

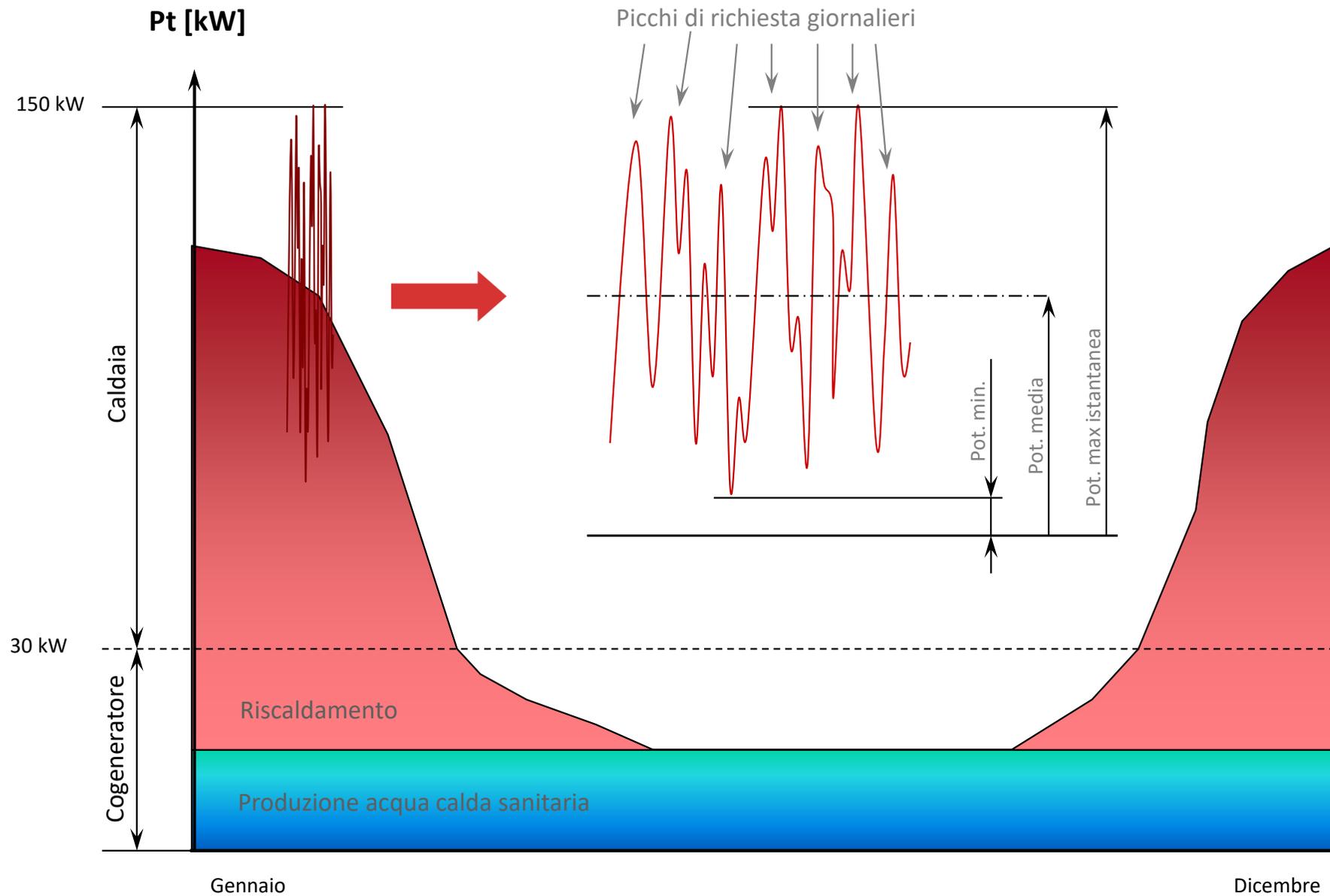
# **SISTEMI ENERGETICI COGENERATIVI**

**La trigenerazione:  
motivazioni e tecnologie**

**Prof. Pier Ruggero Spina**

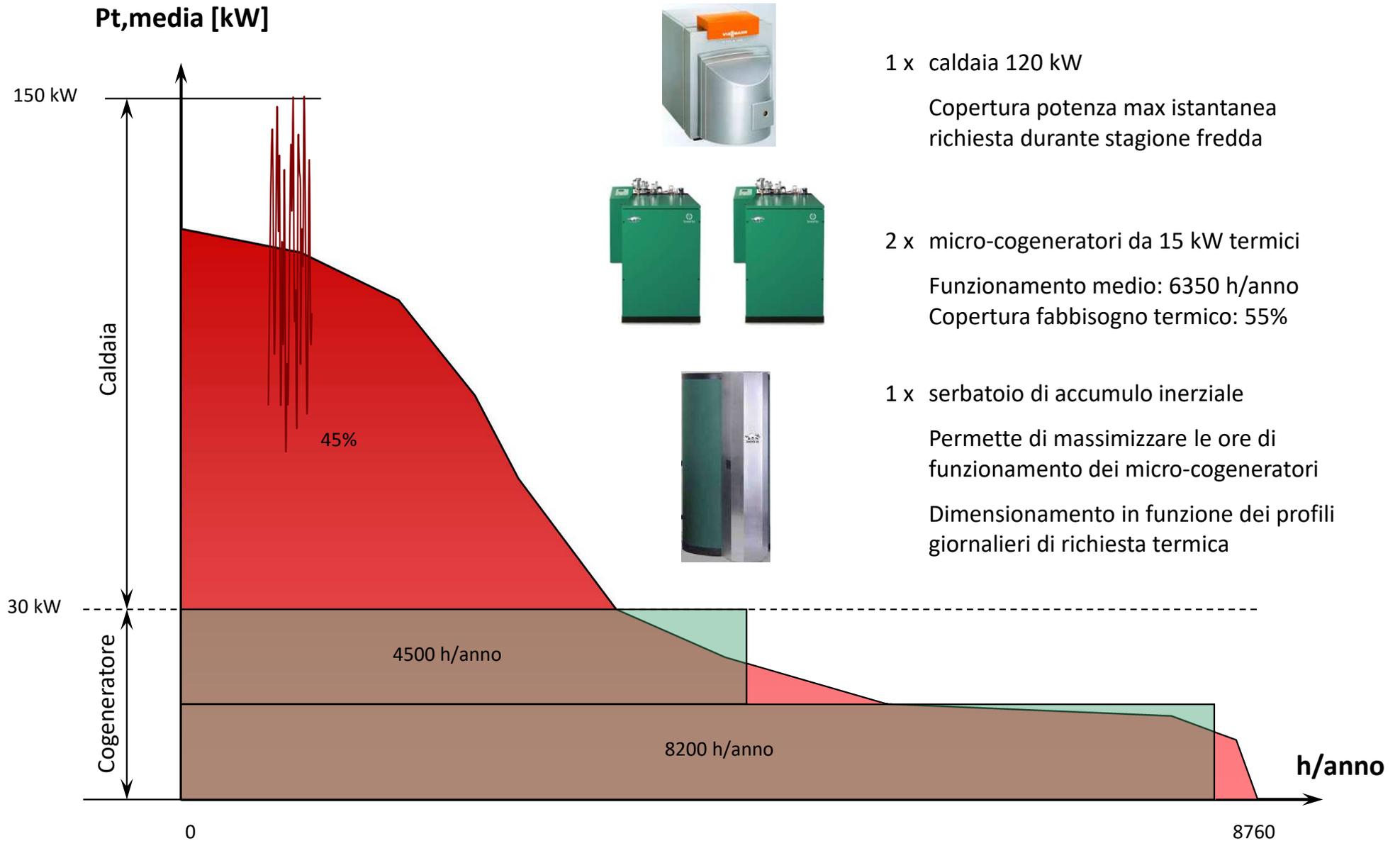
**Dipartimento di Ingegneria - Università di Ferrara**

# Il fabbisogno termico



**Potenza termica richiesta**

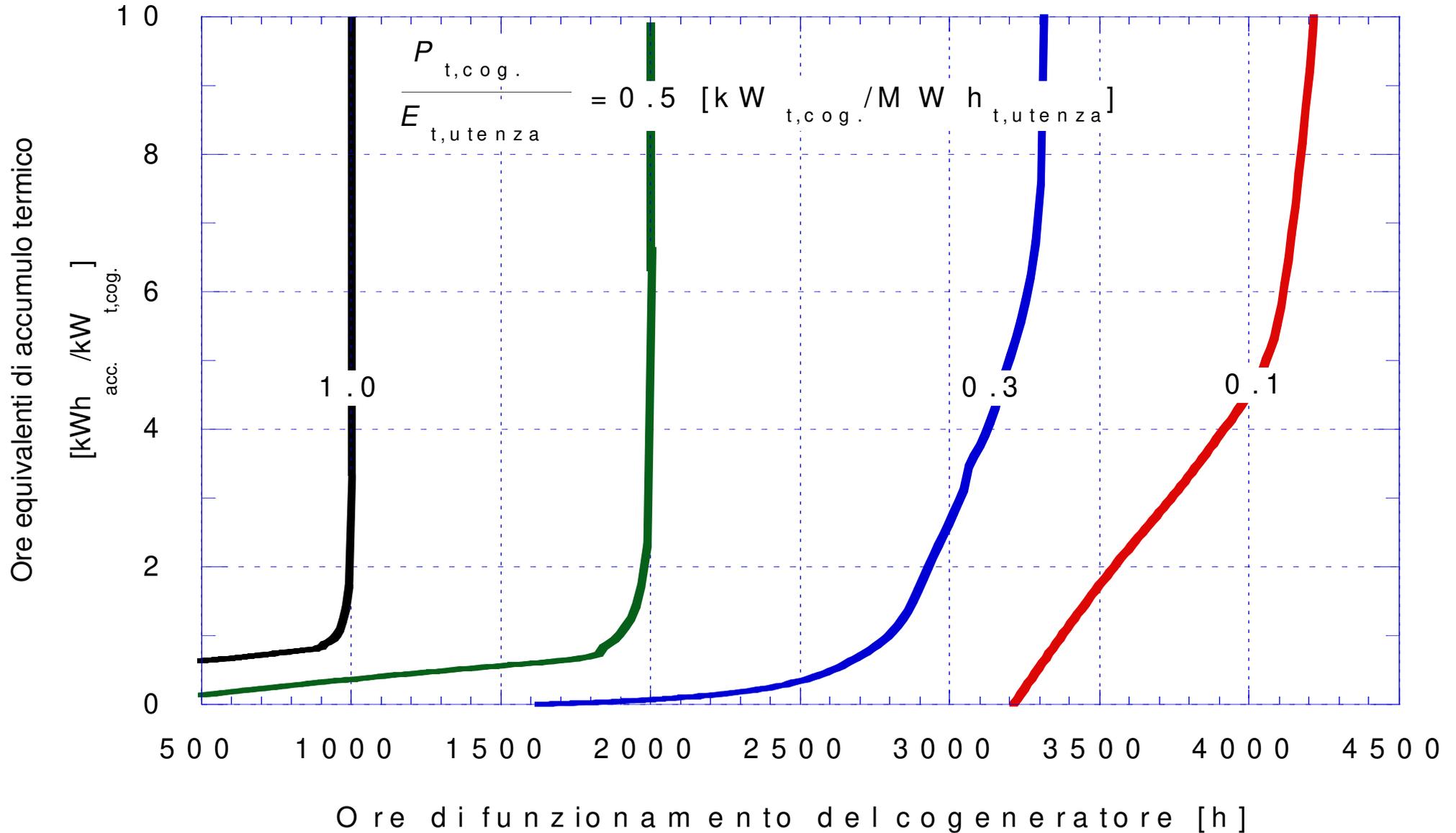
# Copertura del fabbisogno termico



**Curva cumulata**

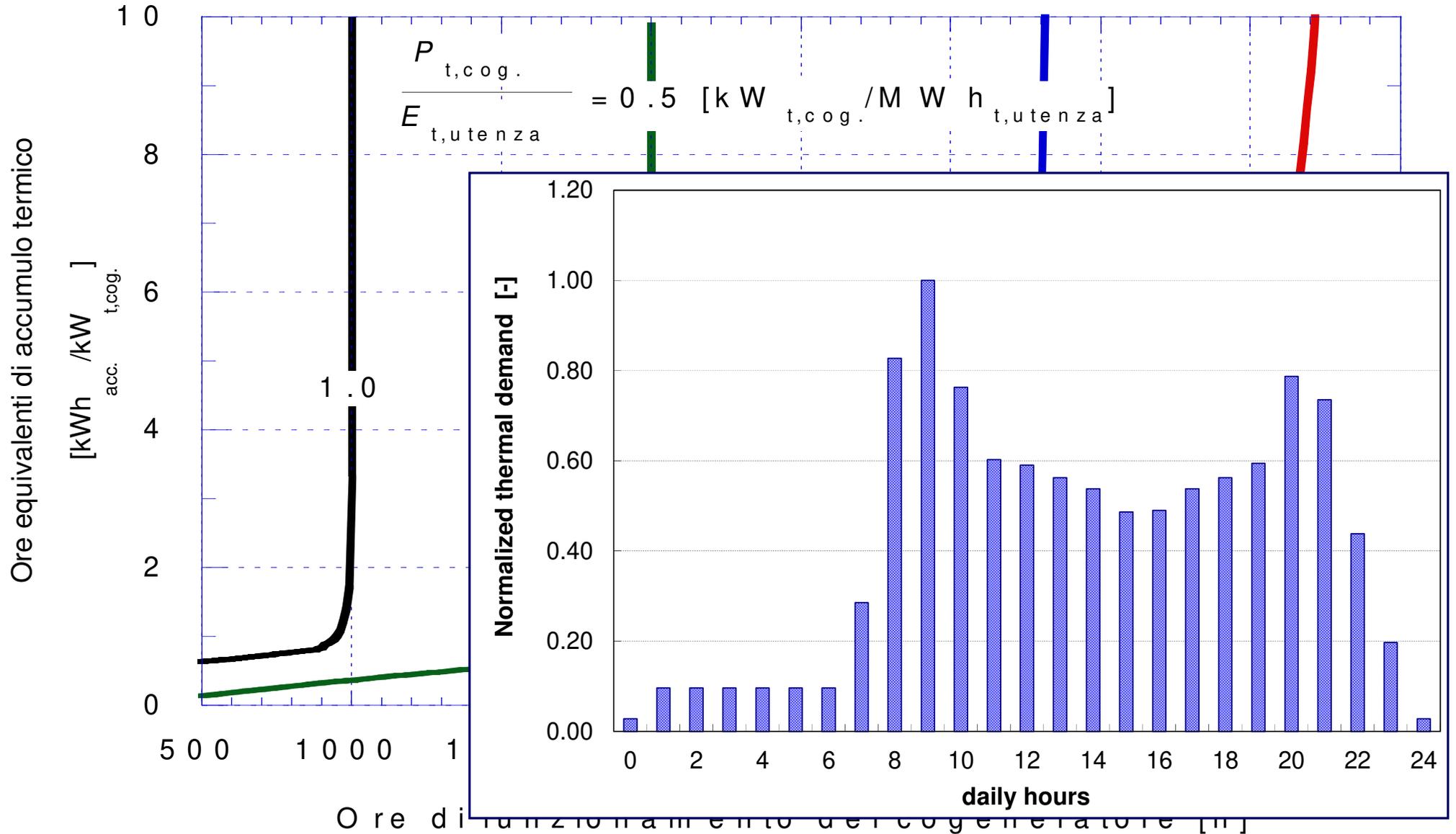
# Ruolo dell'accumulo termico

(zona climatica E)



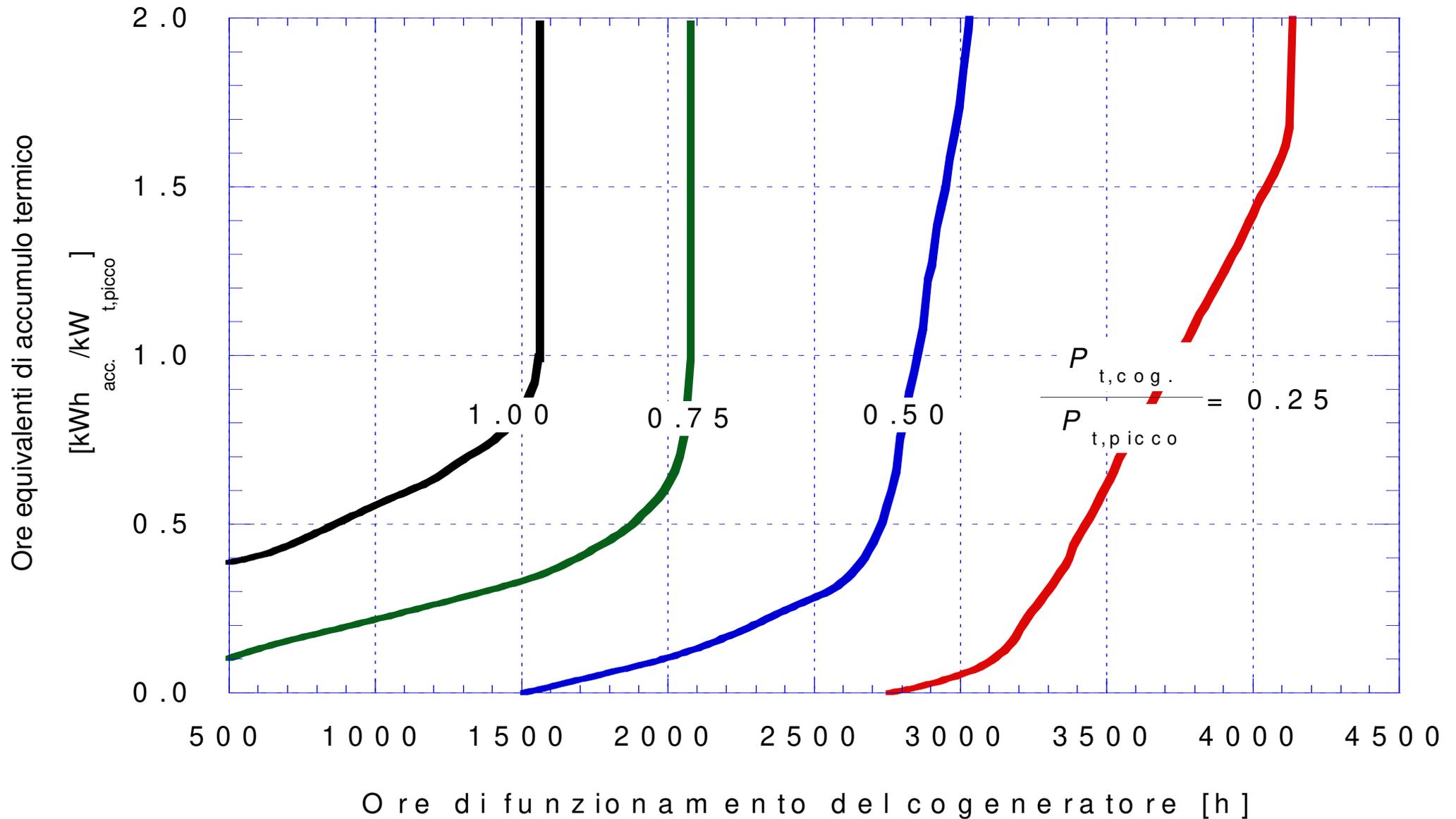
# Ruolo dell'accumulo termico

(zona climatica E)

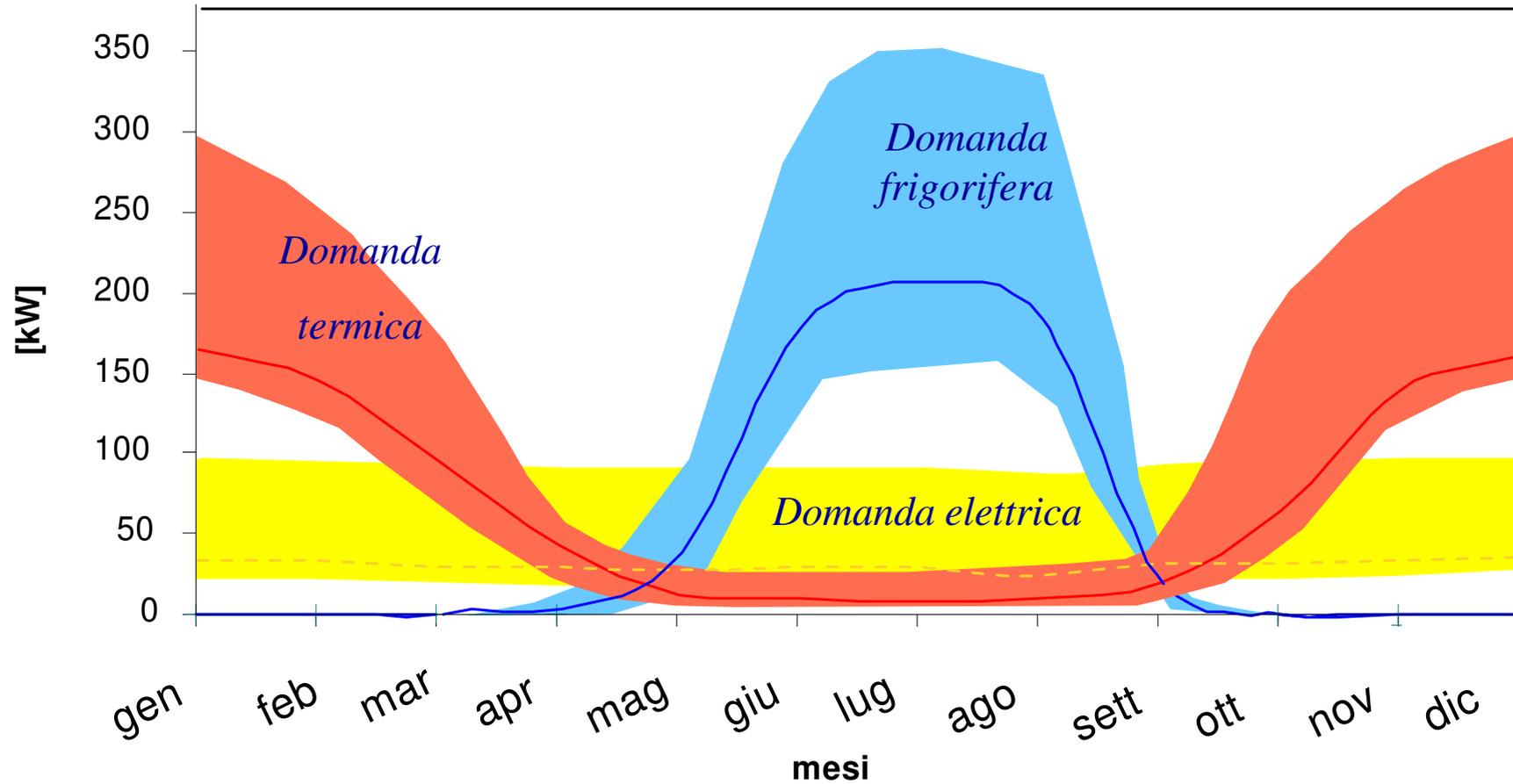


# Ruolo dell'accumulo termico

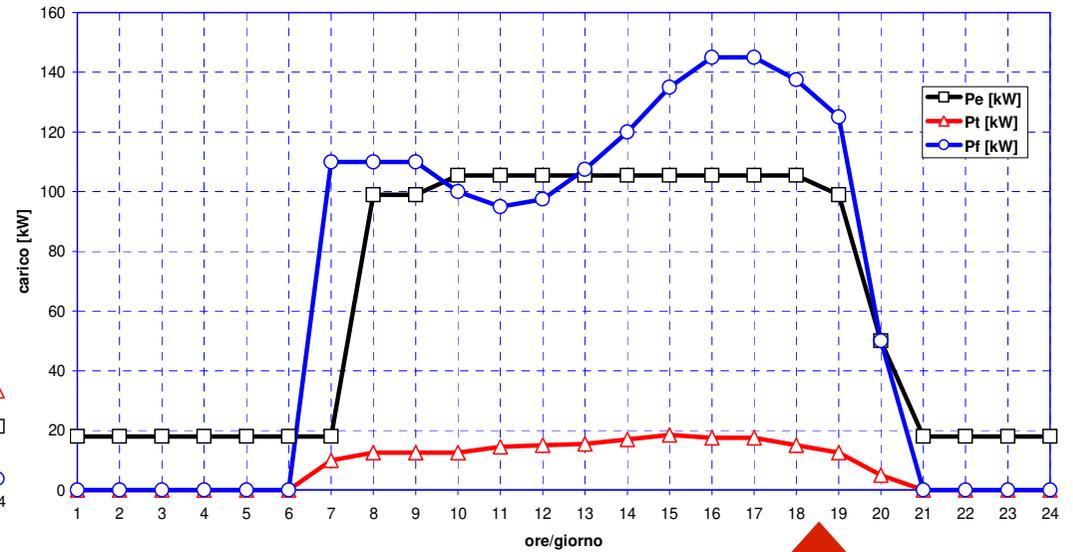
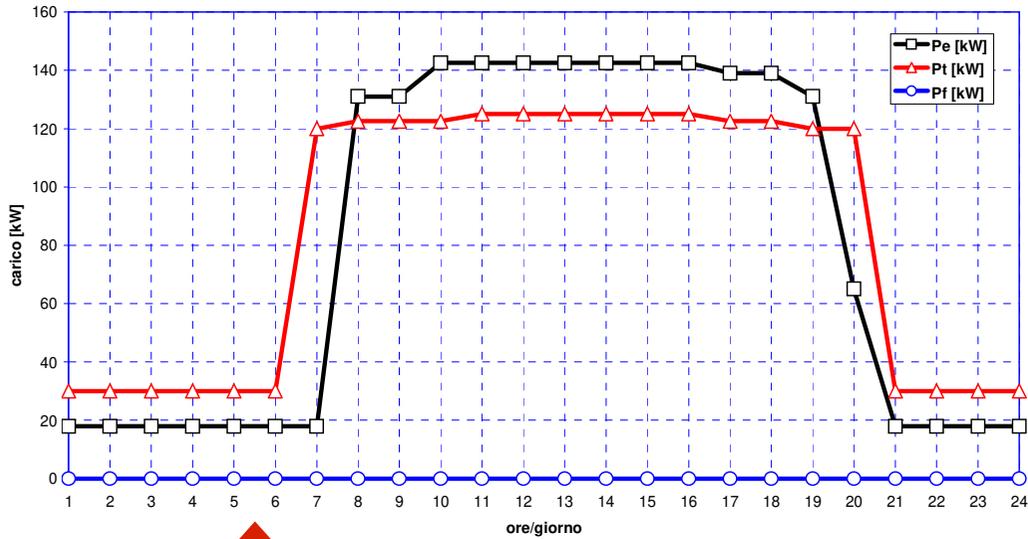
(zona climatica E)



# Trigenerazione: la necessità

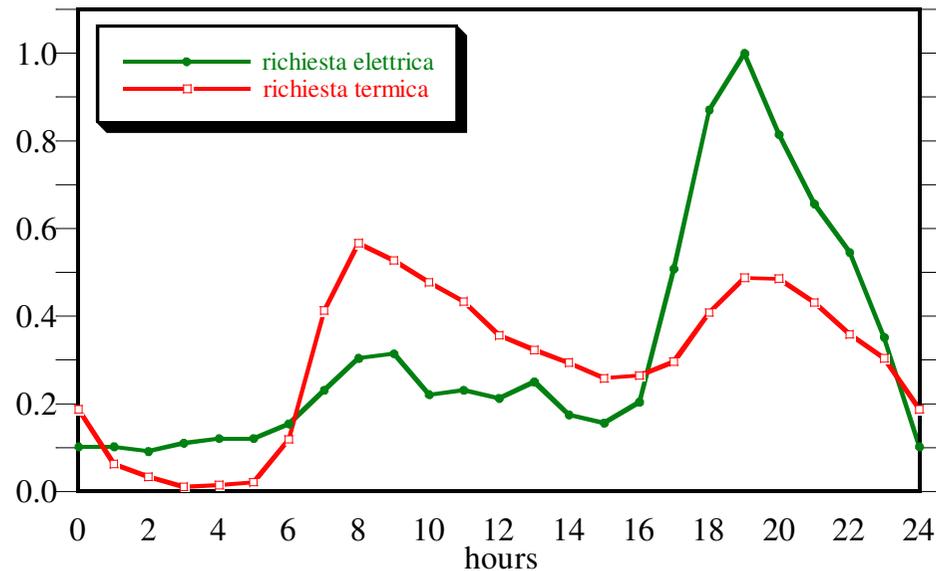


# Trigenerazione: la variabilità del carico



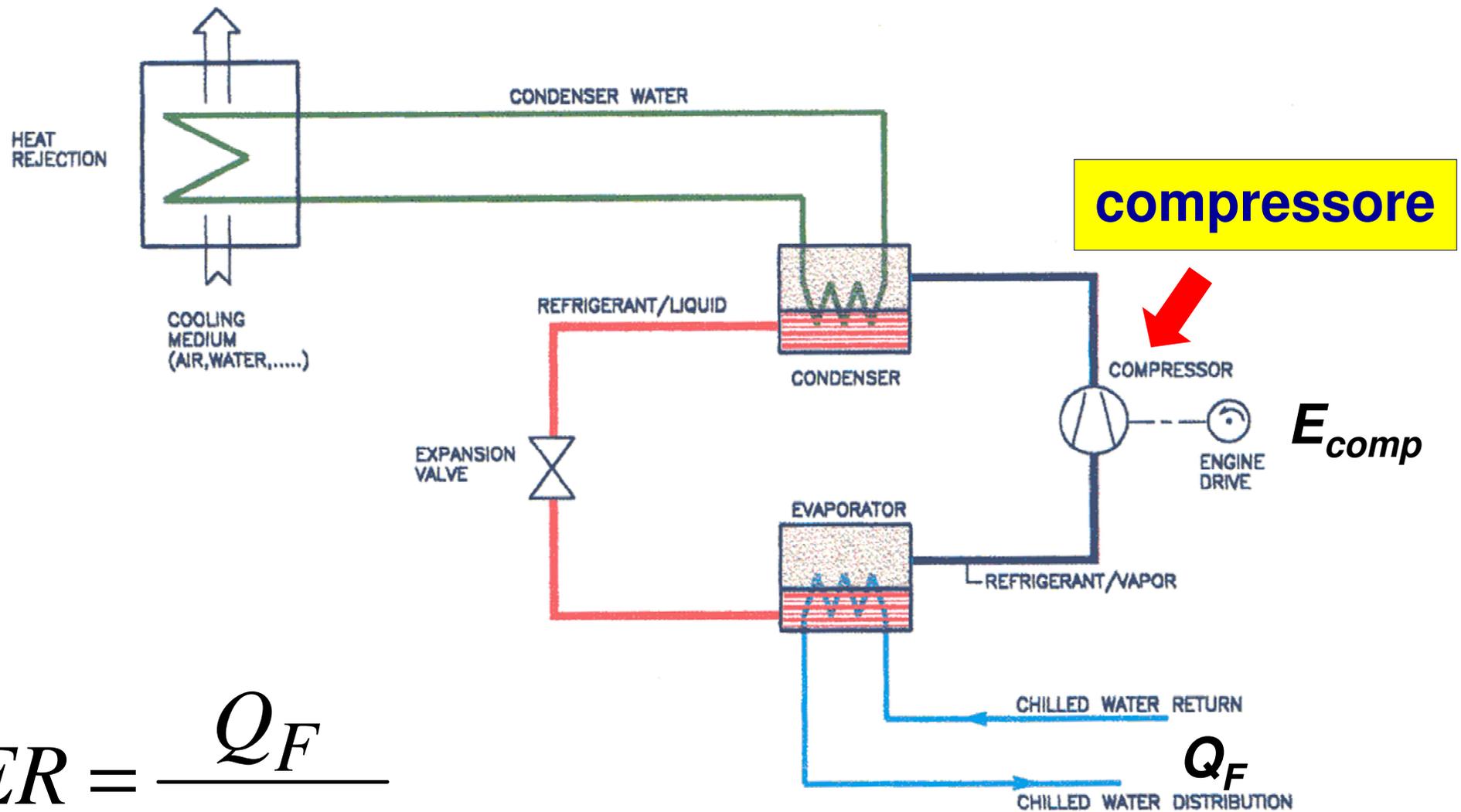
**utenza nel  
terziario  
(inverno)**

**utenza nel  
civile  
(inverno)**



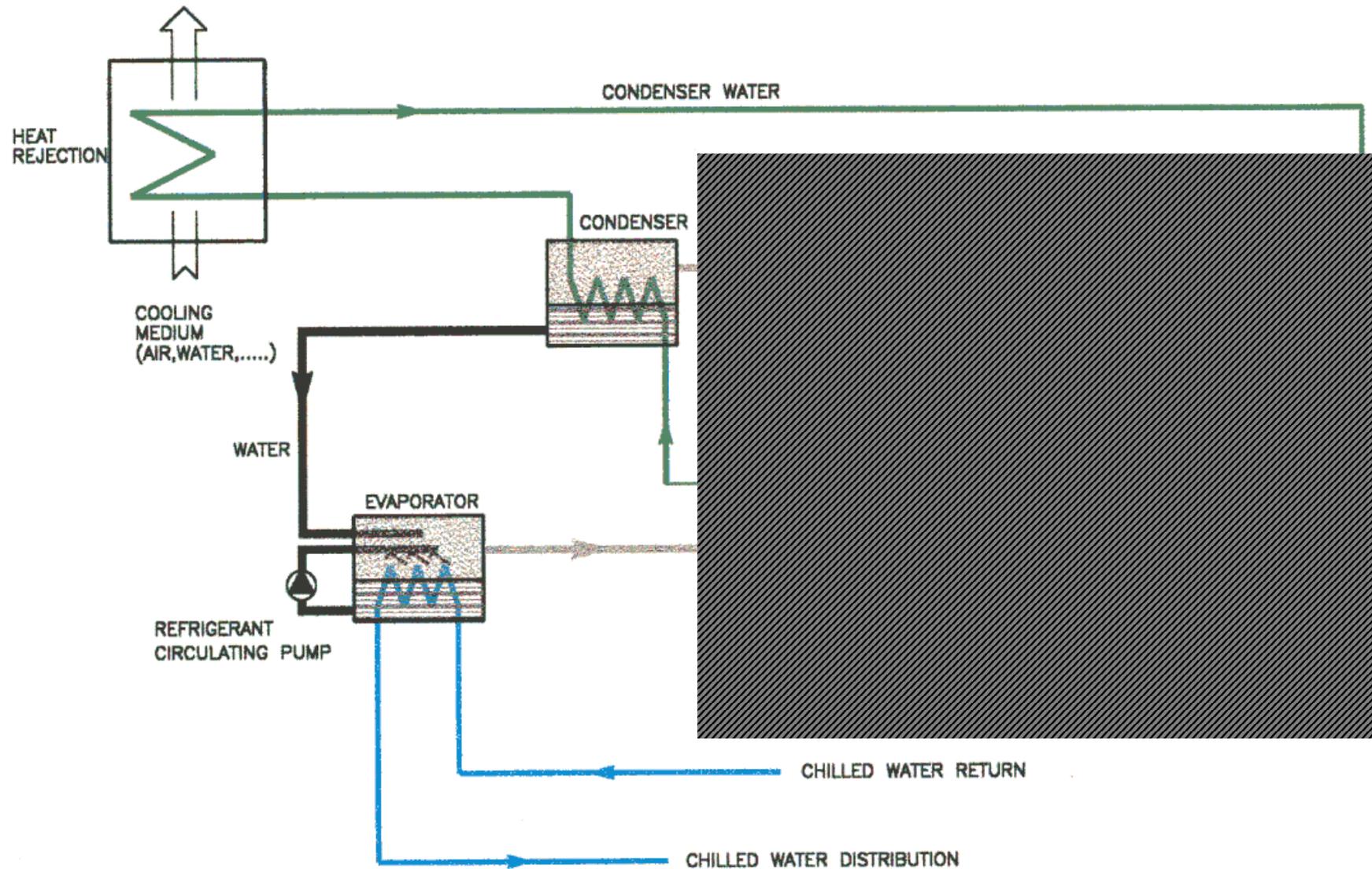
**utenza nel  
terziario  
(estate)**

# Trigenerazione: gli impianti Frigorifero a compressione

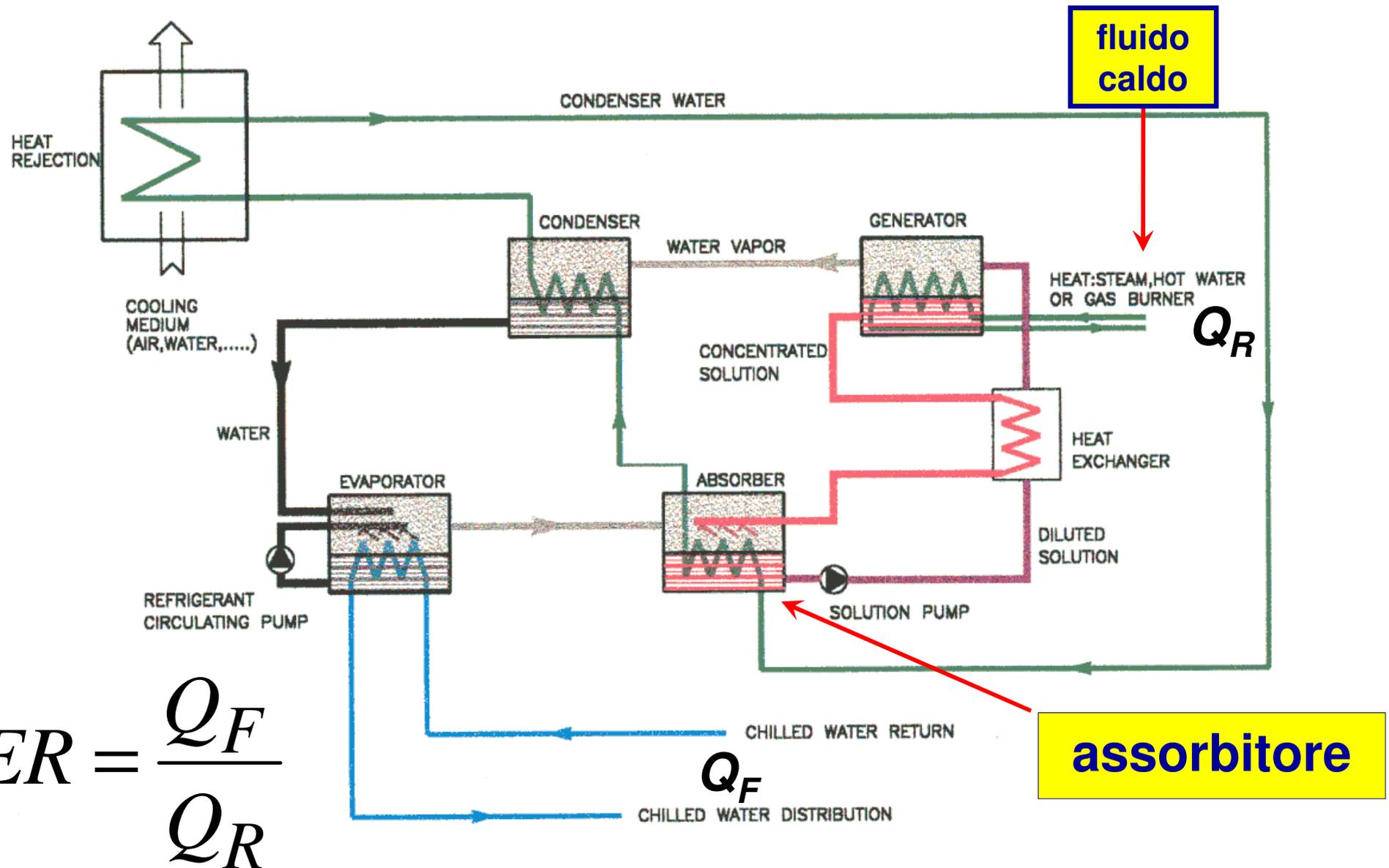


$$EER = \frac{Q_F}{E_{comp}}$$

# Trigenerazione: gli impianti Frigorifero ad assorbimento

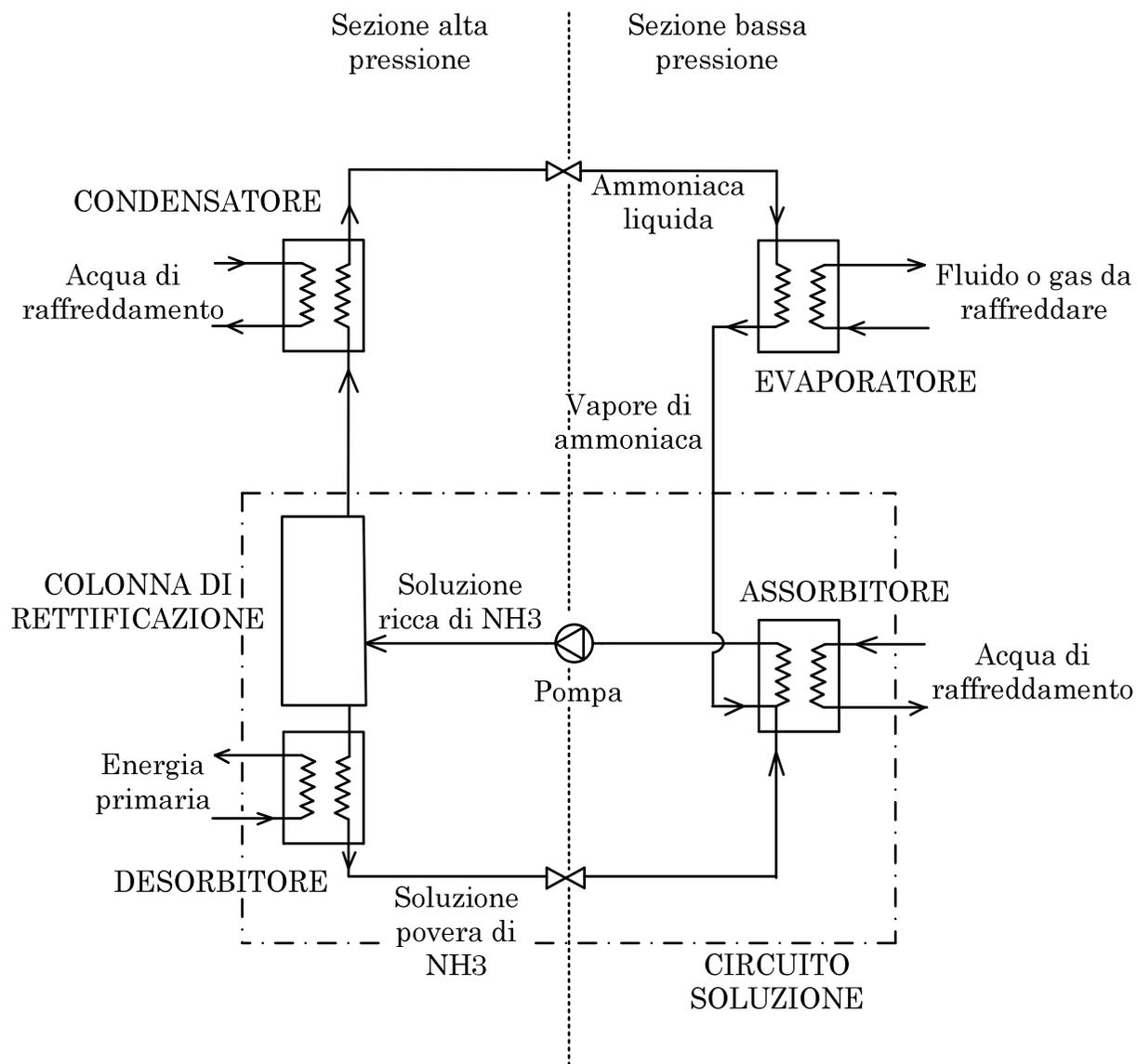


# Trigenerazione: gli impianti Frigorifero ad assorbimento

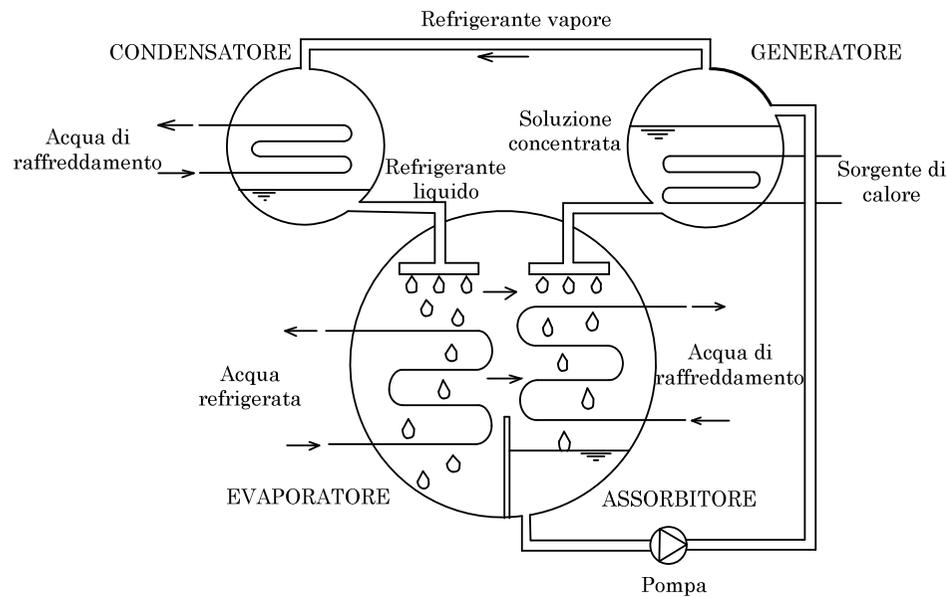


$$EER = \frac{Q_F}{Q_R}$$

# Frigoriferi ad assorbimento ammoniaca-acqua ( $NH_3-H_2O$ ) (temp. refrigerante fino a $-40 \div -60 \text{ } ^\circ\text{C}$ )



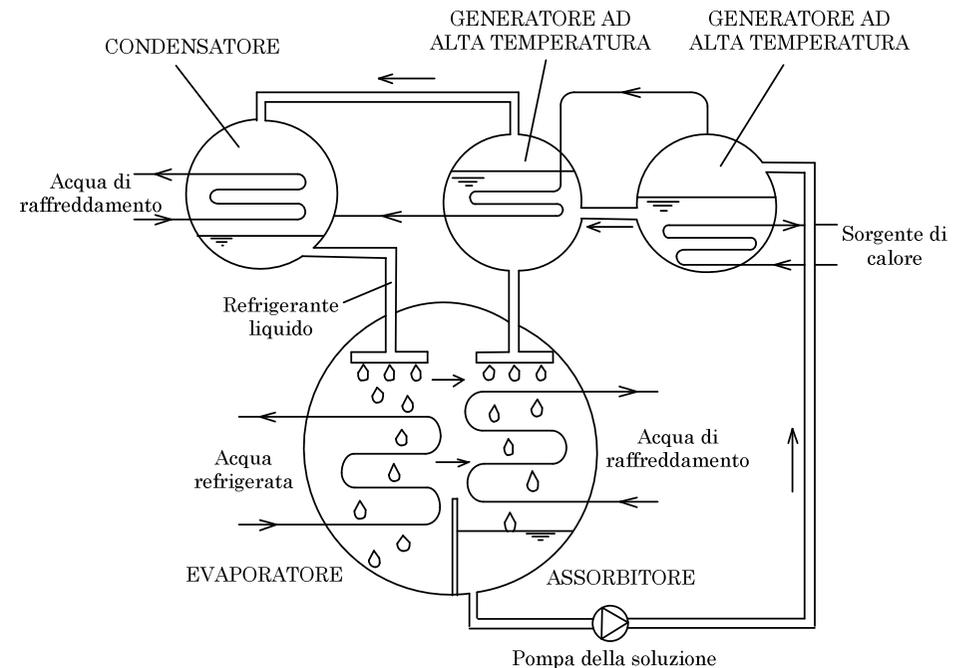
# **Frigoriferi ad assorbimento acqua-bromuro di litio ( $H_2O-BrLi$ ) (temperatura refrigerante $> 0\text{ }^\circ\text{C}$ )**



## **Semplice effetto**

$$T_{\text{sorgente calore}} \approx 60 \div 130\text{ }^\circ\text{C}$$

$$\text{EER} \approx 0.60 \div 0.75$$

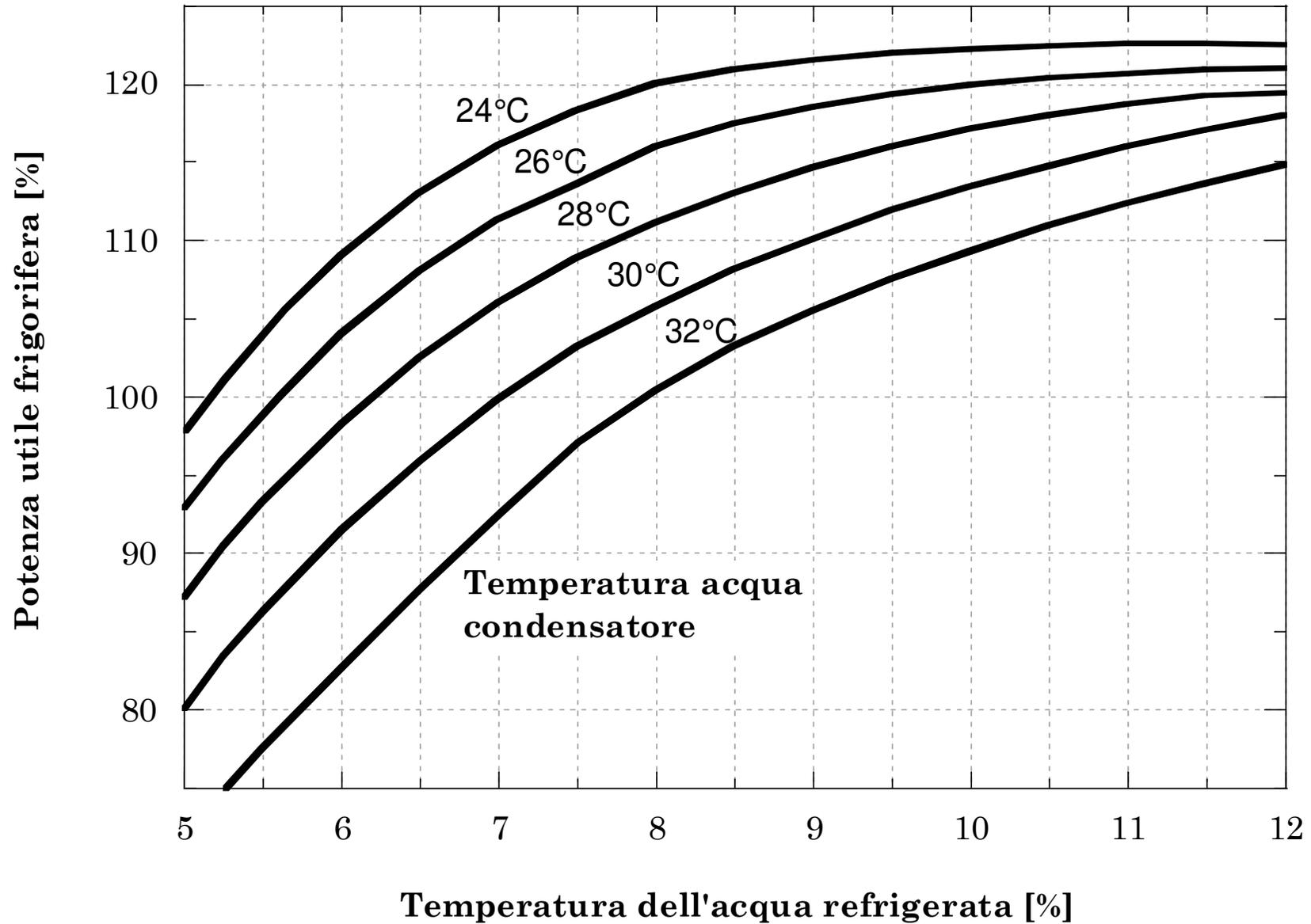


## **Doppio effetto**

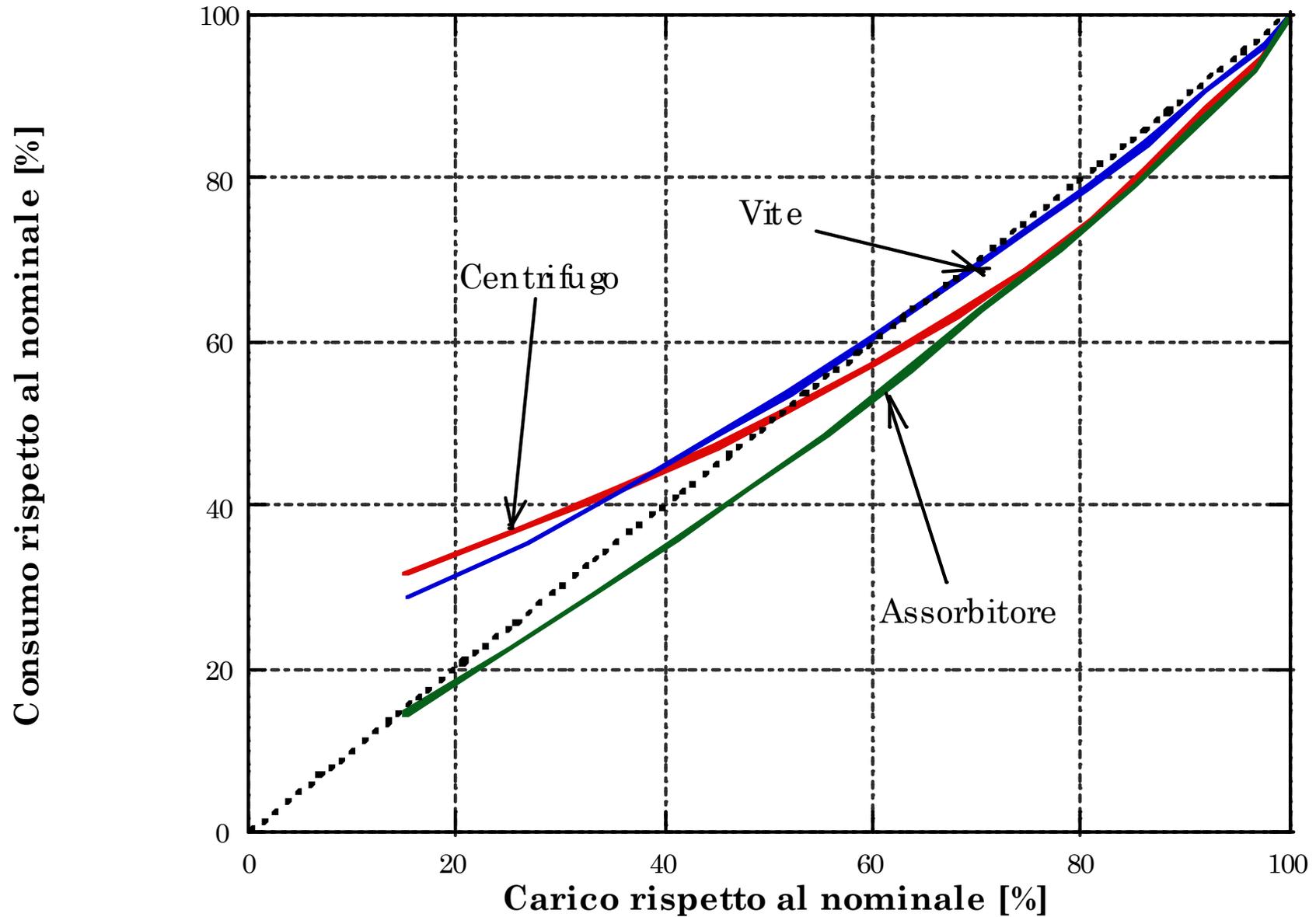
$$T_{\text{sorgente calore}} \approx 150 \div 200\text{ }^\circ\text{C}$$

$$\text{EER} \approx 1.1 \div 1.3$$

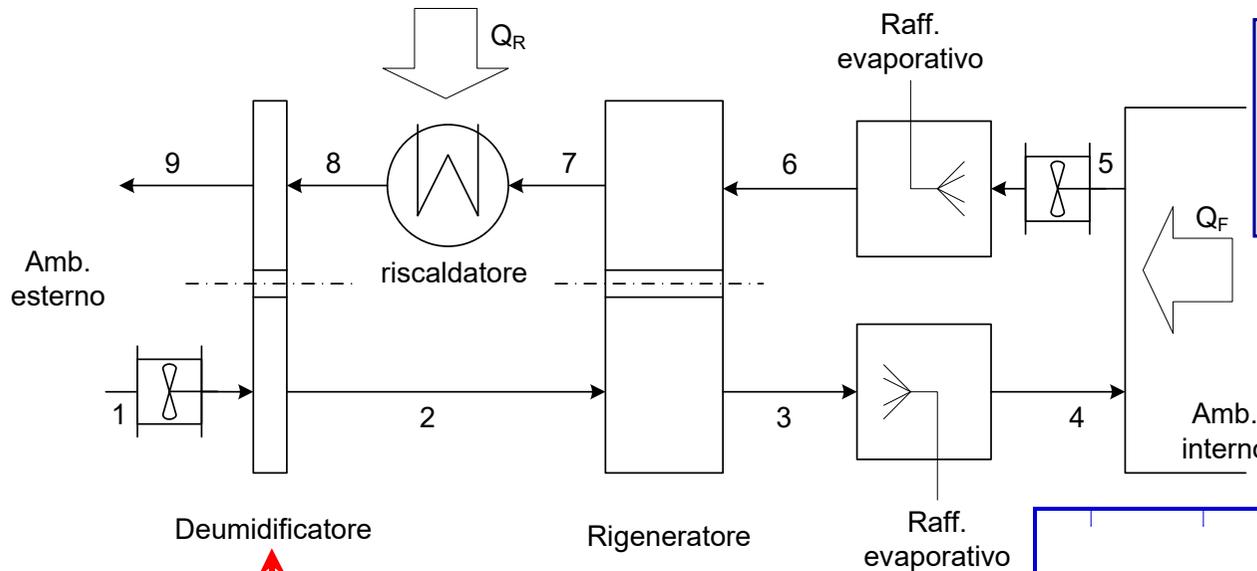
## *Frigoriferi ad assorbimento: prestazioni*



# Frigoriferi ad assorbimento: Funzionamento ai carichi parziali



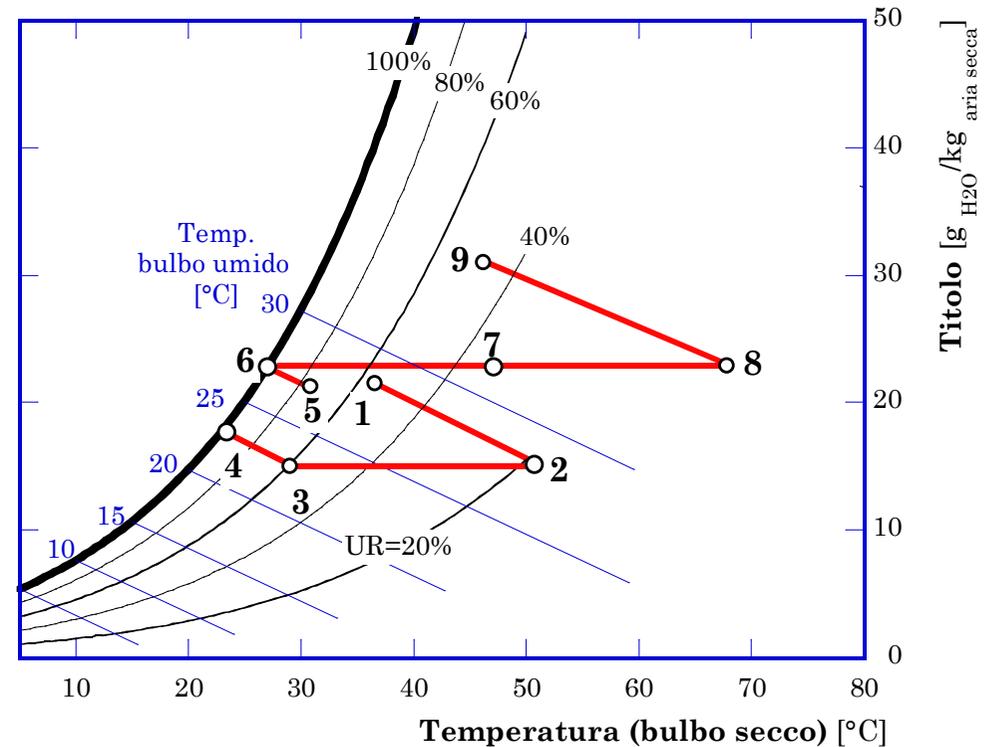
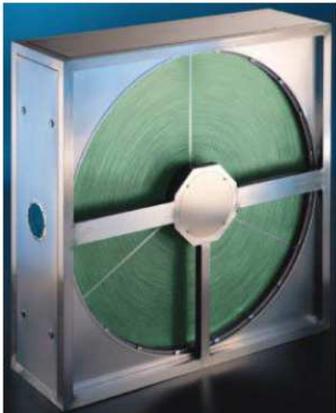
# Trigenerazione: gli impianti Desiccant cooling



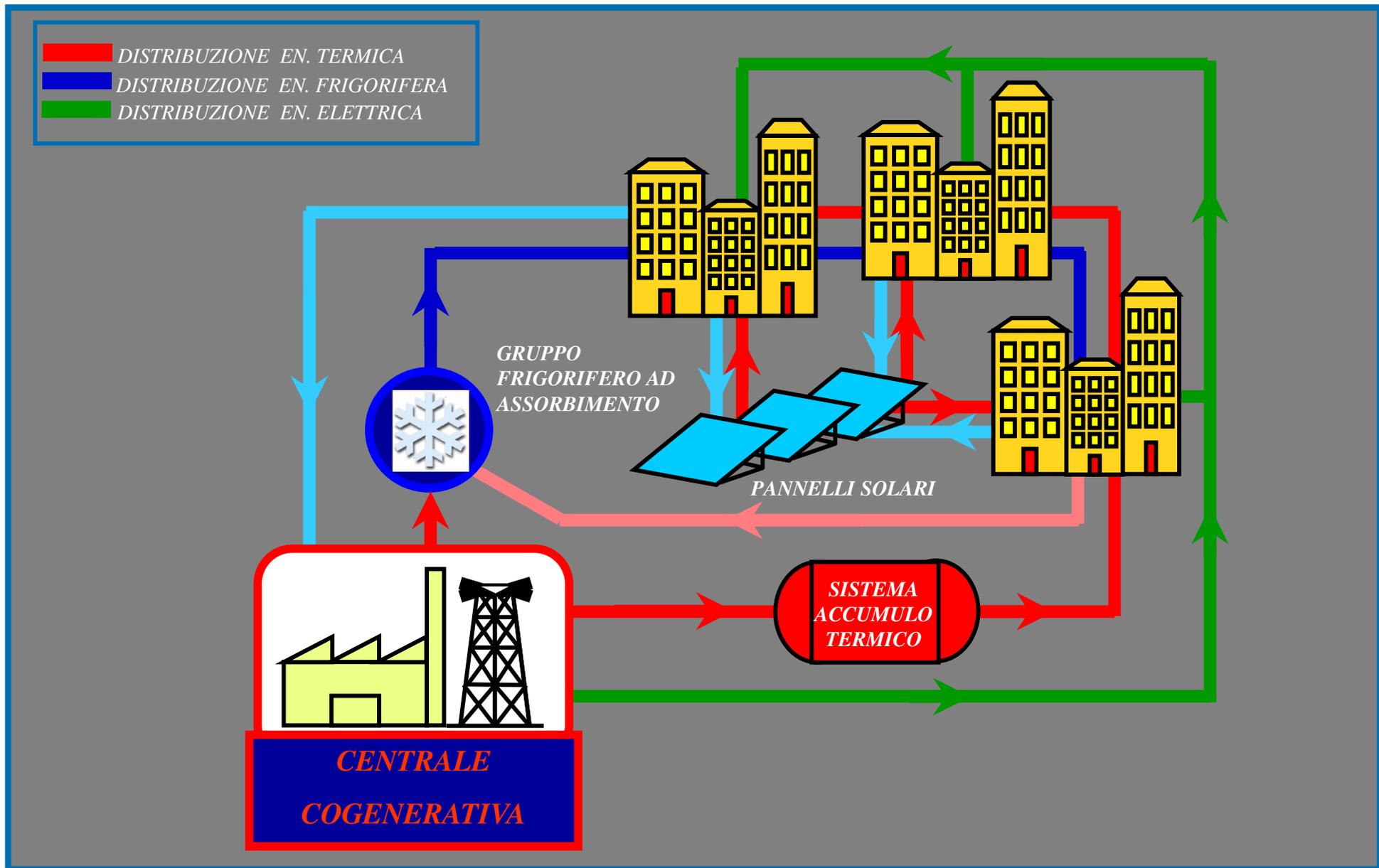
- ✓ **EER ≈ 0.5 ÷ 0.6**
- ✓  **$Q_F/E_{el} \approx 5 \div 6$**
- ✓ **Assenza di fluidi pericolosi**

$$EER = \frac{Q_F}{Q_R}$$

**deumidificatore igroscopico  
(con sostanze chimiche "silica gel")**



# Trigenerazione: le applicazioni



# Trigenerazione: le applicazioni

