Design of a Control System

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Report from the project: IDEEB
Intelligently Designed Energy Efficient Buildings
–assessment and control by an Eco-Factor system

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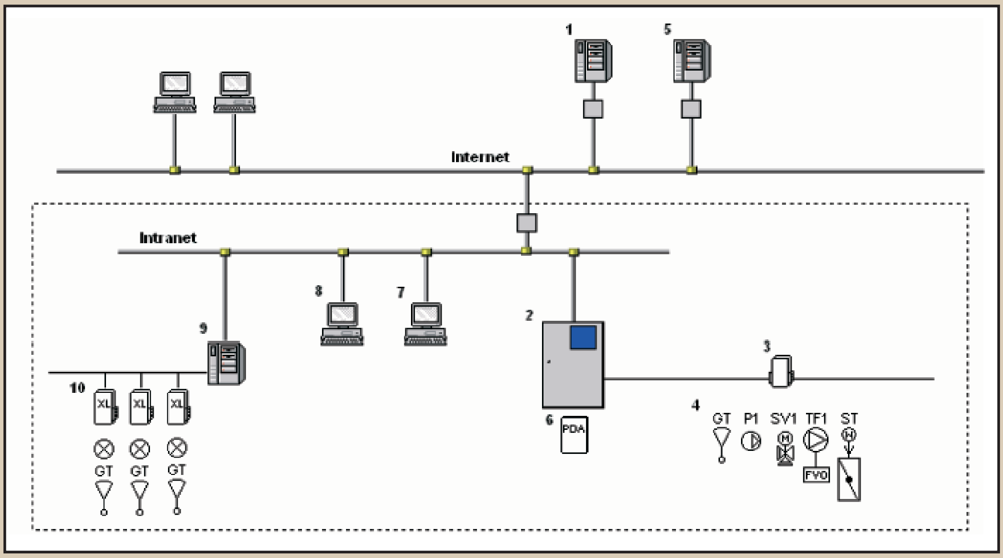

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Preface

This report is produced within the research project IDEEB, Intelligently Designed Energy Efficient Buildings -assessment and control by an Eco-factor system.

The holistic approach of the IDEEB project is to adopt comprehensive view. This considers the building itself and its installations as one energy system to achieve required indoor climate at the same time as reducing environmental impact. Since each building is unique there are no all-encompassing solutions, and therefore the project aims to develop a concept (based on an Eco-factor) that describes the way of working to reach the goal.

The IDEEB project consists of three parts:

1. *A theoretical part* with separate developments of new guidelines and methods for the building process and design of a control system.
2. *A demonstration and improvement part* there the results from the first part should be tested, improved and extended in construction of four office buildings situated in different European climates.
3. *An evaluation and connection part*. Here all the improved results from the second part should be merged into a concept that would describe a way of working to achieve energy efficient buildings with good indoor climate and low environmental impact.

Unfortunately the market situation for construction of office buildings changed after the start of the project and therefore could only the first part of the project be performed. This means that the total project result consists of nine separate reports with theoretical background for guidelines and methods, which are ready to be tested in practice for improvements and extensions into a new way of working.

This part of the project has developed a technical system for control and monitoring of the energy use in an office building. The system's main purpose is to achieve a building with required indoor climate by causing minimum impact of the environment. The second purpose is to measure and store information about the building's performance so it could be evaluated with the IDEEB Eco-factor system and give information to maintenance personal, house owners, etc.

The design of this control system is based upon a web-based controller, which uses weather forecasts to regulate the heating system and use the Intranet/ Internet for monitoring, sharing and receiving information.

The author would like to thank all of the participants in this project.

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INU control

Summary

Future technical solutions will require information technology that is independent of branch, hardware and geographical location. The dominating technology today originated from the Internet and its application is therefore a natural development in the control of heating and ventilation. It is platform-independent and can be accessed from any geographical location where there is an Internet connection.

A modern office building has requirements of good indoor comfort achieved by low energy use with minimal impact of the environment. The operation of heating, cooling and ventilation systems must be carefully and integrated controlled in order to reach the goal. Additional functions as separate control of individual offices may also be required. To minimise the energy use during the lifetime of the building it's critical to use the new technology and continuously track the energy use.

The design of this control system is, therefore, based upon a web-based controller, which uses weather forecasts to regulate the heating system and use the Intranet/ Internet for monitoring, sharing and receiving information.

The system's main purpose is to achieve a building with required indoor climate by causing minimum impact of the environment. The second purpose is to measure and store information about the building's performance so it could be evaluated with the IDEEB Eco-factor system. The developed technical system has, therefore, two functions in the same device: control and regulation systems (controllers) and monitoring systems (BMS).

The technical system has three different types of information – operational, administrative and user information. Operational information refers to functions for handling operation for optimisation of indoor climate and energy use with its related environmental impact. Administrative information primarily entails the capability to monitor energy use for each energy source and indoor climate during specific periods and to statistically present the monitored values so that the building's performance can be evaluated with the Eco-factor method. User information shall provide the opportunity for tenants to receive general information on the building's indoor climate for well-being purposes, energy use for cost estimations purposes and the building's Eco-factor (environmental index) for behaviour-awareness purposes. All types of information can be handled by a Web-portal through Internet.

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1. Introduction

Future technical solutions will require information technology that is independent of branch, hardware and geographical location. The dominating technology today originated from the Internet and its application is therefore a natural development in the control of heating and ventilation. It is platform-independent and can be accessed from any geographical location where there is an Internet connection.

Over the years, there has been an abundance of standards and supplier-specific software within the control and regulation branch. This has become an outdated and costly way of working now that Internet technology is readily available, a technology that is open to everyone, all over the world.

Broadband installations are becoming increasingly common. Pacing this increase, an expanded range of services – for example, TV, telephony and the Internet – is available to tenants. By also utilizing existing investments in IT solutions and broadband technology in building automation, whether for monitoring, alarms, physical access security, financial systems or control and monitoring of heating and ventilation, we have taken an important step towards fully integrated building automation.

Traditional control and monitoring solutions are divided into two functions: control and regulation systems (controllers) and monitoring systems (BMS). Honeywell's new control and monitoring device i30 features both of these traditional functions (controllers/BMS) in the same device. The i30 is the future's Web-based control and monitoring system and can be designated as WDC.

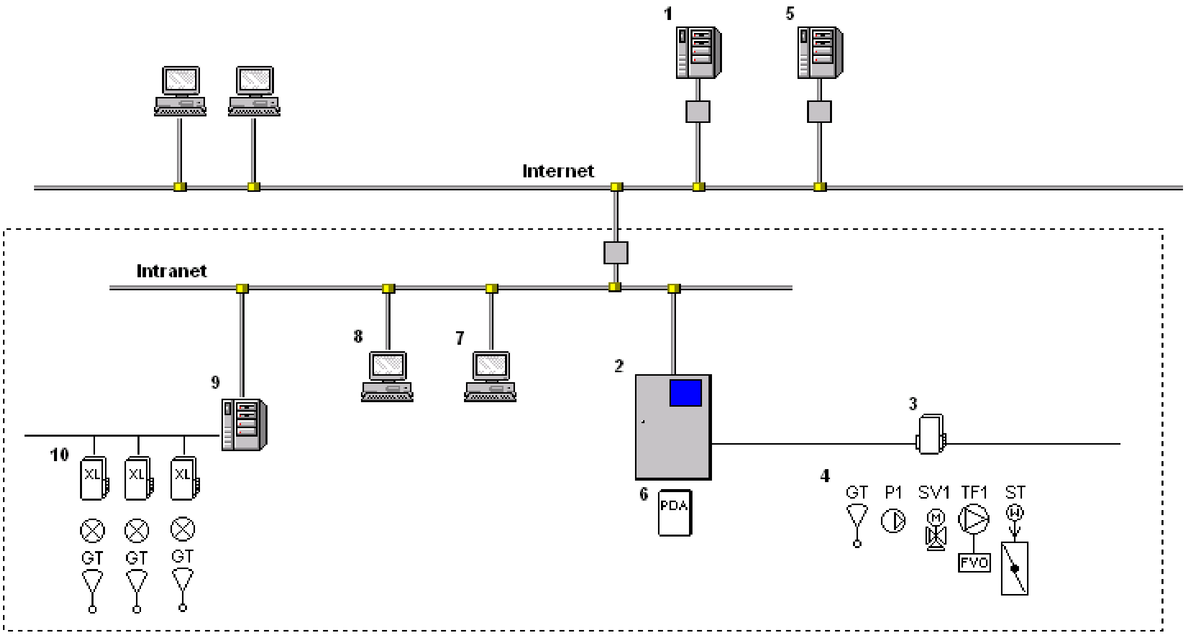
The technical solution for IDEEB (Intelligently Designed, Energy-Efficient Buildings) has three different types of information requirements to fulfil – operational, administrative and user information. Operational functionality refers to functions for handling routine operations in the building, while administrative functionality primarily entails the capability to monitor energy consumption and indoor climates for specific periods. User information shall provide the opportunity for tenants to receive general information on the building's energy consumption and indoor climate. This information is structured with consideration to simplicity, clarity and information content.

- Operational functionality is handled with the Web-based control and monitoring system i30 SPC, which is installed locally in the respective buildings and takes care of all control and regulation functions, as well as monitoring functions, for the building's systems for heating and ventilation. The i30 SPC control and monitoring system also handles time-control, energy measurements and alarm functions for the building's other technical components.

- Administrative functionality is handled from a central Web portal for the building. Comprehensive energy and climate data is collected at the Web portal. The current alarm list for each building is also compiled here as well as settings for alarm forwarding to appropriate service personnel in the respective operational organizations.

- User information is handled through a simplified combination of various components from operational and administrative functionality, presented in an uncomplicated and informative manner. User functionality is administered from a central Web portal for the building.

It is also important that the technical installation be flexible and adaptable in the event of, for example, restructurings and changes to activities in the building. These types of adaptations are facilitated by a control and monitoring system that is freely programmable and that has the capacity for the connection of in/out-signals in the building with distributed modules.



Overview of the technical solution using Intranet/ Internet and web-based controllers.

2. Web Portal, Operational and Administrative Information

2.1 Energy Consumption and Indoor Climate Monitoring

Monitoring of energy consumption and interior climate in a building is accomplished through a general report, presented on a single page, which provides general information on the building's technical status. In this way, a unique all-encompassing view is attained and appropriate measures can be prioritized. Just as a car has its dashboard with all information collected in one place, the general report is the building's dashboard where all relevant facts are presented. The report includes information on accumulated media consumption as compared with that budgeted, key ratios compared to house type, total alarms during the month, and information on indoor climate, temperatures and air quality. Moreover, there are usage reports in which respective media usages are each presented in separate reports. The usage reports contain, besides numbers and diagrams for media usage, a prognosis that indicates overall usage for the entire year. Energy reports serve as additional operative tools by showing the periods during which the most energy is consumed and how this compares with the subscribed energy for the building. The energy signature provides useful information for operational optimization of heating. The energy signature presents energy usage in relation to outdoor temperatures and shows when a building's heating needs begin, as well as an indication of a building's insulation or the level of efficiency for a building's heat recycling.

2.2 Alarm Status

In a building, there are often several control and monitoring systems installed for various types of systems, such as for heating and ventilation. The respective control and monitoring systems include a current alarm list for the systems that the control and monitoring device handles. However, to achieve effective operation and administration, a general alarm list for all control and monitoring systems installed in buildings is required. This need is met by all i30 devices in the buildings transmitting alarm information to the central Web portal, which always has a current compilation of all alarms in the buildings.

2.3 Alarm Forwarding

To minimize operational disturbances for tenants and to be able to keep concerned service personnel informed of a building's status, service personnel must receive immediate notification when an alarm in a building has been activated. With the central Web portal, information on current alarms can be forwarded directly to concerned service personnel in a number of ways. The most common is to send alarm messages via SMS, e-mail or fax so that service personnel can immediately take appropriate actions. For example, all alarms activated during the day can be sent to the building's service personnel via e-mail or SMS, while in the evening and on weekends, notification can be via SMS to service personnel who have on-call duty for the building.

3. i30 Control and Monitoring System

3.1 WDC, (Controllers & BMS)

The i30 is a device that features both control and regulation functions. These functions are similar to those provided by traditional controllers and BMS (Building Management System), i.e. with flow charts, alarm management and history, but packaged in one and the same product. The i30 is connected to an office network via the Ethernet port, or to a computer or modem via the USB port.

3.2 Web-based, Flow Charts, Alarm Lists, Trend Curves

Many of today's control and regulation systems have their own communications protocols, which entails that when a user needs a PC-based monitoring system, the options are more or less restricted to using the supplier's software. The i30 is based on technology for future control and monitoring systems. The system can be accessed via an intranet or the Internet with a standard Web browser. Users are thus not dependent on any one supplier's specific software to monitor buildings, but in principle, can use any computer that is connected to the Internet. The i30 is Web-based, which means that flow charts, alarm lists and trend curves for detailed monitoring of regulating functions, etc. can be administered via a standard Web browser.

3.3 Freely Programmable, SPC

The i30 is a freely programmable, Web-based control and monitoring system. This entails that the control and regulation functions for a building that shall be controlled and regulated are programmed individually for the respective control and monitoring systems. The programming language SPC (Sequence Programmable Controller) is a powerful high-level language and can handle most of the functions within building automation. The control and regulating functions are programmed with a programming tool (SPIDER – Sequence Programming Integrated Development Environment) to create a sequence program where the respective functions are administered.

3.4 Installation, Controllers/BMS

Traditional solutions with control and regulation systems – controllers and BMS monitoring systems – require two installations, one for controllers and the other for BMS functions. With the i30 – a Web-based, freely programmable, control and monitoring system that includes flow charts, etc. – only one installation is required, which is an advantage in the that site work is minimised.

3.5 Remote Programming

The sequence program SPC, which is created in the SPIDER programming tool, is uploaded to the i30. It can later be downloaded and modified via an internet or the Internet and uploaded once again. All of these actions are performed remotely. This means that when reprogramming or expansion of functionality is necessary, this can be carried out remotely by the supplier without needing to visit the site.

3.6 Flow Charts, Function Text Integrated

With the Web-based user interface, one can view dynamic flow charts showing technical systems (such as for ventilation); current information on the operating status of pumps and fans; valve positions in regulating systems; and current temperatures in the various parts of the system. There is also a function description for each flow chart that describes in detail the control and regulation system's various operational and regulation functions. This documentation, which is of considerable importance to service personnel, is stored in the i30 and accessible via the Web interface.

3.7 I/O Distribution

As required, a number of I/O (Input/Output) modules are linked to the i30 for connection to the system's various components, such as sensors, controlling devices, pumps, fans, etc. The I/O boards are available in two configurations: one for analogue in/out-signals and one for digital in/out-signals. These I/O modules can either be installed at the i30 or be distributed in the building to minimize wiring runs. An i30 can handle up to 16 different I/O modules, which means that up to 450 I/Os can be connected to an i30. See Section 3, "I/O Modules".

3.8 Weather Forecast Control

Traditional control and regulation systems take consideration to the current situation rather than to that which will occur in the near future. In practice, this means that most buildings' heating systems are regulated by the current outdoor temperature alone. WeatherGain considers all external factors, such as temperature, sunshine, wind strength and direction, and the control system receives this information in advance. WeatherGain is based on utilizing a building's heat inertia, which permits the building to take advantage of the sun's energy supplement and covers a portion of heating needs. If one knows in advance that a cold night will be followed by a warm and sunny day, the building's heat inertia can become an advantage. Heating can then be reduced several hours in advance without the indoor temperature having time to fall. And vice versa – when windy and overcast weather is on the way, heating can be increased in advance. A balancing of the energy supply and a more stable indoor climate are attained, which also provides lowered energy consumption. See Chapter 6, "Weather Forecasts, SMHI".

3.9 Centralised Power and Indoor Climate Monitoring, Alarm Management

To co-ordinate comprehensive control of operations and administration when there are several buildings with i30 systems, or buildings with several different i30 systems, a central Web portal is used. This functionality either is provided by the supplier or is installed at customer sites. See Chapter 2, "Web Portal, Operational and Administrative Information".

4. I/O Modules

The PSR-I/Os are digital and analogue I/O modules that can be installed at strategic locations within a building, up to 1000 m from the i30 device. As a part of the control and regulation system, these modules convert sensor values for the computer system and transmit out-signals to controlling devices. The modules are attached to DIN35 rails. Each I/O module can be located either in an apparatus cabinet or in a standard enclosure.

4.1 Analogue Signals

The analogue I/O module has eight analogue inputs that can be used for sensors or other devices that produce analogue signals. The input value is converted by the CPU (i30, PSR-2000 or other device) and can be used for monitoring or as a parameter for controlling other devices. With switching, the inputs can even feed individual sensors. This makes it possible to connect sensors directly to the I/O boards. The analogue module also has eight outputs that can be connected to controlling devices or other appropriate analogue devices.

In-signals: 0 to 10 Vdc, 0 to 20 mA, 4 to 20 mA, NTC 20K ohm (-50°C to +150°), PT 1000 (-50°C to +150°C), Ni 1000.

4.2 Digital Signals

The digital I/O module has 16 inputs that can be used for sensors or other devices that produce digital signals. The input signal status is read by the CPU (i30, PSR-2000 or other device) and can then be used for indication or for controlling other devices. The digital module also has 12 potential-free relay contacts that can be used for controlling devices, contactor coils or other controllable devices. Via a manual switch, one can choose if an output shall be always on, always off or be controlled from the CPU.

5. Components, Sensor Types, Regulation Components

5.1 Temperature

The temperature element continually senses the temperature and its resistance changes in relation to the temperature. The measurement element is a Pt100, class B and has a temperature range of -50’C–150’C. The sensor’s accuracy is ± 0.5^{o}C at 20^{o}C (DIN IEC 751 class B); the analogue (Pt100) input, 0.15% of the measurement range = 0.3^{o}C.

5.1.1 Room Sensor

The room temperature sensor is used for measuring the room temperature in heating and ventilation systems.

5.1.2 Duct Sensor

The duct temperature sensor is used for measuring the air temperature in ventilation ducts in heating and ventilation systems.

5.1.3 Immersion Sensor

The immersion temperature sensor is used in heating and ventilation systems for measuring water temperatures.

5.1.4 Strap-on Temperature Sensor

The strap-on temperature sensor is used when the immersion temperature sensor cannot be used. With its small size, the sensor is suitable for measuring temperatures in confined spaces.

5.1.5 Outdoor Sensor

The outdoor temperature sensor is used for measuring outdoor temperatures in heating and ventilation systems.

5.2 Air Quality

The air quality sensor is used in heating and ventilation systems when one wants to control ventilation needs via the air’s degree of pollution. Air quality can be measured in dPol, which measures the concentration of the various gases found in the surrounding air, such as carbon monoxide, methane, methanol, ethanol, acetone, etc. Other gases are also registered, such as those from cigarette smoke. Air quality can also be measured in ppm and measures the concentration of carbon dioxide CO_2. The measurement ranges are 3–5 dPol and 0–2000 ppm. Accuracy is 1%.

5.2.1 Room Sensor

The room sensor is used for measuring air quality in rooms in heating and ventilation systems.

5.2.2 Duct Sensor

The duct sensor is used for measuring air quality in ventilation ducts in heating and ventilation systems.

5.3 Pressure

The pressure sensor is used for measuring pressure (Pa) in ventilation ducts in heating and ventilation systems. The pressure sensor has a measurement range of 0 to 5000 Pa.

5.4 Humidity

The humidity sensor is used for measuring humidity (%RH) in room environments in heating and ventilation systems. Measurement range: 0–100%RH

5.5 Light Sensor

Light sensors measure ambient light (lux) and are used for control of outdoor lighting, for example. Measurement ranges: 50–5000 lux and 100–100,000 lux

5.6 Wind Speed Sensor

The sensor measures wind speed (m/s) and is used in climate systems in glassed-in environments where ventilation is achieved with openable windows/skylights, and where limitation of the opening function can be required.

5.7 Presence Sensor

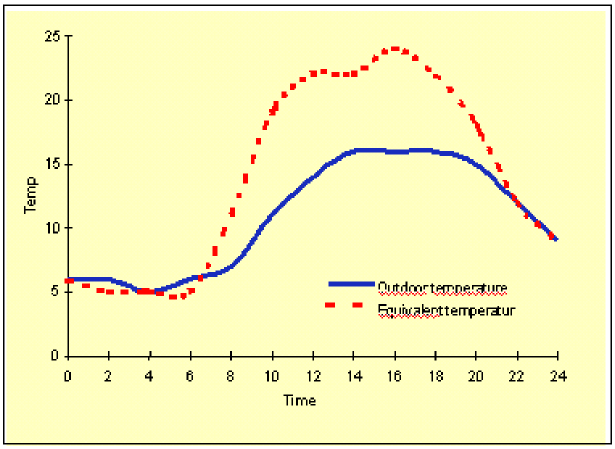
The presence sensor is used to detect the presence of people in a room. The signal is used to start or force ventilation, cancel nighttime reductions or only as an indicator of presence in a room. The sensor detects motion of an object with a temperature higher than the ambient temperature and transmits a signal with a breaking relay contact.

6. Weather Forecasts, SMHI

6.1 ENLOSS

Weather forecasts are now used within the most varying areas with excellent results. For example, IKEA uses weather forecasts for planning personnel schedules. Other areas that use weather forecasts professionally are aviation, ice cream production, agriculture, shipping, advertising and now even building automation, thanks to WeatherGain. This type of weather forecast is not the same as we see on TV. The forecasts that WeatherGain uses are extremely local and include other values.

When WeatherGain is used, the building's regulating equipment is made aware of the weather and forthcoming energy requirements, hour by hour, 3–5 days in advance. WeatherGain was developed by Honeywell INUcontrol and SMHI (the Swedish Meteorological and Hydrological Institute), through Professor Roger Taessler's efforts in developing what is referred to as "equivalent temperature" (ET). ET describes the effects of temperature, sunshine and wind, which are considered with data on the building's characteristics pertaining to position, orientation, properties and method of use. The customised five-day forecast is sent daily via e-mail to the building's control centre. In this way, an optimal value is achieved for each building in ample time before the weather changes. If the ET forecast should be incorrect, which is very unusual, there is always a traditional outdoor sensor as added security.



The figure shows the difference between traditional "Outdoor temperature" compared to the "Equivalent temperature".

6.2 Forecast Content

et = equivalent outdoor temperature (ºC)
ot = outdoor temperature (ºC)
ws = wind speed (m/s)
wd = wind direction (0-360º)
gs = global sunlight (W/m²)
mt = momentary temperature (ºC)

6.3 In-data Form

For each building to be controlled via weather forecasts, an in-data form is filled in with information on the building’s position, surroundings, properties, window surfaces, air exchange, activities, etc.

6.4 Distribution

The weather forecasts are delivered to the control and monitoring device via e-mail (POP3).

7. Operational Information

7.1 PDA, Standardised Operations Tool

As an operations tool for the i30, standardised handheld computers are used, so-called PDAs such as the Compaq iPAC. This entails that a service technician with a PDA can manoeuvre the control and monitoring system locally in, for example, the fan room where the i30 is located.

The PDA receives information on the current values and the limit values that the control and monitoring system uses, as well as information on the alarm status and the operational status of the outputs. Function text, which in plain language describes the control and monitoring system's functions, is also available. The PDA is connected to the control and monitoring system with a cable.

7.2 Web Client through PC with no installation

Because the control and monitoring system is Web-based, no supplier-specific software need be installed; it is enough with a standard Web browser. The flow chart shows how the technical system is designed and displays statuses pertaining to temperatures, operational modes for pumps and fans, valve positions, etc. The alarm list shows the status of the control and monitoring device. Even trend curves for monitoring regulation are possible. Function text, which in plain language describes the control and monitoring system's functions, is also available.

7.3 Feedback to Users

A Web portal is used to provide users and tenants with information on the building in regards to energy consumption and indoor climate. Relevant information is presented with consideration to users: no prior knowledge of the building's technical systems or solutions is required

Information presented on a page includes:

- A simple presentation of the building's energy and media consumption compared to that which is budgeted for the building
- The building's environmental index – the ECO factor [1]
- Graphical presentation of local weather data that is used by the building
- An overview of the building with dynamic information pertaining to room temperature, air quality and operational status

8. Demand Control, Individual Room Control, WOC – Web Office Console

8.1 Individual Web Page, No Installation in Room

Web-based software for individually controlling room regulator (only Honeywell XL10, XL12) for individual rooms via a network. The room regulators are connected via a LON network.
In practice, each person has a personal Web page for his or her room where the temperature, lighting, sun screening, etc. can be set individually.

The solution makes installation simpler and quicker, with standardised room images where each person can control the environment of his or her room. The Web pages for the respective room occupants may include a number of basic modes, such as In, Lunch, Out, etc. so that the room can be set to predefined comfort levels.

8.2 Room Regulator, XL12

The XL12 room regulator is a product installed in the ceilings of the respective offices. For local service, a WOC (Web Office Console) is used.

8.2.1 Temperature

The XL12 affects room climate (heating/cooling) individually by way of a locally placed room temperature sensor that registers the current room temperature.

8.2.2 Lighting

Modern lighting systems feature energy-efficient fluorescent lamp fittings with so-called HF units and full-spectrum lamps. The lighting level in the room (lamps) is controlled by a locally placed presence/light sensor that measures the current lighting strength and then regulates the lighting strength by making adjustments to the lamp fittings. This function turns down lighting when sunlight shines into the room, which provides additional energy conservation.

8.2.3 Presence

Presence in the room is detected by a combination of the presence and light sensors. The presence sensor, in turn, is used to set the room to predefined comfort levels.

8.2.4 Sun Screening

Sun screening is controlled by sunblind regulation to block direct sunlight. Sunblinds also block in windy weather.

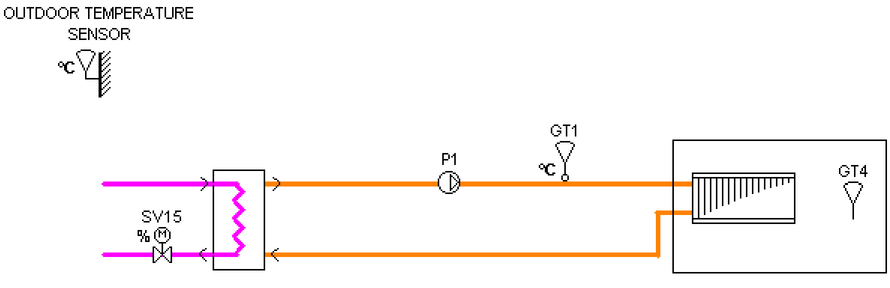
9. System Solution, Office Building

A modern office building with requirements for low energy consumption with good indoor climate has a heating system, often water-borne, for warming the building. Ventilation systems supply the building with fresh air to achieve good indoor climate. There may also be capabilities for separate control of individual offices.

In this section the “Heating system” and the “Mechanical ventilation” are described. For further information regarding control strategies, see Control Strategies [2].

9.1 Heating System

The following basic diagram shows a radiator system.



Heating system, based upon hot water.

The radiator system should be regulated via thermostat valves located on the radiators that ensure that the temperature is correct in the room. To achieve even regulation, the flow temperature to the radiator is regulated in relation to the outdoor temperature.

The outdoor temperature sensor modifies the flow temperature (GT1) in accordance with the set regulator curve. The regulator curve is set using a number of breakpoints so that one can achieve the correct room temperature regardless of the outdoor temperature. For increased heating needs, the control valve (SV15) opens for heat. The inverse function applies for reduced heating needs.

It is exceedingly important the outdoor temperature sensor is correctly located, so that it isn’t affected, for example, by sunlight.

To conserve both electrical and heating energy, the circulation pump (P1) shall be stopped if there is no need for heating. On should always have a so-called **pump-stop function**. This has traditionally been accomplished by the pump stopping when the outdoor temperature exceeds an adjustable temperature, for example, 17°C. When the outdoor temperature is 3°C lower, the pump starts again.

A better alternative, however, is to let the control valve stop the pump when there is no need for heating, which is indicated by the out-signal to the control valve being 0 %.

When the pump is stopped for an extended period, it shall be periodically run to prevent seizing.

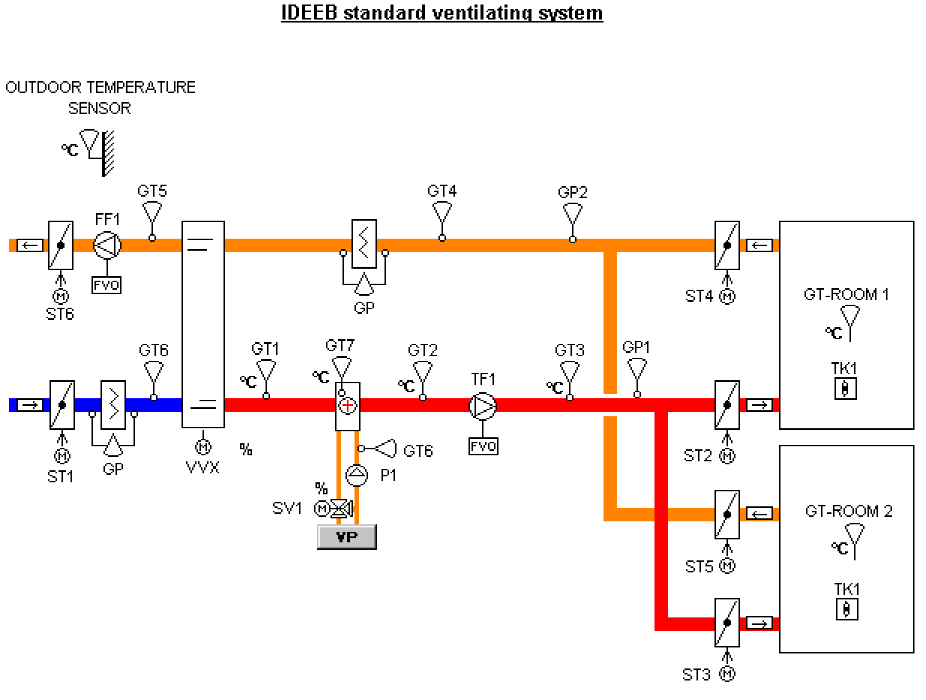
There are different methods for further optimising regulation. Here are some of these methods:

- WeatherGain
- Room compensation
- Night reduction
- Morning increase
- Curve optimisation

For further information regarding these methods see Control Strategies [2].

9.2 Mechanical ventilation

A standard solution for ventilation in an IDEEB building is proposed to have the following basic construction.



Ventilation system with heat recovery and the fan is variable-speed controlled with frequency converter.

The total ventilation devices per building and which premises that the various devices shall support must naturally be adapted to each individual building.

The standard solution is constituted by a mechanical intake and discharge air system with efficient heat recovery via a rotating head exchanger (VVX).

The intake and discharge air ducts are branched out to the various rooms that are supplied. For each room, or groups of rooms, there are regulator dampers (ST2, ST3, ST4, ST5, etc.) in the intake and discharge air ducts so that the flow to parts of the building can be eliminated when there is no need. The flow is adapted by the intake air fan (TF1) and discharge air fan (FF1) being variable-speed controlled with the frequency converter (FVO). Control is accomplished based on the values from the pressure sensors (GP1 and GP2).

It is exceedingly important that the outdoor temperature sensor is correctly located, so that it is not affected, for example, by sunlight.

Operation principles in IDEEB standard configuration:

- Day operation via time channel and extended operation via pushbutton (TK1) in respective rooms.
- Sequence start of fans to minimise electrical power usage.
- Start-up of discharge air fan and heat exchanger before intake air fan.
- Pump-stop function with motion operation on weekdays of pump for heating coil.
- Night cooling function that cools with fresh outdoor air to load cooling energy into the building framework.
- The discharge damper (ST6) closes when the device is stopped to prevent energy losses.

Regulation in IDEEB standard configuration:

- Constant intake air temperature regulation.
- The fans are variable-speed controlled by frequency conversion.
- The heating coil is kept warm when the device is stopped and it is winter.
- Blast-cleaning function of the heat exchanger.
- Full recovery at start-up of the rotating heat exchanger during the winter.
- The heat exchanger is variable-speed controlled to reduce recovery at higher outdoor temperature.

Safety, alarm and monitoring in IDEEB standard configuration:

- The outdoor air damper (ST1) closes via return spring when the intake air fan stops.
- Anti-freezing monitor function prevents freeze damage to the heating coil.
- Operation fault alarm for all motor groups.
- Regulation deviation alarm.
- Filter monitor with alarm function.
- Monitoring of heat exchanger’s temperature efficiency with alarm upon low value.
- Alarm on three levels (classes A, B, C).

The following are some available options:

- Cooling via cooling coil in intake air duct.
- Room temperature regulation.
- Flow control via CO_2 sensors in various rooms.
- Flow control via presence detectors in various rooms.
- Outdoor temperature compensated airflow.
- Fan monitor function.

For further information see Control Strategies [2].

10. Results and conclusions

The design of the web-based controller using weather forecasts, where the building's regulating equipment is made aware of the weather and forthcoming energy requirements, has resulted in major energy savings and a more stable indoor climate has been attained. Energy savings for about 20kWh/m^2 has been the result due to the use of weather forecasts, instead of using the traditional outdoor temperature only.

The web-based controller has a end-user-friendly interface used for operational functions and feedback to the tenants. Due to the web interface the controller has a very high availability for the purpose, which is appreciated of the users.

The controller has also been used for measuring comprehensive energy and climate data of the buildings, which has been collected at the central Web portal. This information are used for further optimisation, and as feedback to the owner of the building, tenants. This database also serve as a base of experience when comparing different buildings.

11. References

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