LOCAL ENERGY RESOURCES IN THE INTEGRATED SYSTEM OF ENERGY PRODUCTION AND USE

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Absract. Households are the most heat energy consuming sector. The biggest part takes heat energy consumption for household heating. In the research energy supply system of the energy efficient house for 5 people family with floor area 130 m^2 was analyzed. Energy supply system is provided with solar energy collector, gas type furnace system, hot water accumulation system, divided canalization system (toilet wastewater and wastewater from washing machines), air ventilation system with heat recovery equipment, greenhouse (indoor garden) as essential element of the building where bioprocesses and effective wastage utilization are realized. The energy consumption of the "passive" house due to heat insulation and tightness enormously decreases. There are many researches and experiments about possibilities of the use of local renewable energy sources such as solar, wind and biomass, but possibilities of the use of energy recovered from waste matter resources (water, air, food) from domestic activities is not still researched appropriately, therefore this kind of energy source is used only partially. In integrated energy supply system it is possible to cover considerable part of energy from total heat energy consumption recovered from waste matter, to optimize variable seasonal demand and availability of heat energy, to minimize electric energy consumption.

Key words: passive house, local energy sources, heat supply, energy efficiency.

Introduction

In Latvia 60 % of annual energy consumption is used for heat energy production. Households are the most heat energy consuming sector. At the moment average amount of energy used for space heating per m^2 per Latvian dwelling is 230 kWh per year, what is mostly dependent on heat resistance of the building [1].

Table 1

Consumption of energy in the dwelling house depending on heat insulation (building construction) of the building

Type of the building	Value, kWh·m^{-2} per year
Built in 1952.-1980.	200-400
Built in 1981.-1998.	150-200
Built in 1998.-till now	50-80
"Passive" house	20-40

For comparison, annual energy consumption for space heating accounts only 15 kWh·m^{-2} accordingly to the standards of passive house. At the moment space of dwellings is up to 56000 m^2, space of offices and shop floors is 24000 m^2. The potential of decline of heat energy consumption in such kind of buildings is tremendous.

The European standard on passive houses provides different parameters, for example, annual heat energy consumption for space heating is not greater than 15 kWh·m^{-2}, however total energy consumption (space heating, water heating, and electricity use for appliances/lighting) is not greater than 120 kWh·m^{-2}. Standard provides different solutions for construction design, including use of available renewable energy resources in the particular district – solar, biomass, wind, geothermal and other type of energy sources [2]. Previous experience shows that building expenses for passive house building in comparison with traditional buildings increases only for 15-20 %. In turn energy consumption decrease accounts 85-90 %.

The aim of the research is to evaluate energy efficiency of the traditional thermal and bio-processes in the integrated heat supply system using renewable energy sources.

Materials and Methods

In order to evaluate energy efficiency of the traditional thermal and bio processes in the integrated heat supply system using renewable energy sources [3], it is necessary to analyze the model of heat supply system for 5 people family house with heat insulation like in “passive” house, total floor space 130 m^2. For ensuring heat energy demand solar energy (heat collector), greenhouse (indoor garden), gasification furnace for decomposition of various biomass of origin, voluminous heat accumulation, separated sewerage system – when feces and greywater (bath, kitchen, shower) are separated, recuperative air ventilation system, wind generator depending on local weather conditions are used. Taking into account operational parameters of the most popular in previous years built houses and our experience in the use of solar and biomass energy in previous researches [4, 5] calculations were made.

Results and Discussion

In Table 2 calculated distribution of energy consumption of the energy efficient family house is presented. The biggest amount of energy is needed for floor heating – 3000 kWh per year, interesting fact is that energy demand for electrical appliances is nearly the same 2800 kWh per year. For water heating about 2400 kWh per year is required, what is only for 600 kWh less as for floor heating. Energy demand required for floor heating is a seasonal occurrence, but energy demand for water heating is required all over the year. During the summer period for water heating it is possible to use heat energy obtained from solar collectors.

Table 2

Distribution of energy consumption of the energy efficient family house

Position	Consumption, kWh per year	Percentage, %
Floor heating	3000	35 %
Electrical appliances	2800	32 %
Hot water	2400	28 %
Ventilation system	440	5 %
Total:	8640	100%

In Table 3 results [9] obtained from previous experiments are shown. From the Table 3 follows that in Latvian weather conditions it is possible to produce about 500 $kWh \cdot m^{-2}$ during the season March-October. The biggest amount of energy is possible to gain during June and July; certainly results are dependent on weather conditions – outside air temperature, amount of rainfall and nebulosity.

Table 3

Amount of heat energy gained from solar collector if, coefficient of performance is 44.3 %

Month	Amount of heat energy gained from solar collector, $kWh \cdot m^{-2}$
March	42.8
April	55.8
May	71.7
June	89.3
July	88.5
August	71.2
September	53.3
October	25.5
Total	498.1

Speaking about twenty four hour turnover of renewable energy sources (waste matter) it is usefully to mention about water, air and food. During the twenty four hour cycle 1.25 m^3 water is used, where 1.0 m^3 is greywater and 0.25 m^3 are feces; airflow for 3600 m^3 occurs; waste matter of food for 0.65 kg remains.

At the moment a lot of different information about proposed and realized projects of energy efficient premises is available, when heat insulation of the building is accentuated especially [6].

Local energy sources even as heat energy production of man and pet is analyzed, but power potential of waste matter and possibility of the use of waste matter in heat supply system is not assessed yet. Analysis of recycling of waste matter using environment friendly technologies and its influence on the envoronment should be analyzed more properly.

Table 4

Compostition and quantity of household waste per family

Type of the household waste	Ammount of the household waste, kg per 24 h	Ammount of the household waste, kg per year
Food waste	0.3-0.5	100-180
Glass	0.1-0.2	40-80
Paper	0.05-0.1	20-40
Metal	0.01-0.02	4-8
Textile	0.01-0.02	4-8
Plastic materials	0.02-0.03	9-10
Incineration materials	0.05-0.1	20-40
Stone, clay	0.05-0.1	20-40
Dust, ashes	0.3-0.5	100-180

As waste utilization problem becomes more actual, conception of modification of the environement becomes more popular and understandable not only among specialists but also in all society. Nowadays waste is seen as resources – raw materials wich are not located in the same place, where they can be used; it is necessary to recycle waste as close as possible to their location [7].

In Table 4 compostition and quantity of household waste per family (5 persons) is shown. One family in average produces 400-700 g of organic and incineration wastage, in further calculations it was taken 650 g. The biggest household waste production groups are food waste and dust waste and its production is about 0.3-0.5 kg per 24 h [10].

Table 5

Premises of the building and people who uses it

Users	Floor area, m^2
Bedroom (2 parents) / bedroom (2 young ones) / bedroom (1 grandparent)	18/14/10
Kitchen / dining room	17
Resting room / sitting room	26
Bath / shower/ toilet	8/2/5
Toilet	2.5
Corridor / hall	6.5/6
Greenhouse / winter garden	15
Premises for solid fuel	2.5
Premises for heat supply system / furnace, heat accumulator, heat pump	2.5
Total	130.5

In Table 5 simulated premises and floor area of them are shown. For the development of optimal ventilation system it is necessary to take into account amount and time of stay of dwellers. For example, 1 person during the 8 hour sleep sweats for about 1 l of water, consequently during period of sleep is necessary to ensure definite level of air exchange. This example describes the special need for ventilation system and necessity of management of it, especially in “passive” very well heat insulated house.

In Table 6 amount of energy obtained from local energy sources ~3300 kWh is presented. Variable energy demand of heat energy for heating the floar area and water is squared by using heat accumulator with gasified type furnace (solid fuel) [8] which uses the stabilized waste matter with humidity up to 60 % as energy resource.

Table 6

Resources of the family building and gained ammount of energy

Resource	Volume	Power intensity	Amount of obtained energy
Organic and incineration waste matters	0.6 kg per 24h	~2.6 kWh per 24h	~950 kWh per year
Green mass. Grass, branches, foliage from ~ $500 m^2$	~1 $kg \cdot m^{-2}$ per year 500 kg × 0.15 =75 kg dry matter 75 kg	4 $kWh \cdot kg^{-1}$ dry matter	~300 kWh per year
Air Outflow/Inflow	3600 m^3 per 24 h	Recovery of necessary energy for preheating ~50 % 500 × 0.5 = 250	~250 kWh equably all over the year
Greywater	1.0 m^3 per 24 h	Recovery of necessary energy for preheating ~30 % 2500 × 0.3 = 750 kWh	~750 kWh equably all over the year
Solar collector	1 m^2	Per month 25…40…80 kWh	~460 kWh per season
Wind generator at available wind intensity	1 kW 100 days ,12 h 100 × 12 = 1 200 h coefficient of generator 0.5	Transformation of electricity to heat 1200 × 0.5 = 600 kWh	~600 kWh depends on resource availability in different places

Our experimental device demonstrates the possibility of stabilization-condition of waste matter (domestic and garden waste) in greenhouse with natural air flow and indirect solar energy. Dry matter we can keep till winter/autumn period. In the greenhouse partial purification of greywater is realized where humidity-loving plants are used for this purpose. Purified water can be used as washing out water in the toilets. Heat exchanger partially recovers amount of energy from outflow greywater heating flowing in clean water.

Stabilization of waste matter during the winter/autumn period takes place in the furnace premises, in the stationary layer at outside air temperatures 20-30 ˚C, stabilization cycle ~3 × 24 h, overbalance of dry matter ~90 % (humidity ~10-11 %), unit weight of stabilized mass ~0.2-0.3 $kg \cdot l^{-1}$. Daily available amount of waste matter (organic and incineration part) ~0.65 kg and its power intensity is ~2.6 $kWh \cdot kg^{-1}$ of dry matter [10].

Conclusions

1. Systematic approach to the problem of heat supply system enables to study all the facets of the matter about the potential and possibities of effective use of local energy sources. Use of the waste matter enables optimization of the heat energy demand in dependance on the seazon.
2. Joining to up-to-date technologies and equipment with sensible use of energy sources, it is possible to get safe, effective and suistanable local energy supply system.
3. Combained renewable energy systems produces less emissions of carbon dioxide, these systems are cheaper and less dependent on imported fuel.

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