Heating control – Main control functions are standardised, how to apply these functions?

Control systems present a large economic potential, adapting energy delivery to meet the comfort demand profile as close as possible. This applies in particular to heating, the largest part of buildings energy use in Europe is for heating purposes. The keys of the control system performances are: standardized quality products, closely adapted to heating systems and properly operated and used. EN 12098 series of standards and technical reports will provide specifications and recommendations to achieve these goals.

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Standards EN 12098 (parts 1, 3, 5) prepared under CEN/TC247/WG6 committee describe ability of devices and integrated functions to control heating systems. These standardised functions are leading and necessary. They are completed by added functions for specific applications and performance improvements.

Associated draft Technical Reports CEN/TR 12098 (parts 6, 7, 8) summarise some recommendations for how to design, how to use these functions for energy efficiency of heating systems. Energy impact of these control functions are detailed in EN 15232-1.

> Many of these EN and CEN/TR (Technical Reports) are formally drafts until mid of 2016 and will go out for Formal Vote by October 2016. Publication by the national standards bodies of CEN is expected by the beginning of 2017. They were prepared in the frame of the standardisation mandate M480 with the terms set in the recast of the EPBD (2010/31/EU).

Efficiency of control imply properly divided heating systems

First, application of control functions implies that the building is properly divided into elementary spaces and zones according to various conditions of use.

For this, **EN ISO 52000-1**, "Energy performance of buildings – Overarching EPB assessment – Part 1: General framework and procedures" gives pertinent indications for zoning in clause 10. Although this clause is formally applicable to calculated energy performance, it may be applied to design and realisation of separated zones. Reality of zoning is a necessity for control, limited areas up to 1 000 m² is recommended.

Controllers distributed on zones of buildings shall be related to hierarchical level in the zoning and organised in a coordinated system. Energy performance of heating systems involves suited BAC functions.

The major function for saving energy: start-stop scheduling

Properly heating system zoning is a prime importance for application of this simplest but most effective function.

> Note that energy use is approximately proportional to the ambient temperature related to outside temperature. Any stopping or reducing heating lowering this temperature brings savings.

For this, **12098-5 standard** describes characteristics of scheduling clocks for the operation requirements.

Five categories cover all technologies on the market, from mechanical clocks mains frequency synchronised to networked clocks put in sync with a high precision master clock like the European emitter in Mainflingen (D) giving real time, date, and automatic summer-winter time change.

Categorized clocks may differ by programming periods, number of switch times per day, number of daily programs. Accuracy is given for the clock itself and for switch time settings.

Basic scheduling function should be completed with added functions.

For adaptation to different user needs:

- Derogate or overlap scheduling for temporary demand,
- Start timer function for a single start-stop cycle.

For adaptation to technical constraints:

- Fixed start period anticipating inertia of heating before the normal occupation time,
- Tariff compensation in case of variable tariff energy price, like electricity, for start switching with respect to the tariff rising time. This function provides cost saving.

Put rhythm of energy use in buildings

CEN/TR 12098-8 recall that switching on-off energy services related to actual or predictable use of rooms, zones or buildings is the basic, simplest and more effectiveness function. Special attentions shall be given to keep watch for update schedulers to real conditions of use, during exploitation.

Figure 1 indicates where start stop functions may be applied to heating systems parts:

- Generation: switch on-off or allow-prohibit operating of generators and related auxiliaries: pumps, valves.
- Distribution: switch pumps and tree ways valve controlling temperature at the head of distribution zones. In some cases, elementary spaces and zones may be switched by on-off seal valves.
- Emission: scheduling clocks are normally included in each room controller for local adaptation of heating needs. Programming of generation and/or distribution take priority to local programming, avoiding forgetful use or malfunctioning room controllers (**Figure 2**).

Scheduling functions in heating parts and heating zones imply a digital network linking these functions for easily coordinate and manage.

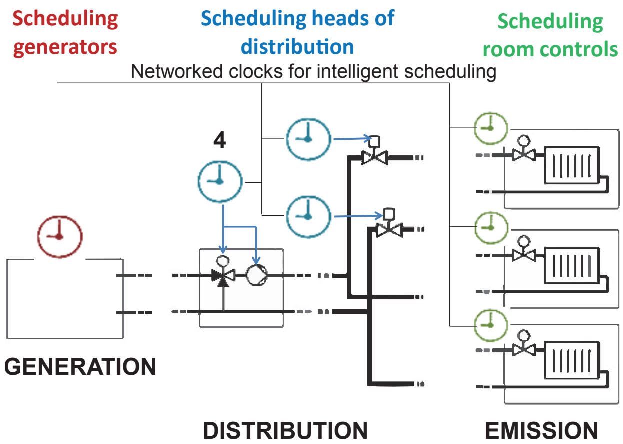

Figure 1. Scheduling clocks on different parts and zones of heating systems are efficiently synchronized and managed by the way of a digital network dedicated to HVAC applications.

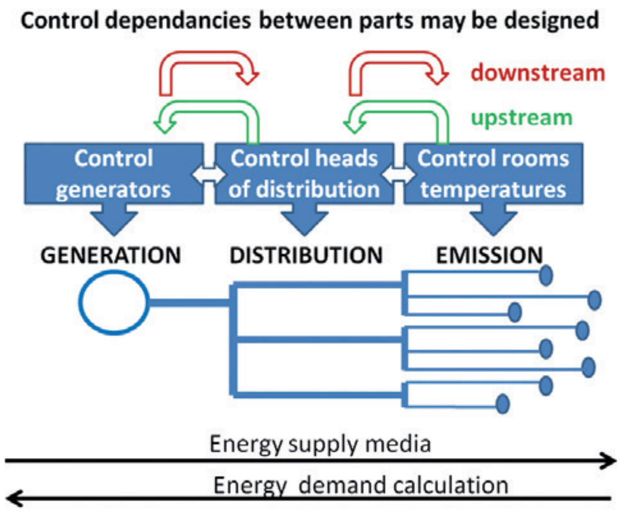

Figure 2. Energy demand and supply model for heating plant. The control system may follow an upstream or downstream model. The difference is the freedom allowed to users acting set-points in view to take account user behaviour encouraged or not.

Clock scheduling intermittences is completed with derogation possibilities for override programmed periods. A timer function for single period may also be proposed. These added functions started manually or automatically satisfy unexpected needs.

The lot of individually programmed clocks distributed in buildings imply to link schedulers on a BAC (Building Automation and Control) system by the way of a digital network.

> A BAC is - at least - a super, multi ways scheduling clock to put rhythm of energy use in buildings.

To pilot heating: two main functions

Piloting heating systems necessitate two main functions: Outside Temperature Control (OTC) and improved scheduling, the Start-Stop Optimiser (SSO). For an efficient heating control these two functions are inseparable and integrated on a heating pilot controlling many parts of these systems (**Figure 2**).

The **EN 12098-1** describes operating requirements of OTC and SSO functions and tolerances limits for their ability. This standard concerns either standalone devices or integrated functions in BAC systems.

OTC – Outside temperature controlling flow temperature may be completed by these useful functions:

- Auto tuning heating curve parameters;
- Compensation by emitters energy demand transmission;
- Other meteorological variables and forecast.

OSS – Optimum start-stop function may be completed by these switchings:

- Pumps control;
- Summer-winter switch related to calculated mean forecast outside temperature.

CEN/TR 12098-8 points out that the role of heating outside temperature control acting generation and/or distribution parts remains alone for the room temperature control in some cases:

- Heated spaces don't permit to measure a representative temperature for individual (closed loop) control (e.g.: entrance, corridor, reception hall, exhibition hall, atrium...),
- Users are not encouraged to adapt set point of their room temperature controller,
- Emitters are equipped with inefficient or damaged individual emitters thermostats.

And even if each room is equipped with emitter's controller:

- Limit the higher room temperature able to be reached, even in case of maladjusted settings,
- Adapt the water temperature to the actual heating load, allowing to avoid hanging of the closed loop room controls, and permitting the room control accuracy.

> This rule applies specially to mechanical and electronic thermostatic radiator valves, water temperature must be adapted to the heating charge, i.e. outside temperature.

Energy impact of these functions: OTC, intermittent control and pump control may be fund on many parts of EN 15232-1.

Thermal calculations impact of these functions may also be found in EN 15316 series:

- Improve efficiency of generators, reduce losses: EN 15316-4-1 gives algorithms for calculates efficiency related to the mean temperature,
- Reduce heat losses of thermal storages, pipes, auxiliaries, and other equipment (e.g. valves): EN 15316-3 gives algorithms for calculate heat losses for these periods,
- Reduce pumps consumption during intermittent periods and summer-winter switch: see EN 15316-3.

Control of electrical heating systems follows the same principles

Energy efficiency of electrical heating requires central functionalities for improve control and scheduling of terminals and their thermostats.

The **EN 12098-8** describe Outside Temperature Control (OTC) and improved scheduling the Start-Stop Optimiser (SSO) for electrical heating control systems.

Although these functions are similar to principles applied to water heating, technical solutions and constraints specific to this electrical heating necessitate this separated standard.

Optimum start function may take account of the variable price of energy, for that the switch time for rise to normal room temperature should be anticipated with respect to the tariff rising time.

CEN/TR 12098-7 point out the roles of outside temperature control limiting electrical energy available at the emitter. This CEN/TR indicates also energy impact of central control and intermittent control on distribution and emission electrical heating, as it can be found in EN 15232-1.

Content of this EN standard and accompanying CEN/TR presents many similarities with water heating documents EN 12098-1 and CEN/TR 12098-6. It's an advantage for technicians to find similar concepts for starting up and commissioning heating controls, whatever energy source is used.

Concepts for heating control systems: upstream or downstream?

For energy calculation following EN ISO 52000-1, emitter's energy demand begins on an upstream calculation process, distribution and production delivery follows.

Physical is opposite: energy is supplied from generators to emitters through distribution, control falls water temperature or flow along the chain.

A control system allows choosing subordinations between parts (**Figure 2**). Two directions are feasible:

- The upstream control process: demand of room temperature controllers govern distribution, storage and generation water temperature. This satisfies a comfort point of view: delivered energy must satisfy demand.
- The control system may behave on a downstream process: generation and distribution control water temperature available for each elementary spaces or rooms. Delivered energy respond to a predicted demand, no more. This satisfies an energy point of view. This control is based on models.

OTC and OSS are basic functions for this downstream principle (but recommended in any cases). Through this way, control may receive many refinements like TABS control (Thermally Active Building Systems).

> Note that these subordinations may confer a "character" to a control system: "obedient" or "authority" over users.

An "obedient" system, i.e. allowing some settings access, convene to encouraged users to pay attention to energy conservation. In other cases, an "authority", i.e. closely pre-set system convene to not encouraged users.

Conception of control systems based on data networks and intelligent controls allow such possibilities, introducing expected behaviour of contributors.

For that, man-machine-interface is an important topic for any contributor. In this way, CEN/TC247 standards refer to graphical symbols for users in CEN/TS 15810 (Technical Specification, **Figure 3**). ■

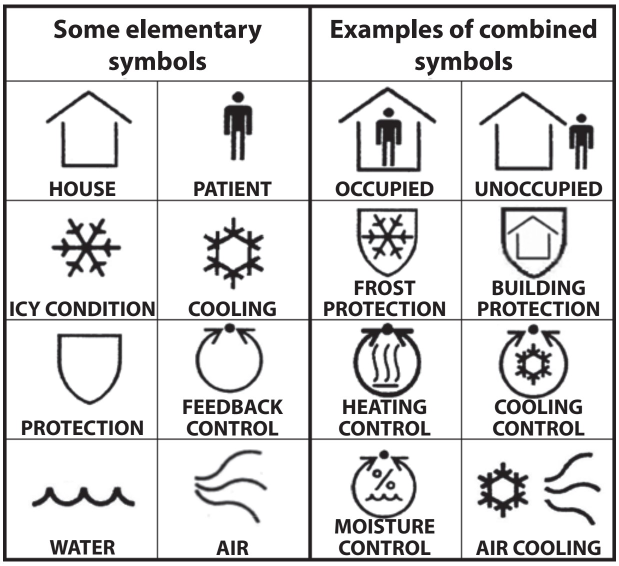

Figure 3. Some symbols fund on CEN/TS 15810 "graphical symbols for use on integrated building automation equipment" designed from elementary symbols.