Mobile Energy Efficiency

Innovative energy saving technology implemented by mobile network Vodafone Romania

Since 2006 Vodafone Romania has been closely managing its energy consumption and purchasing policy. At the end of 2011, it decided to implement a free cooling system that was particularly innovative. In one building alone this system has resulted in annual costs savings of €13 700, and carbon emission reductions of 54 TCO_2e. A roll out of the system for four other locations is planned, starting in 2013, with a projected investment cost of €127 000, annual costs savings of €43 000 and annual carbon emission reductions of 215 TCO_2e.

The impact of Vodafone Romania's energy efficiency initiatives is noticeable in results from the GSMA's Mobile Energy Efficiency Benchmarking which show a strong performance in RAN energy per connection, per cell site and per unit traffic.

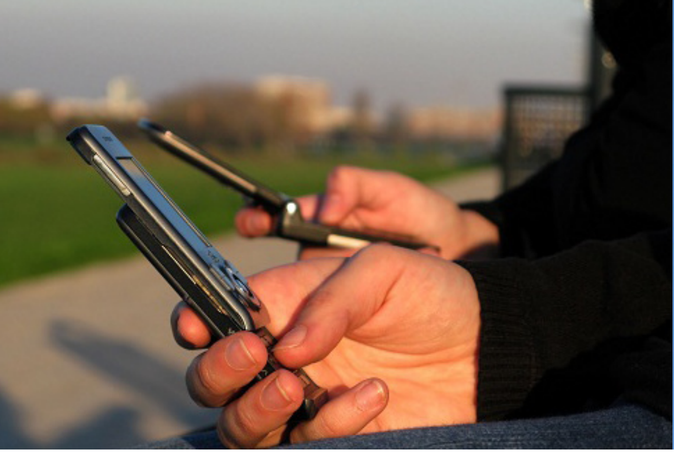
Background

Vodafone Romania is one of the leading mobile operators in Romania with over nine million connections in 2011 and a network that covers over 99% of the population. It was launched in 1997 and originally known as Connex prior to the acquisition in 2005 by Vodafone.

Energy costs are significant, even though the price of electricity is relatively low. Although the grid infrastructure covers most of the population, electricity supply to rural areas suffers from frequent interruptions so assuring the stability of power supply to the network is critical. Romania's climate includes hot humid summers, so reducing energy used in cooling is an important element of energy management.

Opportunity

Vodafone Romania went through a process from 2006 to 2010 of negotiating new energy contracts for all of its sites so that today prices are negotiated on an annual basis on more attractive terms. Since then, the focus has moved to becoming more energy efficient, especially where short payback periods are achievable.

Cooling is a high percentage of total energy consumption and an obvious target for energy and cost reduction using free cooling solutions. This is the focus of the case study.

Vodafone Romania has also implemented a range of other energy savings initiatives, including the following which focused on MSCs and data centres:

- Trial to replace thermostatic expansion valve with electronic expansion valve for old generation HVAC (Close Control) units
- Swap of old R-22 HVAC units with new generation HVAC units with electronic expansion valves
- Adiabatic cooling of condenser units
- Heat recovery from technical areas to heat offices in winter.

Solution

Vodafone Romania investigated different possible free cooling solutions, and focused initially on the largest opportunity which was in a building with an MSC and a data centre (containing both telecom and IT equipment).

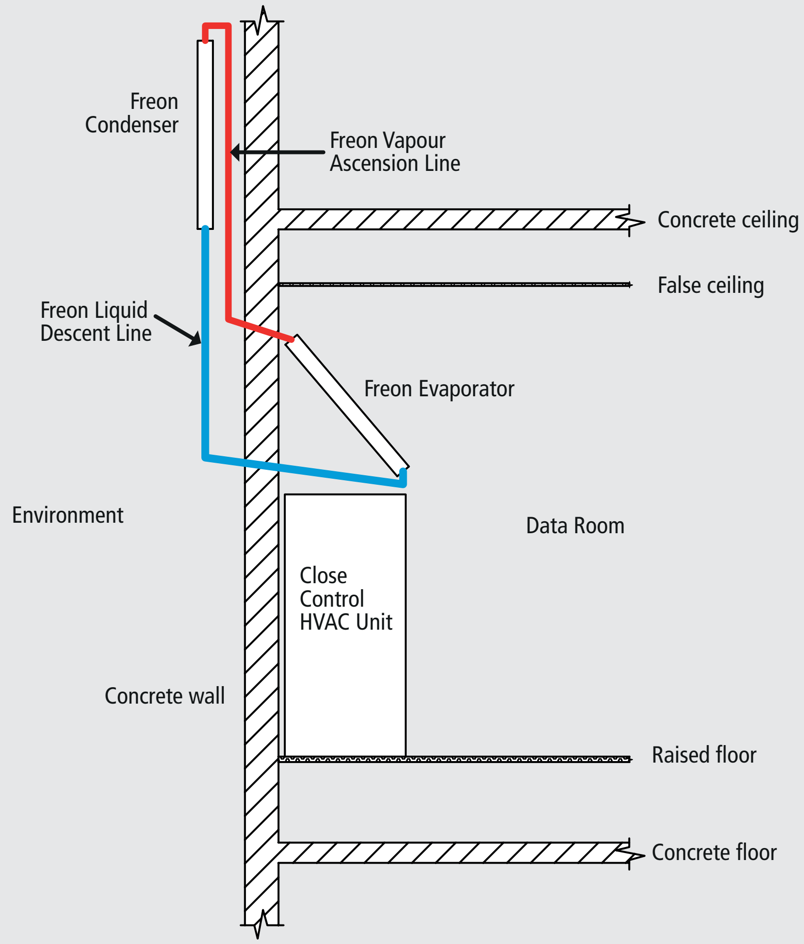
Vodafone Romania found the most cost-effective free cooling solution to be an "economiser", which provides indirect free cooling to buildings which already have air conditioning systems. Because of the low power price, keeping capex low is particularly important in Romania to preserve the business case, and so the economiser was built by reusing materials and components that were available onsite.

The economiser system incorporates principles from both a thermosiphon and a heat pipe. The thermosiphon element is a passive heat exchanger based on natural convection, which circulates the refrigerant without the need for a mechanical pump. Heated fluid moves upwards in the system, replaced by cooler fluid returning by gravity. However, as in a heat pipe, the economiser also incorporates phase change of the refrigerant: when heat is applied to one end of the system, the liquid inside evaporates, moves through a pipe to a cooler location where it condenses and gives up heat, and is returned by gravity to the hot interface where the cycle is repeated.

The economiser uses an evaporation heat exchanger on the hot air intake, mounted above HVAC equipment inside the Data Centre, and a condensing heat exchanger mounted outside the building. Connections between the two heat exchangers are made with different diameter pipes (gas / liquid). Installing the evaporator in the MSC and Data Centre and the condenser outside ensures cooling of the building without mechanical compression. If the external temperature is lower than the MSC and Data Centre temperature, then the economiser extracts heat from the MSC and Data Centre. If the external temperature is higher than the MSC and Data Centre temperature then no heat transfer takes place and the MSC and Data Centre is cooled by the air conditioning system. See figure below.

The economiser will only work when the external temperature is low enough, normally in winter time or during cool nights. If the MSC and Data Centre upper temperature is 23 °C and the temperature difference to the evaporator is 5°C, then the vaporisation temperature of the refrigerant will be 18°C. Through the heat exchange mechanism the condensing temperature of the refrigerant was assumed to be 17°C. This temperature can be achieved when the external temperature is 12°C (with a similar temperature delta of 5°C). These are theoretical assumptions of temperatures because, while the temperature inside the MSC and Data Centre is quite constant (between 23 and 26°C), the external temperature varies and of course the condensing temperature of the refrigerant will vary too. Practically, the pressure inside the economiser will be equalised by the principle of communicating vessels.

Figure 1: Economiser in the MSC and Data Centre



The most important factors impacting whether the economiser works correctly are:

- The condenser position must be higher than the evaporator
- Type of refrigerant
- Pressure of refrigerant
- Diameter of connecting tubes, to minimise the pressure drop.

R134a Freon was chosen because it is a low pressure refrigerant and it does not have temperature glide at phase change, i.e. there is no difference between the saturated vapour temperature and the saturated liquid temperature. Freon has a vapour pressure of 5.37 bar at 18°C, and a condensing pressure of 5.21 bar at 17°C. The pressure difference of 0.16 bar will ensure that the Freon vapour will flow upwards, shown in the figure as the Freon Vapour Ascension Line. Once condensed, gravity enables the Freon liquid to follow the Freon Liquid Descent Line as it returns towards the evaporator.

All Freon connections must have minimal pressure drop. To ensure a proper thermosiphon the minimal geodesic difference is 1 metre. The lengths of horizontal piping must be limited as much as possible to ensure an easy circulation, as refrigerant circuits require short paths.

The condensing units were reused from out of service Isovel or Liebert Hiross HVAC units and transformed into trough heat exchangers in order to optimise the pressure drop and the Freon circulation. This innovation was trialled in December 2010 in Brasov and implemented fully in December 2011 in Bucharest. For the trial, the evaporator was recycled from an old Liebert Hiross HVAC system, but in Bucharest specially designed evaporators manufactured by a Romanian company were used. These novel evaporators had a large surface area with aluminium fins and copper pipes, with a fin distance of 3 mm in order to provide the cooling required and to ensure an optimal pressure drop enabled for an easy air flow circulation.

The economiser system has several advantages over alternatives, including:

- Low implementation costs as parts of the economiser are built from reusing condensing units, taken from replaced R22 HVAC old units
- High operational reliability as the only moving mechanical parts of the system are the fans of the condenser units
- Low maintenance requirements.

Furthermore, in future it should be possible to:

- Combine the economiser with an adiabatic cooling system which can increase the working hours of the economiser by 1 500 hours per year, compared to the 3 300 hours per year if it is used on its own. Vodafone Romania has already implemented adiabatic cooling at two of its MSC sites
- Adapt the economiser system for use in indoor cell sites within buildings
- Connect the economiser to the chilled water distribution from an absorption chiller, such as where a combined cooling, heat and power system has been implemented. In this case, the free cooling system's operation will not depend on the external temperature and the system can be used throughout the year. To implement this, the condensing units would need to be replaced with a plate heat exchanger.

Results

The economiser system began operation as a real and verified solution in December 2011 and has led to a successful reduction in energy consumption of almost 150 MWh per year, and also a decrease in maintenance costs as the upgraded HVAC units are now used in stand-by mode. The capital cost of the system, implemented on three different HVAC units, was €39 500, and results to date indicate expected annual energy cost savings of €11 700 and additional annual maintenance cost savings of €2 000. The energy saved implies a reduction in carbon dioxide emissions of 54 tonnes per year and overall the payback period is a slightly less than three years.

Vodafone is one of 35 mobile operators participating in the GSMA Mobile Energy Efficiency Benchmarking initiative.

For more information visit www.gsma.com/mee.