecting between energy tariffs. To provide decision support, the EnRiMa DSS makes use of state-of-the-art optimisation software. The EnRiMa DSS can be used via a standard web browser, it is sufficient to use the link provided by the EnRiMa team to log into the system. Once you have logged in, the EnRiMa main window is displayed.

The two Decision Models in EnRiMa

The **Operational Model** optimises the usage of on-site and purchased energy without the installation of any new technologies. The inputs to the model are the properties of the building and installed equipment, as well as desired indoor temperature ranges. The result is optimal indoor temperature set-points as well as information about when to use which of the installed technologies in which amount. The model provides decision support for the upcoming 24 hours.

The **Strategic Model** optimises the long-term energy fulfilment through the use of new technologies. The inputs to the model are the properties of the installed technologies as well as those of future considered technologies. Furthermore the model makes use of estimations of energy price developments. The result is investment advice, in the form of which technologies to buy and when to buy them. The model provides decision support for the forthcoming 15 years.

EnRiMa main window

Figure 1: The top of the main EnRiMa screen shows the selected building and decision model

In the upper part of the EnRiMa main window, the following key elements are found:

1) The currently selected building. Press “Change” to switch to another building.

2) The currently selected optimisation model. Two decision-making models are supported by the EnRiMa DSS, an operational and a strategic model. The selected model can be changed by pressing the “Change” button, located next to the model name.

3) The currently selected data set. The EnRiMa DSS allows you to manage several data sets per building, each data set contains a complete building configuration. Changing data sets allows you to switch between different building configurations. Press “Change…” to manage the available data sets.

4) The tabs used to navigate through the system screens. The screens that are displayed under each tab are dependent on the model that is selected.

General working procedure

In the following, the basic steps for operating the EnRiMa DSS are explained.

1) Set building and environment properties, such as the current installed technologies and the current and estimated future electricity price.

2) Start the decision model optimisation, set the goal to be either the minimum emissions or the minimum cost.

3) Review the results. The results for each optimisation run are shown as a set of graphs. The values set during Step 1 are stored for later use. This makes it easy for you to modify the values and re-run the optimisation (Step 2)

Working with the Operational Decision Model

The Operational Decision Model determines the optimal operation of the building's existing technologies for the forthcoming day. To do this, the operational model requires information about the desired indoor temperature ranges, weather forecasts for the next day, and short-term energy prices and carbon emissions.

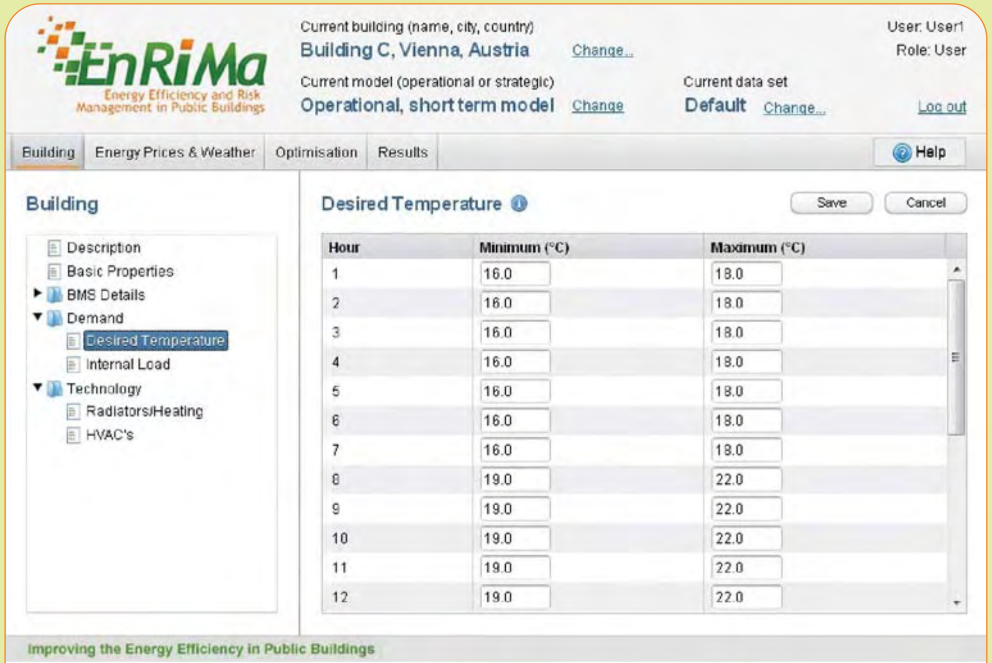

Figure 2 : Setting the desired temperature range in the operational model

Operational Decision Model - working procedure

1) Set the building properties

► *Building properties:* This includes setting values for the building insulation, the building volume and so on.

► *Demand:* the heating, ventilation and cooling demand is dictated by the desired indoor temperature ranges. Furthermore, the internal load of the building is set in the form of its electricity consumption.

► *Weather and energy prices:* Energy prices and weather information (such as solar irradiation and temperatures) are set for the forthcoming 24 hours.

2) Start the optimisation. Based on the provided input, the operational decision module will calculate the overall heating, ventilation and cooling requirements for the next day. The calculations may take several minutes.

3) Review the results. The results can be viewed as a series of graphs presenting the hourly indoor temperature and energy consumption.

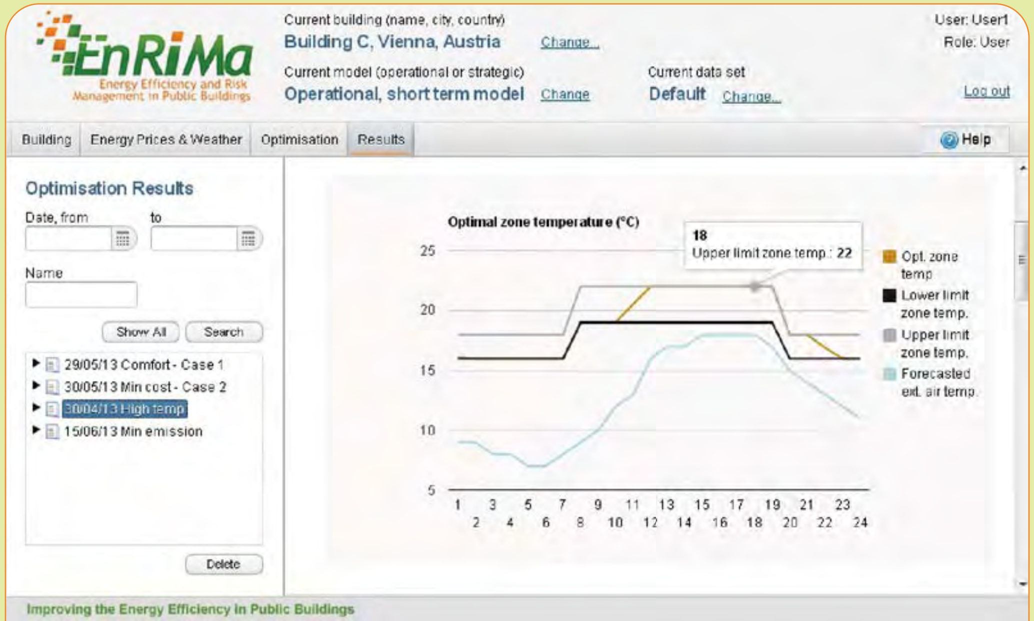

Figure 3 : Example output from the operational decision model

Making use of the Operational Decision Model result

The main output from the operational model is the indoor temperature set-points (see Figure 3). The set-points are calculated by the DSS so that using them will result in minimal energy consumption for the building. To make use of the set-points they need to be transferred to the BEMS, either manually or automatically via an integration with the BEMS. Currently, the DSS uses the following fully automatic procedure for feeding the set-points into the BEMS:
Every evening the DSS fetches a weather forecast for the next day.
An optimisation is started, taking as input the fetched weather forecast, and the building properties as configured by the user. The result is made available for download.

The BEMS fetches the calculated set-points via the DSS web-service API and controls the building technologies such that the set points are reached.
Given that the BEMS is integrated with the DSS, the above procedure is executed automatically every day. If the BEMS is not integrated then the set-points can be transferred manually. This can be done every day, or for example on a bi-weekly basis.

Working with the Strategic Decision Model

The Strategic Decision Model (SDM) suggests a strategy for the investment in technologies or the decommissioning of existing ones, given a set of input parameters that describe these technologies and the tariffs used to buy and sell energy. The DSS generates a number of scenarios, each describing a possible future development of the parameters. The DSS then determines the best strategic decisions for today, considering the future possible scenarios. In addition, the future building performance and investments for each possible scenario is calculated. In order to perform the calculations, the DSS needs to be configured with numerical values that depict how parameters, such as electricity prices, may change over the forthcoming years.

Setting parameter values

The SDM is working on data sets covering up to 15 years. In general, parameters that can change over time, such as electricity prices and the maintenance cost of technologies, are expressed using a base/current value and an anticipated future development.

Figure 4 shows an example of a base value (for subsidies) and its future development (1% increase per year). The future development can be described both as the increase/decrease per year, and a standard deviation that express the future variation.

Figure 4 : Example of setting a parameter using a base value and its future development

Some parameters can change both from year to year and within each year. Those parameters can be described using a future development and a seasonal profile. The example in Figure 5 shows that the electricity price depends on the seasonal variations ("Elec price profile") and yearly development ("increase 1%"). Seasonal profiles can be configured separately to exactly describe how a parameter varies over time. If no seasonal profile exists the average value can be given instead.

Figure 5 : Example of a parameter that changes depending on the season

The DSS comes pre-configured with both a set of seasonal profiles and a set of pre-selectable values for the yearly development. If desired the pre-configured values can be changed in the configuration tab.

Strategic Decision Model – working procedure

1) Set the building properties

►*Building properties:* Setting up the building properties includes changing the overall energy demand of the building, changing the overall limits for pollutants and investments and configuring existing technologies and technologies that are being considered as an investment.

►*Adding and removing technologies:* Each technology listed in the Building tab can be either an existing technology, or a technology that is being considered for installation. For technologies that are not already installed, the DSS will suggest when to install the technologies.

►*Energy data:* In the energy data tab it is possible to set the current and future energy prices, as well as the emissions that the use of energy creates.

►*Data configuration:* The data configuration tab gives access to detailed configuration settings. This includes the available energy types, pollutants, and settings for specifying the possible developments of the uncertain parameters and settings for adjusting how the DSS handles uncertainties.

2) Run the optimisation

When running the strategic decision model, the system will generate a set of possible future scenarios. Each scenario represents a combination of changes in the parametes, such as possible changes in energy prices. For each scenario, an investment plan is proposed, giving the optimal investment in technologies for the scenario. For each scenario, the total energy and investment costs are calculated. Running the optimisation can take up to one hour.

3) Review the results

The result consists of a set of scenarios and possible investment strategies. Thus, browsing the results consists of selecting one or several scenarios and reviewing the options that the system suggests.

Figure 6 : Configuration of technology parameters in the strategic model

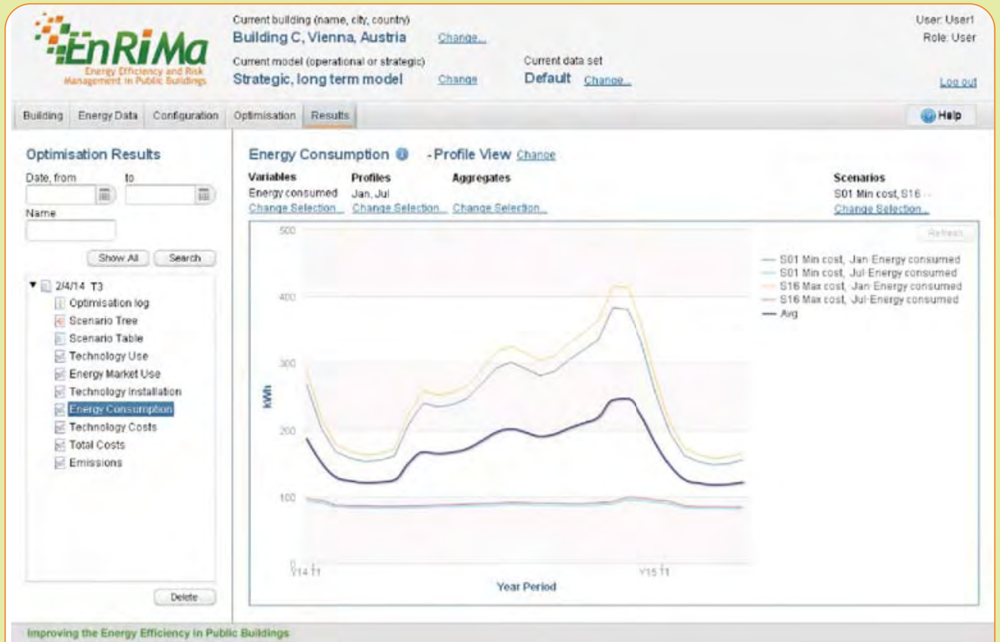

Figure 7: Example output from the strategic model showing the maximum and minimum energy consumption during a day in January and July

Making use of the Strategic Decision Model result

You can use the result from the Strategic Model to make informed technology investments, as well as a mean to prepare for external changes, such as a change in energy prices. For example, if you are considering an investment in solar panels, the Strategic Model can calculate when and if this investment is a viable option.

The Strategic Model can also suggest when to decommission a technology. To help prepare for external changes, the monetary and emission effect of these changes can be calculated by the strategic model. For example, if the subsidy for a technology is expected to increase, the system can calculate how this affects the overall cost of the building. Moreover the Strategic Model makes it simple to see the effects of an increase in energy prices.

Integrating with your Building Management System

The EnRiMa DSS can be used as a standalone tool. However, to let the EnRiMa DSS automatically give your Building Energy Management System (BEMS) the optimal temperature set points from the operational model it provides an Application Programming Interface (API) based on standard Web-Service (WS) technologies.

The Web-Service API for the BEMS and site communication are designed and available for two test sites and general enough for other buildings. The Web-Service can easily be reprogrammed for other sites assuming similar set-ups as at the Spanish and Austrian test sites used in the EnRiMa project. By using the Web-Service API, it is thus possible to integrate the EnRiMa DSS with a modern BEMS. A world-wide weather forecasting service is already fully integrated.