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Full CO2: Integration of Cooling, Heating and Air Conditioning Systems in a Supermarket

A Successful SCM FRIGO installation in South of France

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BEIJER REF

Introduction

Integration between Cooling, Heating and Air Conditioning is becoming increasingly important for Supermarkets as well as the use of Natural Refrigerants.

The following study will show the results of application of a CO_2 “Full Integrated System” including:

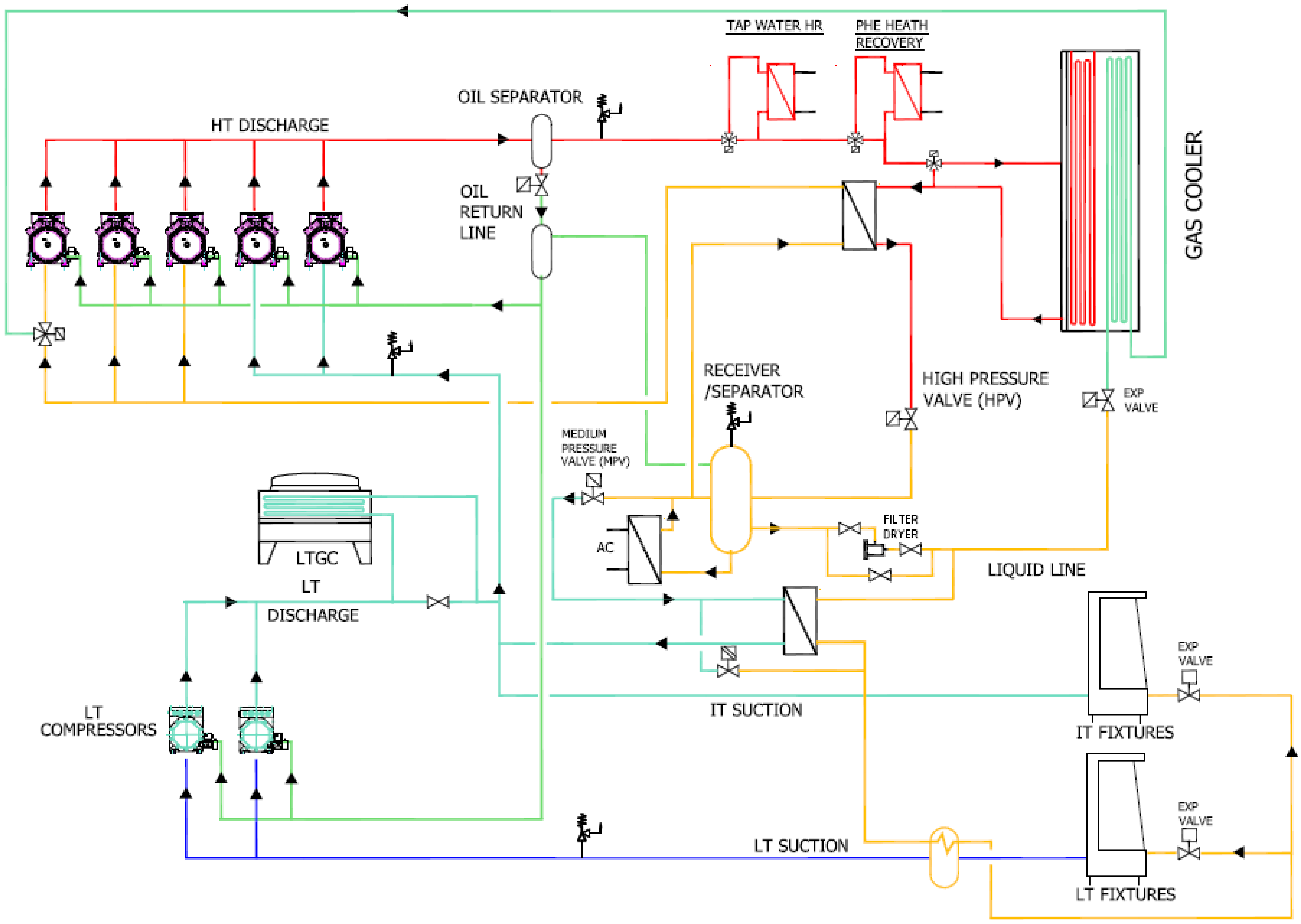
- Cooling load: 194 kW @ -9°C evaporation; 45 kW @ -36°C evaporation
- Air conditioning load: 230 KW @ water 7/12°C
- Heating load: 200 kW @ water 27/42°C

Installation South of France

Method

The energy efficiency of the integrated system is analysed in summer and winter design conditions and in monthly average temperature conditions.

Refrigeration load is considered constant throughout all months being the closed cabinet cooling demand rather insensitive to seasonal temperature variations. For winter design conditions, the refrigeration load was lowered in order to find the minimum value that allows full heat recovery considering also the activation of the back-up heat pump cycle.



Method

The tested conditions are reported in Table 1, average temperature values were calculated from Location supplied data.

The refrigeration cycles boundary conditions and controlled approach set are reported in Table 2.

The integrated system performance was compared against that of a traditional solution adopting the same R744 booster system dedicated only to refrigeration and a R410A air-cooled reversible heat pump with scroll compressors

Table 1: Test conditions.

Reference	Ambient temperature	Ambient relative humidity	MT cooling load	LT cooling load	Cooling load	Heating load
[-]	[°C]	[%]	[kW]	[kW]	[kW]	[kW]
Summer design	37.0	50	194	45	230	0
Winter design	-5.0	90	146	34	0	200
January (avg)	11.1	70	194	45	0	200
February (avg)	10.2	70	194	45	0	200
March (avg)	11.2	70	194	45	0	200
April (avg)	14.1	60	194	45	230	0
May (avg)	14.9	60	194	45	230	0
June (avg)	19.6	50	194	45	230	0
July (avg)	20.4	50	194	45	230	0
August (avg)	20.0	50	194	45	230	0
September (avg)	20.4	50	194	45	230	0
October (avg)	18.8	50	194	45	230	0
November (avg)	14.2	60	194	45	230	0
December (avg)	8.6	75	194	45	0	200

Table 2: Booster cycle boundary conditions.

	Evaporation temperature	Condensation temperature	Air inlet temperature	Approach	Water inlet temperature	Water outlet temperature	Approach
	[°C]	[°C]	[°C]	[K]	[°C]	[°C]	[K]
MT section	-9	-	37	2	-	-	-
LT section	-36	-9	-	-	-	-	-
Chiller section	4	-	37	2	12	7	3
Heat reclaim section	-9	-	-	-	38	43	3
False load heat reclaim	-15	-	-5	-	38	43	3

Results

- The integrated system can satisfy cooling and heating load in all conditions. In winter design conditions, the minimum refrigeration load necessary to satisfy the maximum heating demand is about 75%. The heating demand satisfied by heat recovery and back-up heat pump cycle.

- In winter heating months the efficiency of the integrated system is far higher than that of the traditional solution with a dedicated air-conditioning heat pump. Up to 30% efficiency improvements are guaranteed in winter months. From Figure 4 it can be observed the integrated system control rises discharge in order to improve heat recovery.

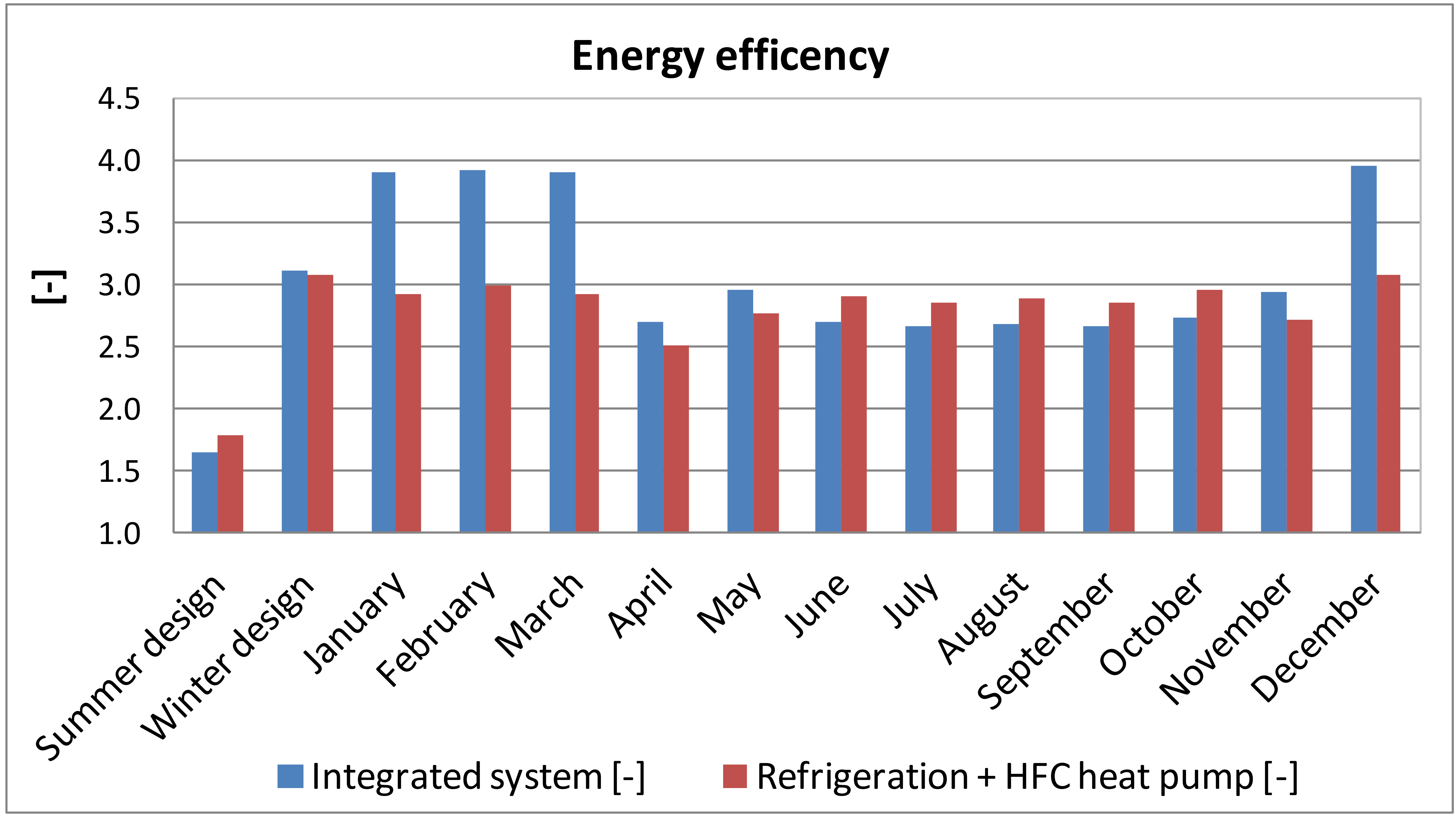


Figure 2: Overall energy efficiency.

Results

•In summer cooling conditions, the traditional solution over performs the R744 integrated unit by 8.6% in design conditions and +7.5% in August.

This is caused by the improved efficiency of R410a thermodynamic cycle at high fluid source temperatures, nevertheless the "air-conditioning" R744 cycles behaves rather well because it benefits of the refrigeration cycle parallel compression solution. This penalization would be reduced considering part load operations.

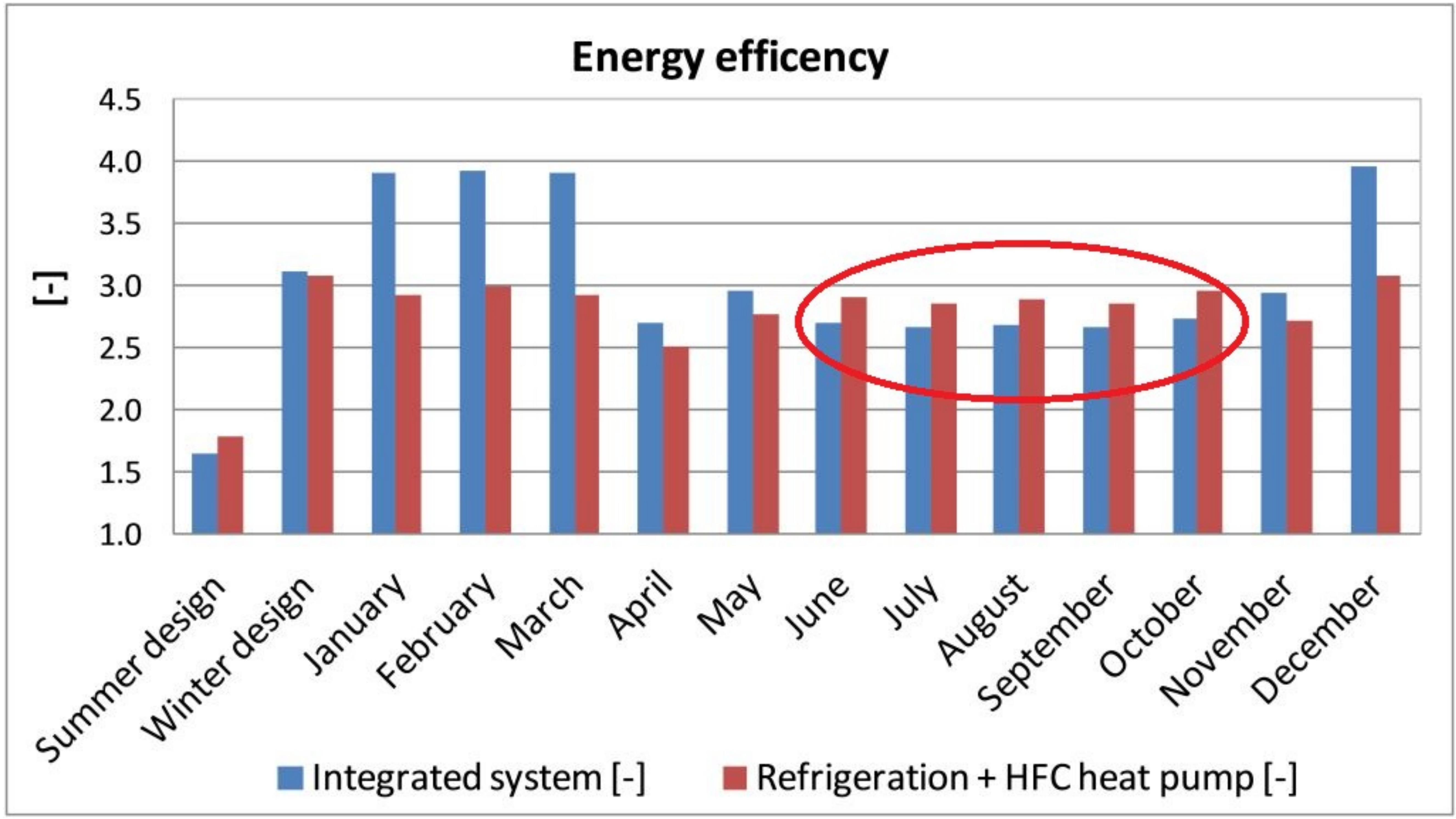


Figure 2: Overall energy efficiency.

Results

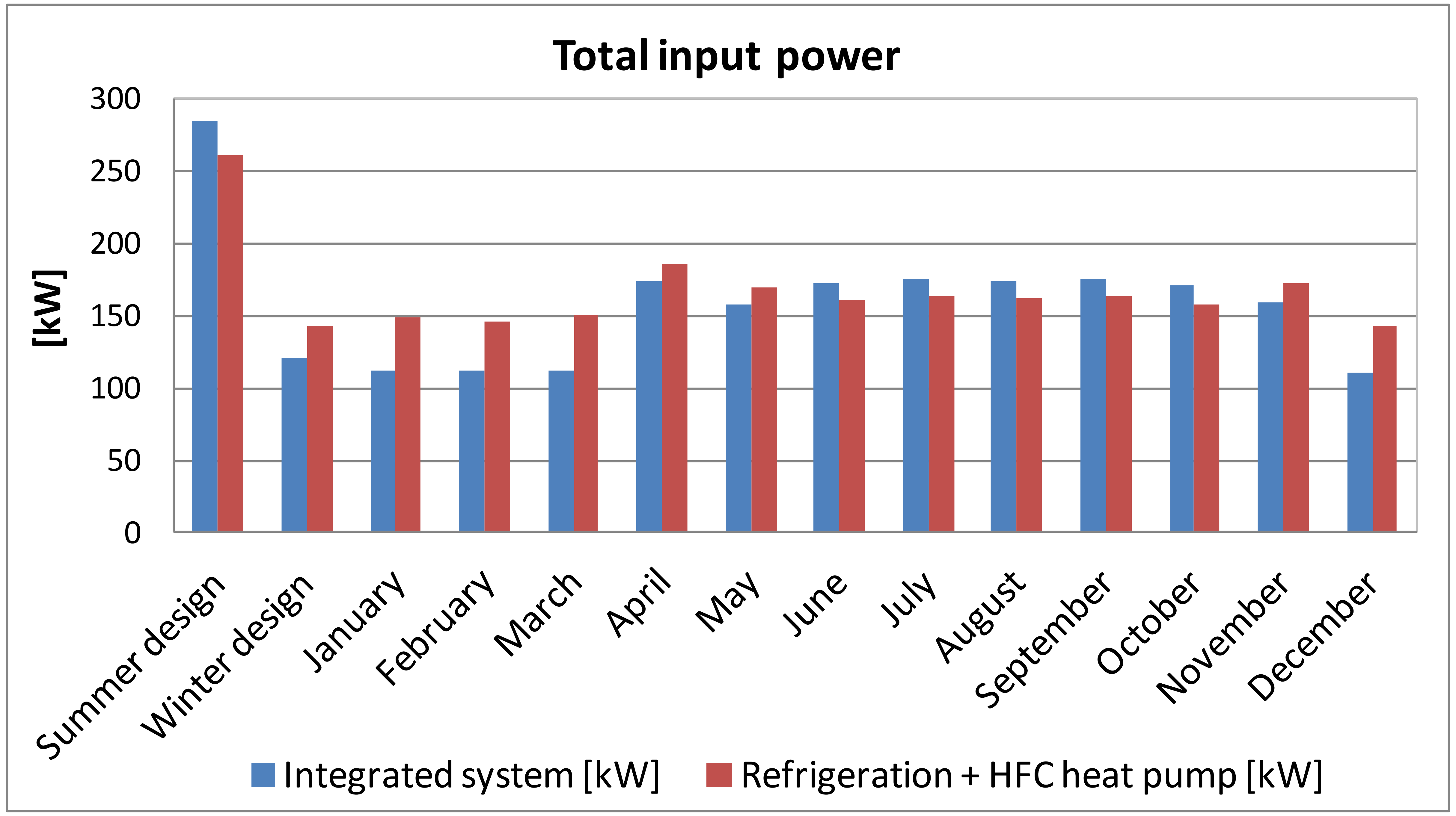


Figure 3: Overall input power.

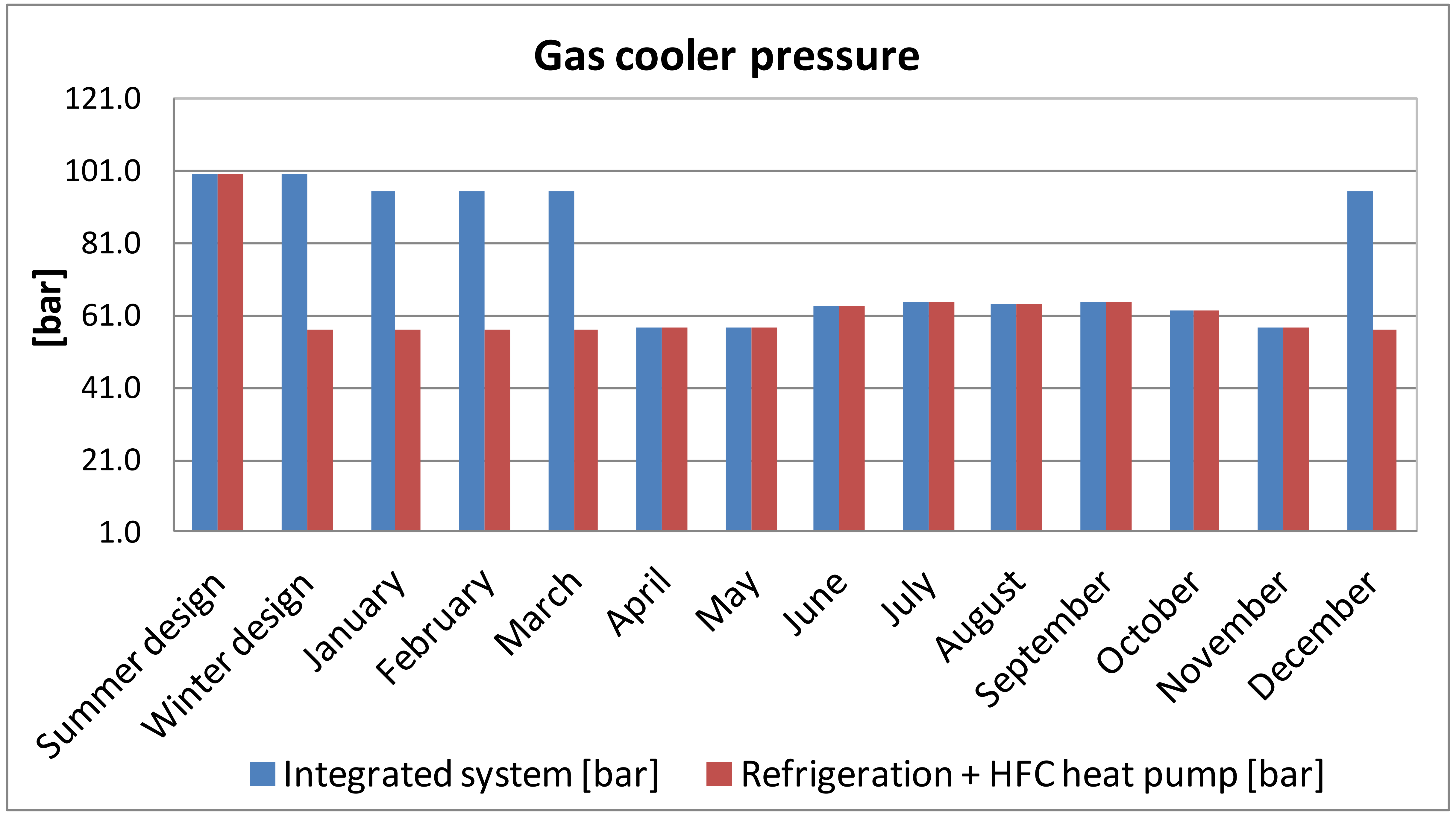


Figure 4: Booster cycle gas-cooler pressure.

Conclusions

- The integrated systems appears a convenient solution from the energy and cost point of view.

- The system is particular suited to reduce winter space heating associated cost by using total heat recovery from the refrigeration plant high pressure side.

- In summer, the integrated system energy efficiency is slightly penalised but this penalisation can be neglected considering winter strongly reduced energy cost; the lower capital and maintenance costs together with the reduced encumbrance and noise (no heat pump needed).

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Thank you very much!