Utilization of latent heat of 330 kV autotransformer for space and water heating in substation Imanta

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***Abstract*—This paper analyzes possibilities to use a latent heat from a cooling system of autotransformers to provide space and water heating to the substation "Imanta". Technical and economical calculations were made for evaluation of the feasibility of proposed modernization of the substation.**

***Keywords*—power transformer, cooling system, heat losses, heat exchanger, heat pump.**

I Introduction

110 kV and 330 kV power transformers and autotransformers are used to transfer large amounts of electrical energy. Although, power losses of such transformers are below 1% of nominal power, overall losses can be significant. At the present time all high voltage power transformers and autotransformers installed in Latvia have cooling system, where heat losses are dissipated into environment. Latvia as the member state of the European Union is going to reach 30% growth in energy efficiency by the year 2030. This target could be reached in different ways. One of them is to use waste energy. There are many power transformers, which are in operation for 20-30 years. It is difficult and requires a lot of investments to replace old power transformers. That is why it is vital to look for more efficient use of old power transformers and the ways, how to modify them to reduce maintenance costs and increase their efficiency. Power transformer losses mainly appears as low potential heat energy which can be effectively transformed to the energy with higher potential via heat exchangers or heat pumps. It means, that usage of it could positively effect general energy efficiency. [1]

II Research object

330 kV high voltage substation "Imanta" in Riga was selected as the research object in this study. Comparatively old power autotransformers are operated in this substation. The building of the substation includes a control room and operative personnel building. At present time electric heaters are used to produce heat for these buildings with electric boilers to provide hot water. Central district heating system is not available for this substation. Both buildings one-storey, the total area of both buildings is 594 m^2. Operating power autotransformer АТДЦТН 125000/300 was manufactured in the USSR. Performance data of this autotransformer are indicated in the Table I. [2]

TABLE I

АТДЦТН 125 000/330/110/10 nominal data		
Manufacturing year	1971	
Nominal power, S_{nom}	125	MVA
Higher voltage winding, U_A	330	kV
Medium voltage winding , U_V	110	kV
Lower voltage winding , U_Z	10,5	kV
Overall weight of autotransformer	211,15	t
Mass of active part	99	t
Weight of transformer oil	57	t
No-load losses, $\Delta P_{tukš.}$	97,9	kW
Full-load losses HV-LV, $\Delta P_{sl.}$	410	kW
Full-load losses HV-MV, $\Delta P_{sl.}$	313	kW
Full-load losses MV-LV, $\Delta P_{sl.}$	271	kW
Short circuit voltage HV-LV	9,63	%
Short circuit voltage HV-MV	32,4	%
Short circuit voltage MV-LV	21,4	%
Cooling system	Oil Forced Air Forced (OFAF)	

Autotransformer has cooling system with forced oil flow and forced air flow (OFAF). Nominal data of one cooler is provided in the table II. Oil is driven through cooler by 2.8 kW oil pump with nominal flow rate of 100 m^3/h. Each cooling section contains one cooler, one oil circulation pump and two fans. Autotransformer has 6 cooling sections.[2]

This type of cooling system is perfectly suitable for the modernization, because it is already equipped with oil circulation pumps, which could be used to deliver oil to heat exchanger of the heating system Fig. 2. It also allows a better metering of transformer heat losses, that could be used as low potential heat. [2]

TABLE II

Cooler nominal data		
Type	ОДЦ 180-У1	
Heat flow	180	kW
Oil flow through cooler	108	m^3/h
Temperatures at cooler inlet		
Of air	40	°C
Of oil	75	°C

Number of oil inlets	2	
Volume of oil in a cooler	0,13	m3

III Calculation of Heat Losses

First of all we shall calculate energy demand for the space and water heating of operating personnel and control room buildings. Based on these calculations we shall determine overall capacity of the heating system and select necessary heating equipment.

To calculate heat energy necessary for compensation of heat losses in the building in this study we have used a method based on specific heat losses per cubic meter. Calculations using this method was performed for each room separately, because specific heat losses depends on room location within building. This calculation can be applied only for one-storey buildings. [3]

$$Q_l = V * q * (t_t - t_{A5}) = (S * h) * q * (t_t - t_{A5}) \quad (3.1)$$

where Q_l – heat losses, W;
V – volume of room, m^3;
q – specific heat losses per cubic meter, $W/m^3{*}°C$;
t_t – temperature in the room, °C;
t_{A5} – five coldest day average ambient temperature during a heating season, °C;
S – room area, m^2;
h – height of ceiling, m.

Area of rooms and ceiling height are known, specific heat losses are taken from guidelines. Five coldest day average ambient temperature during a heating season can be found in statistics. Ambient temperature during 2013 / 2014 heating season was one of the highest in last decade. Nevertheless five coldest day average temperature stays almost the same during these years, so we used air temperatures of this heating season for our calculations. The average five coldest day temperature was –14,8°C. In our calculation we chose 22°C temperature for most of rooms in both buildings, except few rooms such as garage, workshop and specific rooms where temperature could be lower. [3]

Now we will make calculation for one room with temperature of 22°C :

$$Q_l = (S * h) * q_c * (t_t - t_{A5}) = 18.3 * 2.75 * 0.96 * (22 - (-14.8)) = 1777.88, \mathrm{W} \quad (3.2)$$

where q_c – corner room specific heat looses, $W/m^3{*}°C$.

Calculation example for room with 18°C temperature:

$$Q_l = (S * h) * q_c * (t_t - t_{A5}) = 75.03 * 2.75 * 0.93 * (18 - (-14.8)) = 6293.97, \mathrm{W} \quad (3.3)$$

Coefficient q is applied depending on room location within the building: q = 0,93–1 $W/m^3°C$ for corner rooms and hallways with doors to the outside;q = 0,58–0,82 $W/m^3°C$ for rooms with one outer wall; q = 0,23–0,35 $W/m^3°C$ for rooms without outer walls. Calculations for all rooms are shown in table III. As operating personnel building has old less efficient heat insulation, we have used the lowest level of q coefficient, for the renovated control room building we have used the highest q coefficient. [2] [3]

TABLE III

Operative personnel building				
S, m^2	**h, m**	**t_t-t_{a5}** °C	**q,** $W/m^3{*}°C$	**Qz, W**
18,3	2,75	36,8	0,96	1777,88
33,5	2,75	36,8	0,96	3254,59
12,5	2,75	36,8	0,96	1214,40
17,1	2,75	36,8	0,96	1661,30
4	2,75	36,8	0,96	388,61
1,4	2,75	36,8	0,96	136,01
19,3	2,75	36,8	0,7	1367,21
16,7	2,75	36,8	0,7	1183,03
11	2,75	36,8	0,7	779,24
20	2,75	36,8	0,7	1416,80
16,6	2,75	36,8	0,29	487,18
2,5	2,75	36,8	0,29	73,37
1,5	2,75	36,8	0,29	44,02
4,8	2,75	36,8	0,29	140,87
2,8	2,75	36,8	0,29	82,17
4,2	2,75	36,8	0,29	123,26
			Qol	14129,95
Control room building				
S, m^2	**h, m**	**t_t-t_{a5}** °C	**q,** $W/m^3{*}°C$	**Qz, W**
75,03	2,75	32,8	0,93	6293,97
33,19	2,75	32,8	0,58	1736,37
69,13	2,75	32,8	0,93	5799,04
45,77	2,75	32,8	0,93	3839,46
23,54	2,75	32,8	0,93	1974,68
22,14	2,75	36,8	0,93	2083,73
2,58	2,75	36,8	0,93	242,82
11,31	2,75	36,8	0,93	1064,45
3,6	2,75	36,8	0,93	338,82
5,17	2,75	36,8	0,58	303,46
24,17	2,75	36,8	0,58	1418,68
16,4	2,75	36,8	0,58	962,61
44,27	2,75	36,8	0,58	2598,47
18,8	2,75	36,8	0,23	437,59
1,95	2,75	36,8	0,23	45,39
2,38	2,75	36,8	0,23	55,40
8,49	2,75	36,8	0,23	197,61
			Qcl	23098,58

Overall heat losses for both buildings:

$$Q_{ov} = Q_{ol} + Q_{cl} = 14129.95 + 23098.58 = 37228.53, W \quad (3.4)$$

where Q_{ov} – overall heat losses for the substation, W;
Q_{ol} – overall heat loses in operative personnel, W;
Q_{cl} – overall heat losses in control building, W.

When choosing capacity of a boiler or, as in our case, a heat pump, one shall take into account a 10% reserve. This means that for our project needed heat capacity is [3]:

$$Q_{ht} = Q_{ov} * 1.1 = 37228.53 * 1.1 = 40951.38 \approx 41\ kW \tag{3.5}$$

where Q_{ht} – total needed heat capacity, kW.

Autotransformer load graph gives us an idea, when we can use it for heat production. Data about autotransformer No. 2 loads in substation Imanta was taken for the time period from 1.09.2013. till 29.04.2014. and are shown on Fig. 1. [4]

From the load graph we can see that during the heating season, (for Latvia usually it is from end of October till end of April) from 22.01.2014. till 31.01.2014 the auto transformer was out of operation. It means that during this period autotransformer cooling system could not be used for providing heating and hot water. Autotransformer average load for the whole period shown in graph was 57,12 MVA it is about 45% from nominal load, this means that in operation are at least two cooling system oil pumps, which is known from the algorithm of the cooling system. As we could see from the graph, load mostly was higher than 45% of nominal capacity from the middle of October and onwards. [4]

We can calculate how much waste heat goes through one cooling section, when oil pump is in operation. We can calculate amount of energy flowing through cooling section using this formula:

$$Q = cm(T_2 - T_1), \tag{3.6}$$

where Q – amount of energy flowing through cooling section, kcal/h;

c – oil specific thermal capacity, kcal/kg°C;

m – amount of flowing oil, kg/h;

$(T_2–T_1)$ – oil temperature difference between autotransformer top part and lower part, °C.

Specific thermal capacity of transformer oil is c = 0,4 kcal/kg°C. Temperature difference between cooling system inlet and outlet for normally operating power transformer is about 3 degrees Celsius. We made temperature measurement at ambient temperature of 0°C and 60% loading of power autotransformer. In a result for operating cooling sections oil temperature difference between inlet and outlet was 3–4°C.

For our calculations we have used $(T_2–T_1) = 3$°C. Weight of oil that flows through oil pump can be calculated as we know density of transformer oil, which is 0,86–0,89 kg/l, for our calculation we used ρ = 0,875 kg/l. [2]

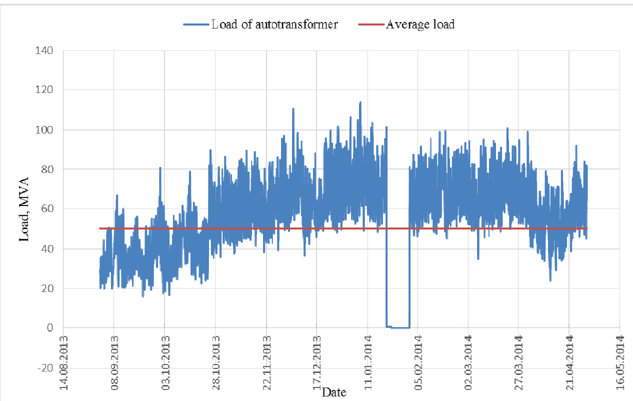

Fig. 1. Autotransformer AT Nr. 2 load graph [4]

$$m = \rho V = 0.875 * 100000 = 87500\ kg/h \tag{3.7}$$

where m – weight of transformer oil, kg/h

ρ – transformer oil density, kg/l;

V – flowrate, l/h.

According to (3.7) we calculated oil weight which flows through one cooling system section in 1 hour in consideration of oil pump flowrate V= 100 m^3 = 100000 l.

$$Q = cm(T_2 - T_1) = 0.4 * 87500 * 3 = 105000\ kcal/h \tag{3.8}$$

Result from (3.8) is converted to more convenient form:

$$Q_{kW} = Q * 0.001163 = 105000 * 0.001163 = 122.12\ kW \tag{3.9}$$

where Q_{kW} – heat power that is cooled by one cooling system section, kW.

Theoretically, we can substitute one cooling system section by one heat transforming apparatus with power of 122,12 kW.

IV Waste Heat Absorbtion Models and Proposed Model

There are several models proposed for waste heat harvesting. Simplest model has heat exchangers connected to power transformer tank and water circulation pump for heat distribution. This model is cheap, but it can not heat up water more than few degrees over oil temperature. So this model is not suitable for Latvian climate.

Other model was realized at Romania. They used several heat exchangers connected to power transformer cooling system and to heat accumulator with electrical heating elements, so this allowed to save hot water and rise temperature for heating purpose. As alternative they had connection to central district heating system. This system is quite simple and effective, but for heating they would need to use significant amount of electricity.[5]

One more model comes from Romania. This system is very complicated it contains many heat exchangers, compression heat pump, absorption heat pump and handful of circulation pumps and complicated connections. This system don't need any back up heat source and can provide not only heating but also cooling for building. Unfortunately, this model is very expensive and complicated in maintenance. [6]

For Latvian climate conditions, we need stable highly effective heating system. Our solution is to use heat exchanger between cooling section and compression heat pump. Scheme of our solution is shown at Fig. 2. Heat exchanger and small circulation pump allows to remove from cooling section as much heat as it is needed for heat pump. Taking into account results of (3.5) and (3.9) we can see that one cooling system section with parameters which were set before could provide 122 kW of low potential heat, but to provide heating and hot water to substation buildings heat pump will use about 30.75 kW of autotransformer power losses, if heat pump has COP=4 (The coefficient of performance or COP of a heat pump is a ratio of heating or cooling provided to electrical energy consumed). It means that at least 91,37 kW of low potential heat is not used, and it is only for one cooling section. Still we need to get away this 91,37 kW of heat from transformer. Most time of heating season heat pump will use even lower power to provide heating and hot water.

Usually oil is driven through cooling section by oil pump, we will use two three-way valves 3 and 4, that will allow to pump hot oil through heat exchanger 8. Heat exchanger and its circulation pump will be designed in such way that allows maximally use low potential heat and provides optimal parameters for heat pump 10. Cooling system algorithm provides that in same time operates at least two cooling sections. So if something happens to cooling section 7, for example outage of oil pump, then valves 5,6,13,14 can be used to provide hot oil for heat exchanger from cooling section 15.

During heating season power autotransformer may be shut down during planned or unplanned circumstances. This can be seen from Fig. 1. Also, some problems can occur to heat pump or to heat exchanger circulation pump. At low ambient temperature oil temperature from cooling section could be too low to gain in heat exchanger high enough temperature for heat pump operation. That is why we need alternative heating source. We analyzed several possibilities, such as usage of geothermal heat and sun heat collectors as alternative low potential heat source. In addition, we analyzed possibility to use heat accumulator. All alternative low potential heat source were very expensive because of low efficiency. Heat accumulation was effective only for short time outages. As studied substation already have heating system, it is preferable to keep it and operate in emergency cases as back up source of heat and hot water. Heat pump gives us possibility to obtain high enough water temperature for heating. Heat exchanger provides balance between power which must be cooled, and power which could be used by heat pump. Thee-way valves allows to switch cooling sections, in case if something wrong with main section.

V Economical Calculation for Proposed System

There are known two main heat pump types: absorption heat pump and compression heat pump. In this paper we will make calculation only for compression type heat pump. Natural gas or other fuel is needed to operate absorption type heat pump. There is no natural gas supply for our substation as for many other substations. Also absorption type heat pump can use smaller amount of waste heat, because COP of absorption heat pump is about 1.2-1.3 for comparison compression heat pumps mostly have COP-3.5-4. We will do calculation according to scheme shown at Fig. 2. Calculation made in this paper should be used as an example. Prices for different apparatus, heat radiators and montage could differ depending on many factors, but for beginning of 2015 they are close to reality. For our economical calculation we have chosen type 22 panel radiators made by *Purmo*. Approximate price for one kW powerful panel is 45 EUR. Additional details, pipes and montage works will cost also about the same.

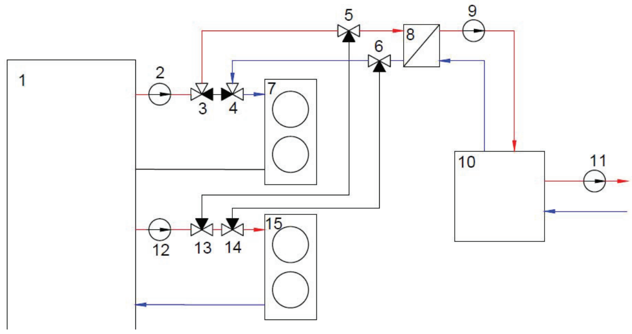

Fig. 2. Scheme of proposed modernization
1 – autotransformer tank; 2 – cooling section 7 oil circulation pump; 3, 4, 5, 6, 13, 14 – three-way valves; 7 – cooling section; 8 – heat exchanger; 9 – heat exchanger circulation pump; 10 – heat pump; 11 – circulation pump of heating system; 12 – oil circulation pump; 15 – reserve cooling section

So we need to spend about 90 EUR to install 1 kW of heating system. Panel radiators have 10 year quality guarantee and their minimal expected life time is 15 years. As heating system circulation pump we have chosen *Wilo-Yonos* PICO 25/1-8. This pump costs 260,30 EUR. Previously we have calculated (3.5) the maximal heat losses for our buildings, so we need to install enough panel radiators to compensate those losses. Now we can calculate how much will cost new heating system:

$$C_{hn} = Q_{ht} * (C_r + C_m) + C_{cp} = 41 * (45 + 45) + 260.30 = 3950.30\ EUR \qquad (5.1)$$

where C_{at} – costs for heating network, EUR;
Q_{ht} – overall heat losses to compensate, kW;
C_r – cost of panel radiators, EUR/kW;
C_m – cost of montage works, EUR/kW;
C_{cp} – cost of heating system circulation pump, EUR;

Also we have found compression heat pump *Junkers Supraeco T 430-1* with nominal thermal power 42,5 kW and nominal electric power 11,5 kW. This heat pump costs 14 438 EUR. Also we need heat exchanger which approximate value is 500 EUR. Circulation pump *Wilo-Yonos MAXO 25/0,5-12* value is 734 EUR. We have arranged all costs in table IV. As additional expenses will be montage works for heat pump and some additional details, which we think will cost about 20% of heat pump value.

All previous calculations were made for maximal heat losses, but during all heating season there will be an average value of heat losses.

TABLE IV

Overall expenses	
Position	**Price, EUR**
Junkers Supraeco T 430-1	14 438,00
Wilo-Yonos MAXO 25/0,5-12	734,00
Heat exchanger	500,00
Installation costs	2887,60
Heating network	3950,30
Overall expenses	22 509,90

We have calculated average air temperature in Latvia during heating season for past 5 years. We modified (3.1), now we instead of 5 coldest days average air temperature use average air temperature during last 5 heating seasons.

$$Q_{ova} = Q_{ola} + Q_{cla} = 8578.62 + 13384.09 = 21962.71, W \quad (5.2)$$

where Q_{ova} – overall heat losses for substation, W;
Q_{ola} – overall heat loses for operative personnel, W;
Q_{cla} – overall heat losses for control building, W.
Now we can calculate heating power that is average needed during the heating season for substation buildings:

$$Q_{aht} = Q_{ova} * 1.1 = 21962.71 * 1.1 = 24158.98 \approx 24\, kW \quad (5.3)$$

where Q_{aht} – average heating power during heating season, kW.

Now we need to calculate, how much costs heating with electricity for substation buildings. Latvia is participant of Nord Pool Spot market. We will calculate electricity price as following [7;8]:

$$C_{el} = C_e + C_{tr} + C_{mc} = \frac{48.58}{1000} + 0.02679 + 0.00438 = 0.07975\, EUR/kWh \quad (5.4)$$

where C_{el} – costs of electricity at substation, EUR/kWh;
C_e – average electricity price for Latvian region at Nord Pool Spot market from September 2013 till May 2014. It was 48.58, EUR/MWh;
C_{mc} – Mandatory component for, EUR/kWh;
C_{tr} – cost for electricity transmission to 110/6-20 kV power transformer 6-20 kV side, EUR/kWh.

Expenses for electricity will be, if it is used for heating:

$$C_{elht} = C_{el} * Q_{aht} * T_{hs} = 0.07975 * 24 * 4896 = 9370.94\, EUR \quad (5.6)$$

where C_{elht} – expenses for electrical heating during heating season, EUR;
T_{hs} – heating season duration, h.

Our model heating system is made from many elements. We think that whole system should operate for at least 15 years. So we calculated amortization percent basing on previous statement:

$$p_{as} = \frac{100}{15} = 6.67\, \%/year \quad (5.5)$$

where p_{as} – heating system amortization, %/year;

Usually heating season in Riga lasts for 204 days, or 4896 hours. We will calculate expenses for heating with electricity, our system with heat pump and heating from central district network. The calculations will be based on electricity price, required heating power and average duration of heating season. Also for this calculation we assume that there will not be any autotransformer shutdowns during heating seasons. All variants are calculated with annual expenses method. All results will be compared to annual expenses for heating with electricity, this allows to evaluate benefits and disadvantages of other proposed heating types. [9]

In this calculations we keep electricity price same for all years. Average electric power that will be used to run heat pump:

$$P_{hpa} = \frac{P_{hpn} * Q_{aht}}{Q_{ht}} = \frac{11.5 * 24}{41} = 6.73\, kW \quad (5.7)$$

where P_{hpa} – average operating electric power of heat pump, kW;
P_{hpn} – heat pump nominal electric power, kW.

In this project we assumed that we will need a credit and the interest rate of the bank will be i = 7%, discount rate i_d = 4%. Amortization rate p_{as} = 6,67%, expenses for maintenance p_{mu} = 2,5%. Example of calculation is made for solution proposed in this paper.

Expenses in 0 year: total expenses for project construction:

$$C_0 = K_p = 22509.90\, EUR \quad (5.8)$$

where C_0 – total expenses for 0 year, EUR;
K_p – total expenses for project construction, EUR.

Our expenses for construction K_p are shown in table IV.

$$NPV_0 = -C_0 = -22509.9\, EUR \quad (5.9)$$

where NPV_0 – net present value (NPV) in year of project montage, EUR.

Expenses in 1 year: credit interest expenses:

$$C_{cr1} = K_p * i = 22509.90 * \frac{7}{100} = 1575.69\, EUR \quad (5.10)$$

where C_{cr1} – credit charge in first year , EUR;
i – interest rate, %.

Expenses for amortization and maintenance:

$$C_{am1} = K_p * (p_{as} + p_{mu}) = 22509.90 * \frac{(6.67+2.5)}{100} = 2064.16\, EUR \quad (5.11)$$

where C_{am1} – expenses for amortization and maintenance in first year, EUR;
p_{as} – heating system amortization rate, %;
p_{mu} –maintenance and repairs rate., %.

Expenses for electricity:

$$C_{d1} = C_{el} * P_{hpa} * T_{hs} = 0.07975 * 6.73 * 4896 = 2627.77\, EUR \quad (5.12)$$

where C_{d1} – expenses for heat pump operation in first year, EUR.

Total expenses in the end of first year :

$$C_1 = C_{kr1} + C_{au1} + C_{d1} = 1575.69 + 2064.16 + 2627.77 = 6267.62\, EUR \quad (5.13)$$

where C_1 – total expenses in first year of operation, EUR.

Discount coefficient for first year:

$$d_t = \frac{1}{(1+i_d)^t} \rightarrow \frac{1}{(1+0.04)^1} = 0.961538 \quad (5.14)$$

where d_t – discount coefficient;
i_d – discount rate, %;
t – year of calculation.

NPV for first year:

$$NPV_1 = NPV_0 + (I_1 - C_1) * d_1 = -22509.90 - (0 - 6267.62) * 0.961538 = -28536.46\ EUR \quad (5.15)$$

where NPV_1 – net present value in first year, EUR;

We imagine that substation is already connected to the central district heating system. Such calculation allows us to analyze if our system is suitable for substations with heating provided by central district heating system. Tariff of Riga district heating provider AS „Rīgas siltums" in December 2014 was 0,05740 EUR/kWh. So expenses for one year, using heating from central district heating system approximately are[10]:

$$C_{adh} = C_h * Q_{aht} * T_{hs} = 0.05740 * 24 * 4896 = 6744.73\ EUR \quad (5.16)$$

where C_{adh} – approximate expenses for one year using district heating system, EUR;

C_h – price of one kWh of heat energy in December 2014, EUR/kWh.

Same discount coefficients were applied for calculations using electricity for heating, using central district heating system and for our proposed solution. All net present values are compared on graph Fig. 3. The net present value for heating with electricity is used as base value, other values are shown relatively to it. From graph on Fig. 3. we can see, that both alternative heating possibilities, from central district heating system and from our proposed model, are cheaper than heating using electricity. Also we can see, that our proposed model is not cheaper than heating from central district heating system. On other hand, we can use European funds to partly finance our proposed model, because it uses waste heat and rises efficiency of power autotransformer. Also expenses will be slightly lower, because substation with heating from central district heating system already has hot water heating system, so we do not need to mount radiators and pipes. For studied substation our proposed model, probably, is the best solution from variants calculated in this paper.

Substation connection to the central district heating system will need some investments, but we can not calculate them. Also expenses for mounting heating system inside of buildings will stay same.

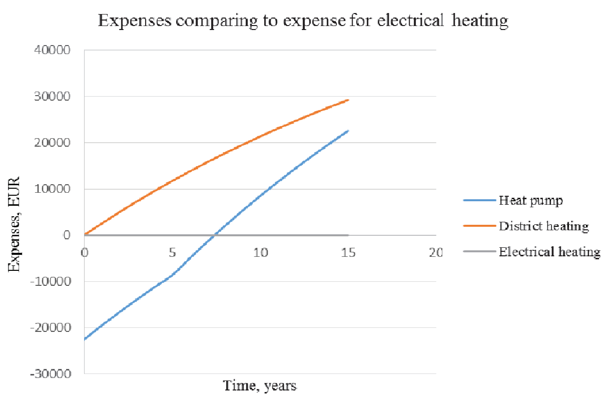

Fig. 3. Comparison of variant expenses.

VI Conclusions

1. There are several ways how to transform heat of power transformer losses into useful heat. Useful heat could be used for space and water heating in buildings nearby to power transformer. However, regular waste heat transformation system with heat exchanger could not provide suitable temperatures, which would be high enough for heating purposes.
2. Our research shows that the most effective way to utilize waste heat from power transformer cooling system is utilization of a system with compression heat pump. Also it allows to use bigger amount of waste heat than absorption heat pump.
3. In our example power transformer produces more waste heat than it is necessary for the space and water heating of the substation. It means that more powerful heat pump could be used to supply heat to nearby buildings.
4. All heating system which use waste heat from power transformers shall be equipped with backup heating sources. Transformers may be shut down even during heating season, not only during maintenance at summer.
5. Our technical and economical calculation shows, that for the substation "Imanta" our proposed system is more efficient than existing heating system with electricity. Still, it may be more expensive than using central district heating system.
6. Proposed model of waste heat valuable usage can be co-financed from European Union funds.
7. The lack of normative documents and standards slows growth of usage of similar waste heat recovering system.
8. Even one experimental model of proposed solution could give enough information about real efficiency and economical advantages or disadvantages of such heating system. Also possibilities to connect other user to this system, if power of heat pump is greater than needed for substation buildings.

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