Ecostar® Condensing Units – with frequency regulation and intelligent control
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BITZER is expanding its product range in the field of air-cooled condensing units. The Ecostar® range provides a comprehensive and high-quality range of units with a large number of innovative details to produce an attractive price-performance ratio. BITZER is utilising the potential of its Octagon® compressor range and combining it with integral, suction gas-cooled frequency inverters and state-of-the-art regulation and controls technology to improve the efficiency of the system and thus also its operating costs. Furthermore, the integral controls technology monitors the application limits and thereby increases operating safety.

![BITZER Ecostar® condensing unit with open front panel](image1)

**Fig. 1** BITZER Ecostar® condensing unit with open front panel

![Aerial view of the BITZER production plant in Schkeuditz (near Leipzig)](image2)

**Fig. 2** Aerial view of the BITZER production plant in Schkeuditz (near Leipzig)
Frequency regulated Octagon® reciprocating compressors are at the very heart of the new Ecostar® condensing units

The new Ecostar® series has been developed in the BITZER plant in Schkeuditz, where it is also produced. At the start of production of the new series 3 models are available.

The heart of each condensing unit is a BITZER Octagon® compressor with suction gas-cooled frequency inverters flange-mounted motor-side. The smallest model is currently fitted with a 2-cylinder compressor and the other two models are fitted with 4-cylinder types.

The frequency inverters used have been reliably proving themselves for years with Octagon® compressors in the tough world of sea container cooling.

The frequency inverter is rigidly connected to the compressor and integrated in the motor cover. Unlike when the frequency inverter is fitted to the compressor’s terminal box, this rigid fitting avoids vibration problems and, at the same time, provides suction gas cooling of the power electronics.

This reliable suction gas cooling makes external ventilation of the frequency inverter and accompanying maintenance work on cooling bodies and possible required fans unnecessary.

The series currently has a capacity range of approx. 7 to 24 kW cooling capacity at maximum speed (87 Hz operation), depending on the refrigerant and temperature range used.

By means of motor connection at 230VΔ3/50 Hz, the 4-cylinder compressor can be infinitely speed-controlled at a supply voltage of 400V/3/50 Hz in the range of 25../87 Hz (2-cylinder 30../87 Hz). This corresponds to a compressor speed regulation range of 725(870) to 2520 1/min.

In this way, infinite part-load operation in the range of approx. 30(35) to 100 % is possible.

This infinite capacity regulation prevents mechanical stresses on the compressor, which would otherwise be produced by start-stop operation. The efficiency losses caused by fluctuations in suction pressure – which are inevitable for non-regulated compressors – are reduced to a minimum.

Moreover, when using frequency inverter high motor inrush current is avoided in contrary to DOL (direct on line) start which would otherwise be produced by the energy supply companies. During operation, the frequency inverter continuously carries out a power factor correction of the compressor motor and, in doing so, manages to keep the proportion of reactive current not of use for operation, but not insignificant in terms of power costs, as low as possible.

Infinite speed regulation of the compressor fans for further improvements in efficiency

In addition to fan speed regulation of the compressor, the two condenser fans are also infinitely speed regulated. An external temperature-guided phase section controller is used, that regulates the condensing fan speed between around 20 to 100 %. Below a fan part-load of approx. 20 %, the controller switches the condenser fans completely off, taking into account a temperature hysteresis.

The fans can be operated either in "eco mode" or "low sound mode", whereby the mode of operation can also be changed, if required, via the timer incorporated in the controller (see page 8).
**Design**

Contrary to conventional experience, the Ecostar® is designed to maintain the maximum cooling capacity at 87 Hz and not at 50 Hz as is usual. This top speed is only used at maximum cooling demand. With more usual part-load conditions, the Ecostar® perfectly adapts to demand by varying compressor and fan speed.

The Ecostar® condensing units have also been included in BITZER’s selection software, in order to make the selection as simply and easy, and yet also as precise and accurate as possible for the user.

**The controller**

The Ecostar® condensing units are fitted with a high-quality controller manufactured by Lodam, a company belonging to the BITZER Group. Lodam has specialized in solving challenging controls issues in the fields of cooling and air conditioning technology. The controller used is a modification of the model that has been used thousands of times in ship container cooling. When they are delivered, the controllers and frequency inverters have been preconfigured in such a way that the condensing unit can be prepared for its cooling role in a few steps. During commissioning, the desired operating parameters (evaporation temperature or room temperature) and the refrigerant used have to be entered, should these not agree with the basic setting ($t_o = -10^\circ C$, R404A). When in operation, the controller then takes on a whole series of roles to ensure optimum, energy-efficient operation.

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Fig. 4 Capacity range of an Ecostar® condensing unit LHV6/4EC-6.F1 for R404A at $t_o = -10^\circ C$ plotted above the ambient temperature for operating frequencies of between 25 and 87 Hz. The data marked in red refer to an assumed ambient temperature of $+32^\circ C$. 

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**Performance Characteristics**

<table>
<thead>
<tr>
<th>Cooling capacity (W)</th>
<th>LHV6/4EC-6.F1Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>30000</td>
<td></td>
</tr>
<tr>
<td>25000</td>
<td></td>
</tr>
<tr>
<td>20000</td>
<td></td>
</tr>
<tr>
<td>18000</td>
<td></td>
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<td>12000</td>
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<tr>
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<tr>
<td>8000</td>
<td></td>
</tr>
<tr>
<td>6400</td>
<td></td>
</tr>
<tr>
<td>5000</td>
<td></td>
</tr>
</tbody>
</table>

- **$Q_{o \text{ max}}$ at 87 Hz**
- **$Q_{o \text{ min}}$ at 25 Hz**

**Ambient temperature**

- $t_o = 10^\circ C$
- $t_o = 15^\circ C$
- $t_o = 20^\circ C$
- $t_o = 25^\circ C$
- $t_o = 30^\circ C$
- $t_o = 35^\circ C$
- $t_o = 40^\circ C$
- $t_o = 45^\circ C$
The application determines the regulation principle

Depending on the demand profile, there is an option to regulate the Ecostar® condensing unit’s compressor according to suction pressure or alternatively to regulate the temperature.

If it is proposed to connect several evaporators to the Ecostar®, then the use of suction pressure regulation is recommended. Each and every cold space can then independently demand "cooling".

The Ecostar® determines the total demand of the system by the suction pressure produced and regulates this by means of adjusting the compressor speed and thus also the coolant mass flow required.

If evaporators are connected, the suction pressure rises and the compressor reacts to this by increasing its speed. If cold spaces are switched off, the suction pressure falls and a frequency inverter reduces the compressor speed accordingly.

Fig. 5  Suction pressure-guided control of the condensing unit

1 Terminals for solenoid valve
2 Set point adjustment
3 External activation
4 Ecostar fault
5 Cooling room temperature
6 Ecostar controller interface
7 Cooling unit controller interface

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Due to the close match of cooling capacity required by the evaporators to the actual cooling capacity of the compressor suction pressure fluctuations in the system are minimized. The number of compressor shut-offs by low pressure on account of a too high compressor cooling capacity, as is the case with unregulated condensing units operating at part-load, is reduced to a minimum or does not even occur at all. The refrigeration plant works at both full and part-load at constant optimised operating conditions. This improves the COP of the plant and helps to reduce operating costs in comparison with unregulated condensing units. See Figs. 5 and 6.

Controlling according to cold room temperature is appropriate if, for example, a single cold room or low temperature room is to be connected to the condensing unit. There are particular benefits in doing so when the unit is used with seriously fluctuating cooling loads, as can be the case with fruit and vegetable cold stores or with bakery fermentation equipment. In air conditioning too, temperature-guided control is the preferred option for air handling equipment. The units are manufactured and delivered ex-works suitable for both temperature-guided and suction pressure regulation. An optional temperature sensor can also be supplied for temperature-guided regulation.
Comparison of the suction pressures of Ecostar® versus standard condensing units

![Graph showing comparison between Ecostar® and standard unit suction pressures.](image)

Fig. 7 Illustration of the suction pressures of a condensing unit with 2-point regulation and pump-down cycle (light blue) compared with a suction pressure-guided Ecostar® condensing unit (dark blue). Optimum evaporation pressure without cyclic operation by speed control of the compressor.
Intelligent control concepts help to adapt to local conditions

Depending on the load demand and the ambient temperature, the compressor and the condenser fan both find their optimum speed independently and thus also the required cooling capacity and the most efficient evaporating and condensing temperature for the chosen operation point. The condensing unit can optionally be activated by a potential-free contact of an upstream external plant controller.

It is possible to raise the evaporation temperature overnight by means of an integral timer. This is useful, for example, if a cold space has reduced load during night and weekends allowing for higher evaporating temperatures during these periods. Linked to that, the energy requirement for cooling over the whole year can be significantly reduced.

In supermarkets, in which a centralised BMS is used, the adjustment of the evaporation temperature in the refrigeration units overnight can be activated by a 0–10 V or 4–20 mA input by an analogue signal from the upstream BMS system, as an alternative to a timer. It is then not necessary to programme the timer.

On the high pressure side too, measures to adapt the unit to local conditions are also recommended. The respective location of the units can be taken into account by means of two selectable modes to regulate the condensing temperature.

In “eco mode” (standard setting), the air volume is regulated by the condenser in such a way that the most favourable balance between energy demand (compressor and fan) and cooling capacity is set. This results in the highest possible COP and lowest operating costs at all load and operating conditions.

However, if noise-reducing mode is required, then in “low sound mode”, the controller limits the speed of the condenser fan, which makes up the main proportion of noise emission. This allows the sound pressure level to be reduced by around 3 dB(A) and the noise level by half.

In order to use both modes to their best advantage, it is possible to specify to the controller, via the integral timer, when each mode should be used. This means that, for example, during the day, when it is less critical in terms of noise, the unit can operate with higher air volumes (reduced condensing temperature), whereas “low sound mode” can then be used to advantage during the night.

### Basis: R404A; $t_o = -10^\circ$C; $t_{amb} = 32^\circ$C

**Average sound pressure level based on 50 Hz**

<table>
<thead>
<tr>
<th>LHV6 units</th>
<th>Sound pressure level [dB(A)]*</th>
<th>10 m</th>
<th>Sound pressure level [dB(A)]*</th>
<th>10 m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Eco mode</td>
<td></td>
<td>Low sound mode</td>
<td></td>
</tr>
<tr>
<td>LHV6/2DC-3.F1Y</td>
<td>44</td>
<td></td>
<td>41</td>
<td></td>
</tr>
<tr>
<td>LHV6/4FC-5.F1Y</td>
<td>45</td>
<td></td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>LHV6/4EC-6.F1Y</td>
<td>47</td>
<td></td>
<td>44</td>
<td></td>
</tr>
</tbody>
</table>

* For free field conditions according to EN13487 at a distance of 10 m with a square reference

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Tentative values

**Fig. 8** Sound pressure level EcoStar® condensing units
Ecostar® condensing units with extensive standard components:

- Robust, vibration-optimised base frame
- Octagon® reciprocating compressor with integral, suction gas cooled inverter
- Crankcase heater
- Oil charge B5.2 for R22 or optional BSE32 for HFC refrigerants
- Large-sized, air-cooled condenser with 2 infinitely speed-regulated condenser fans
- Large-sized liquid receiver with Rotalock shut-off valve at the outlet, 2 sight glasses and connection for pressure relief valve
- Discharge line, suction line and liquid line including sight glass and filter drier fitted up to external casing
- Powder-coated weather protective housing for outdoor installation
- Electronic pressure transducers for high and low pressure
- Electromechanical high pressure limiter
- Discharge gas temperature sensor
- Ambient temperature sensor

- Complete electrical switchboard incl.:
  - Main switch
  - Contactors for compressor and condenser fans
  - Electronic speed regulator for condenser fan
  - Microprocessor controller with operating display for compressor speed regulator and for regulating the functions of the condensing unit
  - Connections for analogue input signals
  - All electrical and electronic components are internally wired and connected to connecting terminals

- Optional: electronic oil level monitoring

Monitoring the application limits

A particular feature of this controller is its active monitoring of the compressor application limits. The controller continuously monitors operating status and intervenes into the operation in a regulatory manner if factory-preset limits are reached. In this way many potential malfunctions are prevented before they result in the unit shut-down.

A dirty condenser, for example, results in an increased condensing pressure. The controller detects this and initially increases the fan speed of the condenser fan in order to continue to produce the required cooling capacity. If the controller detects that this measure is not sufficient, then it automatically reduces the speed of the compressor until stable operation has been re-established. Admittedly the full cooling capacity is no longer available, but the unit remains operational without it having to be shut down, something that could result in damage to cooled products.

If the unit reaches one or more pre-programmed limits, then the controller generates an appropriate alert, depending on priority, writes this into a fault memory and displays the alert at the same time. The controller differentiates between warning, alarm and critical alarm alerts. While countermeasures can be taken automatically by the controller with warning and alarm signals, the controller shuts the unit down to protect the unit with critical operating conditions. The cause of the fault has to be solved by a service technician on site and the fault indicator on the display has to be acknowledged before the condensing unit can be put to operation again.

This active monitoring of the application limits by the controller helps to increase the operational safety of the unit and to reduce the risk of an emergency shut-down. At the same time the reading of the fault memory helps to document the operating status of the condensing unit on a continuous basis and to counteract potential risks for the coming operating cycle at the regular service inspection.
The use of standard components guarantees quick replacement during service

Start-stop cycles are reduced to a minimum because of the fact that the compressor is speed-regulated by a frequency inverter. Its continuous operation means that the compressor is constantly and reliably supplied with oil via the integral centrifugal lubrication. This has a positive effect on the service life of the compressor.

The oil level monitoring unit OLC-K1, ideal for use with the Octagon® compressors, is also available for more complex applications with, for example, an extensively branched pipe work.

Nevertheless, the supply of spare parts has to be guaranteed to service every technical piece of equipment. For this reason, BITZER is relying as far as possible on tried-and-tested and available standard components for the Ecostar® condensing unit. Even the Octagon® compressors conform to the standard and can be replaced by spare parts from the refrigerant wholesaler’s stock. When servicing the unit, the motor-side cover with fitted frequency inverter only has to be moved from the old unit onto the new compressor. If damage to the frequency inverter has been diagnosed, the compressor contactor in the switch board allows emergency operation on the 400V/3/50 Hz mains until the replacement part is available on site.

Ease of installation and commissioning helps to save installation and service costs

The well thought-out design of the units makes them simple and easy to handle, quickly and straightforward to install and commission on site.

The condensing units are built on a solid base frame and are made ready for transportation by fork-lift and crane. Adjustable mounting blocks (optional) make the correct alignment of the unit easier at its position of installation. The unit design, with its diagonally positioned condenser and vertically slightly forward-angled fans, ensures that there is an adequate supply of air for optimum condensing and also excellent cooling of the compressor even if the unit is positioned directly up against a wall. All components can be reached from the front.

On the refrigerant side, the suction and liquid lines have been factory-fitted up to the external casing of the unit. A filter drier and sight glass are pre-installed in the liquid line.

The switchboard and all control components have been electrically wired and connected to the terminal board. The controller is pre-programmed and ready for commissioning with a few small adjustments.

The comprehensive standard equipment and pre-programming shorten the installation time quite considerably and also help to prevent, as far as possible, refrigerant related, electrical and programming errors during installation.
Multiple refrigerants and wide application range

The new Ecostar® condensing units prove once more the innovative capacity of BITZER. Using BITZER’s modular design helps to provide solutions at a marketable price.

An equivalent price comparison of the new Ecostar® condensing units with other condensing units shows the marketability of this new range of units, yet at the same time these provide a wider extent of supply and operation capability.

The integral frequency inverter that regulates the speed of the compressor and the temperature-guided speed control of the condenser fans help to keep operating costs as low as possible under all operating conditions.

With the release of the R134a, R407C, R404A/R507A and R22, the Ecostar® condensing units are available for a wide application range in high, medium and low temperature systems.

Possible applications for the new Ecostar® condensing units:

- Kiosks, filling station shops
- Smaller supermarkets, discount retailers
- Refurbishment of existing plants
- An alternative to smaller parallel racks
- External liquid sub-cooling to increase capacity and efficiency with larger compound systems
- Cold rooms, such as in restaurants and hotels
- Bakery fermentation equipment
- Fruit and vegetable cold stores
- Air handling units
- Cold water production without buffer reservoir
- etc.

etc.