



OFFICINE MARIO DORIN S.P.A.

CO₂ IN INDUSTRIAL APPLICATIONS

- **CO₂ PROVIDES SIGNIFICANT ADVANTAGES:**
 - **CO₂ MACHINERY ROOM LOOKS MUCH LEANER**
 - **UP TO 2 MW REFRIGERTION DUTIES: ALREADY POSSIBLE IN A COST EFFECTIVE WAY**



- AMMONIA MACHINERY ROOM -

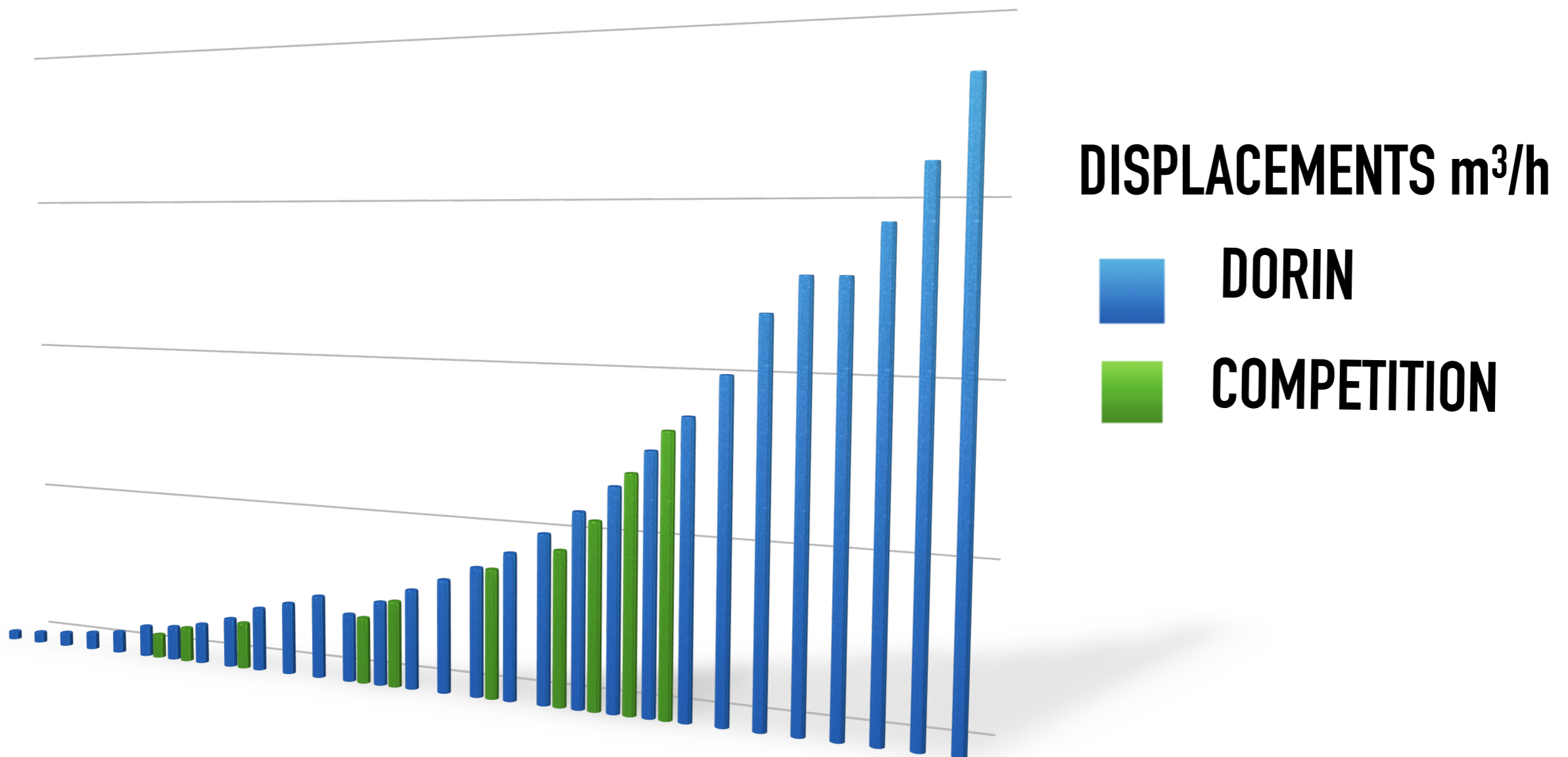


- CO₂ MACHINERY ROOM -

- **CALL FOR LARGER CO₂ COMPONENTS, ESPECIALLY VALVES AND COMPRESSORS**



- **EXAMPLE - TOTAL MT CAPACITY: 850 kW**
- **COMPETITION CO₂ COMPRESSORS**
- **(30-38) m³/h: 10-15 PIECES NEEDED**
- **N.2 RACKS - EXPENSIVE SOLUTION**
- **DORIN 6 CYL CO₂ RANGE - 60 m³/h**
- **6 PIECES ONLY ARE NEEDED**
- **N.1 RACK ONLY - SIMPLER SOLUTION**



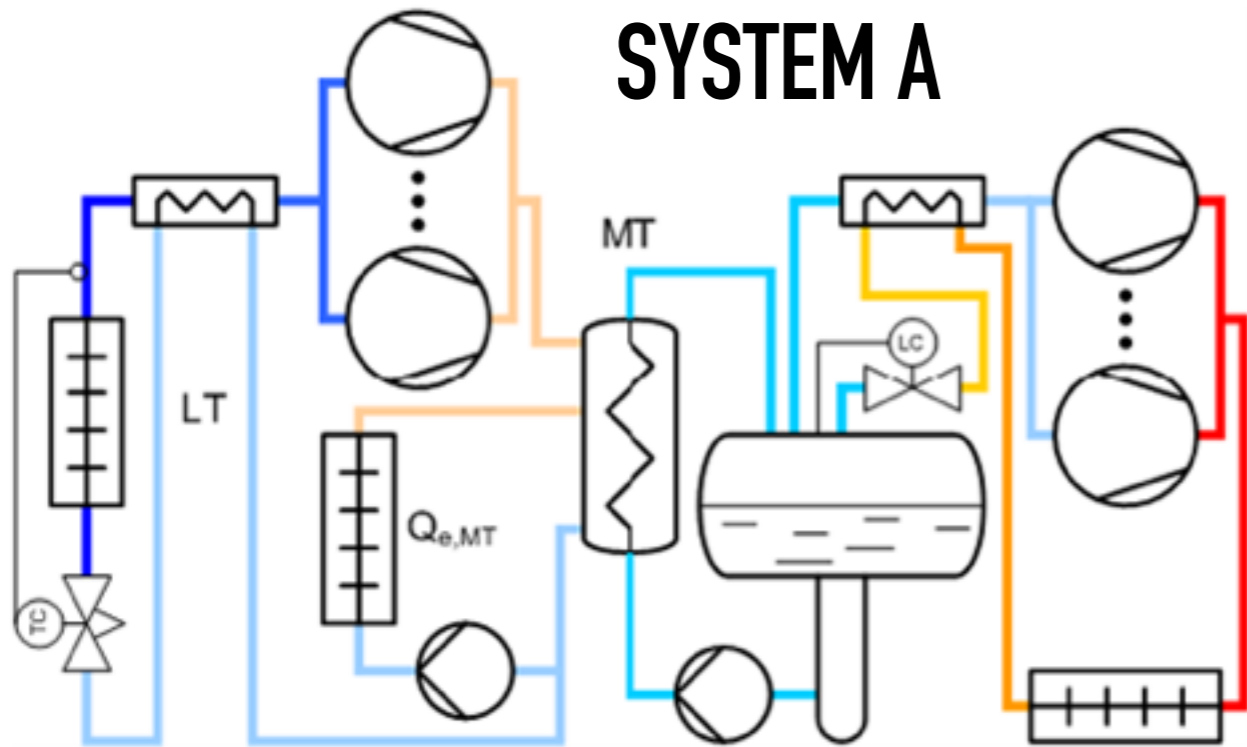
- **EXAMPLE – TOTAL MT CAPACITY: 850 kW**



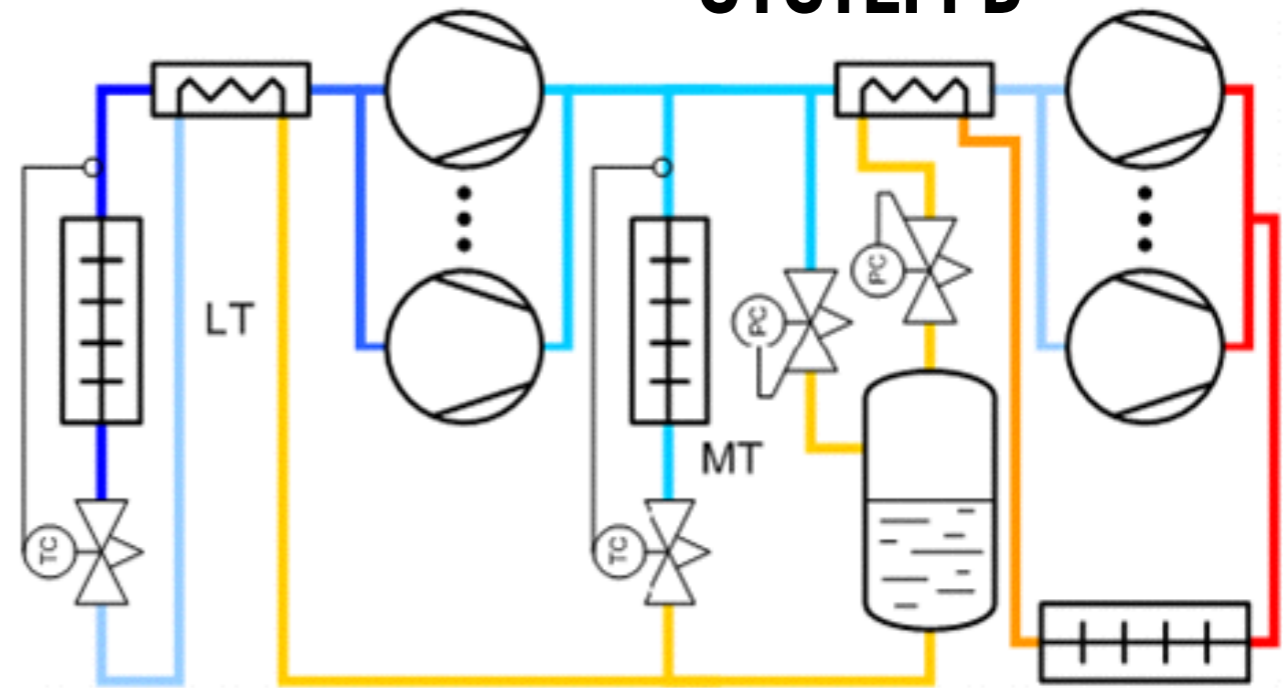
**POLAND – RACK WITH DORIN 6 CYL. TRANSCRITICAL COMPRESSORS 60 m³/h
courtesy PROFROID – GREEN & COOL**

- **COMPARISON – NH₃ vs CO₂ – SYSTEM FEATURES:**
 - **250 kW LT CAPACITY (@ -25°C)**
 - **500 kW NET MT CAPACITY (@ -12°C)**
 - **NO HEAT RECLAIM (TO BE CONSERVATIVE)**
- **SYSTEM A: CO₂ CASCADED WITH NH₃**
- **SYSTEM B: FULL CO₂ BOOSTER – FLASH GAS BYPASS (FGB)**
- **SYSTEM C: FULL CO₂ BOOSTER – PARALLEL COMPRESSION (PC)**
- **NH₃: MINIMUM T_{COND} ACCORDING TO COMPETITOR RANGE ENVELOPE**
- **CO₂: MINIMUM T_{COND} ACCORDING TO DORIN CD RANGE ENVELOPE**

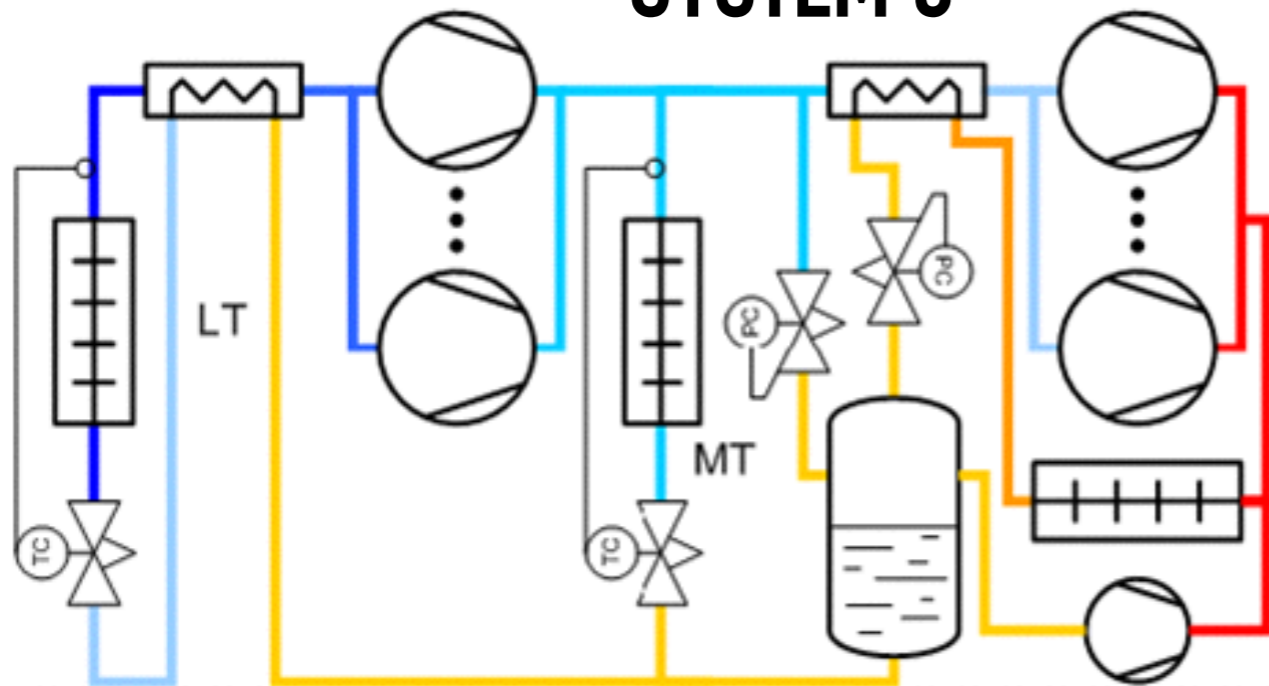
SYSTEM A



SYSTEM B



SYSTEM C



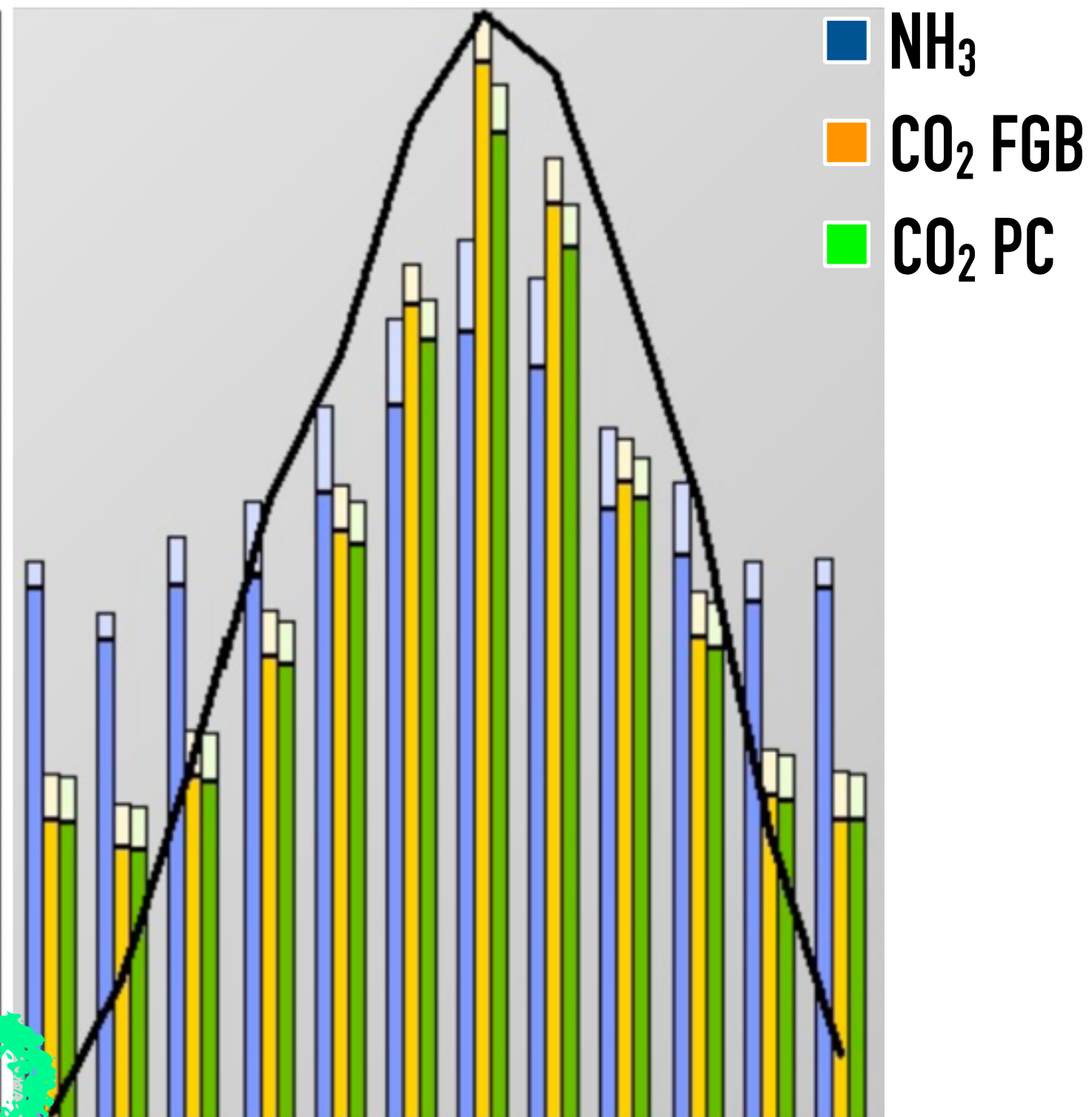
A: CO₂ CASCADED WITH NH₃

B: CO₂ - FLASH GAS BYPASS (FGB)

C: CO₂ - PARALLEL COMPRESSION (PC)

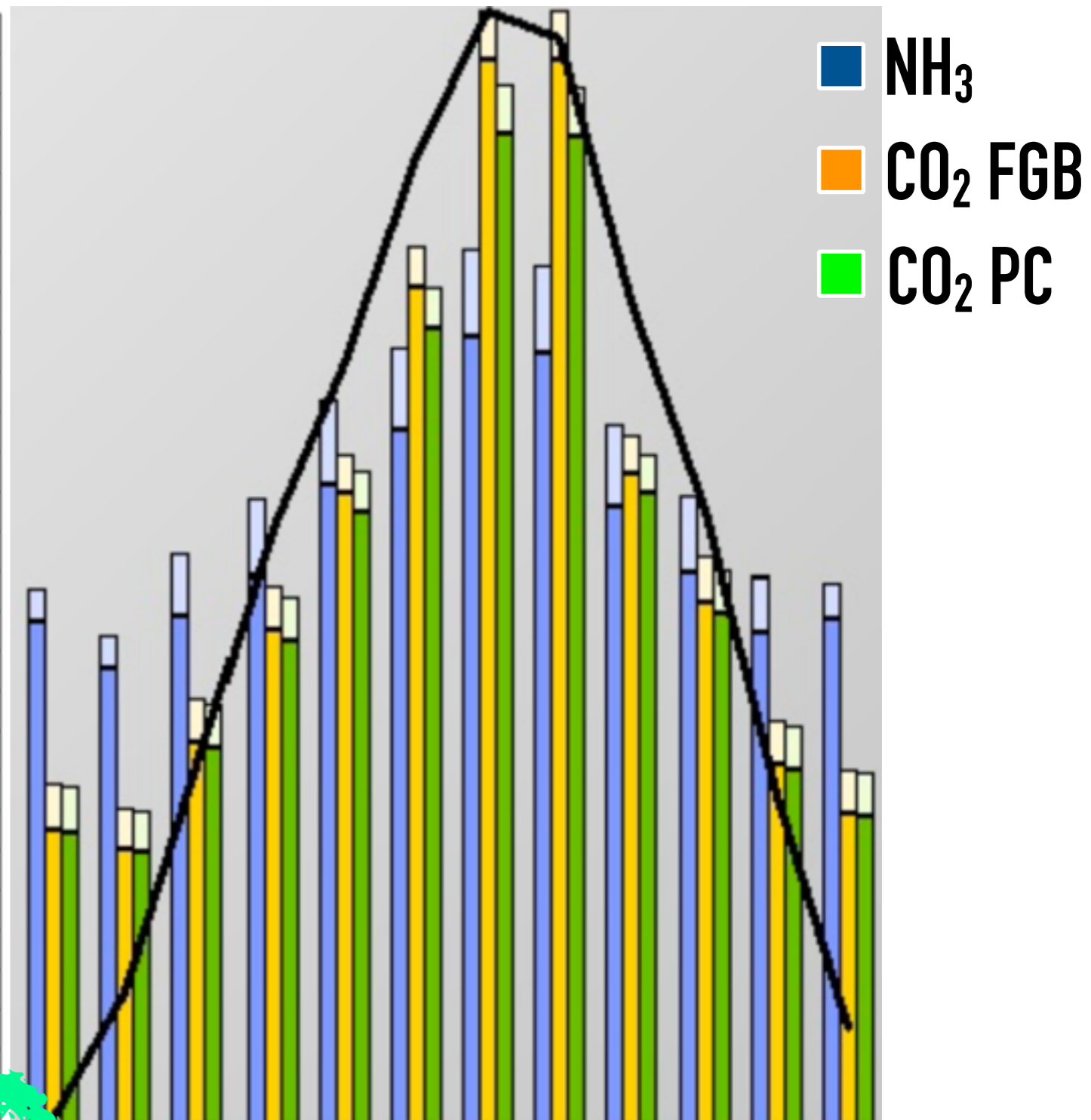
● YEARLY ENERGY & COST COMPARISON: HARBIN

	NH3 (riferimento)	CO2 FGP	CO2 PC
Soddisfacimento del carico in % del tempo			
LT:	100,0	100,0	100,0
MT:	100,0	100,0	100,0
Totale:	100,0	100,0	100,0
Soddisfacimento del carico in % di energia			
LT:	100,0	100,0	100,0
MT:	100,0	100,0	100,0
Totale:	100,0	100,0	100,0
COP medio			
LT [-]:	4,50	4,99	4,99
MT [-]:	4,24	4,76	4,98
Totale [-]:	2,64	2,97	3,07
Consumo di energia di pompe e ventilatori			
LT [kWh]:	0	0	0
MT [kWh]:	300.027	218.814	218.252
Totale [kWh]:	300.027	218.814	218.252
Consumo di energia del compressore			
LT [kWh]:	949.824	855.634	855.634
MT [kWh]:	1.937.867	1.755.289	1.337.354
Parallel [kWh]:	0	0	331.852
Totale [kWh]:	2.887.690	2.610.923	2.524.841
Consumo totale di energia			
LT [kWh]:	949.824	855.634	855.634
MT [kWh]:	2.237.894	1.974.103	1.887.459
Totale [kWh]:	3.187.718	2.829.737	2.743.093
Risparmi			
Risparmi di energia annui [kWh]:	-	357.980	444.625
Risparmi di energia annui [%]:	-	11,2	13,9



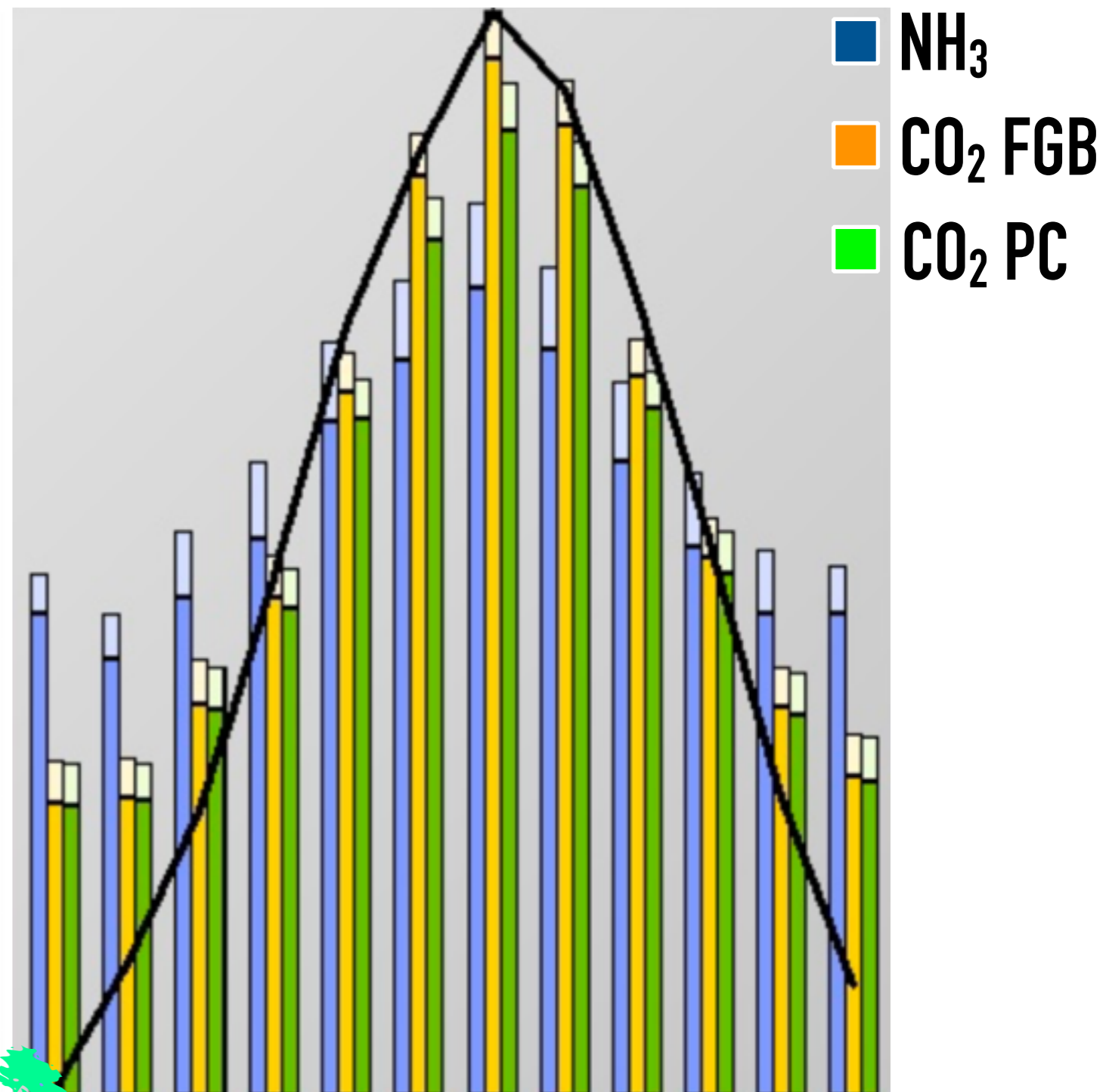
● YEARLY ENERGY & COST COMPARISON: SHENYANG

	NH3 (riferimento)	CO2 FGB	CO2 PC
Soddisfacimento del carico in % del tempo			
LT:	100,0	100,0	100,0
MT:	100,0	100,0	100,0
Totale:	100,0	100,0	100,0
Soddisfacimento del carico in % di energia			
LT:	100,0	100,0	100,0
MT:	100,0	100,0	100,0
Totale:	100,0	100,0	100,0
COP medio			
LT [-]:	4,50	4,99	4,99
MT [-]:	4,00	4,13	4,35
Totale [-]:	2,53	2,69	2,79
Consumo di energia di pompe e ventilatori			
LT [kWh]:	0	0	0
MT [kWh]:	334.480	221.549	220.996
Totale [kWh]:	334.480	221.549	220.996
Consumo di energia del compressore			
LT [kWh]:	953.553	858.994	858.994
MT [kWh]:	2.048.107	2.063.244	1.522.008
Parallel [kWh]:	0	0	426.779
Totale [kWh]:	3.001.660	2.922.238	2.807.781
Consumo totale di energia			
LT [kWh]:	953.553	858.994	858.994
MT [kWh]:	2.382.587	2.284.793	2.169.783
Totale [kWh]:	3.336.140	3.143.787	3.028.777
Risparmi			
Risparmi di energia annui [kWh]:	-	192.353	307.363
Risparmi di energia annui [%]:	-	5,8	9,2



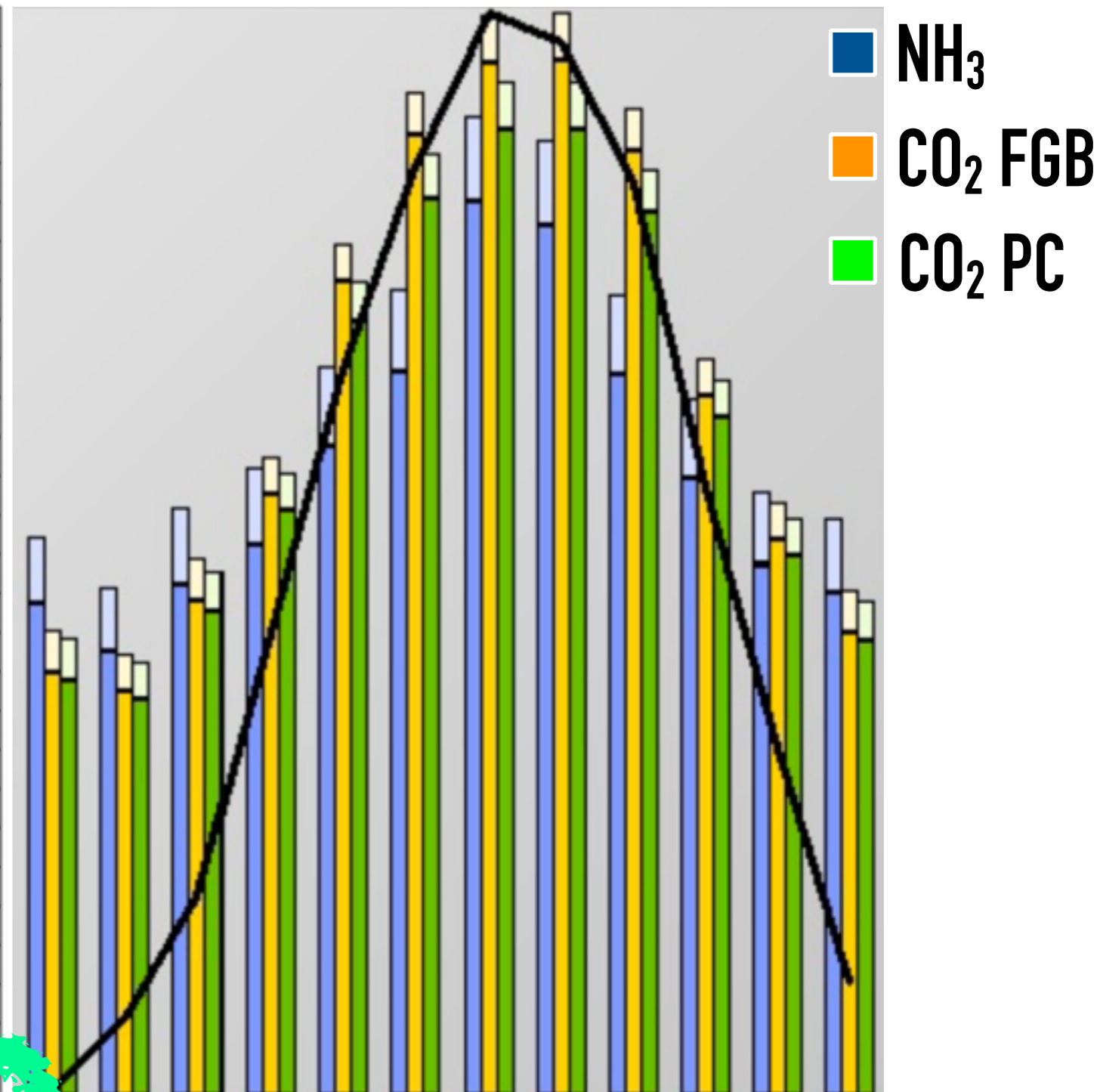
● YEARLY ENERGY & COST COMPARISON: BEIJING

	NH3 (riferimento)	CO2 FGP	CO2 PC
Soddisfaccimento del carico in % del tempo			
LT:	100,0	100,0	100,0
MT:	99,9	100,0	100,0
Totale:	99,9	100,0	100,0
Soddisfaccimento del carico in % di energia			
LT:	100,0	100,0	100,0
MT:	100,0	100,0	100,0
Totale:	100,0	100,0	100,0
COP medio			
LT [-]:	4,50	4,99	4,99
MT [-]:	3,76	3,80	4,02
Totale [-]:	2,42	2,53	2,63
Consumo di energia di pompe e ventilatori			
LT [kWh]:	0	0	0
MT [kWh]:	363.704	222.939	222.372
Totale [kWh]:	363.704	222.939	222.372
Consumo di energia del compressore			
LT [kWh]:	959.380	864.243	864.243
MT [kWh]:	2.183.475	2.276.997	1.651.856
Parallel [kWh]:	0	0	489.804
Totale [kWh]:	3.142.855	3.141.240	3.005.903
Consumo totale di energia			
LT [kWh]:	959.380	864.243	864.243
MT [kWh]:	2.547.179	2.499.936	2.364.033
Totale [kWh]:	3.506.559	3.064.179	2.928.276
Risparmi			
Risparmi di energia annui [kWh]:	-	142.381	278.283
Risparmi di energia annui [%]:	-	4,1	7,9



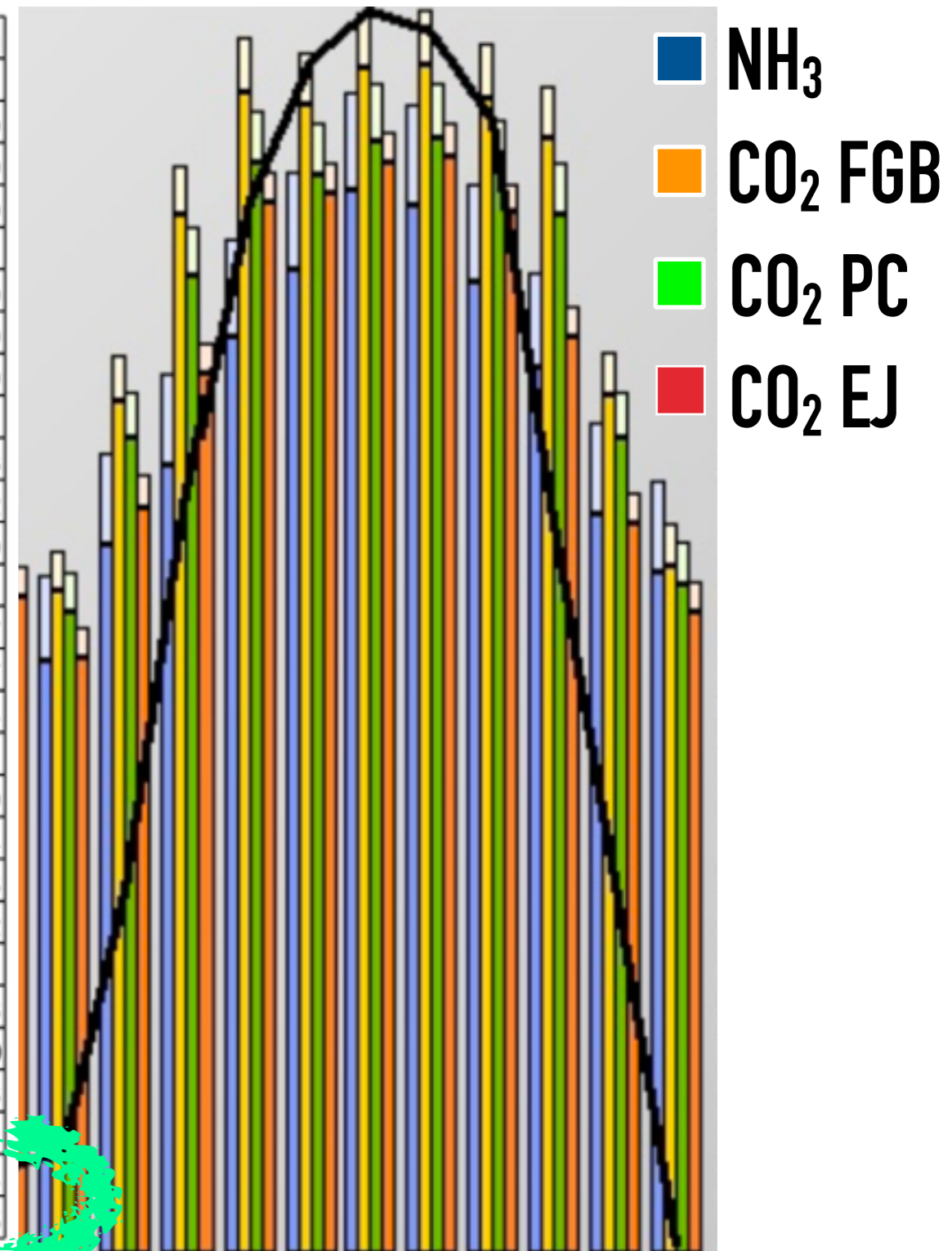
● YEARLY ENERGY & COST COMPARISON: SHANGHAI

	NH3 (riferimento)	CO2 FGP	CO2 PC
Soddisfamento del carico in % del tempo			
LT:	100,0	100,0	100,0
MT:	99,3	100,0	100,0
Totale:	99,3	100,0	100,0
Soddisfamento del carico in % di energia			
LT:	100,0	100,0	100,0
MT:	100,0	100,0	100,0
Totale:	100,0	100,0	100,0
COP medio			
LT [-]:	4,50	4,99	4,99
MT [-]:	3,48	3,09	3,28
Totale [-]:	2,29	2,16	2,26
Consumo di energia di pompe e ventilatori			
LT [kWh]:	0	0	0
MT [kWh]:	405.482	221.790	221.156
Totale [kWh]:	405.482	221.790	221.156
Consumo di energia del compressore			
LT [kWh]:	965.922	870.136	870.136
MT [kWh]:	2.363.945	2.867.603	2.014.956
Parallel [kWh]:	0	0	680.546
Totale [kWh]:	3.329.867	3.737.739	3.565.638
Consumo totale di energia			
LT [kWh]:	965.922	870.136	870.136
MT [kWh]:	2.769.428	3.089.393	2.916.658
Totale [kWh]:	3.735.350	3.969.529	3.786.794
Risparmi			
Risparmi di energia annui [kWh]:	-	-224.179	-51.444
Risparmi di energia annui [%]:	-	-6,0	1,4



● YEARLY ENERGY & COST COMPARISON: GUANGZHOU

	NH3 (riferimento)	CO2 FGP	CO2 PC	CO2 PC EV COND
Soddisfacimento del carico in % del tempo				
LT:	100,0	100,0	100,0	100,0
MT:	99,5	100,0	100,0	100,0
Totale:	99,5	100,0	100,0	100,0
Soddisfacimento del carico in % di energia				
LT:	100,0	100,0	100,0	100,0
MT:	100,0	100,0	100,0	100,0
Totale:	100,0	100,0	100,0	100,0
COP medio				
LT [-]:	4,50	4,99	4,99	4,28
MT [-]:	3,01	2,55	2,72	3,12
Totale [-]:	2,05	1,85	1,95	2,10
Consumo di energia di pompe e ventilatori				
LT [kWh]:	0	0	0	807
MT [kWh]:	430.083	227.491	226.996	140.227
Totale [kWh]:	430.083	227.491	226.996	141.034
Consumo di energia del compressore				
LT [kWh]:	986.424	888.605	888.605	1.035.769
MT [kWh]:	2.844.992	3.606.903	2.409.351	2.372.674
Parallel [kWh]:	0	0	953.447	604.418
Totale [kWh]:	3.831.416	4.495.508	4.251.403	4.012.862
Consumo totale di energia				
LT [kWh]:	986.424	888.605	888.605	1.036.576
MT [kWh]:	3.275.075	3.834.394	3.589.794	3.117.319
Totale [kWh]:	4.261.499	4.722.999	4.251.403	4.153.896
Risparmi				
Risparmi di energia annui [kWh]:	-	-461.500	-216.900	107.604
Risparmi di energia annui [%]:	-	-10,8	-5,1	2,5



● YEARLY ENERGY & COST COMPARISON (0.5 RMB / kWh)



- CO₂ (-222.312 RMB/YEAR)
- CO₂ (-153.681 RMB/YEAR)
- CO₂ (-139.141 RMB/YEAR)
- CO₂ (-25.722 RMB/YEAR)*
- * PC REQUIRED
- CO₂ (-13.802 RMB/YEAR)**
- ** EJECTORS REQUIRED

- **INDUSTRIAL REFRIGERATION**

- **HFCs – WILL DISAPPEAR**

- **AMMONIA – NICE BUT BUT WITH SOME HEADACHES**

- **CO₂ PLAYS AN IMPORTANT ROLE THANKS TO:**

- **AVAILABILITY OF LARGE COMPRESSORS**

- **INTERESTING PERFORMANCE FIGURES AT ANY LATITUDE**

- **EASIER AND OFTEN MORE COST EFFECTIVE**

- **BETTER PERFORMANCES WITH HEAT RECOVERY AND INTEGRATION**



Business Case for
Natural Refrigerants

11-12/04/2018 – Beijing

Thank you very much!

