Energy Performance Contracting Plus

Technical Toolbox for Technical Measures for use in SPIN-constellations

Night cooling

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www.epcplus.org

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Content

1. General description and explanation how-to-use

EPC+ aims at standardizing technical measures in order to make them predictable for other SPIN members (including the SPIN coordinator) and thereby to reduce transaction costs.

The toolbox can serve as a guide for the providers of EPC+-services for the standardization of the measures (design parameters, calculation method, process flow) and defines quality standards for the M&V-method. Text-modules of the descriptions may also be used for the communication with the client in order to create trust into the proposed measures.

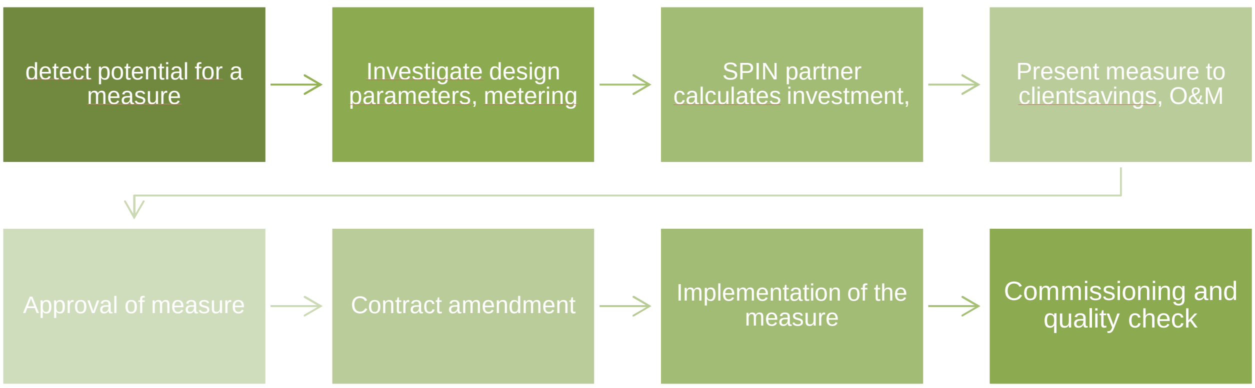
Each measure applicable for EPC+ is described on a general basis. Moreover the design parameters and the possibilities for application are defined, last but not least including a list of situations, where the specific measure is not applicable.

Calculation method

For the facilitation to introduce the measures for a SPIN the generic method of calculating effort for implementation, O&M and savings is described, ideally in form of a product-unspecific, open-source calculation tool.

Process flow

The generic process flow is identical for all measures. Therefore it is also part of the business model of EPC+, variations might be necessary for specific business cases, i.e. if measures interact with each other during their implementation or in their performance phase. See therefore also the interaction matrix of EPC measures, which serves as a quick indicator in which way measures might interact.



1.1. Toolbox

Each measure is being described in general and in detail. The measures are categorized in energy-efficiency and renewable energy measures. All measure descriptions can be downloaded at http://epcplus.org/energy-service-packages/. Here is an overview of all measures that have been elaborated:

Energy-efficiency-measures:

1. Indoor lights: LED lights + control system
2. Hydraulic adjustment of heating system
3. Energy efficient pumps
4. Modernization of electrical motors
5. Night cooling
6. Optimising parameters of HVAC systems
7. Managing and metering systems for buildings
8. Renovation/replacement of heating boilers
9. Efficient windows
10. Industrial steam boiler blowdown heat recovery

Renewable energy measures:

1. Solar Thermal Domestic Heating Water
2. Biomass for heating and/or domestic hot water
3. Combined Heat and Power (CHP)
4. PV-panels
5. Wind-power
6. Heat pumps

2. Night cooling

2.1.1. Technical description

2.1.1.1. General description (PU)

A common approach to cooling buildings in the past has been to rely on air conditioning. However, use of mechanical cooling, and particularly use of air conditioning, can be energy intensive with high associated levels of carbon dioxide (CO_2) emissions and significant heat output (which can in turn exacerbate the overheating of dense urban areas)[1].

Various technical options exist to reduce the need for cooling with normal HVAC installations. In this toolbox one particular technical option will be discussed: **night cooling**. Night cooling is a technique that assists in dissipating heat from buildings during night time.

Night cooling (also known as night ventilation, night purging, night flushing) is a passive or semi-passive cooling strategy that requires increased air movement at night to pre-cool the structural elements of a building[2] . Unlike **free cooling**, which assists in chilling water for classic HVAC purposes, night cooling cools down the thermal mass of a building. During the day, the building structure acts as a sink and absorbs internal heat gains from occupants, equipment, solar radiation, etc. At night, when the outside air is cooler and the air is not too humid, the building envelope is opened, allowing cooler air to pass through the building, so heat can be dissipated from the structure by convective heat loss. This process reduces the temperature of the indoor air and of the thermal mass inside the building, allowing convective, conductive, and radiant cooling to take place during the day when the building is occupied.

1. **Natural** night cooling can occur by opening windows at night, letting wind-driven or buoyancy-driven airflow cool the space, and then closing windows during the day.
2. **Mechanical** night cooling can occur by forcing air mechanically through ventilation ducts at night at a high airflow rate and supplying air to the space during the day.
3. **Mixed-mode** night cooling can occur through a combination of natural ventilation and mechanical ventilation, also known as mixed-mode ventilation, by using fans to assist the natural night time airflow.

[1] Islington, Low energy cooling, Good practice guide 5.

[2] https://en.wikipedia.org/wiki/Passive_cooling

2.1.1.2. Design parameters

In order to enable nightly flushing of cold ambient air through a building, basically 2 options exist: natural convection or mechanical flushing. The specific design parameters are discussed in the sections below. So, it is not deemed useful to repeat this information in the current paragraph.

2.1.1.3. Measure suitable for

- Buildings with a high large thermal mass (e.g. concrete or stone structure) that allow to store the nightly cold to be released during day time.
- Night cooling is most effective in climates with a large difference between the daily maximum outdoor temperature and daily minimum outdoor temperature. For optimal performance, the night time outdoor air temperature should fall below the daytime comfort zone limits of 22 °C and 60% relative humidity.
- Night cooling can also be part of a cooling strategy for buildings by creating a shift in peak energy load. Energy is most expensive during the day. By implementing night cooling, the usage of mechanical ventilation is reduced during the day, leading to energy and money savings.

2.1.1.4. Measure not suitable for

- Buildings having a low thermal mass, e.g. buildings in wood.
- Buildings located in areas where air pollution is problematic, not allowing free – unconditioned - air flow through a building.
- Buildings located in areas where air borne insects may contaminate a building together with the unconditioned air flow.
- Buildings located in noisy areas. This only applies if the building is occupied during the hours when a building is being flushed.
- For natural night cooling, the process of manually opening and closing windows every day can be tiresome, especially in the presence of insect screens. This problem can be eased with automated windows or ventilation louvers.
- Natural night flushing also requires windows to be open at night when the building is most likely unoccupied, which can raise security issues.
- Buildings that are too compartmented to enable a smooth nightly flushing process.

2.1.2. Calculation method

2.1.2.1. Expected savings

Night cooling will *reduce* the operating time of a classic HVAC-based cooling system. As such, night cooling does *not replace* the need for a classic HVAC-based cooling system. If a building is thoroughly flushed with cold ambient air during night time, the cooling need may be shifted with several hours, e.g. the cooling system may have to be activated by 11 or 12 AM rather than the usual 8 AM. In other words, the savings can be expressed in a shorter operating time of the cooling function of an HVAC system.

2.1.2.2. Investment costs

In order to enable nightly flushing of cold ambient air through a building, 2 options exist: natural convection or mechanical flushing.

The first option does not require electric fans to be installed/activated, but still requires adjustments to the building to enable the flushing process, e.g. automatically opening windows or valves. In case of mechanical ventilation, the flushing process can be implemented by adjusting the ventilation settings of the classic HVAC system that already is in place. Anyhow, each building will require a tailor made approach, meaning that no reference cost levels can be put forward within the scope of this toolbox.

2.1.2.3. Running costs

The breakdown of running cost has two elements : Operating and Maintenance cost.
The operating cost depends on the selected option: mechanical ventilation with fans consumes electricity, whereas natural ventilation does not require fans.
The maintenance cost of either option is low, but still requires regular checking that the flushing process is not obstructed by malfunctioning valves or blocked inlet screens. The maintenance cost is estimated as a minor percentage of the regular HVAC maintenance costs.

2.1.2.4. Expected life-span of the measure and resulting replacement-costs (if any)

The expected life span of a *mechanical* flushing concept is correlated with the life span of an HVAC system, which is estimated at about 20 years.
The expected life span of a *natural* flushing concept is correlated with the life span of the (automatic) valves and levers, which is estimated to be 20 years as well. Also, during the latter

period, one should stay vigilant that, due to possible functional refurbishing of the building, the flushing 'routes' remain intact, and don't get obstructed by new separating walls, etc.

2.1.2.5. Discounted cash flow analysis and Net present value

In order to elaborate a discounted cash flow analysis, amortization rate and net present value of the investment, tools elaborated within the context of the project can be used, please check the European toolbox package at www.epcplus.org/energy-service-packages/.

Mandatory output parameters:

1. *Loan Amortization (€/year)*
2. *Debt repayment (€/year)*
3. *Interest paid (€/year)*
4. *Remaining amount (€/year)*
5. *Cash flow (€/year)*
6. *Cumulative present value (€/year)*
7. *Internal Rate of Return*

2.1.3. Options on measurement & verification in order to evaluate the performance in relation to the given performance guarantee[3]

The EPC+ project focuses on energy efficiency measures for SMEs. This setting does not allow extensive M&V procedures. So, a balance will have to be struck between gathering sufficient data to avoid disputes, and safeguarding the cost-effectiveness of the data gathering process.

IPMVP Option B is recommended : Retrofit isolation method, whereby both 'performance' and 'operating time' are taken into account when calculating the improved energy performance.

*2.1.3.1. Data to be measured in the **reference scenario**:*

The following data should be available for one, entire and representative cooling season (year)

- Nominal electricity consumption of the cooling part of the classic HVAC system.
- Operating time of the classic HVAC system.
- Cooling Degree Days during the reference period.
- Setpoints of the cooling system (i.e. indoor comfort parameters).

[3] Criteria: minimum effort, but still a proper qualitative proof for solid implementation and a considering performance, not installation only

In case functional changes in the occupation of the building have taken place, or are being considered, these should be documented.

Ideally, information about the indoor comfort level in a building should be available as well: e.g. are there any comfort complaints ?

*2.1.3.2. Data to be measured in the **target scenario**: night cooling*

In the target scenario, the following data set should be measured:

- Nominal electricity consumption of the cooling part of the classic HVAC system.
- Operating time of the classic HVAC system.
- Cooling Degree Days during the monitored period.
- Setting points of the cooling system (i.e. indoor comfort parameters).
- In case of mixed-mode ventilation: Electricity consumption of the fans that assist in flushing the cool air through the building.

Functional changes in the occupation of the building have to be recorded, as well as any feedback with respect to the indoor comfort level in the building (if any).