POLITECNICO
MILANO 1863

DIPARTIMENTO DI ENERGIA

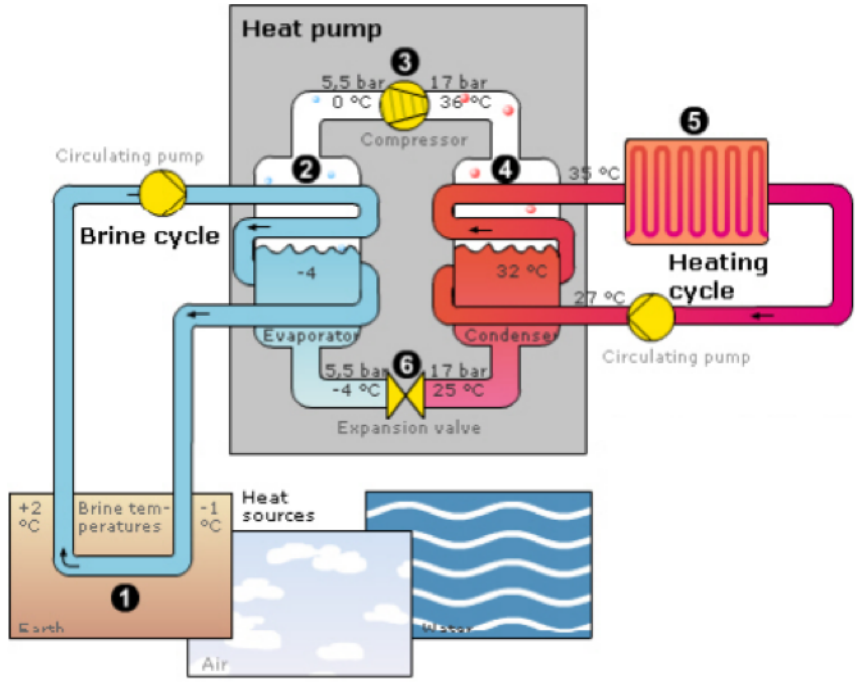
NEEREA for Heat Pump Systems and On-field Monitoring Activities

Lebanese Center for Energy Conservation (LCEC)
Department of Energy, Politecnico di Milano (PoliMi)

Beirut Energy Forum 2018
26th – 28th of September 2018, Beirut

Motivations

High performance technology → money savings and benefit for the environment



Glen Dimplex Deutschland

Motivations

Importance of proper **design, installation and control** to reach high performance

- definition of boundary and design conditions to identify the most suitable technology
- accurate evaluation of energy needs to choose: HP capacity, compressor type, integration with buffer tank, to guarantee high SCOP
- key role of control logics

NEEREA guidelines for heat pump projects

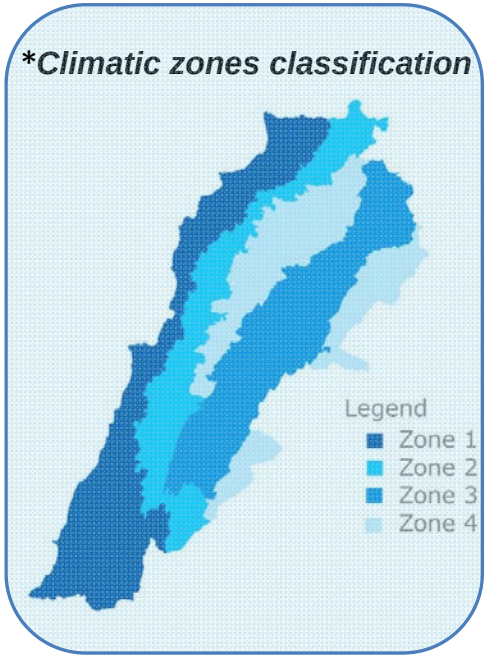
NEEREA Guidelines

Structure

1. Introduction
2. Overview of preliminary study of HP appliance
3. **Heat Pump system sizing**
4. **Post-Installation Measurements**
5. **Reference case**
6. **Financial Analysis**
7. **Green House Gas Emissions Reduction**

- Boundary Conditions

Location	
Latitude	
Longitude	
Climatic Zone*	
Temperature of the water main (°C)	
Heat source temperature (°C) (in case of ground or water source)	



- Design Conditions

Room Set-Point Temperature (°C) during heating season	
Room Set-Point Temperature (°C) during cooling season	
Heating Set-Point Temperature (°C)	
Cooling Set-Point Temperature (°C)	
DHW Set-Point Temperature (°C)	

3. Heat Pump System Sizing

- Energy Needs

Heating and cooling energy needs

Month	1	2	3	4	5	6	7	8	9	10	11	12
Heating energy needs (kWh/month)												
Cooling energy needs (kWh/month)												

Domestic hot water energy needs

Hot Water Use	Average liters per person	Number of persons	Average daily hot water demand (liters/day)											
			1	2	3	4	5	6	7	8	9	10	11	12
Total daily Hot Water Demand (liters/day)														

Month	1	2	3	4	5	6	7	8	9	10	11	12
Hot water for sanitary use energy needs (kWh/month)												

NEEREA Guidelines

3. Heat Pump System Sizing

- Heat Pump Selection

Number of heat pumps	
Type of heat pumps (e.g. air-water, water-water)	
Type of refrigerant per heat pump	
Number of compressors per heat pump	
Inverter compressor (yes/no) per heat pump	
Rated power output per heat pump (kW) (declare the operating conditions)	
$COP_{EN\ 14511}$ per heat pump (heating operating conditions)	
$EER_{EN\ 14511}$ per heat pump (cooling operating conditions)	
Capacity of internal storage per heat pump (if present) (l)	

Push for **Low Global Warming Potential refrigerants**

HP refrigerants remark

Kigali Amendment to the Montreal Protocol: **Hidrofluorocarbons PHASE-DOWN**

HFCs

e.g. R134A (GWP = 1 430), R410A (GWP = 2 088)

Alternative LGWP Refrigerants

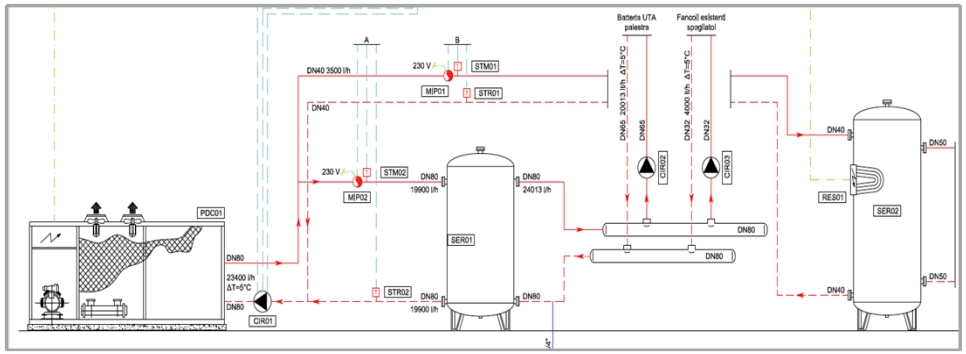
e.g. CO2 (GWP = 1)

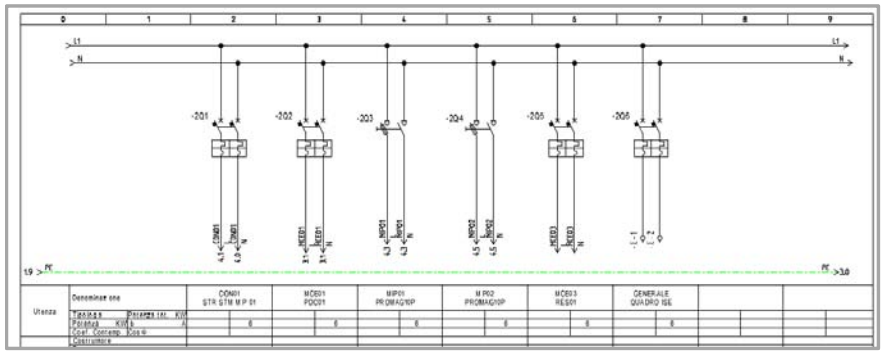
GWP = warming potential of 1 tonne of a greenhouse gas relative to 1 tonne of CO_2, over a period of 100 years

NEEREA Guidelines

3. Heat Pump System Sizing

- Description of calculation methods to evaluate energy needs and design HP system
  - accurate description of calculation methods
  - if a simulation tool has been used, detail the inputs and attach the full simulation report
- Electrical and mechanical drawings





4. Post-Installation Measurements

Objective:

- ❑ Awareness of actual energy consumptions, operating conditions and HP on-field performance
- ❑ Fault Detection and Diagnosis

The <u>minimum set of monitoring data</u> required:

- Energy consumption of the HP
- Thermal energy output of the HP
- HP operating temperatures
- Temperature and relative humidity for indoor and outdoor conditions

4. Post-Installation Measurements

Two levels:

1. For simple system configurations: HP on-board sensors could be enough.

2. For more complex HP system configurations or HP thermal capacity > 20 kW,

   additional measurements, e.g.:

   - energy consumption of the auxiliaries
   - thermal energy after the buffer tank
   - T of the buffer tank

5. Reference case

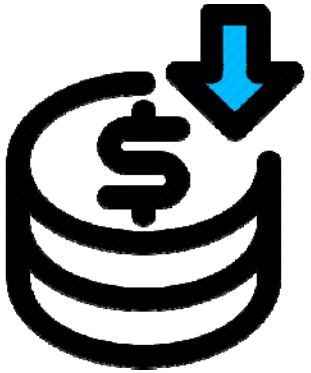
Definition of a reference case to evaluate:

- energy savings
- cost savings
- green house gas emissions reduction

In case of building retrofit, refer to yearly consumptions of the existing system, that will be replaced by the HP system.

6. Financial Analysis

The cost analysis of the HP system should involve:



- initial cost of purchase and installation
- maintenance cost
- energy cost analysis

Yearly energy cost savings

Thermal energy needs covered by the HP system (kWh)	Energy consumptions reference case (e.g. kWh_{el})	Energy cost reference case (USD)	Energy consumptions HP system (kWh_{el})	Energy cost HP system (USD)	Cost Savings (USD)

NEEREA Guidelines

7. Green House Gas Emissions Reduction

Calculation of the avoided green house gas emissions.

Greenhouse emissions factors

Fuel Type	Lower Heating Value (TJ/Gg)	Effective CO_2 emission factor (Kg/TJ)	Units	kgCO2 per unit
Grid electricity	-	-	kWh	0.65
Gas/Diesel Oil	43.3	74 800	Tonnes	3 239
Liquefied Petroleum Gases	52.2	65 600	Tonnes	3 424
Natural Gas	50.4	58 300	Tonnes	2 938
Residual Fuel Oil	41.7	78 800	Tonnes	3 286
Petroleum Coke	41.9	115 000	Tonnes	4 818
Wood Pellets	31	132 000	Tonnes	4 092

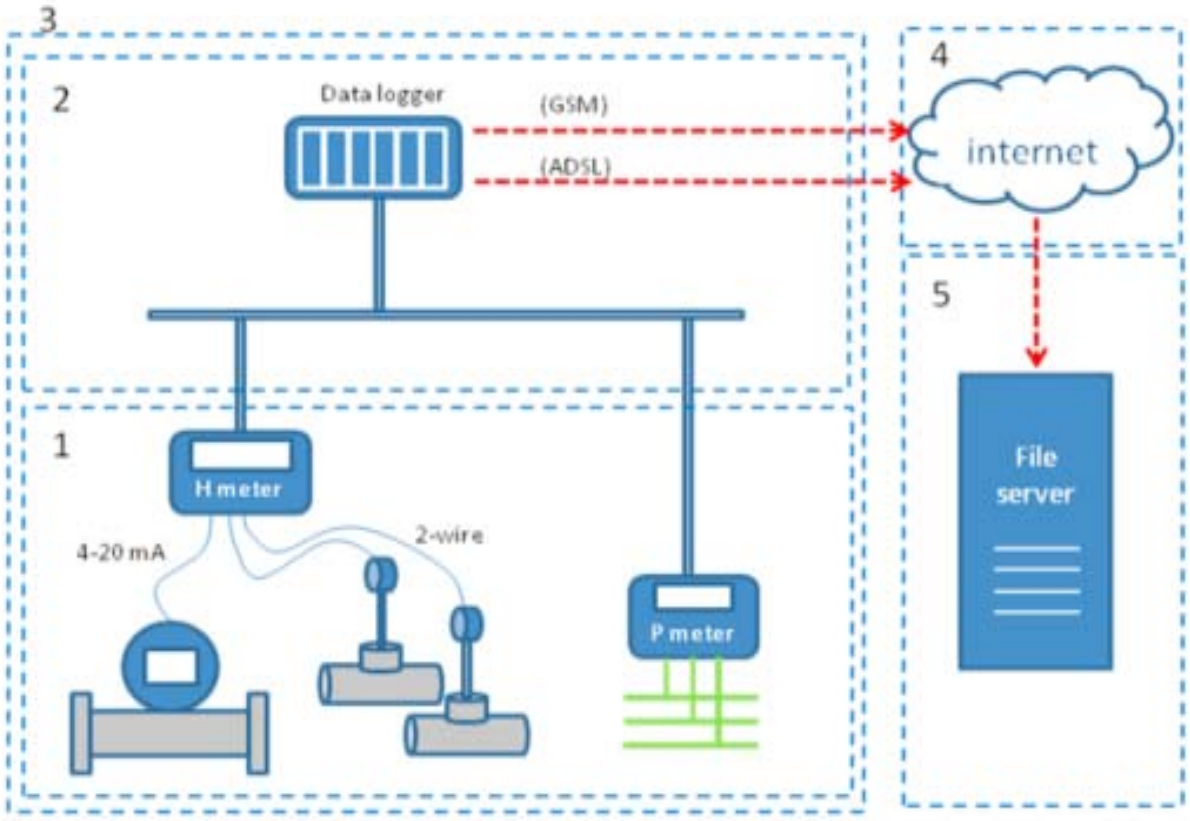
Advanced Energy Performance Monitoring Program

Advanced energy performance monitoring program

- Financing of the advanced monitoring system for a subset of applicants
- The monitoring system architecture and devices will be standardized, in order to guarantee the uniformity of the monitoring data
- The monitoring data will be displayed on a online portal, accessible to the owner of the system, LCEC and PoliMi

Advanced energy performance monitoring program

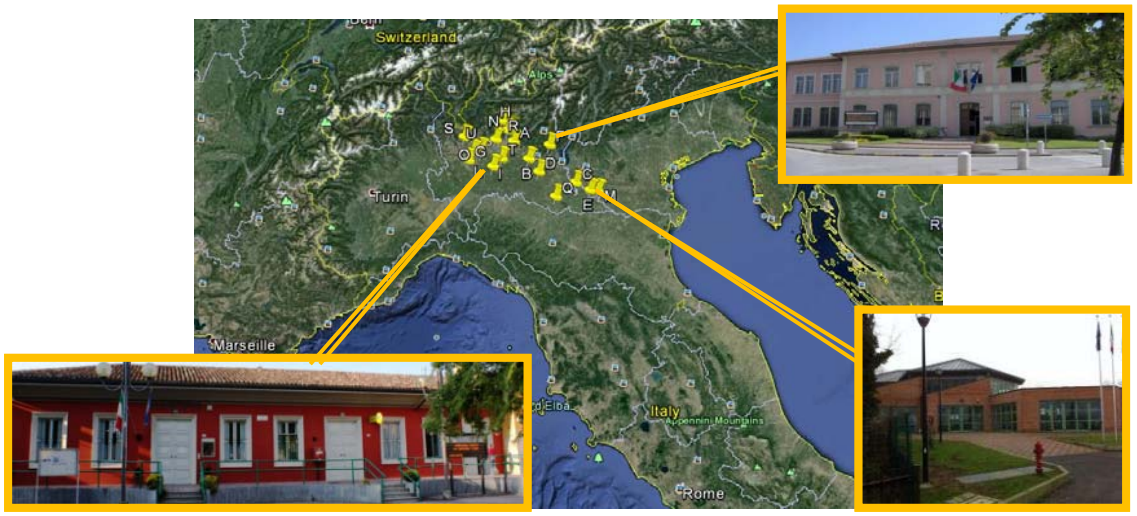
Monitoring system architecture



PoliMi experience: ReLab monitoring project

The project "Relab monitoring" aims to investigate the real behaviour of HP systems, on the basis of the data collected on field from winter 2013-2014 to 2015:

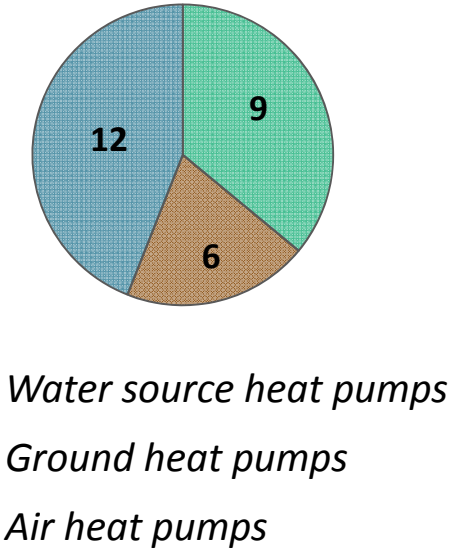
- 25 plants of public buildings (schools, town halls, sport halls, …)
- 2 plants of residential buildings



PoliMi experience: ReLab monitoring project

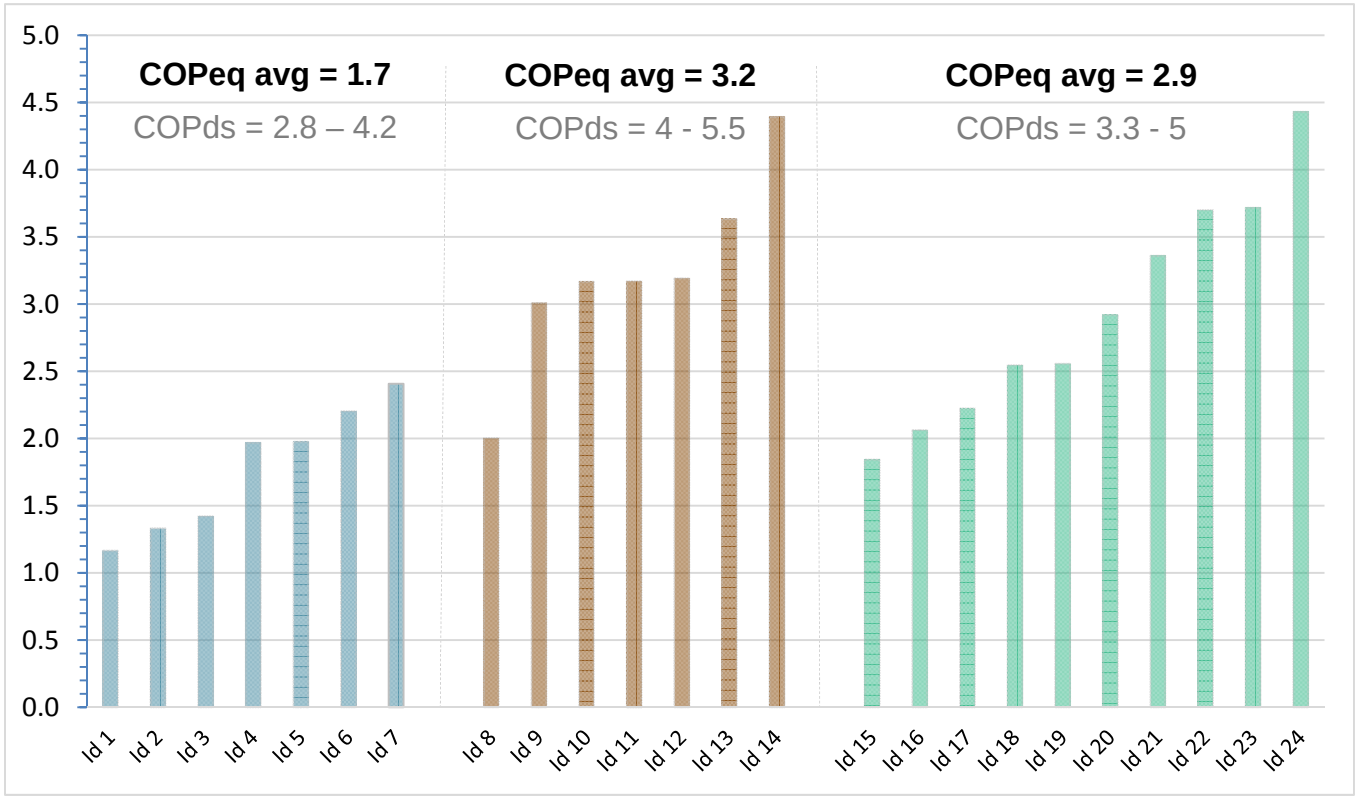
Different features of the HP systems

- heat sources: water, ground, air
- operating modes: heating, cooling, DHW
- system configurations: 1 or more heat pumps
- heating devices: radiators, fan-coil, underfloor heating



PoliMi experience: ReLab monitoring project

Final results: HP performance



- Electrical air/water HP
- Electrical ground/water HP
- Electrical water/water HP

Strong influence of design and control errors.

Conclusions

The NEEREA guidelines for HP projects for heating/cooling/DHW have been presented.

Main aspects:

- accurate evaluation of operating conditions and energy needs to design the HP system and maximize the SCOP
- definition of reference case for the analysis of energy and cost savings and green house gas emissions reduction
- accurate description of calculation methods/simulations tool
- detailed technical drawings
- system monitoring: key role to assess and guarantee HP performance

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