# AUTOMATED MANAGEMENT SYSTEMS OF MULTI-APARTMENT HOUSES

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**Summary**

Since ten years now we preside apartment houses, we are conscious about the contemporaneity demands of building construction, engineering system installing and exploitation. We have established a “smart house” model that provides power effective apartment house exploitation and automatic engineering system operation and energy resource consumption monitoring possibility. Automatic engineering system of operation control and energy resource consumption accounting provides the necessary comfort and safety needs of the inhabitants. It also increases the effectiveness and accuracy of administration.

## INTRODUCTION

If we take general maintenance technologies as a starting-point, we must take into consideration the needs of maintenance:

- maintenance technologies must be energy saving, effective and steady working;
- there must be possibilities of controlling it and automatic adjustment.

Which allows automatic guarantee of optimum working conditions – minimal power – using and maximal effective and safe function with changing maintenance conditions.

Every apartment or office must install its own power resource consumption register, which is meant for account settling with the owner of the house. If power resource metering indicators with a impulse – mode output are installed, then automation devices can be used and to hooked up for achieving an automatized information system, that enables:

1. Automatized (also from a distance) reading of information about buildings overall consumed power (for example, heat energy, hot and cold water, electric power, natural gas consumption) and information about consumed energy if each apartment and office individually. So there is no need to gather information from all the apartments personally.
2. Information system can be established for a group of buildings so that information about each building individually can be received.
3. Consumption of energy resources is stated almost simultaneously on the whole building and each apartment or office individually.
4. Information about consumption of energy resources can be entered into the accounting programmes and payment calculation about certain types of energy resources.
5. Information can be transmitted trough modem (or otherwise) to an institution, which is far enough, for example, to a bank with the accounts of the apartment or office owners.
6. A person in charge can perform automatized data test about the situation of energy resource consumption on the whole building or each client individually. Any period – day, week, month and year can be chosen. Analysis of the power utilizing effectiveness and care and adjustment of the maintenance device function can be done at the same time, if the system is connected to the maintenance devices.
7. As information system is made by standard automation elements, it can be supplement by connecting an extra hardware (for example, security and video camera systems) to a standard bus.

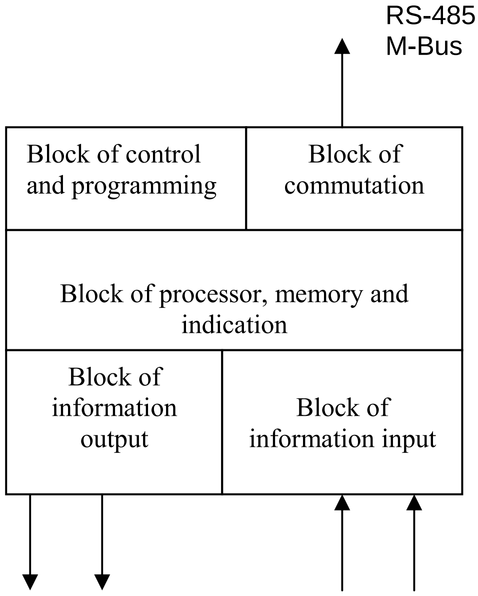
Information system also increases everyday comfort of a population:

- there is no need for lodgers to report on power resource rates
- there is possibility to make a check-up if needed by reading consumption of energy resources from measurement equipment indicator readings and comparing them with the information system results.

Manufacturers of the maintenance technologies offer a wide exposure of programmable - controllable executive mechanism and driving and controlling devices. When choosing automation technologies for a certain function (aeration, heating devices, common use lighting installation etc) with set power, we also must pay attention to the equipment that comes in set (controller), that does working, control and regulation functions in an automatized way.

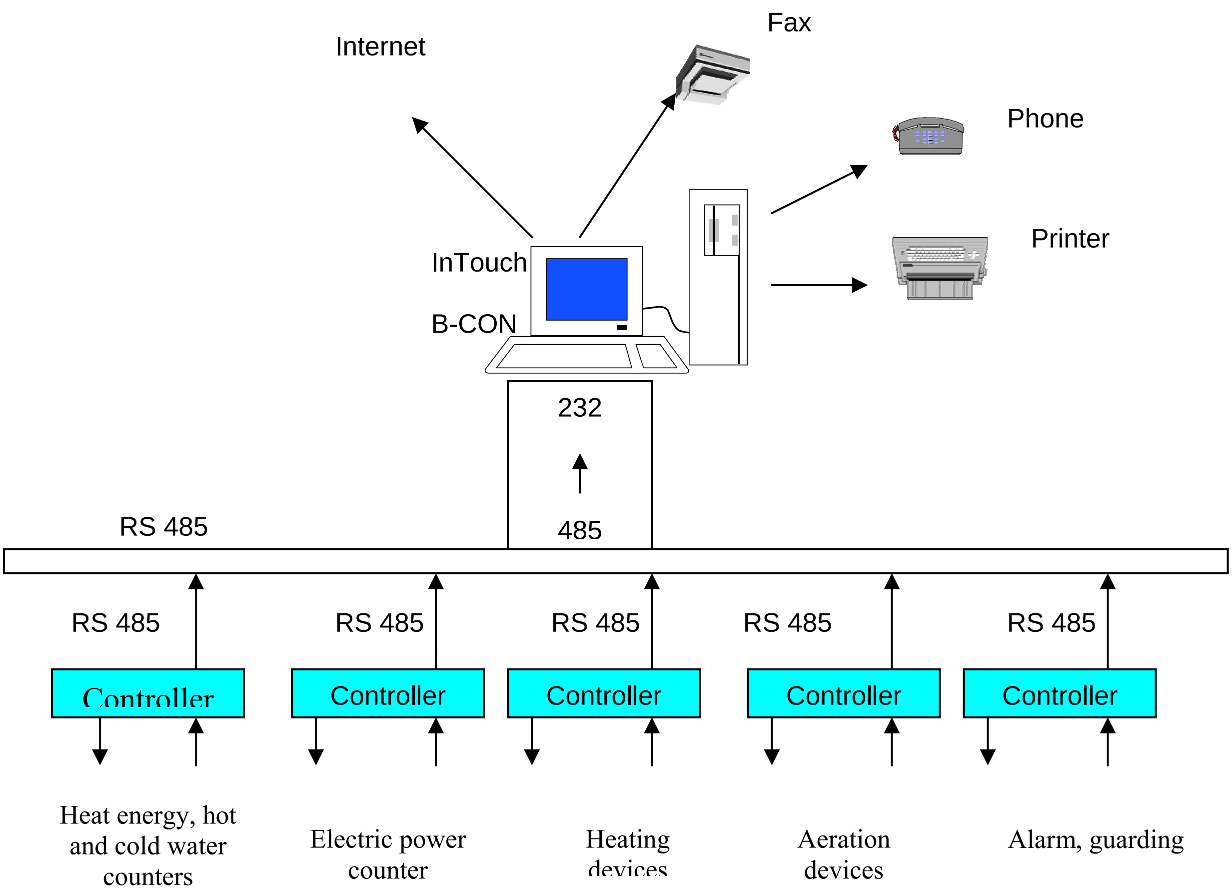
Controller (see Image 1) has following functional blocks[1]: information (analog, discreet) input, processor, memory, indication, control – programming, information (analog, discreet) output and commutation blocks, that provides a connection of controller to a standard interface bus for data transfer and receiving from it.

**Image 1.** Controller[2]




Every chosen technology has its operational control and up keeping instructions. To achieve effective work of buildings maintenance technologies, we can entrust the realization of those instructions to an expert. But more perspective it would be to entrust it to computer, by establishing buildings maintenance monitoring system. System is established (see Image 2) by choosing definite standard interface bus, for example, M – bus or RS 485.

**Image 2.** Buildings maintenance monitoring system




[1] Blocks are conroller's electronic component modules
[2] Block of commutation – these module secure data exchange between controller and other device (Exsample PC)

Bus, that basically consists of 2 or 4 wire lines, can be connected to a personal computer and buildings maintenance technology controllers, that have proper commutation blocks with M-bys or RS 485 bus. Now we must choose program insurance and specialize it for a certain maintenance technology. General-purpose programmes, for example, In -Tach or B-con can be used for that [1].

## METHODS

A fundamental criterion for the quality of the buildings is the consumption of the thermal power, which depends on several factors. 4 apartment houses will be compared, which were built in the time period from year 1995. - 2004, gradually introducing different actions to promote power effectiveness and realize the automatic control system of the building, which at the moment corresponds to the required and available technologies in Latvia. The consumption of the thermal power for square meter per month will be used to measure the power efficiency of the building, which is influenced by:

- heat - technical parameters of constructions (corresponding to norms in Europe, in Latvia determined by LNB-002-01, that came into effect form 01.01.2003. [2]);
- the quality construction work;
- efficiency of engineer systems;
- the possibilities of automatic control and monitoring for power supply;
- registration of energy resource consumption for the building;
- registration of energy resource consumption for individual consumers, providing payments according to consumption register;
- comfort requirements and paying capacity of inhabitants.

In addition to the consumption of thermal power, the degree-days (DD) in a month is being calculated to characterize the weather conditions:

$$DD = (T_{inner} - T_{outer}) * a \quad , \qquad (1)$$

where

DD – days of degrees;

$T_{inner}$ - living accommodation temperature (on average 18 $^{0}$C [3]);

$T_{outer}$ - external environment temperature (data taken from “Latvian Hydrometeorology Agency”);

a – the number of heating days per month.

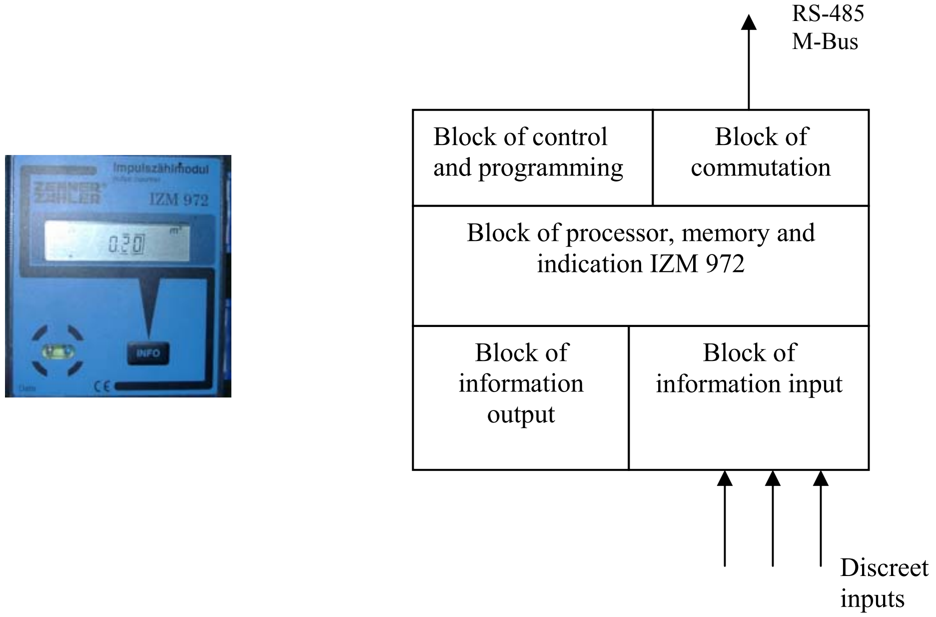
The average number of degree days in Riga during the heating season are 3654 (the average number of days when heating is on - 203, the average temperature doring the heating season is 0 $^{0}$C [4]).

Lets look closer at the apartment house monitoring, control and accounting automation for the energy resource consumption.

First of all there were chosen a certain type consumption counters that had pulse output. In the actual case there were indicators for the cold and hot water consumption and thermal power flow (coexisting with mechanical numeral indicators) that permit receiving of impulse mode information about measurement results while measuring. Impulse mode information output for measurement results permits automatization of control – accounting process and possibility to manage it from a distance. For accumulation, analyzing and visualization of impulse mode information there can be used certain type of hardware like IZM 972 and Multidata 1[5].

IZM 972 is a specialized micro controller that has three (see Image 3) inputs for impulse mode information feeding, processor with memory for analysis and accumulation of information, numeral indicators for measuring data or visualization of measuring results and elements for ensuring of the micro controller commutation (data exchange) with definite standard interface bus, for example, M – bus or ZR – bus). IZM 972 can be used for analyzing, accumulating and transmitting information for two water (cold and hot) consumption counters when using, for example, two wire M-bus.

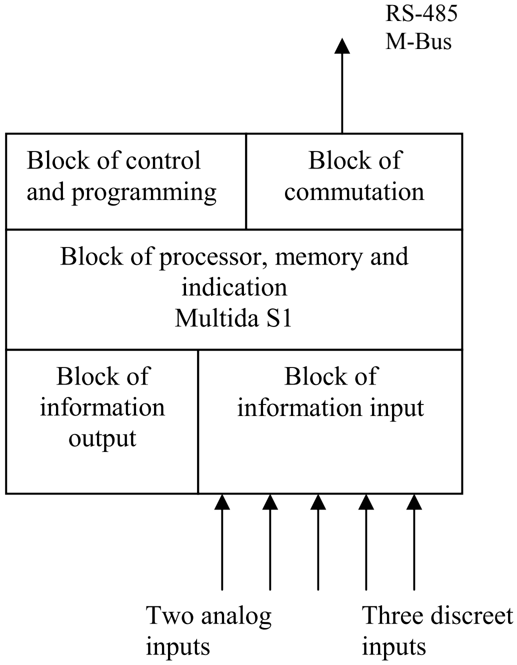
**Image 3.** IZM 972 – photo and scheme.




Multidata 1 also has a specialized micro controller, with 5 lines for information feeding (see Image Nr.4):

- one impulse mode, for example, to fix and to analyze the heat carrier flow that is connected to:
- two analog information input lines, for example, from temperature transducers in feeding-pipes;
- two impulse mode information input lines, for example, for two counters of water consumption.

**Image 4.** Multidata S1[1]




Micro controller has processor with memory for heating and water consumption analysis, accumulation of results, numeral indicators for measuring data or visualization of measuring results and elements for ensuring of the micro controller commutation (data exchange) with definite standard interface bus, for example, M – bus or ZR – bus). With Multidata 1 can be used for analyzing, accumulating and transmitting information about two water (cold and hot) and used thermal energy consumption counters when using, for example, two wire M-bus.

Every apartment owner has a meter box built in his apartment that has counters for hot and cold water and counters for heating energy (see Image 5).

[1] Block of commutation – these module secure data exchange between controller and other device (Exsample PC)

Numeral indicators can give an opportunity for the apartment owner to be informed about his water and heating consumption. Also it is easier for the house manager to read every apartment's consumption through computer when writing out the bills.

**Image 5.** Apartment's technical cabinet of the energy resource consumption register

If you can control water consumption with a tap, then consumption of heating thermal energy can be controlled with the help of convectors thermal-controller. Thermal-controller, according to its workings and construction, is a gate. When closing or unclosing it, the heat carrier flow through convector can be changed. Installing thermal-controller on the certain marks (see Image 6) will ensure a certain penetrable of the flow, which in case of a sudden change of room's temperature will be peripherally controlled by sensor (substance that has a characteristic density changes as the temperature changes too) in the "head" of the thermal-controller.

**Image 6**. Thermal-controller

Every apartment has a separate consumption register for electric power. Though it is not located in the apartment, because the instant supplier of electric power requires a twenty-four hour access to the register. This register is not the property of the apartments owner, like it is with the other registers.

The supply of thermal power and hot running water is provided in the individual steamshop of the building (see Image 7) or in the heat point. That depends on the solution of heat supply for specific building.

**Image 7**. Photo of ndividual gas steamshop

Energy resource consumption registers are installed in the technical point of the building for hot and cold running water, thermal power etc.

Development of the new technologies increases the needs of comfort not only for engineering and technical insurance of buildings and room climate, but also for life safety insurance and use of entertainment and communication industry offerings. When designing new buildings it is important to foresee and to carry out technical provisions, for example, cables and low current netting to provide maximal possibilities of service offerings, so there is no need for fundamental interference in buildings already established communication network.

Live issues of extra services are:

- installation of apartments security alarm devices, for example, on doors and windows,
- internet or computer network connection
- installation of a telephone
- satellite or cable TV

## RESULTS

To evaluate- the possibilities of realizing contemporaneous requirements in the previously described apartment houses; -the desirable level of power efficiency; - the comfort and security level of inhabitants- four actualized apartment house construction projects in Riga, Latvia will be compared:

1. In 1995 apartment house (series 119) project was actualized (see Image 8). It will be taken as a model (hereafter called the "house A") for comparing it with three other house projects;
2. In 1999 apartment house (series 119) project was actualized (see Image 9). There are bureaus and shops on the first and second floor (hereafter called the "house - B");
3. In 2002 apartment house (series 119) project was actualized (see Image 10). (hereafter called the "house – C")
4. In 2003 apartment house (series 103) project was actualized (see Image 11). There are bureaus and shops on the first floor (hereafter called the "house - D").

**Image 8.** House - A

**Image 9.** House - B

**Image 10.** House - C

**Image11.** House - D

In these constructions you can see today's apartment house building tendencies (see Table 1).

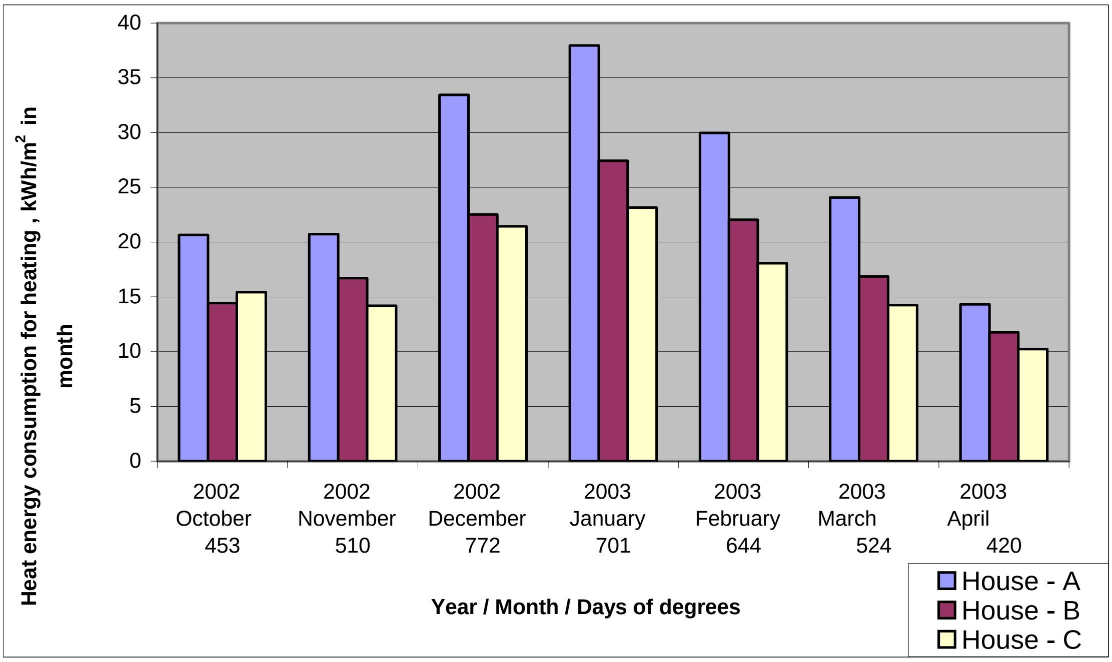
**Table 1.** Data about buildings and accomplished events

| **Data** | **House - A** | **House - B** | **House - C** | **House - D** |
|---|---|---|---|---|
| The year of construction | 1995 | 1999 | 2002 | 2003 |
| The heating area of the house, $m^2$ | 2528,3 | 5695,4 | 2628,3 | 4870,8 |
| The number of floors | 10 | 10 | 5 | 8 |
| The number of staircases | 1 | 2 | 2 | 3 |
| The number of apartments | 40 | 64 | 40 | 62 |
| The number of offices | - | 7 | - | 6 |
| The heat supply of the house | Centralized supply of thermal energy with hot water warm up in the heat linkage of the house | | | Gas steam shop |
| Tariff of thermal energy | 26 EUR/MWh | | | 20 EUR/MWh |
| **Realized events** | | | | |
| Heat insulation of external walls | - | Insulated, according to LBN 002-01 [2] | | |
| Heat insulation of the covering of cellar | - | - | Insulated, according to LBN 002-01 [2] | |
| Heat insulation of the covering of attic | - | - | Insulated, according to LBN 002-01 [2] | |
| Windows | Two-glass windows in the wooden frame, packed tight | Two-glass packet windows in PVC frame $U_{sum}$=1,8 [W/$m^2$*K] | Two-glass packet windows in PVC frame, $U_{sum}$=1,3 [W/$m^2$*K] | Two-glass packet windows in PVC frame(five camera profile), $U_{sum}$=1,3 [W/$m^2$*K] |
| Heating system | Single-pipe | Double-pipe heaters with thermo regulator | | |
| Airway (in apartments) | Natural afflux through windows and non dense constructions and natural air sucking from kitchens and side-leakages | Natural afflux through windows ("winter conditions"[1]) and centralized mechanical air sucking from kitchens and side-leakages | Natural afflux through windows ("winter conditions") and local mechanical air sucking from side-leakages and natural air sucking from kitchens, foreseeing the possibility to set up the steam sucking recirculation regime | |
| **The inventory of the consumption of energy recourses of individual apartments and offices** | | | | |
| Electricity | + | + | + | + |
| Thermal energy | - | + | + | + |
| Hot and cold water | + | + | + | + |
| **The automatization of the building:** | | | | |
| Automatic reading of the consumption of from kitchens and side-leakages | - | + | + | + |
| Monitoring of consumptions of the energy resources of the building | - | - | - | the project is being developed |
| The access of internet data in disposal of inhabitants and house keeper | - | - | - | the project is being developed |
| **Extra service possibilities, employing the existent nets of communication:** | | | | |
| Internet, TV, satellite, phone, guarding | - | - | - | + |
| Domophone (provides communication between apartment and the building entrance) | - | - | + | + |
| television surveillance of house - security | - | - | - | + |

[1] Winter conditions - window packing clearing, providing the gap for airing.

To realize the contemporaneous technological possibilities and comfort requirements, which would be available for realization in large quantity as it is with apartment houses as well as other houses of significance, they must be economically justified [6]. We will evaluate how successfully it has been managed in four previously mentioned apartment house projects. The method will be the comparison of the thermal power consumption in year 2002/2003 (see Image 12) and year 2003/2004 (see Image 13) heating season.

**Image 12.** Heat energy consumed for heating 2002/2003




The final consumption of thermal power in heating season - year 2002/2003 (4023 days of degrees):

– “House - A” – 181,12 kWh / m$^2$ ;
– “House - B”- 131,72 kWh / m$^2$;
– “House - C” – 116,73 kWh / m$^2$.

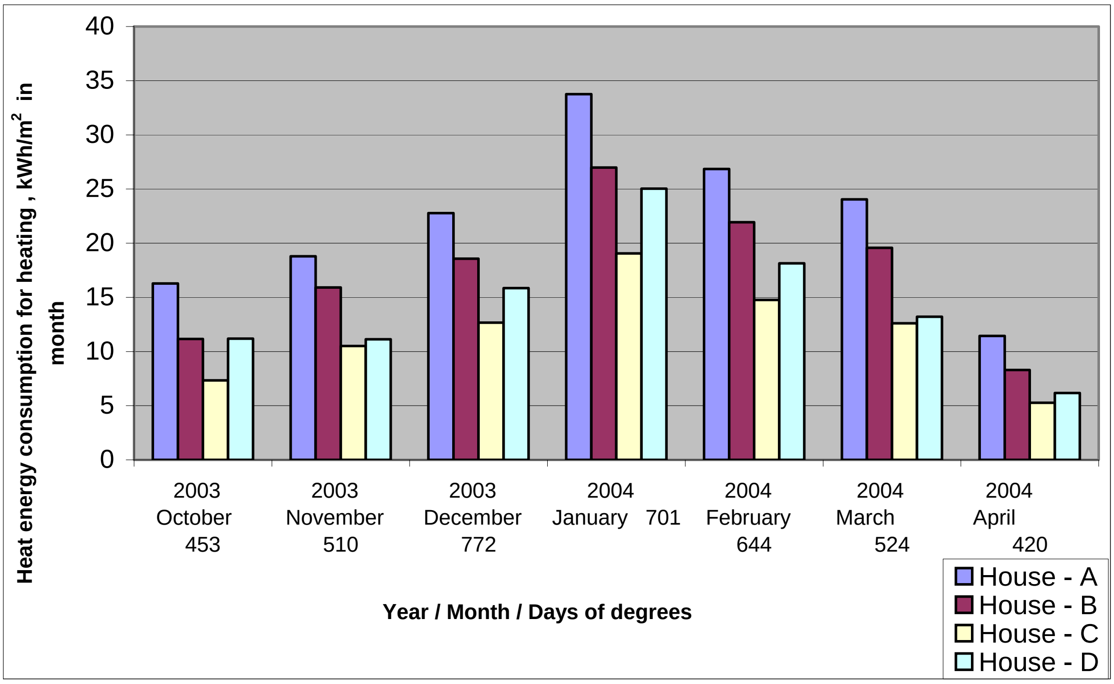
The following heating economy was reached in comparison with “House - A” in 2002./2003. heating season:

- “House - B” – 26 % ;
- “House - C” – 34 %.

The consumption of thermal power in “house-D” is not examined because during this period of time the construction of building was still going on. In this project that is analogue to the “house-C” additional automatic control elements, there were effectuated peripheral elements of automatic control that provide increasing of the power efficiency for the building. But mainly meant for increasing security and service possibilities for inhabitants which ensure the possibility to do the house monitoring and control using computerized system:

- registration of energy resource consumption and production for individual gas steamshop
- registration of separate common use energy resource consumption that provides possibility to part the payments (for example lighting in elevators, stairways etc.)
- for security television surveillance;
- inner internet installing, that will provide the inhabitants with possibility to access the energy resource consumption data of their apartment and whole building.

**Image 13.** Heat energy consumed for heating 2003/2004




The final consumption of thermal power in heating season - year 2003/2004 (3524 days of degrees):

– "House - A" – 153,91 kWh / $m^2$;
– "House - B"- 122,41 kWh / $m^2$;
– "House - C" – 82,20 kWh / $m^2$;
– "House - C" – 100,74 kWh / $m^2$.

The following heating economy was reached in comparison with "House - A" in 2003./2004. heating season:

– "House - B" – 21 %;
– "House - C" – 48 %;
– "House - D" – 36 %.

Planned thermal energy savings "house D" in comparison with "house A" are forcast ~50%. In the first heating season this goal wasn't reached, as it was predicted, because:

- the construction of the house is finished fully in the August of year 2003. And in the first heating season increased consumption of the thermal power is expected, which is connected with the drying of the constructions;
- inhabitants must acquire the possibilities of individual regulation of the heaters and adjustment of optimal regimes to provide the advisable temperature in the rooms together with sparing the consumption of energy resources;
- increased consumption of thermal power is connected with the growing comfort demands of the inhabitants, including the higher temperature in the rooms.

"House – C" affirms theoretical prognosis about the changes in thermal power consumption after construction:

- the economy of thermal power consumption reached 34 % in the first heating season – year 2002/2003.
- the economy of thermal power consumption reached 48 % in the second heating season – year 2003/2004.

in comparison with "house – A". These data allow to expect the same economy of thermal power consumption in "house – D".

When performing renovation similar aims to reduce the consumption of thermal power are set up. Pilot project data approves that. To achieve the result it is necessary to perform whole complex of actions in order to increase power efficiency [7, 8, 9].

## DISCUSSION

The main benefits of installation of computerized energy meters are:

- the option for inhabitants to control and save the consumption of energy resources;
- the controllable consumption of energy resources of the whole building;
- higher building exploitation service level for consumers.

During the last year of exploitation of computerized reading of energy meters several problems were identified:

- the manufacturers of computerized energy meters specify the maximum number of devices in one circuit, but this does not work in practice. Increasing the number of devices in one circuit close to its maximum, the computerized reading does not work for all cases. Therefore we test energy meter devices of several manufacturers;
- the obtained data usually are delivered in unusable form for further calculations (bookkeeping etc.).

It is important to secure against:

- the intermissions in the power supply system;
- unregistered user possibility to access to databases and unapproved usage of it.

To realize convenient usage of automatic control and monitoring system, data processing and visualization project is being developed, with an aim to:

- simplify the access to database – providing access from internet;
- systematize automatic data processing and saving;
- realize data visualization;
- ensure computerized monitoring for administrated objects (with automatic alarm transmission);
- establish web page with restricted access only for authorized users.

Development of this system allows to reduce the consumption of the human work resources and increases the level of service [10, 11].

## NOMENCLATURE

DD – days of degrees;
$T_{inner}$ - living accommodation temperature (on average 18 $^0$C [6]);
$T_{outer}$ - external environment temperature (data taken from “Latvian Hydrometeorology Agency”);
a – the number of heating days per month.

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