Case Study summary

IEA-ECBCS Annex 48

Heat Pumping and Reversible Air Conditioning

Italy Case Study N°2: Reversible air-air VRF HP system in a refurbished 19th Century office building

1859-2009
150 anni di Cultura Politecnica
POLITECNICO DI TORINO 1859 1906

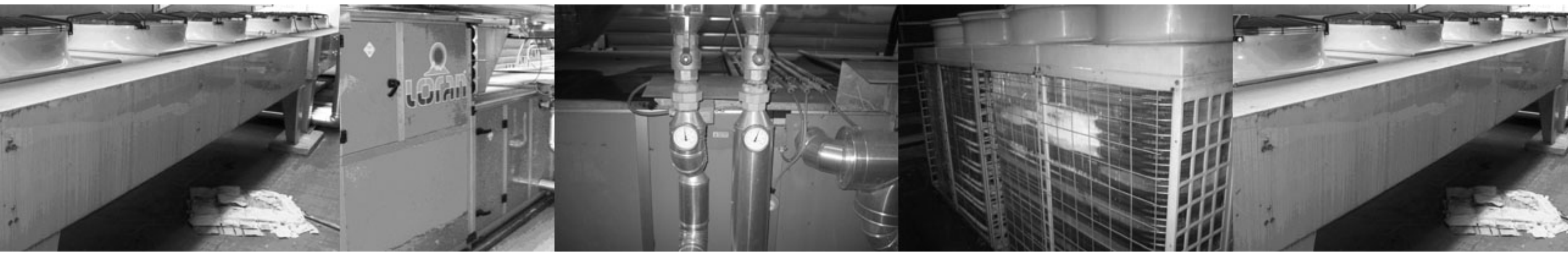
Contribution of Politecnico di Torino

Introduction

The Regione Piemonte Headquarters are located in a XIX century building that was almost entirely rebuilt after World War II. In 2006, a radical refurbishment of the building services has been completed by the ESCO in charge of the energy service contract. The A/C system monitored in this building is a air-air VRF (Variable refrigerant flow) reversible heat pump system with fan coil indoor units. Mechanical ventilation is provided to some areas only. Air cooled water chillers and condensing gas fired boilers supply hot/cold water to AHUs.

Summary

- Location:Torino, Italy
- Building sector: Public building / office
- Gross net area: 11.500 m²
- VRF system nominal cooling capacity: 550 kW
- VRF system nominal heating capacity: 600 kW
- U-value external walls: 1.0 W/(m²K)
- U-value windows: 4.3 (old)- 2.6 (refurbished) W/(m²K)



Background

The modular VRF system employs 16 roof-mounted air-cooled external units. An inverter drives one of the two scroll compressors present in each module, in order to continuously vary the cooling output according to the actual demand. An air cooled water chiller and a modular condensing gas fired boiler supply hot/cold water to AHUs. VRF system was installed to avoid service interruption of the public building during refurbishment. The ground floor and the three top floors of the building are equipped with a two-pipe system, in which the refrigerant fluid is distributed by a single main loop to the internal units that operate either in heating or cooling regime, according to a seasonal changeover scheme. At the second floor, a three-pipe system allows simultaneous indoor heating and cooling.

General concepts

Compared to traditional centralized systems the VRF solution guarantees a main advantage: modular installation that permit continuous building operation during installation. In addiction the system shown a good season efficiency. A BMS (central Building Monitoring System) provides complete monitoring and management of the building services (HVAC, fire prevention, security, lighting) ; in particular the lighting system includes daylight and PIR control.The BMS allows monitoring of the internal / external units using the building Ethernet network from a remote PC. Features include: remote internal unit set-point control, alarm handling, energy consumption recording, fire prevention system monitoring, monitoring of window opening / closing, lighting system and PC on / off switching (internal heat load monitoring). Energy performance data acquired by the BMS have been recorded and stored since 2005.

External unit of the VRF system

Technical data of the system:

VRF system:

- Cooling power: 550 kW
- Heating power: 600 kW

AHUs circuit and DHW:

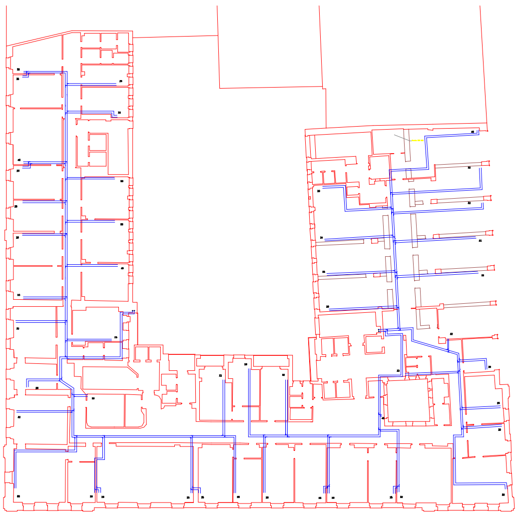
- Modular condensing boiler, rated at 500 kW of heating power
- Electric chiller rated at 223 kW of cooling power

Advantages

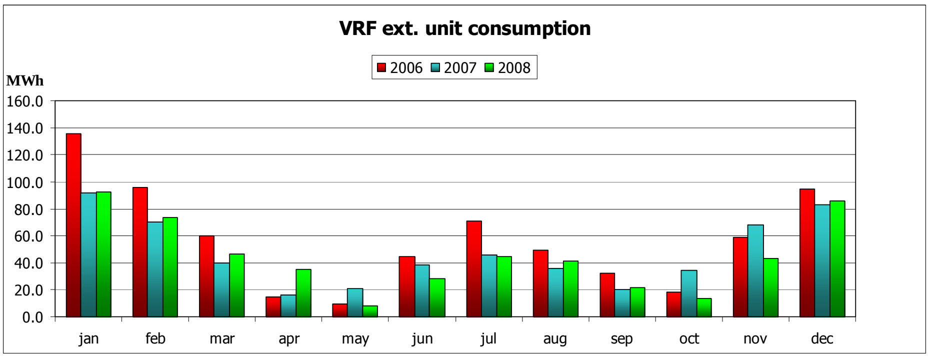
- High efficiency at partial load
- Modular installation
- High modularity of comfort/schedule in conditioned spaces

Drawbacks

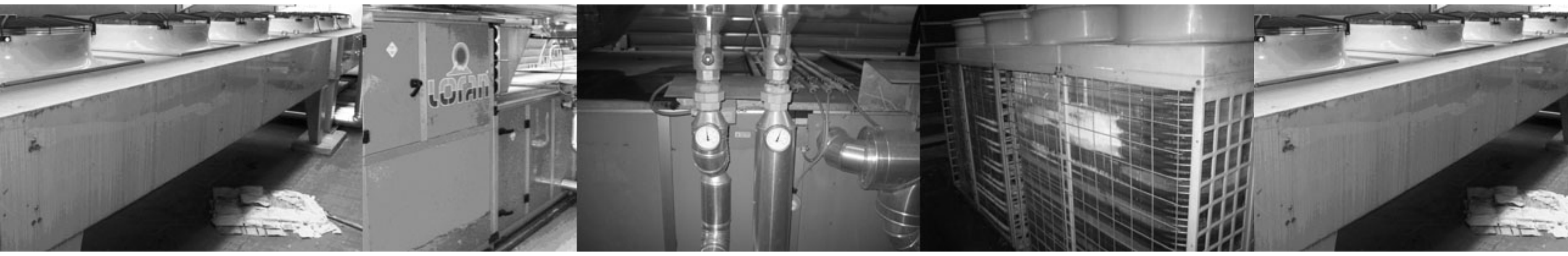
- Higher installation and maintenance cost than traditional HVAC system
- Questionable environmental impact due to the high number of subsystem and to the high amount of refrigerant fluid
- COP lows critically with low external temperature



Lay-out of the refrigerant fluid tubes connecting the internal units.

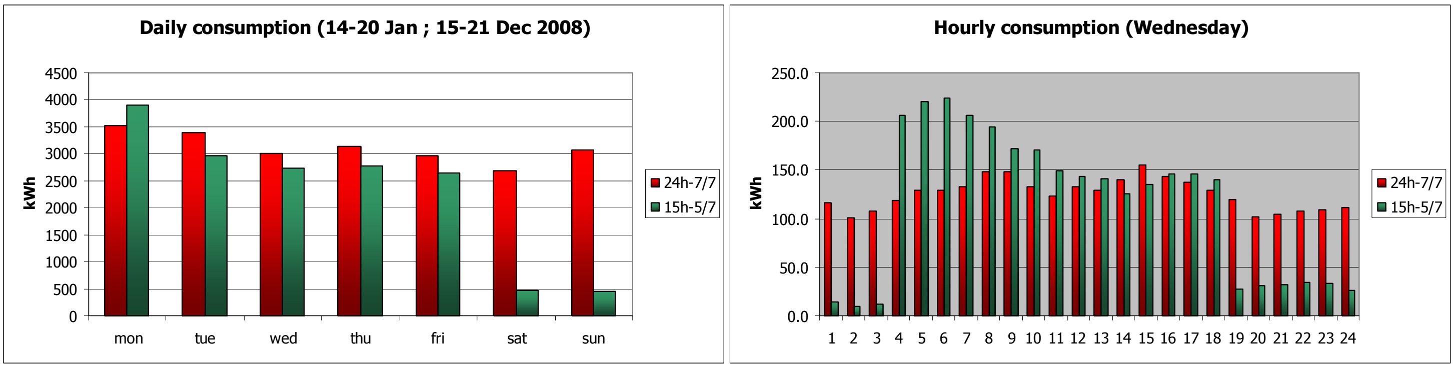


Monthly consumption of VRF system external units. First year consumption is clearly higher than further seasons.



Consumption analysis I

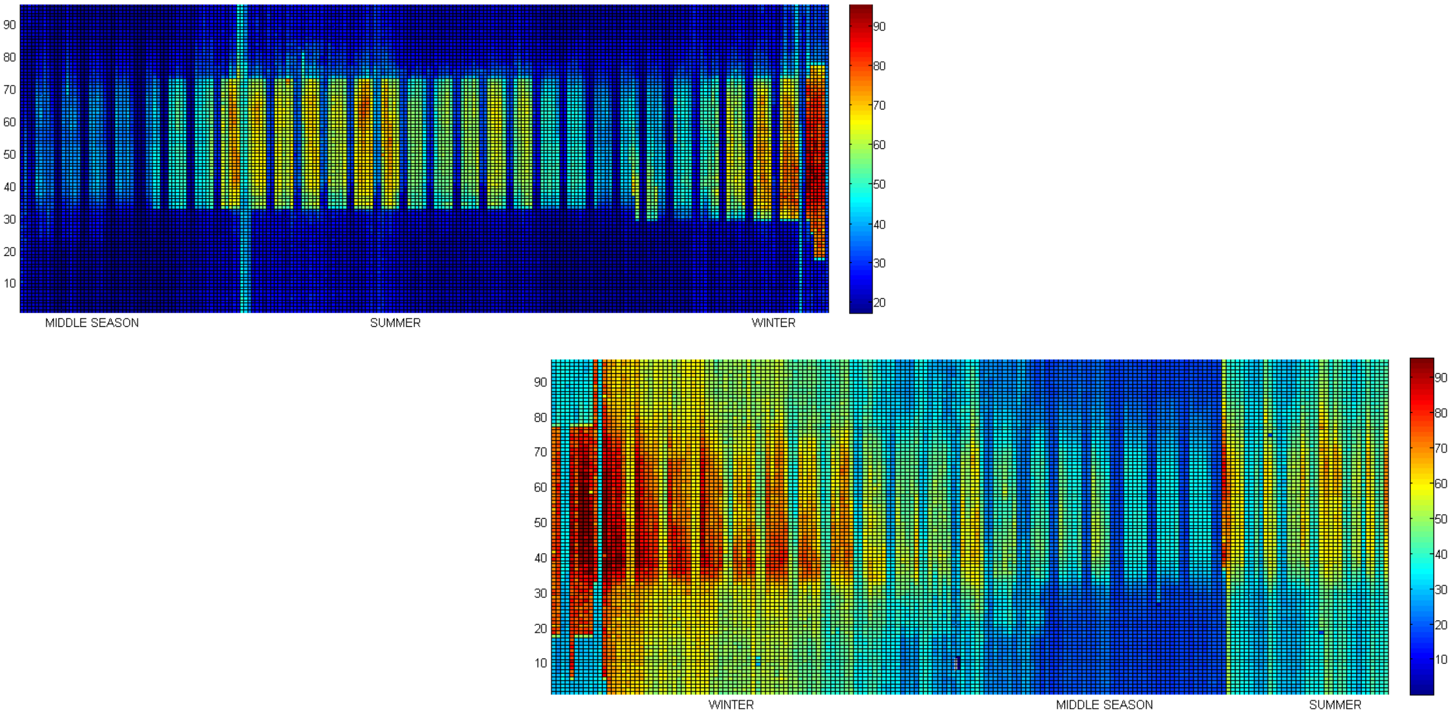
The data records indicate that, in the initial operation period, the HVAC system was running 24/24 hrs – 7/7 days; the operating schedule was subsequently optimized by introducing nighttime and weekend system set-back criteria. The effects are clearly seen in the graphs. The weekend set-back is reflected in the greatly reduced consumption on Saturday and Sunday, and in increased system consumption on Monday; the night set-back determines an increase of the hourly energy demand in the morning period of working days. Referring to typical winter conditions, the following electric energy consumption reductions are achieved: 9% on working days and 85% on weekends, yielding a 26.7% weekly saving.



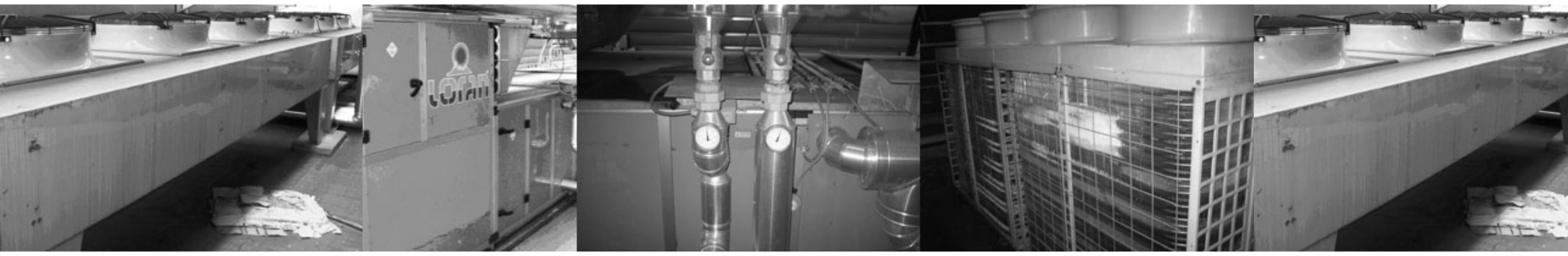
Consumption comparison between different VRF system schedules

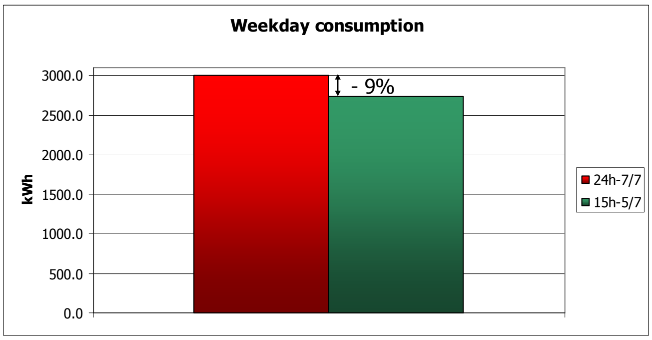
Consumption analysis II

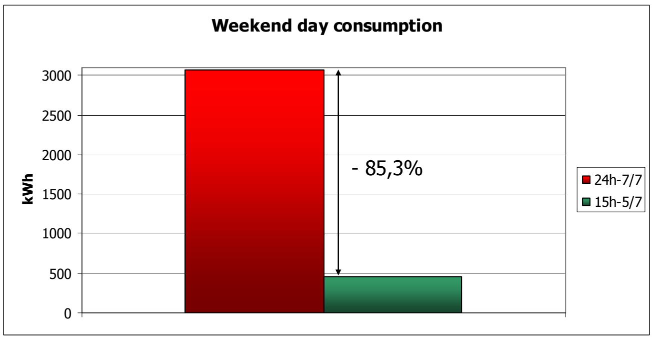
The effects of modified system operation are also well visible in a carpet plot representing the time trend of total electric energy consumption: the plot on the left side refers to a period in which the operation schedule of the VRF system is well defined and stable, while the plot on the right side basically reveals a continuous operation, in which nighttime or weekend setbacks are not clearly applied.



Carpet plots of building global electric consumption. The value are in kWh and refers to sampling time of 15 minutes





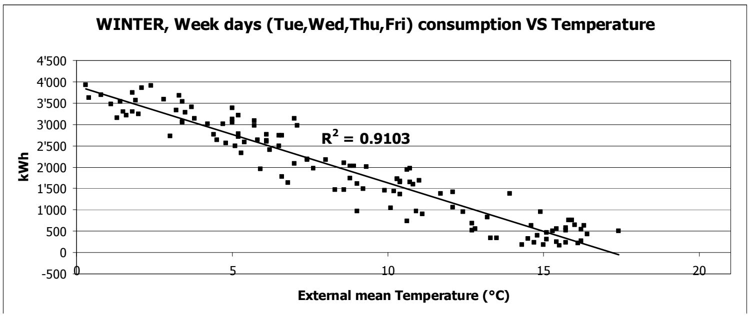


Mean difference on electric consumption between different VRF system schedules

Monitoring Results

Data acquired by the BMS was analyzed with linear correlation to the external temperature, the result, called energy signature, demonstrate a good correlation and stable operation of VRF system.

The internal temperature of office was also logged, in some cases it was more then 23℃. Regulating internal set-points would improve even more the system efficiency.



Energy signature of VRF system, heating season

Conclusion

Data acquired demonstrate that the log of electric consumption of HVAC system is need to provide a correct optimization of the system. In this case the high thermal capacity of the building explain the relative little saving obtained in week days. Further optimization is possible, implementing an autonomous system that set internal space set points at the end of the work day, resetting the users setting.

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Address

Marco Masoero at DENER,
Politecnico di Torino
c.so Duca degli Abruzzi 24
10129 Torino, Italy
marco.masoero@polito.it

Literature

IEA-ECBCS Annex 48 website: http://www.ecbcs-48.org

Article: M.Masoero, C.Silvi, J.Toniolo, Energy performance assessment of HVAC systems by inspection and monitoring, Clima 2010, Antalya 09-12 May 2010.