VUOTSO SCHOOL

Energy audit

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A summary of the energy economy of the site and the proposed improvements

Site details

Property: Vuotson School

Address: Ivalontie 8716, 99690 Vuotso

Type of building: 551 Buildings of general education institutions

Purpose and working hours: School building (lower and upper secondary)

- Working hours from 07:00 to 16:00 on weekdays
- Gym is used in the evening, from 16:00 until 21:00
- Kitchen open from 06:30 to 14:30 on weekdays
- In the kitchen, about 50 servings are made daily

Buildings: School Building, Year of construction: 1969, Multifunctional building 1977

Year of renovations: Kitchen extension (1995), water roof, attic floor insulation & windows 2007

Building volume: 5710 m^3

Gross area of the building: 1155 m^2

Previous studies: Energy Audit 2015, Bioenergy possibilities study 2014

Changes after previous auditing:

- Supply air duct built into classrooms
- Installation / replacement of replacement air heaters
- Modifying classrooms
- Installation of air-to-water heat pump system
- Installation of frequency converters on IV machines

Energy consumption and saving potentials

The heat consumption figures before and after the previous energy auditing are shown in Table 1. Normalized as known as weather-adjusted consumption is standardized for Sodankylä-area. Consumption figures for 2014 are not comparable due to missing measurement data. Heat energy consumption figures have been obtained by calculating oil consumption.

In the energy auditing at 2015, the saving potential of the proposed operations was calculated to be 40 MWh/a, which is about 10% from total energy consumption. However, this has not been achieved. Normalized consumption of 2018 copmpared to the consumption of 2013, achieved saving is about 3,3%.

Year	Measured (MWh/a)	Normalized (MWh/a)	Specific consumption (kWh/m^3)
2013	390,1	427,3	74,8
2014	-	-	-
2015	387,0	441,2	77,3
2016	376,6	419,7	73,5
2017	380,7	394,3	69,1
2018	376	413,2	72,4

Table 1: Heat energy consumption

Consumption readings indicate that the subject's thermal energy consumption has decreased. The net consumption of thermal energy has decreased by 14,1 MWh compared to 2013. Weather-corrected readings have also fallen, so energy savings are not due to the prevailing weather conditions.

In terms of electricity consumption, the previous auditing estimated the savings potential to be 12 MWh of 2014 consumption. Table 2 shows the annual electricity consumption.

Year	Measured (MWh/a)	Specific consumption (kWh/m^3)
2013	79,2	13,86
2014	89,4	15,66
2015	77,2	13,50
2016	94,5	16,55
2017	92,5	16,20
2018	97,2	17,00

Table 2: Electricity consumption

Although in 2015 electricity consumption has fallen considerably, the electricity consumption of the site has increased considerably since 2016. The 2018 consumption increase is understandable with the installation of an air-to-water heat pump. Next year's electricity consumption will increase further due the heat pumps, but correspondingly, oil consumption should fall significantly.

In 2015, the saving potential of the water consumption was estimated to be 39m^3 from the 2014 figure. This would mean about 15% savings. This goal has been achieved. Table 3. shows the water consumptions from 2013 to 2018.

Year	m^3/a	Specific consumption (dm^3/m^3)
2013	**226**	**39,6**
2014	**270**	**47,3**
2015	**314,4**	**55,0**
2016	**148,4**	**26,0**
2017	**118,1**	**20,7**
2018	**215,3**	**37,7**

Table 3: Water consumption

Specific consumption of water has been very variable over the years. The individual leaks in the toilet seats can cause up to twenty cubic meters of additional consumption on a monthly basis. The leaks should therefore be repaired as soon as possible after the leak is detected.

The specific heat consumption of the site has been much higher than the average for general education building in Finland, while the specific consumption of electricity has been very close to the average. However, the specific water consumption has been significantly lower than the average, which is explained by the low number of students.

Summary of energy consumptions and saving potential

Consumption	Saving potential		Investment costs
Heat **376 MWh/a**	**75 MWh/a** **7500 €/a** **19,6 tCO_2/a**	**20 %**	**5400 € + heat recovery investment**
Electricity **97,2 MWh**	**0 MWh** **0 €** **0 tCO_2**	**0 %**	**0 €**
Water **215,3 m3**	**111 m^3** **360 €**	**52 %**	**0-300 €**

Table 4: Energy consumption and saving potential

Notes related to table 4.

- Heat energy consumption is the net energy consumption of 2018
- Boiler efficiency of 0.85 has been used in calculations

• The cost of heat energy has been calculated on the basis of the price level at the time of the auditing
• The heat energy output of the heat pump system has not been taken into account in the calculation

Summary of the proposed improvements

Heat

The following solutions can achieve an annual savings of 75-85 MWh, with annual total savings of about 20%:

• Insulation of the upper base in the ventilated tops. 9,4MWh => about 2,5%

• Heat recovery unit for ventilation machine 65-75 MWh => 17%

• Use of vestibule

Electric

• No proposed operations.

Water

• Repair of water leaks on water fittings

Current state of energy use of the site

Energy and water supply

Heat

- Heat energy is mainly produced by the LAKA ZKL 160 oil burner
- There are three Viessman Vitocal 200-S air-to-water heat pumps installed in 2018
- The Högfors 25 wood boiler is still used as a backup system
- The heating of the kitchen area is provided by electrically heated floor

Electricity

- Transmission of electricity: Rovakaira Oy
- Tranfer tariff: General electricity
- Electricity bought from Energiapolar Oy

Water

- Water connection: Vuotson vesihuolto Oy
- Waste water connection: Vuotson vesihuolto Oy

Description of the heating system

The property's heat distribution has been managed with three different water circuit for radiators, one of which serves the guidance center, one for multifunctional building and one for school building. The multifunctional building's heating network is equipped with a branch for the supply air machines radiator. The building has a Stenfors stematic automation system which is used to control and monitor the operation of the heating system, exhaust air machines and supply air machine.

At the time of the auditing process, the building's room temperatures averaged from 19 to 20 degrees, which can be considered sensible from the point of view of air quality and energy efficiency. The room temperatures were quite uniform across the building. The change from the previous auditing process is considerable, where the average temperature was 22.5 ° C. However, there were considerable differences in the temperatures of the radiators, even by single room. The measurement were done by surface temperature meter. During the auditing process we installed several data loggers on the site. During the two week measurement period, the lobby space temperature dropped to a minimum of 14 ° C at night time, which can be considered to be extremely low.

The energy output of the heat pump system installed in summer 2018 has not been taken into account in the calculations. The savings potential brought by the air-to-water heat pump is not yet fully reflected in the consumption figures for 2018, and there have been problems with the operation of

the system according to the property manager. The operation of the heat pump and consumption figures should be monitored more closely during the spring months, and if there are no obvious savings, pump supplier / service organization should be contacted.

Figure 1: Outdoor units of the heat pumps

The estimate of the consumption share of heat energy in 2018 is presented in Table 5.

	MWh/a	**%**
Heating	281	75
Ventilation	90,4	24
Hot water	3,74	1
Total	376,1	100%

Table 5: Consumption share

Electrical systems

Electricity consumption is shown in Figure 2, which shows a decrease in electricity consumption in the spring months compared to previous years. Since August, electricity consumption has risen markedly compared to previous years, due to the installation of the heat pump system

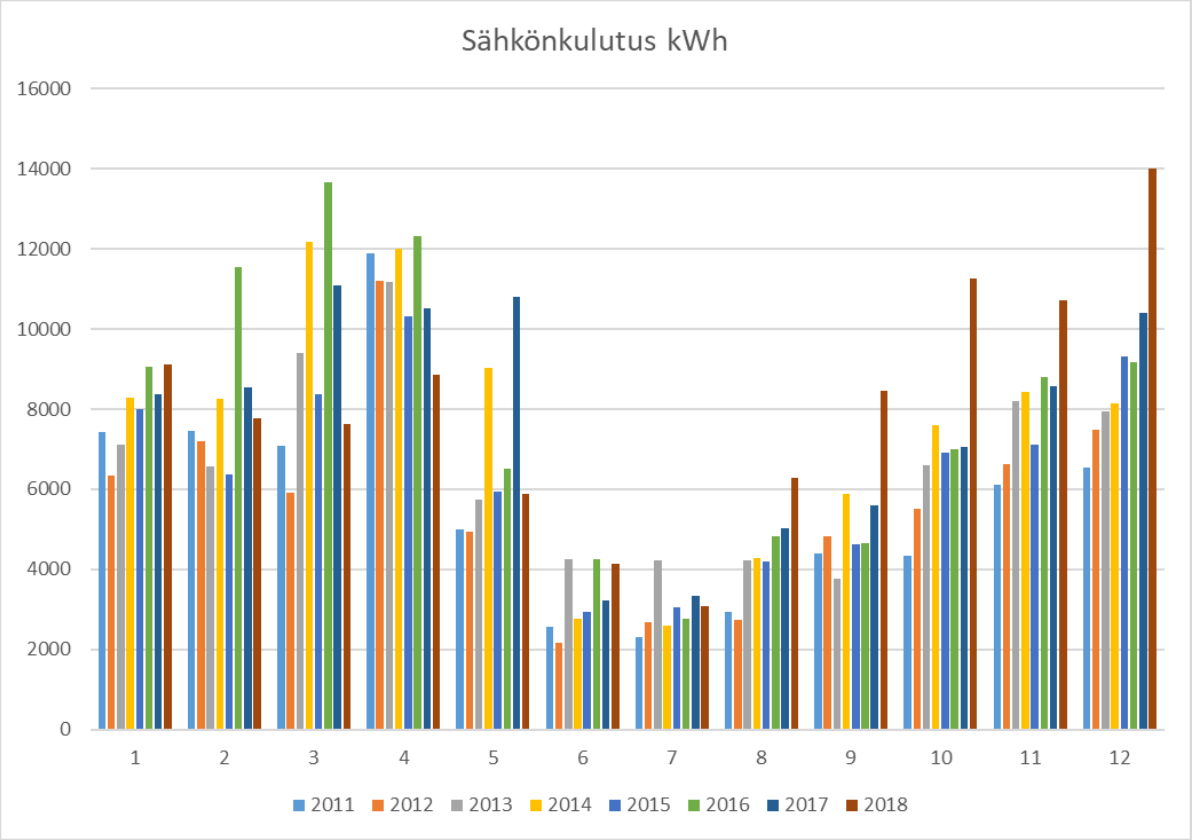

Figure 2: Monthly electricity consumption 2011-2018

Figure 3 shows the visualized electricity consumption of 2018 compared to previous years.

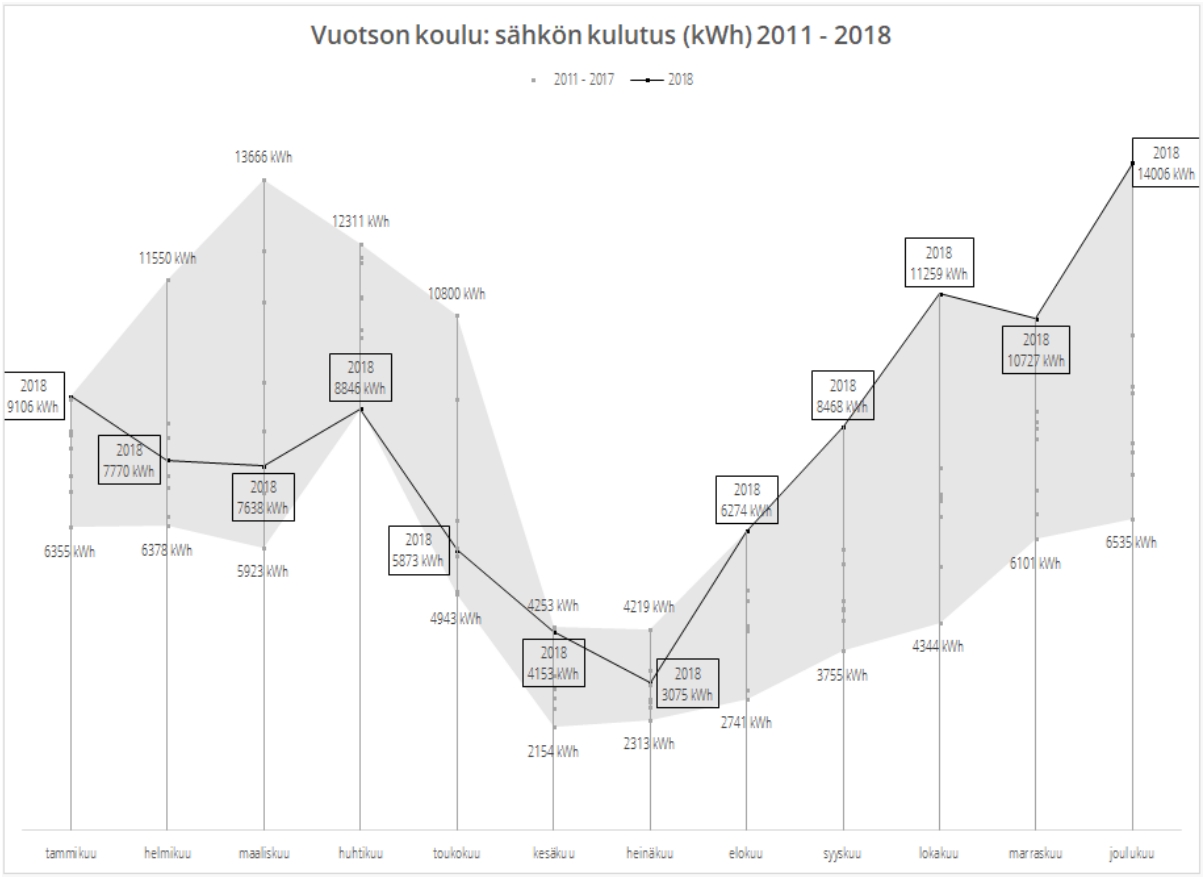

Figure 3: Visualized electricity consumption

The heat pump system

The air-to-water heat pump has been estimated to have consumed about 14,000 kWh since the installation, based on consumption figures. However, oil consumption has not decreased as expected.

Lighting

The lighting in the school building has been made more energy-efficient by installing new LED lights instead of fluorescent lamps. Old fluorescent tubes and halogen bulbs have also changed into energy saving models. Lighting control is further arranged by hand switches.

Supply air heaters

After the previous auditing, new supply air heaters with either 800 W or 1500 W power have been added to the site. The total power of the heaters is about 10 kW. The thermostats of the heaters are adjusted to a temperature of about 20-25 ° C.

Trace heating

In the past, the trace heating system caused high consumption peak loads. Still the trace heating is operated manually, but it has now thermostat control installed. On the basis of the spring consumption figures, it can be estimated that the systems consumption was about 1500 kWh.

Car Heating plug sockets

The control of the car heating sockets has been implemented with day-time clocks, which can be used to schedule the heating period to two hours.

Kitchen

The floor heating in the kitchen consumes about 180kWh /m^2 per year. The kitchen area is about 40m2, so the annual energy consumption is 7,2 MWh.

Other systems

Two indoor air purifiers have been installed in the building, the use of them does not significantly affect energy consumption as the power is only 140W.

Water and waste-water systems

The school is connected to the Vuotso water and sewerage network. Hot water is heated at the site with a coil installed in the oil boiler, with a flow temperature of 57 ° C. It was not possible to check the return flow temperature. The pressure level of the water supply network was 6.5 bar measured from the sink at boys bathroom. The water taps are traditional one-and two-handle taps. The flow of taps varied between 6-19 l/minute. The flow of taps in most spaces is high in relation to the target level.

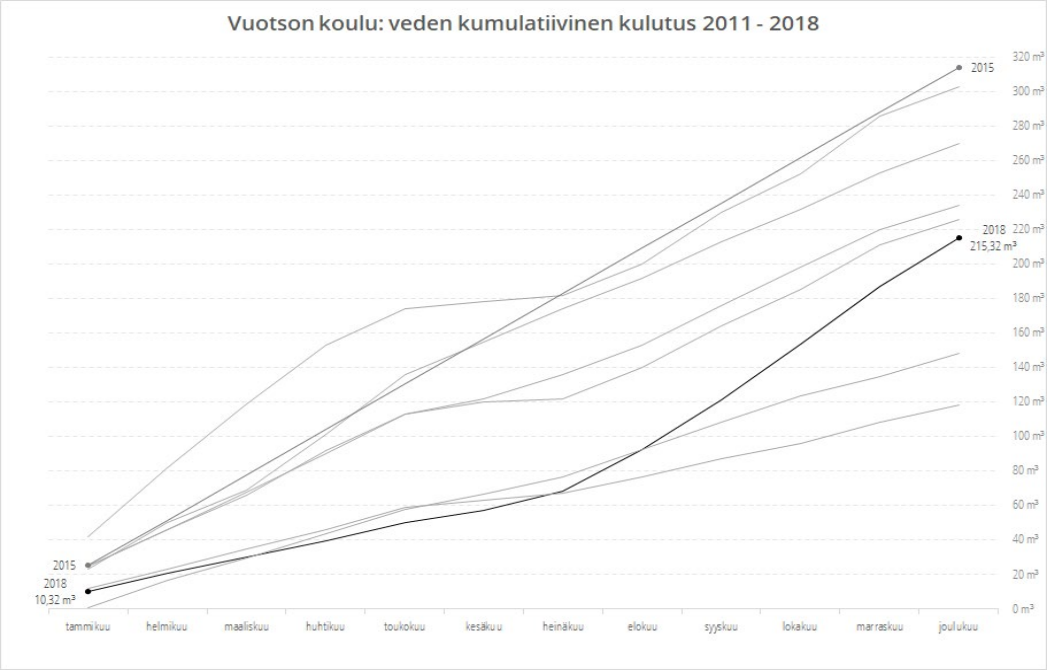

Figure 5**:** Cumulative water consumption

At the time of the auditing, one leaking toilet seat was found. Even single leaks can significantly increase monthly water consumption. A leak that looks like little and nonsense can actually mean hundreds of liters of wasted water per day. From the graph of cumulative consumption (Figure 5), water consumption in 2018 can be seen at relatively a low level until July. Since then, the monthly

consumption has more than doubled. This could indicate that noticed a small leak in the toilet seat has been there for several months already.

Ventilation system

Classrooms and the gym have mechanical intake and exhaust ventilation, in addition to this, replacement air is supplied through separate air heaters in classrooms. In the technical work room, the supply air duct is not in use, even though the line is built.

After the previous auditing, frequency inverters have been added to the intake and exhaust air machines to enable the control of the power of the machines. After the supply air duct has been added to the classrooms, the feeling of draw has decreased. At the time of the auditing, the flow of input air was about 600 l/s measured from the duct in the engine room. Approximately 100 l/s goes into the classrooms. The power of the supply air machine is lowered when the outdoor air falls below -13 ° C according to the following adjustment curve (Fig. 6).

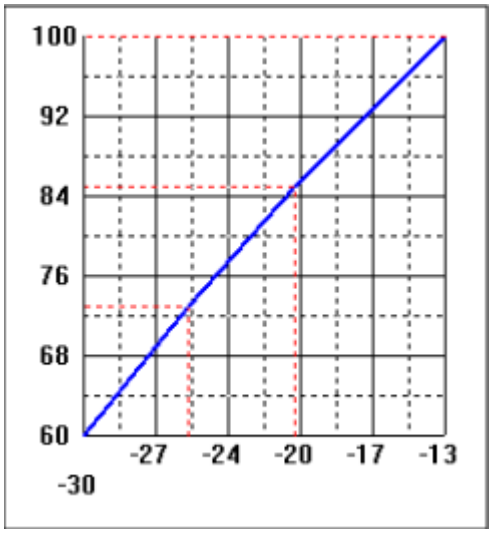

Figure 6: Rotation speed control curve of supply air machine

The supply air temperature setting value is shown in the figure 7. The temperature should be slightly lower than the room temperature, unless the room is intended to be heated by a ventilator. The space's main heating devices reacts faster to changes and utilize free energy more efficiently than a ventilation unit. The recommended value for the blowing temperature is about 15-17 ° C.

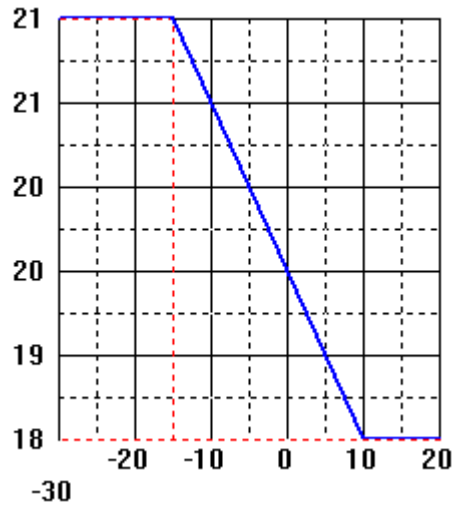

Figure 7: Supply air temperature settings

During the auditing, air volume measurements were done for the classroom air terminal devices. Based on the measurements, the exhaust air flow of the classrooms is about 30 l/s and the supply air flow is about 20 l/s without taking into account the fresh air through the supply air heaters. At the time of the auditing, the building was under pressure of 10-11.5 Pa regarding outdoor pressure, which can be considered too high. The pressure level can be compensated by adding the supply air flow either mechanically or by means of replacement air valves.

According to the manufacturer, the supply air flow of the Mobair 2020 heaters is, about 10-12 l/s at 10Pa pressure difference. The flow can also be enhanced by the device's own fan. The prevailing pressure level shows that the amount of air coming from the replacement air valves of Vallox MUH is about 35 l/s.

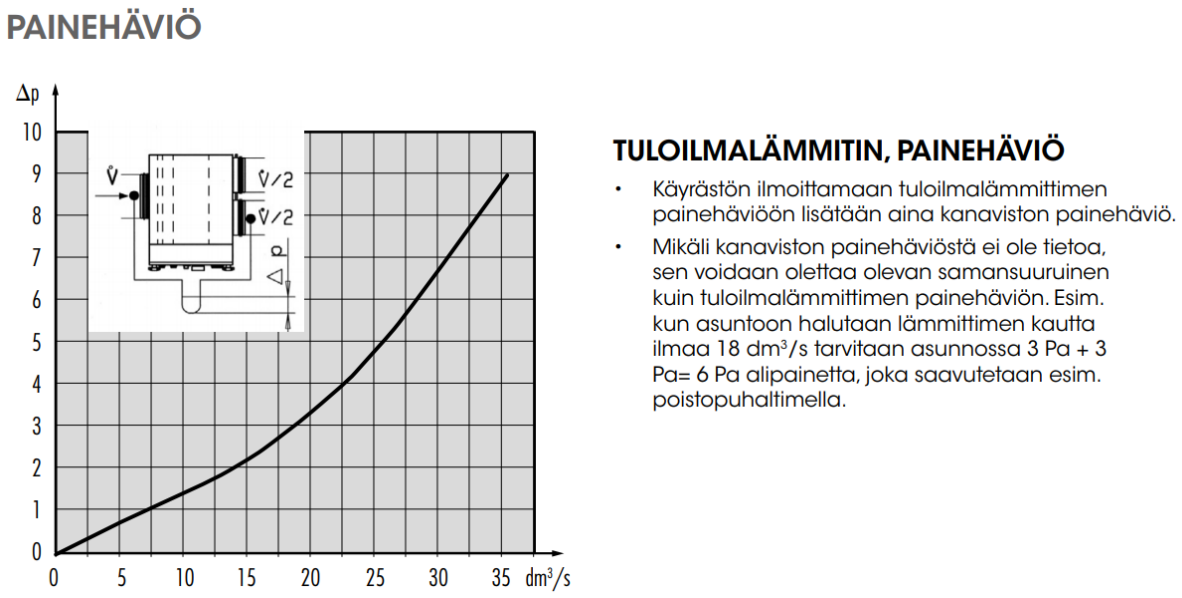

Figure 8: Pressure drop of replacement air heater

Scheduled run times of ventilation machine for school building are implemented by following time programs. Green colour indicates time when ventilation runs at minimum power.

Figure 9: At night time the ventilation is at minimum power

Vallox 132 E. ventilation machine is responsible for the ventilation of the guidance center. The machine has two 1200 W heating resistors for pre- and post-heating. The power of the machine can be adjusted with the switch in the waiting room. It is also possible to adjust the post-heating of the machine with a thermostat.

At the time of auditing, the machine was at minimum power, with an air volume of about 35 l/s, which is sufficient for the space in question. If necessary, the ventilation is easy to enhance with the manual switch.

The exhaust ventilation in the kitchen area is unnecessarily high according to the users. Replacement air is transferred to the space as transfer air from the vents above the interior doors.

Cooling systems

The mobile air conditioner is responsible for cooling the nurse's reception room. The unit automatically maintains the selected temperature between 15-31 ° C. At the time of auditing, the device was not in use.

Malli		MFP26-1021R1
Jäähdytysteho		9 000 Btu/t /2 600 W
Kosteudenpoistoteho (l/päivä)		18
Teho (W)	Jäähdytys	1100
	Kosteudenpoisto	800
Virtausnopeus (m^3/t)		360
Virtalähde (yksivaiheinen) V~/Hz)		220~240V/50
Äänenpainetaso dB (A)		≤52
Nettopaino (kg)		34
Mitat	Runko (mm)	738x446x377
	Pakkaus (mm)	780x460x450
Jäähdytysaine / (g)		R407C/490
Käyttötila (m^2)		18
Huomautus: Yllä mainittu jäähdytysteho on mitattu ympäristössä, jonka lämpötila on 30 °C DB / 25,5 °C WB (sama sisä- ja ulkotiloissa).		

Figure 10: Specs of cooling unit

Structures

Changes have been made to the structure of the property after the first energy auditing. One of the classrooms is divided into two smaller ones, which makes the use of spaces more efficient. The surface temperatures of the structures were measured with a thermal camera and a surface thermometer. In particular, the attic floor temperatures were significantly low. There were also found some low surface temperatures on the walls, mainly due to air leaks.

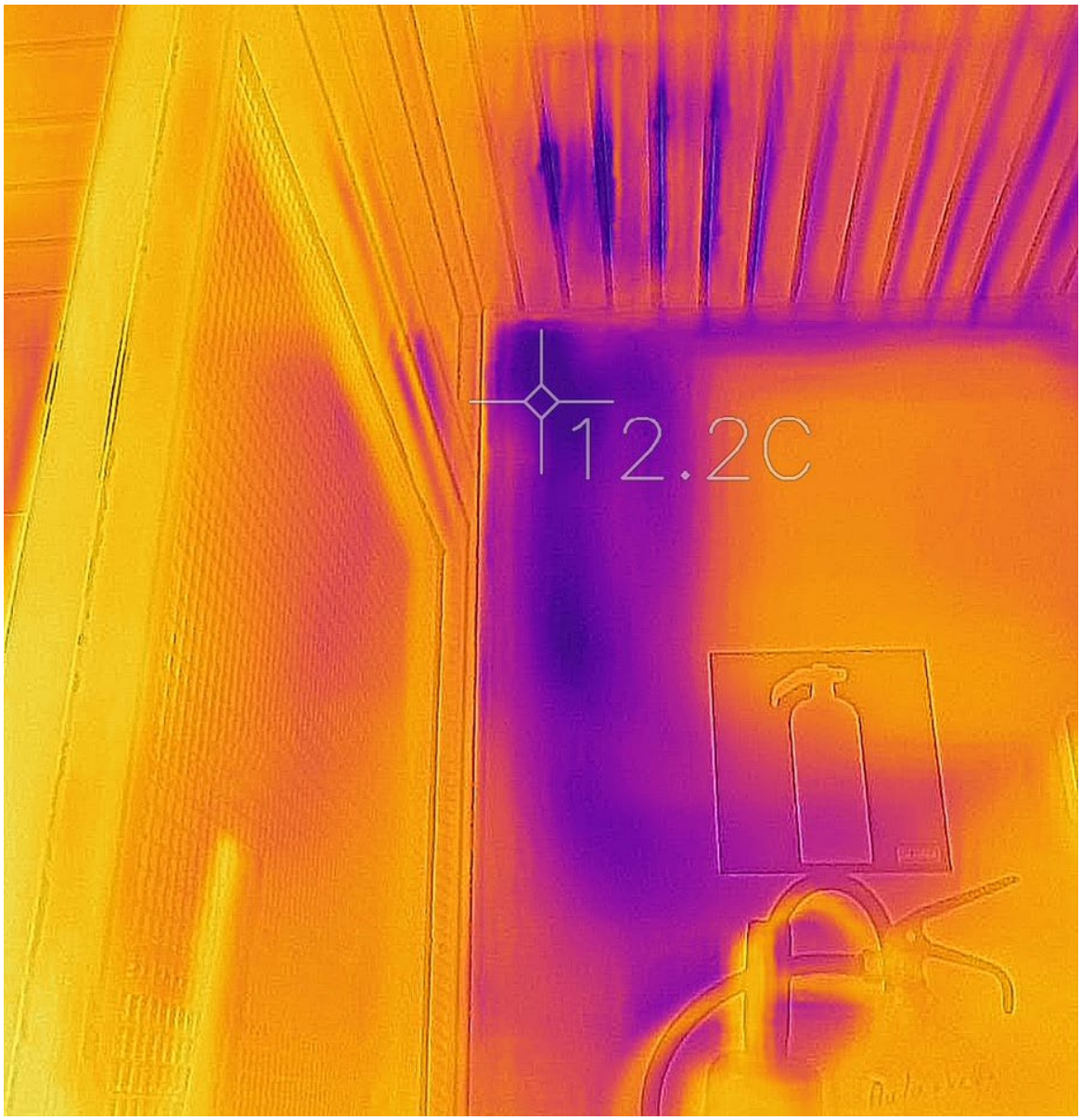

Figure 11: Thermal camera image from the hall

The insulation of the attic floor is carried out with a layer of blowing wool of about 15-25cm, which gives the structure a U value of about 0.27 to 0.17W/m^2. In 2007-2009, the maximum value of the Building Code for the U-value of the upper floor structure was 0.15, and since 2010 the maximum value has been 0.09. Additional insulation of the attic floors would be easy to implement, because of easy access to the attic floor.

The level of insulation of the roof of the gym could not be determined, but according to the observations, there are heat leaks in the structure, or the insulation level is insufficient. Icicles during the winter temperatures indicates heat leaks or insufficient insulation levels.

Figure 12: Icicles hanging from the eaves

Main entrance of the school building does not have vestibule, and also the use of vestibule at the gym side is inadequate. The other door of the vestibule was open. At the same time, the temperature of this vestibule was unnecessarily high. It is advisable to keep the temperature in the cabinet well below room temperature and both doors closed. This minimizes the amount of heat leakage from the external door. With the addition of a vestibule to the lobby and the proper use of it, not only the heat leakage, but also the feel of the draw would decrease in the building.

Proposed improvements

Energy and water prices and CO2 coefficients used in savings calculations

Heat

The heat production of the Vuotso School is carried out on its own light oil boiler with a CO_2 emission factor of 261 kg CO_2 / MWh according to the table in the Motiva calculation guide.

The price of heating oil is the current market price of € 1 / l incl. VAT. 24%

Electricity

- The price of electricity used in the calculations is 0.12 € / kWh
- Average CO_2 emission factor for electricity production in Finland, calculated as a five-year rolling average:
- 164 kg CO_2 / MWh

(Source: Statistics Finland, statistical year 2016) (updated 26.4.2018)

Water

- The price of water is used 1,45€/m^3 + VAT 24%
- The price of waste water is used 1,45€/m^3 + VAT 24%

Heating systems

The performance of the installed air-to-water heat pump has not been effective on the basis of consumption figures. Considering the overall power of the system, oil consumption should decrease significantly.

Proposed improvements

- Inspection of system operation / maintenance
- Guidance for how to use the system
- Lowering the flow temperature of heating water, if possible, it would reduce the use of the oil burner

Water systems

From monthly consumption figures can be deduced the increase in consumption since August compared to the beginning of the year. The single leak in the toilet seat observed in the auditing may be the cause of the rise in water consumption.

A small leak in the toilet seat can be up to about 30 liters/hour. Thus, the monthly consumption increases by about 20 m^3. Similar growth can be seen in water consumption reading. Total leakage consumption is estimated to be 111m^3/a when compared to normal months. Because the spill has been just cold water, the estimated price would be 360 €. In this case, no price was calculated for the leak repair.

Ventilation system

At the moment, about a quarter of the total thermal energy of the building is used to heat the supply air. By installing a ventilation machine(s) equipped with heat recovery unit, saving up to 65 - 75MWh could be achieved, which provides 17-20 % annual savings for heating energy.

65MWh * 261 kg CO_2 / MWh = 16,965 kg CO2

65MWh / 0.85 / 10.02kWh / m^3 = 7600l = 7600 €

If there is desire to invest for a ventilation system with a heat recovery unit, there should be done proper ventilation plan first. Where suitable ventilation machine, ductwork and terminals are selected. The modern air handling unit can also be equipped with various type of sensors (CO2, presence), making it easy to use the machine.

Pallas eAir W oikea

Puhaltimet

	Tulo	Poisto
Mitoituspisteessä		
Puhallinnopeus	54 %	56 %
Syötetty ilmavirta	600 l/s	650 l/s
Kanavapaine	100 Pa	100 Pa
Ottoteho	355 W	407 W
SFP	1.17 kW/(m³/s)	
Huipputeho		
Maksimi-ilmavirta	954 l/s	991 l/s
Maksimikanavapaine	253 Pa	232 Pa
Tehostusvara	59 %	52 %

Vuosilaskenta

Kaupunki	Sodankylä, Suomi
Vuosihyötysuhde	68.8 %
Hyötysuhde yhtäsuurilla ilmavirroilla	71.7 %
Poistoilmasta talteenotettu lämpöenergia	101 344 kWh
Vuotuinen jälkilämmitystarve	12 809 kWh

Äänet (Lw)

	Taajuudet [Hz]									
	63	125	250	500	1k	2k	4k	8k	dB	dB(A)
Vaipan läpi	60	61	65	56	52	40	26	17	67.4	58.9
20 m³ absorptio LpA										51.9
Tuloilmakanava	60	62	69	63	67	65	54	41	73.2	70.5
Poistoilmakanava	52	60	62	48	43	42	32	14	64.3	54.8
Ulkoilmakanava	55	56	56	50	44	39	32	11	60.9	52.0
Jäteilmakanava	60	63	70	64	68	67	61	46	74.6	72.6

Ecodesign

SFPint	799 W/(m³/s)
SFPint_limit,2016	1243 W/(m³/s)
SFPint_limit,2018	1003 W/(m³/s)

Laite täyttää Ecodesign 2018 -vaatimukset

Talvi

Lämmön talteenotto

Tyyppi	Vakio
Mitoituspisteessä	-38 °C / 90 %RH
Tuloilma jälkeen LTO:n	6.7 °C / 71 %RH
Hyötysuhde	74.6 %

Nestepatteri W

Patteri	60/40 °C Sisäinen
Ilma sisään	1.7 °C / 100 %RH
Ilma ulos	13.4 °C / 45 %RH
Neste	0.218 l/s / 12.2 kPa
Neste sisään/ulos	35 / 25 °C
Venttiili	R222, kvs 6.30 DN25, TR24-SR
Teho	8.72 kW

Huom! Tämä on ei ole vakiopatteri tälle laitteelle. Huomauta tästä tilauksen yhteydessä."

Kesä

Lämmön talteenotto

Tyyppi	Vakio
Mitoituspisteessä	25 °C / 50 %RH
Tuloilma jälkeen LTO:n	23.5 °C / 55 %RH
Hyötysuhde	74.6 %

Nestepatteri W

Patteri	60/40 °C Sisäinen
Ilma ulos	23.5 °C / 55 %RH

Huom! Tämä on ei ole vakiopatteri tälle laitteelle. Huomauta tästä tilauksen yhteydessä."

Figure 13: Example of the saving potential of ventilation machine with the heat recovery unit

Structures

Additional insulation on attic floor

The attic floor insulating level was found to be defective. The additional insulation area is about 400 m^2. The thickness of the insulation to be added is about 300mm.

400m^2 * 0.3m = 120m^3. The additional wool cube price blown is approx. 40-45 € / m^3 incl. VAT 24% The investment price will be about 4800 - 5400 €. inc VAT. 24%. The payback period for the investment is 4-5 years.

Figure 14: Calculation of saving potential for additional insulation

Further insulation possibilities for the other attic floor structures should also be explored.

Vestibule

Vestibule should be built at the main entrance. That would prevent the feeling of draw in the hallways. Even with the proper use of the existing vestibule at gym side, small savings in thermal energy consumption would be achievable. In addition, vestibules temperature should be lower than other room temperatures, as it would minimize heat loss through the external door.