User's Help Guide

Chillers Selector &
Saving Analysis Software

An application for Air Cooled & Water Cooled Chillers

version 1

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I) Background Information on Chillers Module

1. Chiller and Energy Efficiency

The chiller is a complicated part of machinery, consisting of a compressor, expansion valve and heat exchanger/s. The refrigerant circulating through, is heated or cooled at various stages to produce the required result. Energy efficiency of a heat pump depends on a number of design choices and parameters such as type of compressor, type of refrigerant, type and control of expansion valve, sizing of heat exchanger/s, etc.

Efficiency, by definition, is the ratio of the energy output of a piece of equipment to its energy input, in like units to produce a dimensionless ratio. The relative efficiency of HVAC equipment is usually expressed as a *coefficient of performance* (COP), which is defined as the ratio of the heat energy extracted to the mechanical (and/or electrical) energy input. For heat pumps it has become customary to use *energy efficiency ratio* (EER), during the cooling period and as coefficient of performance (COP) during the heating period.

The overall efficiency of an HVAC system depends on all the parts that comprise the system. For example under sizing of piping networks leads to high energy consumption from the pumps or fans. Pumps, fans and air handling devices are themselves electricity consuming devices. The current document will focus on the “heart” –the highest energy consumer– of the system, namely, the vapour compression heat pump (chiller).

2. Chillers Module Architecture

The chillers module has been setup according to the structure presented in Fig. 1. It has been implemented following a three-step schema that involves (a) the chillers database, (b) mathematical models for energy and water consumption estimation, and (c) the presentation layer.

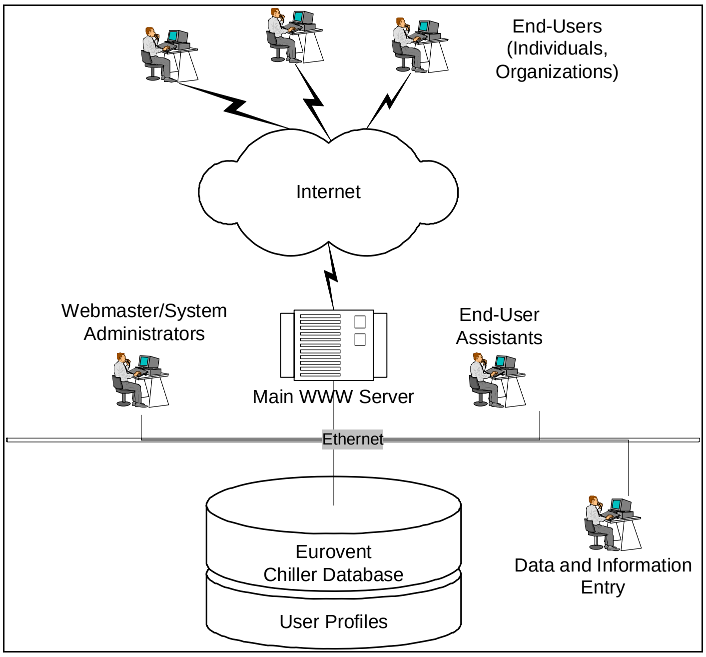


Figure 1: Architecture of the chillers module

Chillers module has been developed and operated as a web based application based on the Microsoft .NET platform (ASP.NET technology). The reason for this choice relies on the fact that web-based applications deliver an enormous range of business advantages over traditional standalone desktop applications.

- Internet powered applications provide companies with significant cost and time savings.
- Deployment is simple and less complicated as clients' posses their own browser software.
- Support and maintenance is also made easier. Businesses avoid the common maintenance problems associated with local applications. Software updates for example can be instant because the application exists only on the web server. Therefore all users access the same version.

For end-users the advantages are just as clear:

- Web based applications are more intuitive and convenient to work with. It is easier to customise the user-interfaces, making them more visually appealing and easy to use.
- Unlike traditional applications, web systems are accessible anytime, anywhere using a PC with an Internet connection.

2.1 Eurovent database

Analytical evaluation of a chiller performance is a cumbersome task, leading to questionable results. A decision has been taken in the current project to adopt the Eurovent database for the chillers module. This database contains a great number of parameters, including COP and EER for a significant number of products. Data and products are constantly updated tested and improved. The organisation and the database are recognised by many major HVAC component manufacturers. Equipment covered by the database is presented in Table 1.

Table 1: Classification of chillers in the Eurovent database

<table>
<tr><th>Heat Rejection</th><th>Code</th><th>System</th><th>Code</th><th>Operation</th><th>Code</th><th>Duct</th><th>Code</th><th>Compressor</th><th>Code</th></tr>
<tr><td rowspan="2">Air Cooled</td><td rowspan="2">A</td><td>Packaged</td><td>P</td><td rowspan="2">Cooling only</td><td rowspan="2">C</td><td rowspan="2">Ducted</td><td rowspan="2">D</td><td rowspan="2">Centrifugal</td><td rowspan="2">G</td></tr>
<tr><td rowspan="2">Split</td><td rowspan="2">S</td></tr>
<tr><td rowspan="2">Water Cooled</td><td rowspan="2">W</td><td rowspan="2">Reverse Cycle</td><td rowspan="2">R</td><td rowspan="2">Non ducted</td><td rowspan="2">N</td><td rowspan="2">Other type</td><td rowspan="2">O</td></tr>
<tr><td>Remote condenser</td><td>T</td></tr>
</table>

2.2 Energy analysis

The aim of ProMot is to examine energy consumption and propose the most energy efficient equipment, to serve cooling and heating loads. A simple relation to be used for energy consumption (E) is:

$$E = \frac{Pc}{EER_{FL}} \cdot t_{FL,cool} + \frac{Ph}{COP_{FL}} \cdot t_{FL,heat} + \sum_{i} \left(\frac{Pc_{PL,i}}{EER_{PL,i}} \cdot t_{PL,i,cool} + \frac{Ph_{PL,i}}{COP_{PL,i}} \cdot t_{PL,i,heat} \right) \qquad (1)$$

where Pc and Ph are the net cooling and heating capacities (kW) respectively, t is the operating time (hrs/yr) and the subscripts FL and PL denote full and part load.

Typically one would discretise time of operation to intervals (i) such as 25-50%, 50-75% and 75-100% and sum the energy consumed during these intervals.

Equation 1 contains more parameters than currently available in the Eurovent database and requires knowledge of operating times in various power range regions. Part load efficiencies are not yet available by Eurovent, but it is foreseen to be included in the data at a later point in time, within the timeframe of the porject. Full load efficiencies may be different than part load ones, depending on a number of chiller characteristics, such as the number and type of compressors, their part load efficiency, existence of inverter controls, sizing of condensers etc. On the other hand, operating hours of the heat pump are difficult to define, especially when in cooling mode. In contemporary chiller systems, operating time for compressors, is registered and can be retrieved from the chiller electronic control devices.

A simplified approach to equation (1) would be:

$$E = \frac{Pc}{EER} \cdot t_{EFL,cool} + \frac{Ph}{COP} \cdot t_{EFL,heat} \qquad (2)$$

where t_{EFL} is equivalent full load hours for heating or cooling. The assumption is that EER and COP do not vary greatly under part load operation.

In case time operation of the compressors of the chiller is unknown, for Greece the rule of thumb used is the equivalent full load hours $t_{EFL} = 0.67 \cdot t_{cool}$ or t_{heat}, with $t_{cool} = 1100$ hrs/yr and $t_{heat} = 1300$ hrs/yr. Although there is a degree of approximation in the equation above, it must be noted that it is intended for comparative study between two similar chillers, using the same approximations.

Currently the module has been programmed using equation (2). Once part load efficiency data is available in the database, equation (1) will be used.

2.3 Water cooled systems

Water Cooled Systems have undoubtedly higher energy efficiency ratio (EER) than the Air Cooled ones. On the other hand in Water Cooled Systems, incorporating cooling towers, the parameter of water consumption should be estimated and taken into account. Water is commonly used as a heat transfer medium to remove heat from the refrigerant condensers or industrial process heat exchangers. In the past, this was accomplished by using a continuous stream of water - from a utility water supply or a natural body of water – which was then discharged directly to a sewer or returning it to the body of water. Nowadays the cost of utility supply water has become prohibitively expensive. On the other hand, ecological disturbance could make the usage of water from natural body (e.g. lake) under certain conditions unacceptable (ASHRAE 2004).

Cooling towers overcome this problem by circulating water and they require a small fraction of the water otherwise needed with a once-through cooling system (ASHRAE 2004, Thumann 1987). The water consumption in a Cooling Tower is needed basically to replace water losses from evaporation and to safeguard the Tower from the concentration of dissolved solids and other impurities in the water.

According to (Rosaler 1995) the water losses which include evaporation, drift (water entrained in discharge vapour), and blowdown (water released to discard solids) could be estimated as the sum of Drift Losses, Evaporation Losses and Blowdown Losses.

Drift losses constitute a small ratio to the total losses of water. Besides, a portion of them can be subtracted from the necessary blowdown. These losses are estimated between 0.1 and 0.2%. Recent technology drift eliminator systems have managed to limit the drift rate to less than 0.001% of the recirculating water rate. Evaporation losses have decreased with improved design over the years. The evaporation rate from some Cooling Tower's Manufactures manuals was estimated to be between1.6% and 1.25%. ASHRAE (ASHRAE 2004) considers the evaporation rate at typical design conditions approximately 1% of the water flow rate for each 5.5 ºC of water temperature range. The blowdown losses depend on the concentration of dissolved solids in water and range between 0.3 and 4% of the water flow rate (Briganti 1994).

Estimation of total losses rate the values given in bibliography ranges from 3.8% to 1.33% of the water flow. The rate of 3.8% was found in a 1977 edition reference, therefore it is considered too high for the Cooling Towers in the market.

From the above we suggest that a typical default rate of water consumption in modern Cooling Towers to be used in our software is 1.5% of water flow through the tower. This value could be changed, should the user have a different estimate for the application at hand.

In case that the water flow through the Cooling Tower is not given, it can be estimated by (ASHRAE: 2004):

$$Q = \dot{m}\, c_p \Delta T \qquad (5)$$

where:

$\dot{m}$: mass flow rate of water, kg/s

Q: Cooling Tower capacity, W

c_p: specific heat of water = 4.19 kJ/(kg K)

ΔT: water temperature range = 5.5 K (typical value)

2.4 Chiller Economic Analysis

Economic analysis for comparison of alternative investments requires an understanding of several issues. The three most important elements to consider are (i) the investment costs for the systems, (ii) energy costs over the expected life of the chiller, and (iii) maintenance costs (including standstill costs) over the life of the chiller.

There are two general categories for economic analysis. Simple payback analysis and detailed economic analysis (LCC: life-cycle cost analysis). A simple payback analysis reveals options that have short versus long payback, whereas LCC calculates the total cost of each alternative during its lifetime. Although the LCC technique allows a more accurate comparison, it requires the knowledge of detailed information such as present value factor and interest rate.

In the chiller module a simple payback analysis has been used to compare alternative chillers, as it requires fewer data from the user. LCC analysis could be incorporated at a later stage. For comparison of chiller systems, payback technique is applied as:

$$\text{Payback (years)} = \frac{\text{investment cost}}{\text{energy savings} - \text{operating \& maintenance costs}} \qquad (3)$$

In case of water cooled chillers with Cooling Tower, water consumption has to be accounted as operating cost.

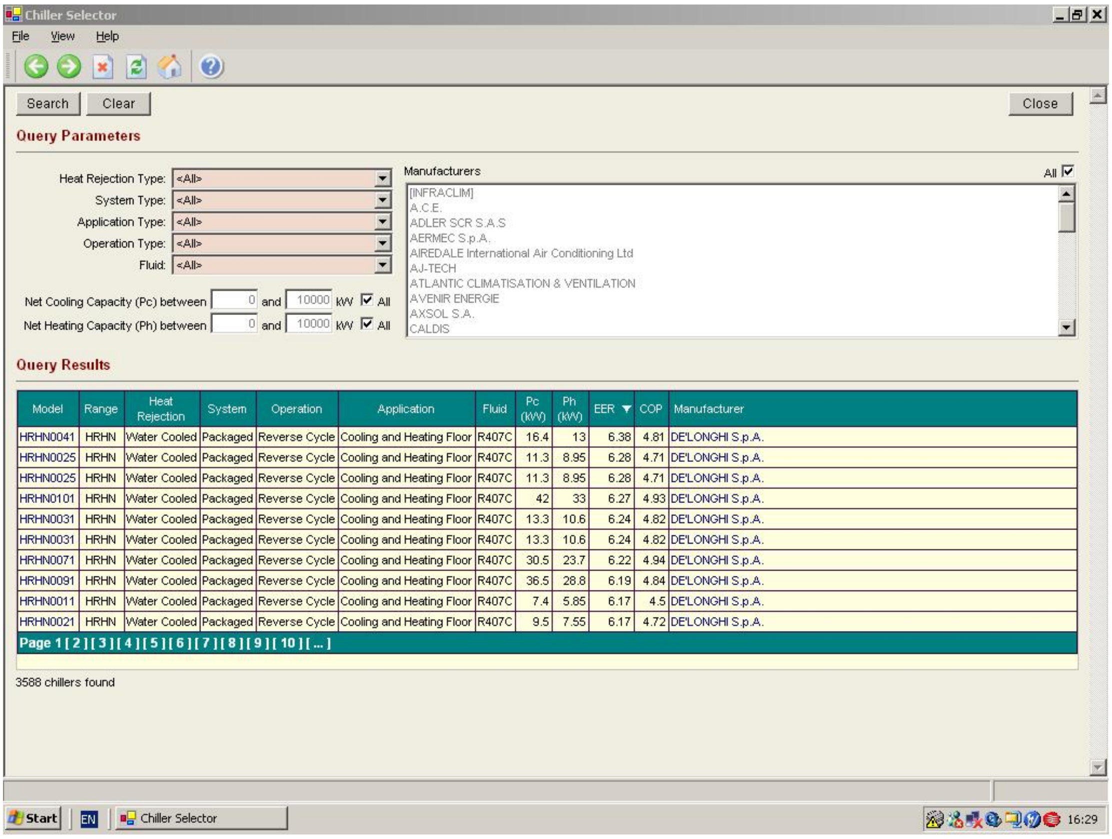
II) Chiller Selection Guidance: Chiller Selector

Use **Chiller Selector** *to find the appropriate chiller for a given application and to create a report showing performance and purchase information for chillers that meet your specifications. The available chillers are listed in descending order of Energy Efficiency Ratio (EER) value.*

Listing Chillers

At the **Main Menu,** click on the **Chiller Selector** destination button. The **Chiller Selector** window appears. See Screen 1. Then define the query parameters. Click on the down arrow at the **Heat Rejection Type** combo box to obtain a listing of the types of chillers contained within the *Eurovent* catalog database. Your choices are All Chillers, Air Cooled Chillers and Water Cooled Chillers. Make your selection. The same way you have to determine the **System Type,** the **Application Type,** the **Operation Type** and the **Fluid**.

Screen 1



System type, application type, operation type and fluid choices are summarized below:

System Type	Application Type	Operation Type	Fluid
All	All	All	All
Packaged	Air Conditioning	Cooling	R134a
Split	Cooling and Heating Floors	Reverse Cycle	R22
Remote Condenser	Cooling and Heating Floors (Brine)		R407c
			R410a

Then, you have to set the limits of the net cooling capacity and the net heating capacity. Clicking the **All** button directs **Chillers Selector** to search without any limits. To select a specific range of capacity you have ***first*** to deselect the checkbox: **All**. You can then change the specified limits of capacity.

You may choose to list qualifying chillers from all manufacturers or from one or any combination of selected manufacturers. Clicking on the **All** button directs **Chillers Selector** to search for chillers produced by all manufacturers. To choose products for a specific number of manufacturers you must **first** deselect the **All** checkbox.

Clicking on a manufacturer's name in the **Manufacturers** combo box will cause it to be highlighted. Use the up- or down-arrow boxes to view the complete listing of manufacturers. To select a number of manufacturers, press **continuously** the **ctrl** button on your keyboard and click on the desirable manufacturers. You can also use the **shift** button - instead of the ctrl button - if you want to select a number of manufacturers in the raw. The **Chiller Selector** search is then limited to highlighted manufacturers.

When you have finished selecting your search parameters, click on the **Search** button. **Chiller Selector** will examine the *Eurovent* database and display a report on the screen listing available chillers. The number of chillers found is indicated on the lower left of the **Chiller Selector** screen. The values you have selected as search criteria will be retained until you change them. Use the **Clear** button to reset all the parameters to default values. Use the **Close** button to go back to the **Main Menu**.

Make sure that the **Query Results** are sorted according the desirable for you criterion (Model, Range, Heat Rejection, System, Operation, Application, Fluid, Pc, Ph, EER, COP, Manufacturer). To change the sorting criterion double-click on any column heading to sort the chillers in ascending order (alphabetically or numerically). Double-click again to reverse the sort order and show chillers in descending order.

Tip: *For **Cooling Operation type** Chillers, the criterion which indicates the most energy efficient of the given chillers is **EER** (descending order).*

*For **Reverse Cycle Operation type** Chillers, besides EER, the descending order of **COP** should also be examined. Use the Chiller Saving Analysis to determine the most efficient chiller for a specific usage.*

The **Chiller Selector** report indicates the model, range, heat rejection type, system type, application type, operation type, fluid, net cooling capacity, net heating capacity, energy efficiency ratio, coefficient of performance, and chiller manufacturer. Click on the model of a chiller to get a detailed report. Detailed **Chiller Selector** report has 3 tabs (**General Information**, **Cooling Operation** and **Heating Operation** for the models with Reverse Cycle Operation Type). The information given at each tab are summarised below:

General Information	Cooling Operation	Heating Operation
Model	Net Cooling Capacity	Net Heating Capacity
Range	Effective Power Input	Effective Power Input
Manufacturer	Energy Efficiency Ratio	Coefficient of Performance
Trade name,	Evaporator Temperatures	Evaporator Temperatures

Heat rejection type System type Application type Operation type Fluid Compressor type Main power supply Outdoor duct Indoor duct and A weighted sound power level	Condenser Temperatures Water Pressure Drop on Evaporator Available Pressure on Evaporator	Condenser Temperatures Water Pressure Drop on Evaporator Available Pressure on Evaporator

Click on the manufacturer's name of any model to view information about the manufacturer.

Each **Query Results** table appears the first 10 results/chillers according to the selected criteria (column heading). Click on the **Pages** at the bottom of the table to view the next 10 selected chillers.

Summary:

1. Click on the **Chiller Selector** button at the **Main Menu**.
2. For each chiller characteristic, special feature or definite purpose listed in the **Chiller Selector** window, either accept the default value, click on the checkbox, or click on the down-arrow box to display your options.
3. From each choice list, scroll until the desired value is displayed. Click to select a highlighted value as your search criteria.
4. Indicate whether you want to list products available from all manufacturers, a specific manufacturer, or any combination of manufacturers. Click on one or highlight any number of manufacturers (pressing continuously ctrl keyboard's button) to make your choice.
5. When you have finished selecting all of your criteria, click on **Search** to provide an on-screen list of the chillers that meet your specifications.
6. Double-click on any **column heading** to sort the chillers in ascending / descending order (alphabetically or numerically) according the desirable criteria (most likely **EER**, descending order).

ATTENTION: If you notice that the query results doesn't seem to work, please open a blank window of Microsoft Internet Explorer and make sure that the sub-menu *Work Offline* of the File menu is *not ticked.*

III) Determining Energy and Cost Savings: Chiller Savings Analysis

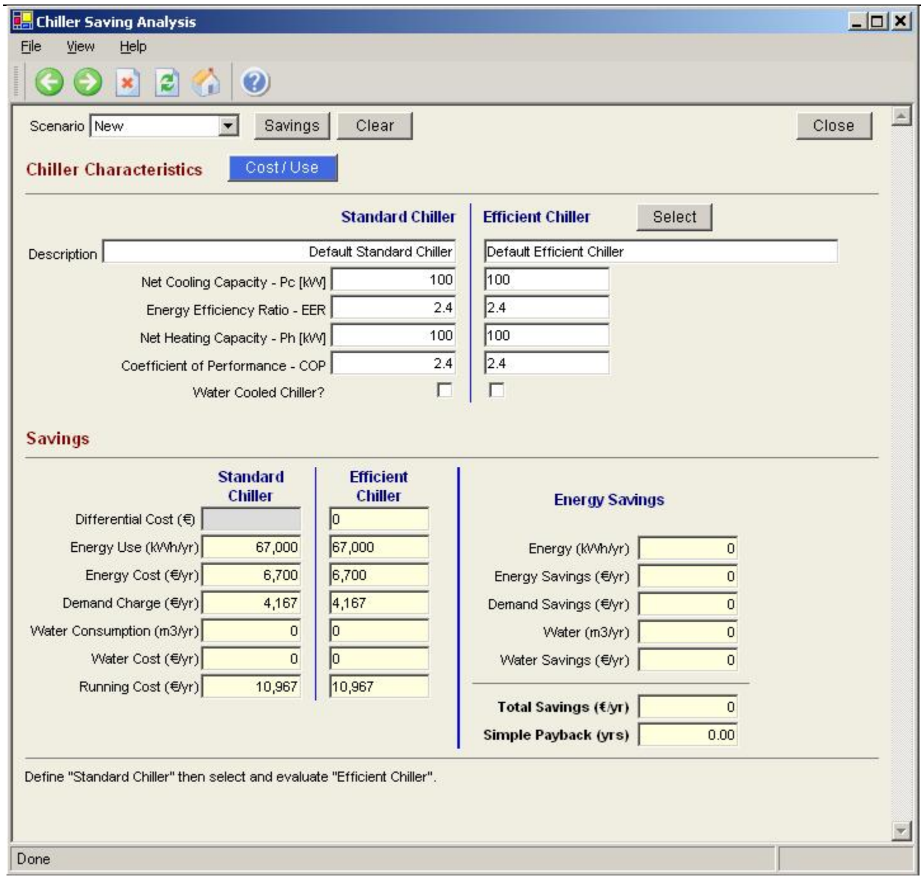
*Select **Chiller Savings Analysis** to calculate the annual reduction in energy use and Euro (€) savings given that you select a specific Efficient Chiller instead of a standard chiller for a particular application. **Chiller Savings Analysis** enables you to identify the most cost-effective alternative when making New Purchase, Refurbishment or Replace Existing chiller decisions.*

Comparing Costs

(I) From the **Main Menu**, click on the **Chiller Savings Analysis** button. A **Chiller Comparison** window appears on the screen (See Screen 2). First of all you have to select one from the three choices from the **Scenario** drop-down list:

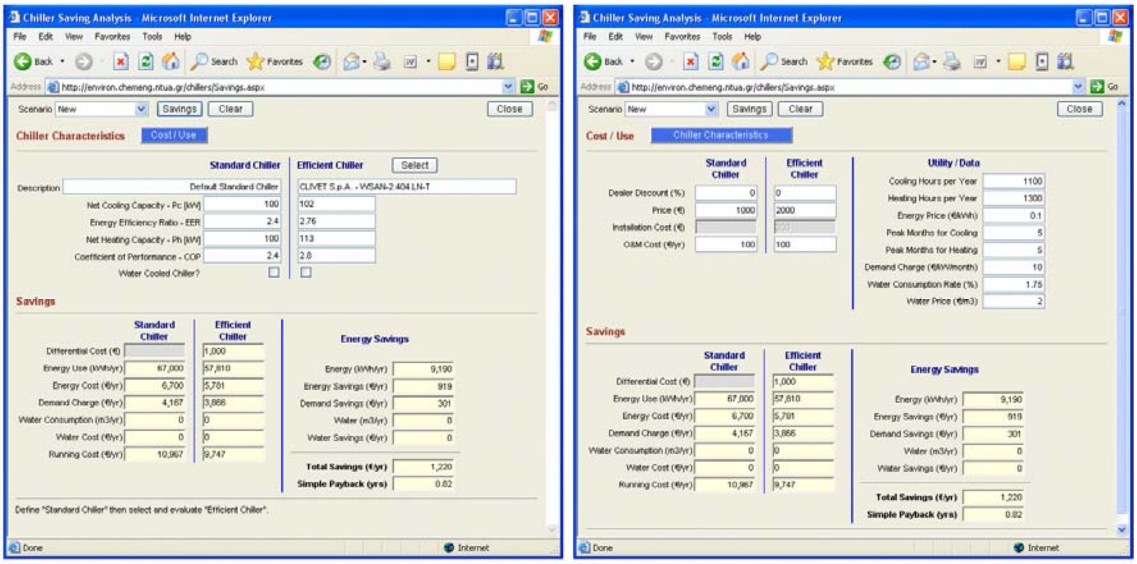
1. **New (Compare New Chillers)** compares the costs of acquiring and operating a new standard chiller with those of an efficient model. A standard chiller is assumed to be the "base case". The module determines the energy and cost savings achievable due to purchase of the higher over a lower efficiency chiller model. Then, assuming that the efficient chiller is also more expensive to purchase, it determines the simple payback on the investment in the efficient chiller. The simple payback indicates the time it takes for the energy-related savings to pay back the price premium or incremental cost of the efficient chiller.
2. **Refurbishment (Repair versus New Chiller Purchase)** compares the cost-effectiveness of refurbishing a standard chiller against the cost of purchasing a new efficient model. This comparison takes into account a reduced efficiency for the refurbished chiller attributable to age and refurbish losses. Default refurbish efficiency loss automatically appear in the **Refurbish** efficiency loss (percent) box. The module assumes a refurbish loss of 0.3 percent for chillers. These values are user-editable. A default refurbish cost also appears in the **Refurbish Cost and Price** box on the **Costs/Use** tab. This value is also user-editable.
3. **Replace Existing (Replace Operable Chiller)** analyzes the cost-effectiveness of replacing an operable standard chiller with a new efficient model. This scenario is used to decide if it is cost-effective to immediately replace older, low-efficiency, and oversized and under-loaded chillers. The analysis considers the entire new chiller purchase price plus installation costs as the chiller price premium when determining the simple payback. A default chiller installation cost is automatically entered into the analysis.

Screen 2



The **Chiller Savings Analysis** screen is designed with two data ***entry*** tabs: the **Chiller Characteristics** tab and the **Costs/use** tab (see **Screen 3 (a)** and **(b)**). In both cases the lower part of the screen, entitled **Saving**, remains the same.

Screen 3



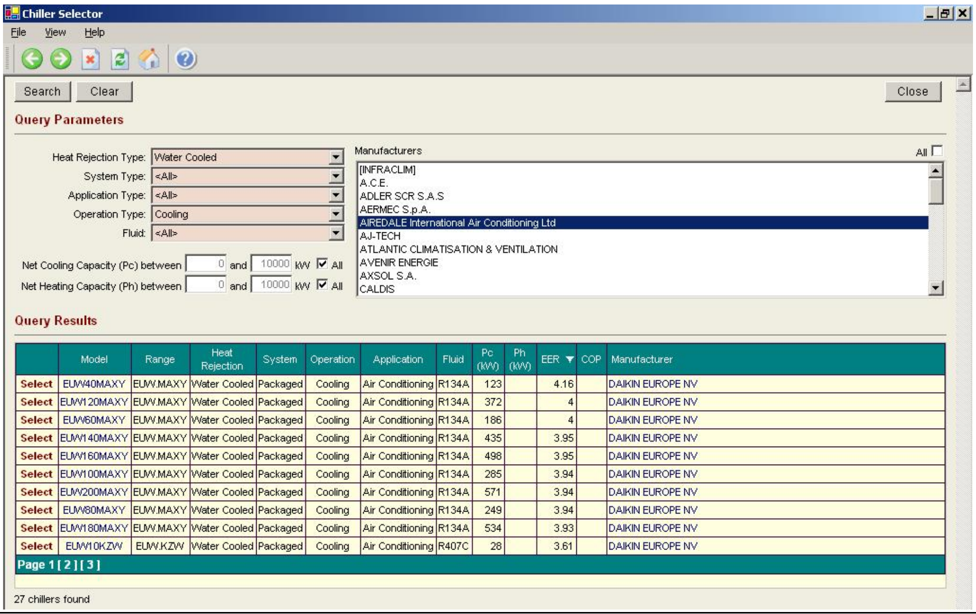
(a) (b)

(II) The **Chiller Characteristics** tab (see **Screen 3.a**) allows the user to specify a chiller by manually entering chiller description, operating parameters, and performance values. Values for the ***Standard*** or ***Refurbished*** or ***Existing Chiller*** are entered in the left column boxes. The respective values for the new ***Efficient Chiller*** are entered in the right-hand column.

Tip: Click on the **Select** button next to the **Efficient Chiller** to simple choose a specific chiller for the *Chiller Saving Analysis*. You are automatically transferred to the **Chiller Selector** window. Choose an efficient chiller (see ***Chapter I****: Chiller Selector Guidance*) and then press the red button "**Select**" on the left of the chosen chiller raw. The Characteristics values of the selected *Efficient Chiller* are automatically filled in the appropriate right column (see Screen 4).

To return to the Chiller Savings Analysis without selecting a chiller press **Close** button.

Screen 4



In any case, the data that should be filled for both **Standard** or **Refurbished** or **Existing** and **Efficient Chiller** are summarised bellow:

Chiller Characteristics
Description
Net Cooling Capacity Pc (kW)
Energy Efficiency Ratio - EER
Net Heating Capacity – Ph (kW)
Effective Power Input
Coefficient of Performance
Water Cooled Chiller?
Refurbish Efficiency Loss (%) *

Old Chiller Efficiency Loss (%) **

* For Refurbished Chiller: Enter the efficiency reduction expected if you continue to use an older, refurbished chiller. Chillers Module assigns a default refurbish loss of 0.3%.

** For Existing Chiller.

(III) After entering the Chiller Characteristics value click at the **Costs/use** tab (see **Screen 3.b**). Enter supplemental information necessary for completion of a Chiller energy savings analysis at the data entry boxes on the **Costs/Use** tab. Values included are summarized below:

Costs	Utility / Data
Dealer Discount (%)	Cooling Hours per Year
Price / Refurbish Cost (€)	Heating Hours per Year
Installation Cost (€)	Energy Price (€/kWh)
Operation &Maintenance Cost (€/yr)	Peak Months for Cooling
	Peak Months for Heating
	Demand Charge (€/kW/month)
	Water Consumption Rate (%)
	Water Price (€/m^3)

Some of the above values are analyzed below:

- **Dealer Discount (%):** Retailers frequently offer discounts of 25 to 40 percent or more off the manufacturer's list price. Contact your vendor for this information.
- **Price (Euros):** Contact your vendor for the most accurate price.
- **Refurbish Cost (Euros):** Costs associated with refurbishing a failed Chiller. (Used only in the **Refurbishment** scenario).
- **Cooling / Heating Hours per Year:** Enter the estimated Cooling/Heating hours the chiller will run per year. For Greece the rule of thumb used is t_{cool} = 1100 hrs/yr and t_{heat} = 1300 hrs/yr. Remember that the highest possible value is 8,760 for a year.
- **Installation Cost (Euros):** Enter labor and materials costs associated with replacing an operable chiller. (Applicable only under the **Replace Existing** chiller scenario.) An editable default chiller installation cost is supplied.
- **Energy Price (Euros/kWh).** Examine your utility bill, or obtain a copy of your utility rate schedule to determine the rate you pay per kilowatt-hour of electrical energy. For utilities with declining block schedules (where the unit energy charge decreases with increasing use) enter your marginal or incremental cost for energy consumed.
- **Demand Charge (Euros/kW-month).** Examine your utility bill or rate schedule to determine whether your peak monthly demand charge is based upon real power (Euros/kW-month).

The peak power use or demand charge is often based on the highest rate of electric energy consumption during a rolling 15-or 30-minute period each month. For large industrial facilities, it is not uncommon for demand charges to represent 40 percent or more of the total utility bill.

- **Peak months.** Enter the number of months per year for Cooling and Heating that the chiller operates during the facility's peak demand period.
- **Water Consumption Rate (%):** Enter the estimated rate of water consumption in case of a Water Cooled Chiller. Some manufacturers give the specific rate in their manuals. A typical default rate through bibliography is 1.5% of water flow through the Cooling Tower.
- **Water Price (€/m^3):** Examine your utility bill to determine the rate you pay per m^3 of water consumption.

(IV) Click the red colored **Savings** button at the top of the screen and view the results of the analysis at the bottom part of the screen, titled: **Savings**.

(V) Chillers module automatically displays the chiller comparison analysis results in the **Energy Savings** window at the bottom of the **Chiller Savings Analysis** screen. If you wish to examine a different Efficient Chiller, once again click on the **Select** button at the **Chiller Characteristics** tab to upload new chiller price and performance information into the analysis. Press the red colored button **Savings** again and the **Energy Savings** window automatically updates and displays the new results.

Like the **Chiller Savings Analysis** screen, the **Energy Savings** window is split into two columns. The left column displays the energy use and annual operating costs for the existing or low efficiency chiller. The right column yields comparable values for the Efficient Chiller alternative. Annual energy use and demand savings, total savings, and the simple payback due to investing in the Efficient Chiller are summarized at the bottom of the screen.

Summary

1. Select **Chiller Savings Analysis** from the **Main Menu**.
2. At the **Chiller Savings Analysis** screen, select the **New, Refurbished,** or **Replace Existing** chiller scenario.
3. Use the mouse or **Tab** key to move to any **Chiller Characteristics** data field that you want to modify. Enter the required chiller characteristics data into the white boxes for both Standard (or Refurbished, or Existing) and Efficient Chiller. For Efficient Chiller Characteristics you can move to **Chiller Selector** by clicking on the Select button. Choose an Efficient Chiller (See Chapter "*Chiller Selector Guidance*" and press the red button "**Select**" on the left of the chosen chiller raw to return to the **Chiller Savings Analysis** screen. The Characteristics values of the selected *Efficient Chiller* are then automatically filled in the appropriate right column.

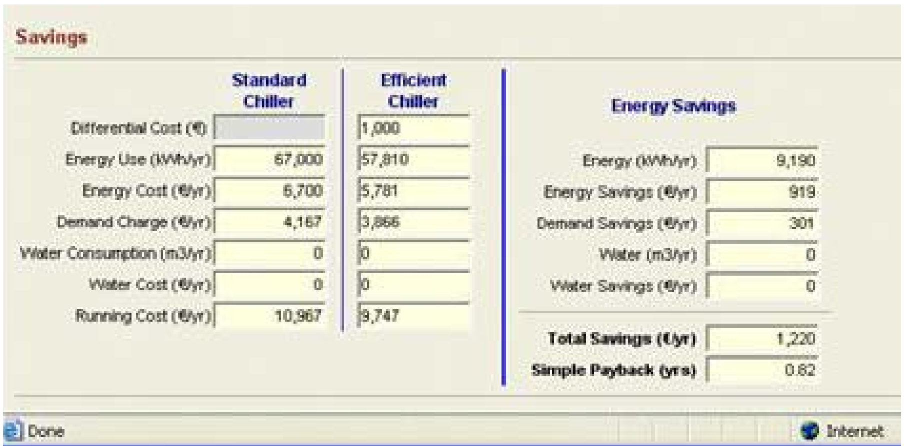
4. Click on the **Costs/Use** tab and fill in the manufacturer's list price discount factor, chiller purchase price, annual chiller operating hours, and utility rates are as you wish. Use your mouse to move through the items, accepting the defaults or entering new information.
5. Click the red colored **Savings** button at the top of the screen and view the results of the analysis at the lower part of the screen, titled: **Savings**.
6. Energy and cost savings are shown in the **Energy Savings** window at the bottom of the **Chiller Savings Analysis** screen. If you modify any input value, the **Saving** button is colored red. Press on it again and the **Energy Savings** window automatically updates and displays the new results.

ATTENTION: If you notice that the Chiller Saving Analysis doesn't seem to work, please open a blank window of Microsoft Internet Explorer and make sure that the sub-menu *Work Offline* of the File menu is *not ticked.*

Viewing the Energy Savings Window

The following definitions will help to interpret the results of the analysis shown in the **Energy Savings** window (see Screen 5).

Screen 5



- **Differential Cost (Euros):** The difference between the purchase or discounted list prices for the Standard Efficiency model and the Efficient model, assuming the Efficient Chiller has a higher price. If a utility rebate incentive is available, the incremental cost is the difference between purchase prices less the rebate. The price premium for a chiller that replaces a working chiller is the total purchase price of the new chiller, plus installation cost, less any available utility rebate.
- **Energy Use (kWh/year):** Energy use measured in kilowatt-hours per year.
- **Energy Cost (Euros/year):** The value of energy used per year in Euros. The formula is:

  Energy Cost = kWh (consumed) *x* cost per unit of energy (Euros/kWh)

- **Demand Charge (Euros/year):** The value of demand costs in Euros per year.
- **Annual Energy Savings (kWh or Euros):** In kilowatt-hours, the difference in annual energy consumption between the standard or refurbished or existing chiller model and the new Efficient alternative, assuming lower consumption with the Efficient Chiller model.

  In Euros, the annual kilowatt-hour savings times the unit cost of energy.
- **Demand Savings (kW, or Euros/year):** The difference in peak demand or annual demand charges between the two comparing chillers.
- **Water Consumption (m^3/yr):** Annual water consumption for Water Cooled Chillers.
- **Water Cost (€/yr):** The annual cost for water consumption for Water Cooled Chillers.
- **Total Savings (Euros/year):** The sum of annual energy Euro savings and annual demand Euro savings.
- **Simple Payback (years):** The time it takes to recover the differential cost from energy and demand cost savings. Simple payback is determined by dividing the chiller price premium by total annual cost savings. See box, **How to Use Analysis Results**.

How to Use Analysis Results

*The **Chiller Savings Analysis** can be used in several ways. The easiest way to compare the cost of purchasing and powering alternate chillers is to compare their simple paybacks. Usually, the shorter the payback period, the more cost-effective the investment. If you are considering several High Efficiency Chiller models, look for the one offering the most rapid payback on investment or shortest simple payback period. Note that once the payback period has passed, your energy cost savings continue.*

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