SWIMMING AND
ICE HALL PORTAL ITEMS
ENERGY CONSUMPTION AND
CARBON DIOXIDE EMISSION ESTIMATION

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CONTENT

Abbreviations used

%	Percent, the unit used for comparison
°C	Degree Celsius, a unit of temperature
€	Euro, unit of money
a	Year, unit of time
VAT	VAT
Br	Gross, total amount
CO_2	Carbon dioxide
CO_2 eq	Carbon dioxide equivalent
GWh	Gigawatt hour, unit of energy
IV	Air condition
JVLTO	Wastewater heat recovery
Pcs	Number of songs
Kt	Kiloton, unit of mass
kWh	Kilowatt hour, unit of energy
l	Liter, unit of volume
LTO	Heat recovery
LVI	Heating, plumbing and ventilation (technology)
m^3	Cubic meter, unit of volume
m^2	Square meter, unit of area
Mt	Megaton, unit of mass
MWh	Megawatt hour, unit of energy
PILP	Exhaust air heat pump
TWh	Terawatt hour, unit of energy

1 Introduction

Finland's goal is to be carbon neutral by 2035, and reaching this goal will require, among other things, reducing energy and water consumption in buildings. In municipalities, large sports venues, such as swimming pools and ice rinks, are the largest individual buildings that consume energy and water.

This report was prepared for a development project, the purpose of which was to gain an understanding of the heat, electricity and water consumption of the sites in the swimming pool and ice rink portals, and to calculate the carbon dioxide emissions resulting from the sites' energy consumption based on this information. Energy and water consumption data have been obtained for the swimming pool and ice rink stairs and can only be considered indicative. The figures entered in the portals are partial incomplete and incorrect, due to, among other things, the annual manual about the consumption data to be entered and the fact that not every object was available necessary information. For these items, the calculation is based on rough estimated consumption there. In the emission calculation, it was assumed that the consumed energy of all objects was os auxiliary energy.

During the project, typical energy savings in swimming pools were also mapped in more detail measures and implemented at the selected pilot site, Te for soma's swimming pool, automatic monitoring of energy and water consumption data swimming pool por with the help of distance reading.

The report has also collected information on the energy consumption of buildings in Finland and Finland's greenhouse gas emissions. The report does not delve into the main features in more detail to the distribution of the energy use of swimming pools and ice rinks in the sports venues in question and not to the technique of saving measures in swimming pools, because there are already comprehensive ones mass publications, such as the "Energiaefektiväts hand letter".

The development project was implemented in cooperation between Sport Venue Oy and Vahanen Monitoring Servi with ces Oy. From Sport Venue, Karri Kylliö, Jarno Re have been involved in the project konius and Jari Räikkönen and Laura Koski from Vahanen Monitoring Services Oy. Ra the gate was compiled by Koski and based on it, his higher vocational school is also being completed thesis of his high school diploma in early 2023. The development project has been financed Ministry of Education and Culture.

1.1 Swimming pool and ice rink portals

The swimming pool and ice rink portals are websites that are backed by Education and Culture the Ministry together with Sport Venue. The portals are built to support swimming and ice rinks in monitoring and enhancing their energy and water use and pre as a sign by enabling comparison with other items found on the portals. Swimming Hall In addition to swimming halls, there are also spas in the portal, but this project has ra the review continued to cover only swimming pools. There are a total of 200 on the swimming pool portal swimming halls (plus 53 spas), and 244 ice rinks from the ice rink portal. Some of the portals find most of the sites are permanently closed.

Currently, energy and water consumption data are entered into the portals manually as read from the main meters and by entering the annual meter readings into the portals. Extract for example, among these portals is the swimming hall portal. On the swimming pool portal website the first view that opens is the swimming halls and spas, whose energy consumption fields have been filled for the past three years. There are currently 36 of these in total of all items on the swimming hall portal. In addition, in this view, por can be viewed the consumption data of the swimming pools and spas entered in taal for the previous year (Figure 1).

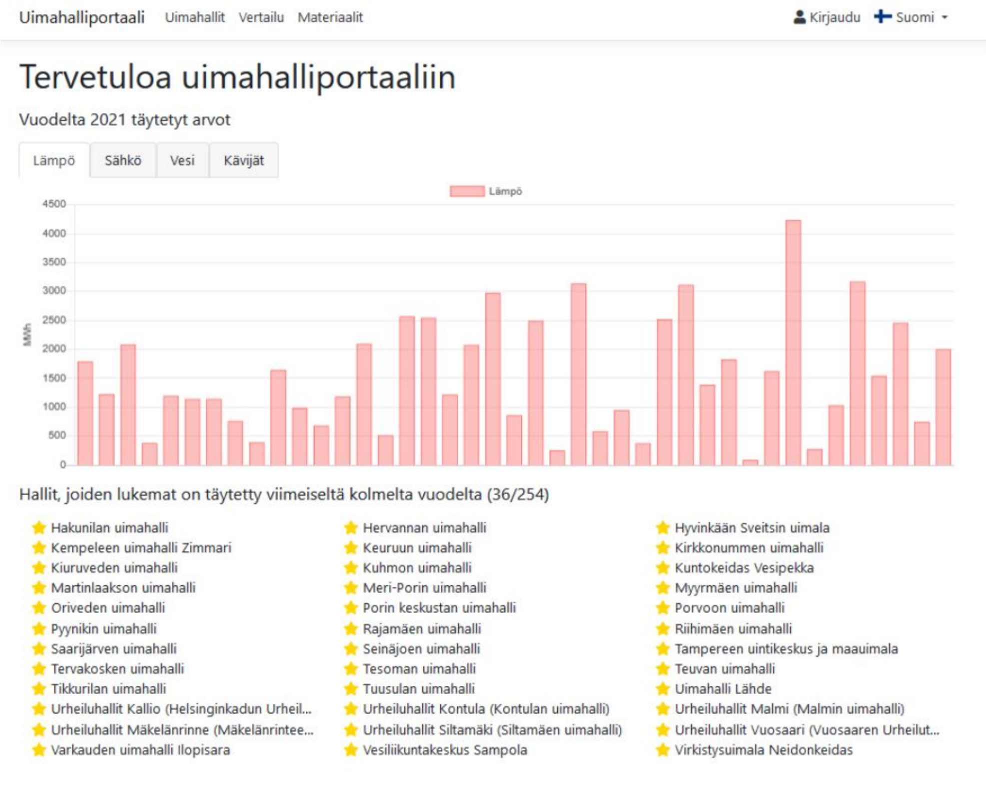


Figure 1. Uimahalliportaali.fi start view

For the mutual comparison of swimming pools, a PowerBI-based one has been built into the portal tool (Figure 2). Mutual comparison is made difficult by the up-to-date energy consumption data mouth and correctness of information between different halls. A pilot was conducted during this project In the Tesoma swimming hall located in Tampere, the consumption data is automatically read by the swamp raa system. The purpose of the pilot was that with the help of automatic reading, the consumption road dot would be more up-to-date and error-free in the portal. From chapter 6 of the report further, the implementation of this part of the project has been discussed.

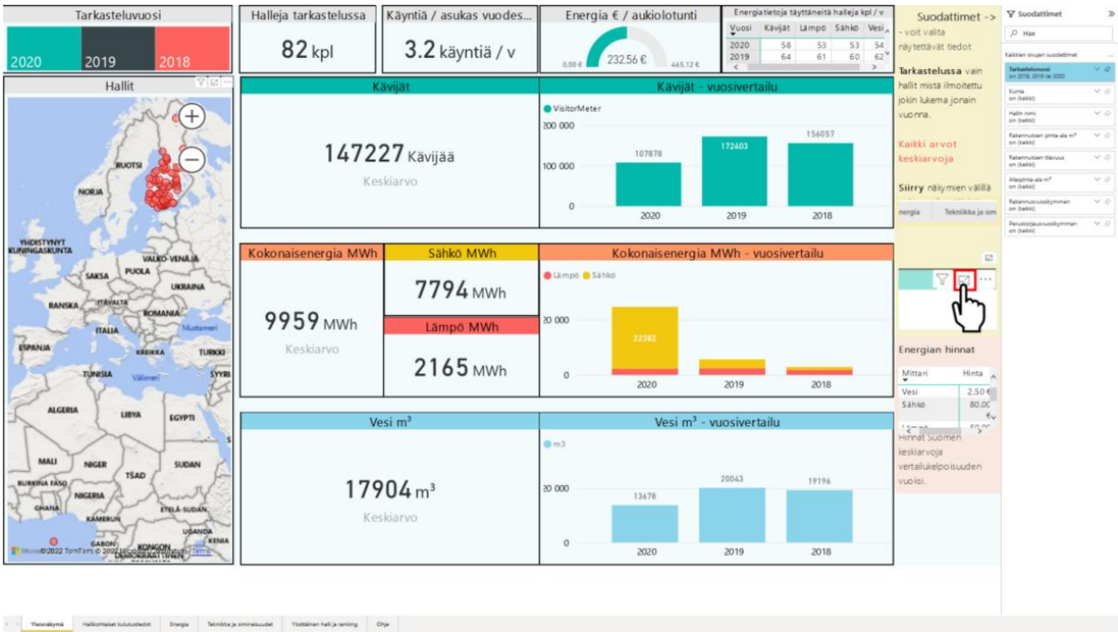


Figure 2. Swimming pool portal's PowerBi-based tool for mutual verification of swimming pools to fit

In addition to these, Uimahalliportaal allows you to view each swimming pool and village on an individual level, such as energy consumption, basic information and functions of the building, water treatment systems and pool information. The portal also contains other material, such as the portal's user manual, a manual for improving the energy efficiency of swimming pools, and ready-made calculation bases for monitoring energy consumption.

Compared to the swimming pool portal and its views, the ice rink portal has been implemented in a similar way.

2 Energy consumption of buildings in Finland

In Finland, buildings have a significant impact on energy use. Just build
the energy use of the kitchens corresponds to about 40 percent of the final energy use in Finland
and causes about 30 percent of Finland's greenhouse gas emissions. About 10 percent
tia of Finland's building stock is owned by the public sector, i.e. municipalities and the state and
administered by. In Finland, according to Statistics Finland, the end use of energy in 2021
was a total of about 305 TWh and a year earlier in 2020 288 TWh. Public sector
the share of energy end-use is remarkably large when owned by the sector in question
and managed buildings cover about 10% of Finland's building stock.

Figure 3 shows the distribution of energy end use by sector in 2021 (en
based on anecdotal information). The other sector, which can also be seen in the picture, includes households
sie, public and private service sector, agriculture and forestry and construction
consumption of electricity and fuels. End use of energy refers to ener
giaa, from which transmission and conversion losses have been deducted.

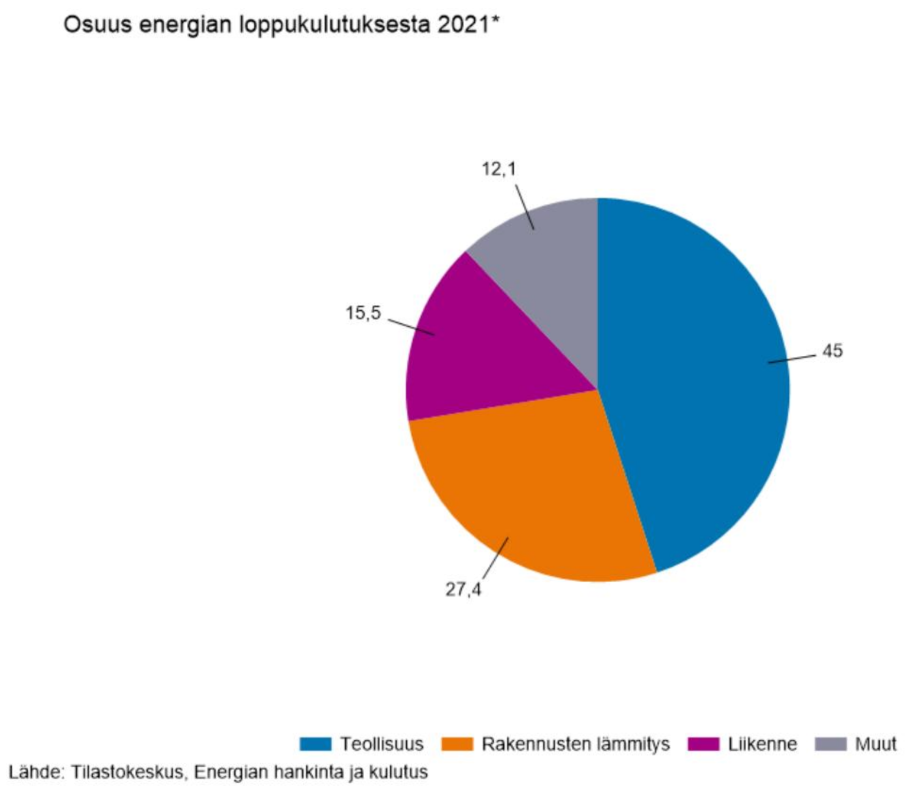


Figure 3. Distribution of energy end-use by sector in 2021 (preliminary information) (https:// www.stat.fi/ julkaisu/ cl1p3puxx03j90cum3pwyy2k5)

The energy consumption of buildings consists of the need for heat and electricity. Warm energy is consumed by heating the premises, the supply air for ventilation and the hot water there. Electricity in the property is consumed by, for example, lighting, consumer appliances and HVAC technical systems. Buildings are mechanically cooled in ever-increasing temperatures rin, which also contributes to increasing energy consumption.

The energy consumption of buildings varies by building type, due to their different characteristics purposes and user numbers. When comparing the energy consumption of buildings to each other, the comparison should be made with buildings of the same purpose category. Also energy from the point of view of improving efficiency, buildings should be compared by purpose of use by category, as this makes it easier to give general instructions for saving energy.

The building's energy consumption is affected by many different factors, such as ra the physical location of the building, the size of the building, the characteristics of the building components, such as thermal insulation of the sheath, heat load and their utilization rate, indoor climate condition relationships and the operation of building technical systems. The users of the property also have an important role nen effect on the building's energy consumption, as already mentioned earlier.

2.1 Municipal energy efficiency agreement

The municipal energy efficiency agreement (KETS) is an agreement between the Ministry of Labor and the Economy, the Energy Agency and the Confederation of Municipalities on more efficient use of energy in the municipal sector during the years 2017-2025. Subscribers to the agreement sign the subscriber-specific ener energy efficiency agreement, in which they commit to the municipal sector energy efficiency agreement to its measures and objectives. It should be noted that according to the agreement, join The residential building stock is primarily connected to the Kiinteistöala energy efficiency agreement mus's program of measures for rental housing associations (VAETS). Contemporary style the first contract period of the second energy efficiency agreement was 2008– during 2016.

Operators who have joined the energy efficiency agreement are obliged to make a yearly gap porting to an internet-based tracking system. Reporting includes, among others, assa's annual energy consumption and implemented energy efficiency measures den reporting. In the municipal sector, operators must report the data annually at the end of April by the tree.

By the end of 2021, the municipality had signed up to the energy efficiency agreement 65 cities, 45 municipalities and 11 municipalities. These 121 subscribers lived in the affected area at the end of 2021, 76% of Finland's residents (nearly 4.2 million people). Of these annual reported energy consumption of subscribers in 2021 was 7,133 GWh, consumption when it is divided by type of consumption, electricity 35%, heat 53% and fuels 13%. Renew there have been more people joining KETS every year, the up-to-date number of people joining and the number of people joining is can be seen on the website of energy efficiency contracts.

In addition to the municipal energy efficiency agreement, other important national energy agreements systems aimed at efficiency and emission reductions include Hinku, among others project, the Fisu network and Motiva's Eco-procurement network. Several municipalities are involved in several overlapping contracts.

In this project, one of the purposes was to find out what is in the swimming pool and ice rink portal the energy consumption of foreign objects and the emission estimates of energy consumption, which are in the municipal sector, the largest single energy-consuming buildings, more specifically, lu in years 4 and 5.

3 Greenhouse gas emissions in Finland

The understanding of the seriousness of climate change has increased the need for large-scale actions to curb climate change. The International Climate Panel IPCC (The Inter According to the governmental Panel On Climate Change, carbon neutrality must be achieved I will do it by 2050 in order to limit global warming to 1.5 degrees seen.

Finland's goal is to be carbon neutral by 2035 and to be the first fos hedgehog-free welfare society. In practice, this means that from 2035 going forward, Finland's emissions must be lower than carbon sinks. Our state will in this case to be carbon negative, i.e. less greenhouse gas emissions are produced than what our ecosystem's ability to store them is. Finland's carbon neutrality goal for one year By 2035 is quite ambitious and requires acceleration from all sectors emission reductions and strengthening carbon sinks.

Finland's greenhouse gas emissions have decreased from 1990 to 2021 (excl including the LULUCF sector) 33%. Emissions have not decreased steadily since last year for example, in the period between 1990-2021 of the time series in Figure 4, the emissions have been at its highest in 2003.

In 2021, emissions in Finland were 47.7, according to preliminary data from Statistics Finland million tons of CO2-eq (hereinafter MtCO2-eq) without land use, land use changes and forestry (LULUCF) sector. The land use sector has previously been A significant net sink in Finland, but according to preliminary information, the land use sector In 2021, the carbon sink turned into a net emission for the first time (unobserved in Figure 4 if this increase), the emissions being 2.1 MtCO2-eq. When Finland's plant of the year 2021 for greenhouse gas emissions, the net emissions of the LULUCF sector would be taken into account that's 49.8 MtCO2-eq emissions for that year.

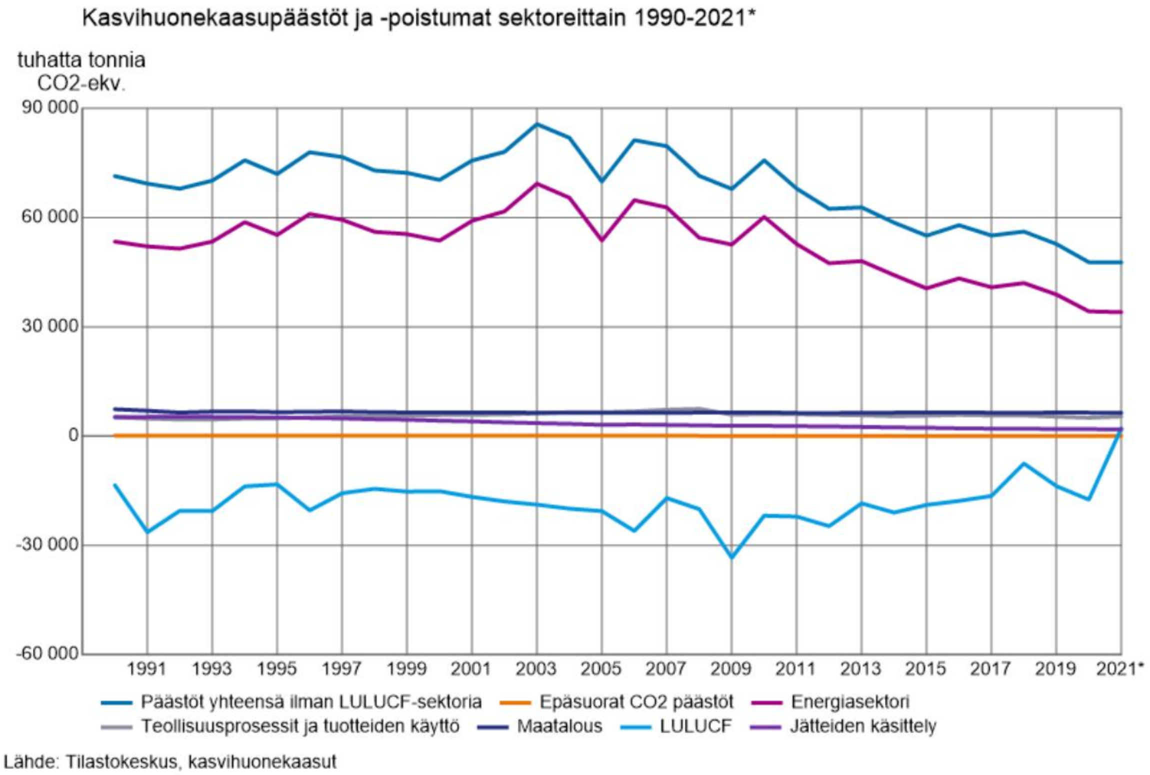


Figure 4. Greenhouse gas emissions and removals by sector 1990-2021 (https:// stat.fi/ julkaisu/ cktlf0i203azm0a519to5exzc)

In Finland, the largest source of greenhouse gas emissions is the energy sector, which covered approximately 71% of total emissions in 2021, according to preliminary information. The most significant emission sources in the energy sector are the energy industry, domestic transport, and industry and construction. Emissions from the energy sector in 2021 were 34.0 MtCO2-eq, being at the lowest level from 1990-2021. In 2021, industrial processes and product use accounted for approx. 11% of total emissions, agriculture approx. 13% and waste

approx. 4% of processing.

3.1 The role of municipalities in reducing greenhouse gas emissions

In Finland, municipalities play an important role in curbing climate change, as does climate police in order to achieve the goals of tics. Building heating, traffic solutions and through community structures, municipalities can significantly affect emissions. Many the municipalities have moved forward with their climate work in order to achieve the goals, etc made their own climate plans and set carbon neutrality or emission reduction goals.

According to preliminary information, the municipalities' combined climate emissions will decrease in 2021 3.1% compared to the previous year (2021 municipal emissions according to advance information approx. 30.5 MtCO2-eq). As can be seen in Figure 5, the largest emission sectors in municipalities were road traffic (approx. 27%), agriculture (approx. 21%), district heating consumption (approx. 14%) and electricity consumption (heating and consumer electricity in total approx. 11%). District heating and the share of electricity consumption in total was approx. 25%, roughly 7.6 MtCO2-eq. The biggest emission sectors most likely have the biggest saving potential, so emission reduction measures should be especially targeted at these above sectors.

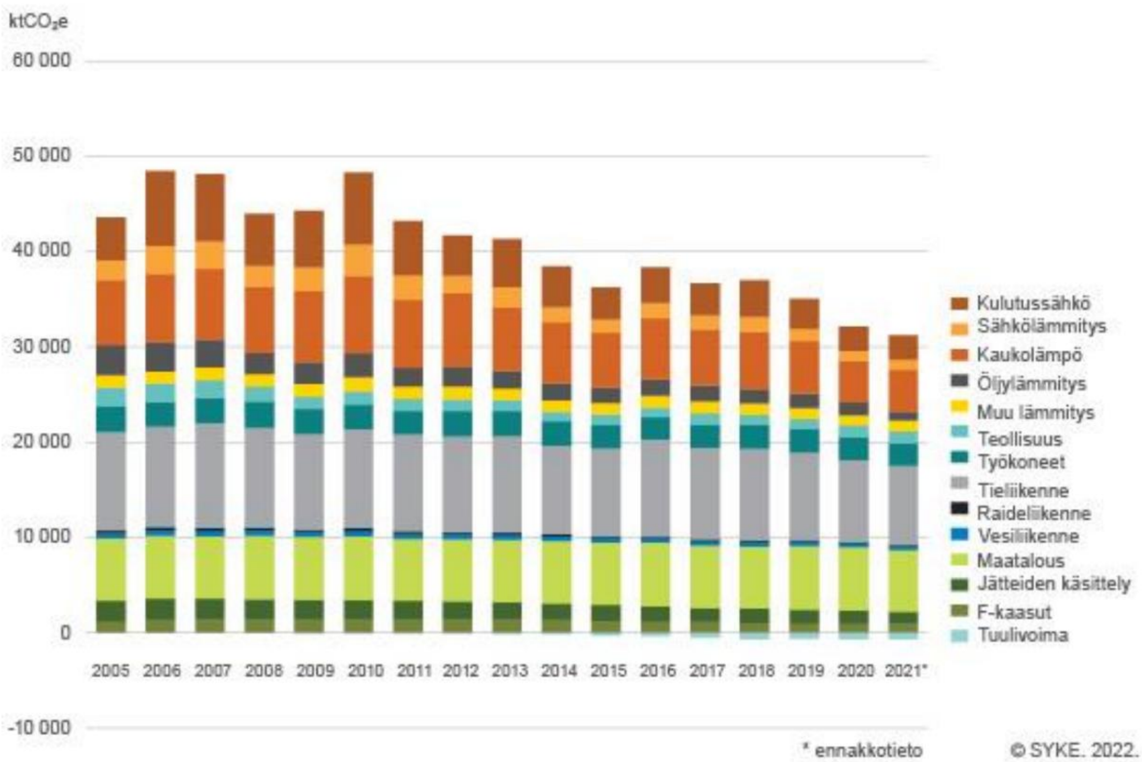


Figure 5. Greenhouse gas emissions of Finnish municipalities by sector in 2005–2021 (https:// www.syke.fi/ fi FI/ Ajankohtaista/ Ennakkotieto_Kuntien_ilmastopaastot_lask(64261))

In 2021, Sitra has published the report "Where are we going in the climate and nature work of municipalities" - a report, in which it is reported that about two-thirds (206/309) of the municipalities in Finland have set climate goals. If the municipalities achieve their goals, their emissions would fly If this goal were reached, it would mean that the annual the job reduction would be 20 MtCO2-eq (Hinku calculation) from the 2018 level by 2035. This reduction would correspond to more than half of Finland's carbon neutrality goal from the last level.

In Sitra's publication, the municipalities' climate actions were analyzed through surveys and interviews through. The investigation was focused on five different themes: traffic, distance for heat, oil heating, energy efficiency of buildings and waste treatment.
Regarding the energy efficiency of buildings, the survey answers and interviews had the findings of the energy efficiency potential of buildings mentioned as implemented climate measures making.

3.2 Greenhouse gas emissions during the use of buildings

Finland's building stock in 2021 covered a good 1.54 million buildings, of which three quarters were single-family and semi-detached houses and, for example, less than a tenth were buildings nuskanna was made up of apartment buildings and townhouses. Summer cottages are not included in the construction stock and no agricultural or other outbuildings.

In Finland, during the life cycle of buildings, by far the largest part of greenhouse gas emissions arise from energy consumption during the use of buildings. The building in the operating phase, energy is used to heat the premises and domestic water, as well as electrical equipment den use and lighting.

Up to three quarters of emissions from the built environment in Finland are generated by buildings during the use phase, the last quarter of the emissions are created, among other things, by construction materials rials manufacturing, site operations and transportation. This big picture it is clear from the calculations, which were done for the first time in such a comprehensive way at Rakennusteolli suus in the current state analysis of RT's low-carbon road map, where the key part was to map the carbon footprint of Finland's entire built environment. Current state analysis works 2017 data were given. Figure 6 shows the calculation of the relevant carbon footprint the result

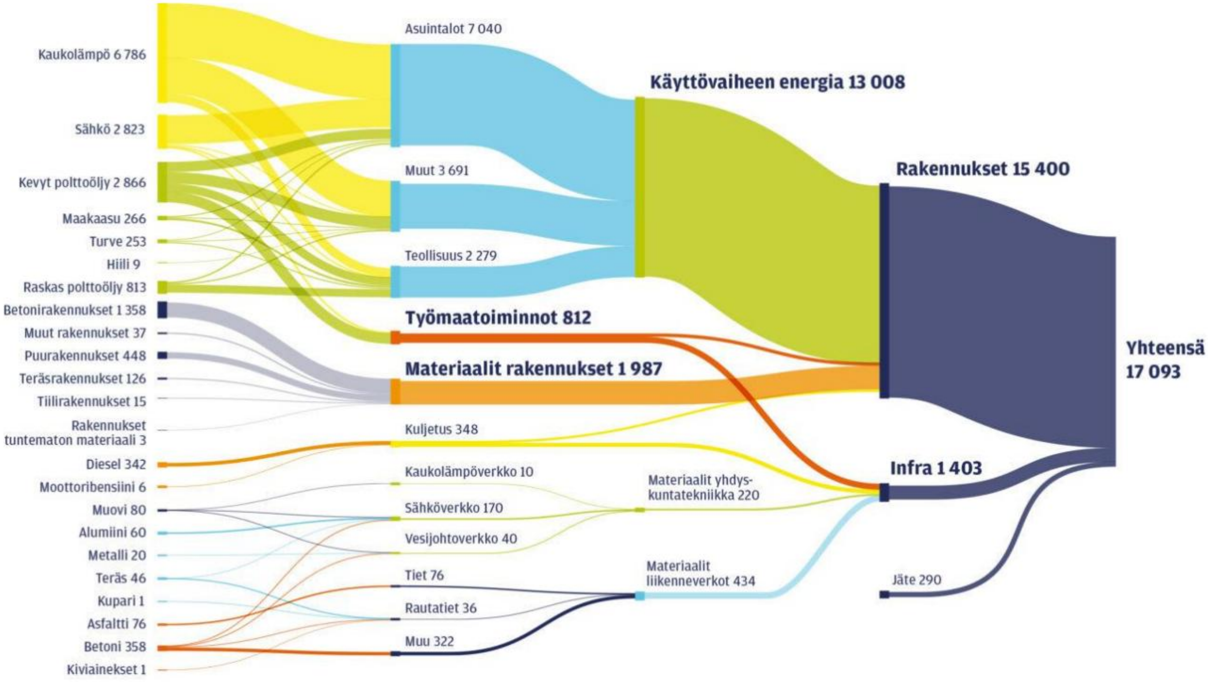


Figure 6. Life cycle carbon footprint (ktCO2) of the built environment (https:// www.rt.fi/ globalassets/ environment-and-energy/ waxcarbon_new/ rt_4.-report_vaxcarbon-tiemap_final-version_clean.pdf).

As far as emission reductions are concerned, it is essential to focus on the biggest and fastest impacting ones reduction measures. As far as the built environment is concerned, they are first and foremost related to existing improving the energy efficiency of existing buildings and switching to low-emission forms of energy. Reduce the energy consumption of existing buildings measures that improve energy efficiency include, for example, heat recovery intake and utilization of solar energy in the form of a solar power plant.

4 Energy consumption and carbon dioxide emissions of ice rinks

As discussed in previous chapters, greenhouse gas emissions from buildings during the period of use are large in Finland, and the structures owned and managed by the municipalities the share of nuses is significant. There are currently a little under 250 active in Finland ice rink. Ice rinks are one of the biggest single energy consumers in municipalities, swimming in addition to halls, which are detailed in the next chapter of the report.

Large amounts of heat, electricity and water are used in ice rinks, and from technical features The ice rinks on the bridge have their own way of building. In ice rinks, you influence energy consumption the hall's size, location, thermal insulation and the number of visitors and hours of use. Ice rink the size of the ice area(s) and the temperature of the ice and room air and ice treatment (water amount/times/temperature of water used) also affect energy consumption. Others Factors affecting the energy consumption of the ice rink are air drying, ventilation, hot domestic water consumed by the wires (for example when washing), lighting and that how the condensation heat of the refrigeration system is utilized.

However, most of the energy consumption in ice rinks is taken up by maintaining the ice rinks frozen and when servicing the ice, freezing the water spread on the tracks. Ice rinks the energy consumption of the refrigeration machines needed for freezing consists of the machines' joking about the need for electricity. The electricity demand of refrigerators is highest in the summer and at night than in winter due to seasonal temperature fluctuations.

There are 244 ice rinks on the ice rink portal, and their energy and water consumption is presented next in this chapter. The calculation has been made using the consumption data obtained from the ice rink portal as follows:

1. First, the sites where energy and water consumption data were found for a certain year were searched. The data for the years 2020 and 2021 were excluded from the calculation due to various restrictions due to the corona pandemic.

2. Next, the objects were searched for which there was no consumption data, but the area information was found and the consumption for the objects was calculated based on the area. In the calculation, I use the average of the characteristic consumption data calculated from the consumption data of the ice rinks in section 1 dirty

3. There were also items in the ice rink portal that had no consumption data entered for anything for the year, and there was no area information. The consumption data for these swimming pools were evaluated as follows: that averages of the consumption of all ice rinks in item 1 were used.

The consumptions of individual ice rinks and consumption estimates are compiled in the appendix of this report seen 1. Table 1 below shows the ener gia and water consumption data.

	Lämpö, GWh	Sähkö, GWh	Vesi, m^3
Yhteensä	114	209	730 614

Table 1. Energy and water consumption data for ice rinks (partially based on estimates)

Table 2 below shows the minimum, maximum and average values of heat, electricity and water specific consumption (kWh/br-m2 and l/br-m2) of the ice rink portal sites. Ar it can be observed that the ratio of the largest and smallest consumptions to the portal eats of the consumptions made, is very large. The calculation of the specific consumption included a total of make 82 ice rinks.

	Lämpö, kWh/br-m^2	Sähkö, kWh/br-m^2	Vesi, litraa/br-m^2
Minimi	2,8	52,2	124,5
Keskiarvo	126,7	222,2	740,4
Maksimi	662,8	988,6	2636,1

Table 2. Specific consumption of ice rinks

The carbon dioxide emission estimate for the sites found on the ice rink portal is approximately **33.5 ktCO2.** In the calculation of the emission impact estimate, city-specific energy methods have been used district heat emission coefficients and Finland's average electricity production tanto's emission factor (average of the statistical years 2018-2020), and it has been assumed that the calculation district heating of the ice rinks that are the destinations for those that did not have a heating type or entered consumption stored in the portal could deduce that from the data. For this reason, the result of the calculation can only be taken for granted to be given, because the group can also accommodate, for example, several electrically heated ones ice rinks. However, within the framework of this project, the temperature of each ice rink was not determined measurement form separately, because for a more accurate emission calculation also energy consumption the information should be more specific for the items. All energy has been assumed in the calculation to have purchasing energy.

5 Energy consumption and carbon dioxide emissions of swimming pools

There are currently around 200 swimming pools in Finland, and most of them are large from all municipalities. Most of Finland's swimming halls are maintained and owned by municipalities, and are (in addition to ice rinks) the municipalities' largest individual energy consumers.

The purpose of this project was to examine the objects found in the ice rink portal in addition, in more detail the energy and water consumption of the halls in the swimming hall portal as well as typical savings measures. Inspector of energy and water consumption in swimming pools The analysis has been done on a rough level, because the energy consumption data of swimming pools is in use were partially incomplete and for some swimming pools, consumption has had to be estimated information.

Swimming pools use a huge amount of heat, electricity and water. The temperature of swimming pools the heating energy demand consists largely of the heating demand of the pool water, domestic water heating, space heating (sheath conduction losses, leakage air and from corridors evaporating water) as well as the heating need for ventilation. Domestic water heating ener water consumption consists of water used in showers, filter rinsing water, washing water, pool water that evaporates, and pool water replacement water. Tub the heating energy demand of the water depends on the surface area of the swimming pools, the temperature of the water in the pools about the dustbins, the hall's air temperature and relative humidity, the number of visitors and about the different amount of activities in the halls, i.e. whether the swimming hall has, for example, a water slide pools, whirlpools or waterfalls.

Electricity from swimming halls is used to heat sauna heaters, water treatment system for water pumping, ventilation fans, lighting, pool equipment water pumping, HVAC pumps and other smaller consumer items.

The total energy and water consumption of the items found on the swimming pool portal is calculated fox in table 3. Compiling the consumption data of swimming pools was also partly challenging, because the information in the portal was incomplete or the quality of the received data was not sufficient, as can be seen in figure 7 found in subsection 5.1.1 of this report regarding the consumption of electricity supplied to the swimming pool in Pietarsaari. Some portal users have encountered comma errors when entering data, which were corrected manually for calculation.

The swimming pool portal contains 189 swimming pools that are not closed. These swimming pools the consumption data has been calculated using the information obtained from the swimming hall portal vast:

1. First, we searched for sites where energy and water consumption was found in a given year dot. The data for the years 2020 and 2021 were excluded from the calculation due to the corona pandemic due to the different restrictions of the supports.

2. Next, we searched for sites where there was no consumption data, but surface data was found were satisfied and the consumption for the objects was calculated based on the surface area. I use it in calculations online, the average of the specific consumption data calculated from the consumption data of the swimming halls in section 1 dirty

3. There were also items in the swimming pool portal where consumption data had not been entered for anything for the year, and there was no information on the area. The consumption data for these swimming pools were evaluated as follows: that averages of the consumption of all swimming pools in point 1 were used.

The consumption of individual swimming pools and consumption estimates are compiled in the appendix of this report seen 2.

	Lämpö, GWh	Sähkö, GWh	Vesi, m^3
Yhteensä	312	165	2 988 629

Table 3. Energy and water consumption data for swimming pools (partially based on an estimate)

Table 4 below shows the minimum, maximum and average values of heat, electricity and water specific consumption (kWh/br-m2 and l/br-m2) of the swimming pool portal sites. Ar it can be observed that the ratio of the largest and smallest consumptions to the portal eats of the consumptions made, are many times tenfold. In the calculation of specific consumption, there was including a total of 134 swimming pools.

	Lämpö, kWh/br-m^2	Sähkö, kWh/br-m^2	Vesi, litraa/br-m^2
Minimi	102,3	13,1	473,7
Keskiarvo	505,5	245,8	4440,8
Maksimi	2181,8	1309,8	15153,0

Table 4. Specific consumption of swimming pools

The carbon dioxide emission estimate for the sites found on the swimming pool portal is approximately **54.5 ktCO2.** In the calculation of the emission impact estimate, city-specific energy methods have been used district heat emission coefficients calculated using the method and the Finnish average emission factor of electricity production (average of statistical years 2018-2020). I'm counting District heating is assumed to be the heating method for the target swimming pools, because stairs the forms of heating of the objects are not sufficiently detailed in the list. Most of the Finnish swimming pools, however, can be assumed to be heated by district heating. I'm counting in nasa, it is assumed that all energy is purchase energy.

5.1 Typical energy saving measures in swimming pools

In swimming pools, the energy consumption is quite high, as was shown in the previous chapter. In swimming pools, energy efficiency can be improved in many cases, e.g crack in lighting, ventilation, by adjusting water temperatures and flows. Saunas and washrooms often also offer opportunities to improve energy efficiency pig. The project aimed to map out what kind of energy-saving measures Swimming pools found in Finland have Information was collected, among other things, from the municipal energy sector about the listing of measures in the municipal sector for the gia efficiency agreement period 2017-2025, uimahal from lipoportal about the real estate technical information of swimming halls, as well as from previous publications, which have discussed the energy efficiency of swimming pools. In addition, the past year 2022 ai chicken has also been featured in the media, due to the topicality of the topic, in several municipalities energy saving measures to reduce the electricity consumption of swimming pools.

The energy efficiency agreement period 2008-2016 was also asked for the survey longlist availability, but this listing was no longer in use.

Energy-saving measures can reduce the energy and water consumption of swimming pools and therefore also carbon dioxide emissions, but in addition to these, the measures bring over time also clear financial savings. In the case of swimming pools, it must be taken into account that their energy and water consumption will always be high because of the services offered, for example the amount of hot domestic water consumed or greatly reduces heating energy consumption. If the number of visitors to the swimming pool increases significantly, energy and water consumption will also increase, this is good to be aware of when considering energy saving measures in swimming pools.

In the subsections of this chapter, typical energy-saving measures for swimming pools that have emerged have been reviewed.

5.1.1 Energy consumption monitoring

To monitor the energy consumption of the swimming pools and the mutual consumption of the swimming pools Uimahalliportali was once developed for comparison. In addition to the swimming pool portal, the swimming pool lei has its own monitoring methods and systems to track its consumption data for For example, Urheiluhallit Oy, whose organization includes eight different water bodies and a hall offering indoor exercise in Helsinki, monitors energy consumption in real time in terms of electricity, heating, water consumption and treatment, so that the system which can be driven on a load basis.

Energy consumption measurements are normally used to monitor heat, electricity and utility its consumption. The best way to keep energy consumption steady is to keep it constant and with goal-oriented energy monitoring. By monitoring and analyzing consumption it is possible to detect potential energy saving points even in the long term roads and to detect even the most acute cases, such as water leaks. Monitoring has the opportunity to also get useful information about the distribution of the building's energy use and temporal variations. In buildings, like in swimming pools, a large part maintenance costs consist of energy and water charges. Just the maintenance fee in order to reduce even the costs, energy consumption should be measured and monitored, as well as trees help with problems that arise.

Energy consumption can be monitored and measured in several different ways. Energy and water the facilities have their own energy and water consumption meters in the buildings. These measure total energy consumption, and based on those measurements, the Energy and Water Act toks bill for the used energy and water. In general, I set these meters replacements, replacements and maintenance are the responsibility of the energy and water utilities. But if you want, for example, to replace a different type of main water meter in the building, then ve silaitos may invoice for the exchange according to its price list. The price lists are usually visible on the websites of water utilities.

Monitoring of energy consumption is typically done manually on site Luke mass meters and recording the readings or using the remote reading of the meters, in which case the data registered by the meter or a separate device connected to the meter is exported to a separate to the system.

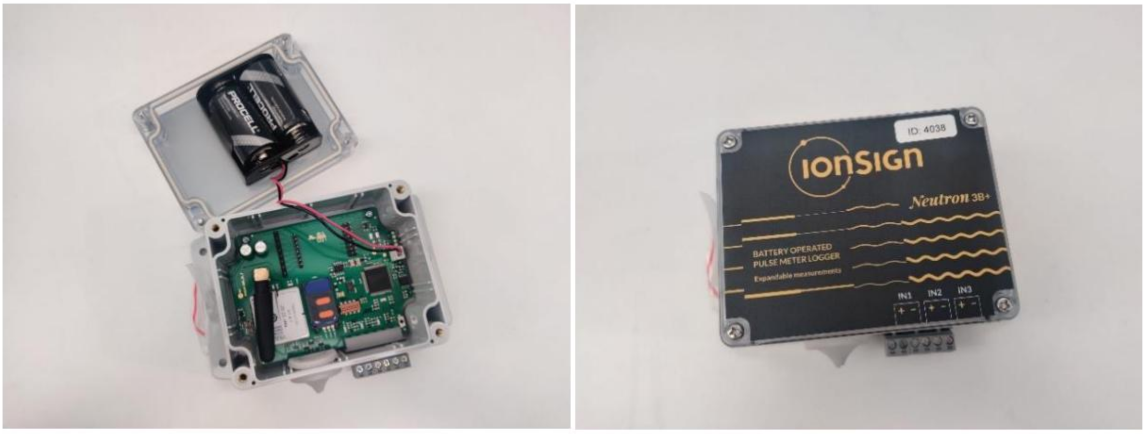
Manual energy monitoring means that meters are visited in the property on site reading and recording consumption readings on different software platforms or, for example, to a spreadsheet program such as Microsoft Office's Excel, to which can be calculated using reading dates and consumption readings for a certain period of time interval consumption data.

Manual energy monitoring is not considered a very accurate way to monitor properties energy consumption, because the readings are recorded manually in the property on site by visiting and the probability of reading errors increases and the end result can be e.g found an incorrectly entered reading, due to which the energy consumption from a certain time interval may be incorrect graceful Figure 7 shows the electricity consumption in Pietarsa fed into the swimming pool portal ren swimming pool for 2021. On the basis of the entered consumption information in that particular the electricity consumption in the swimming hall would have been 866,945 MWh, which cannot be true.

Figure 7. The electricity consumption of the Pietarsaari swimming hall differs significantly from other swimming halls compared to electricity consumption in 2021

Another way in which monitoring of the building's energy consumption can be implemented is **energy consumption monitoring based on remote readings.** In remote monitoring, the consumption data from the meters is automatically updated to the systems at different levels (minute, hour or even day level), and in this case there is no need to visit the building itself to read the meters. Remote reading energy monitoring can be implemented with a few different options. For example, domestic water consumption

can be measured using a remote reading with a separate pulse collection device (battery-powered pulse collection device in pictures 8 and 9), which is connected to the impulse sensor of the water meter. Exists also various devices based on camera technology, which are installed in the water meter on and they read the meter readings using artificial intelligence. Currently becoming more common there are, however, water meters from which consumption information is sent directly to the water utilities, and there is no need to install a separate reading device in addition to the meter.



Pictures 8 and 9. ionSign battery-operated pulse collection device for energy and water for simitaires with impulse readiness

In terms of electricity and heat consumption meters, the energy utilities in Finland are slightly above the waterworks for remotely readable meters. Just like the water utilities in Finland are just getting up to speed with remotely readable meters for the majority hourly consumption data from energy plants has been transferred to buildings for a long time oh However, there are still some places in Finland where, for example, there is no distance heat consumption data can be transferred via remote reading directly from the meter, but here it has also been possible to install a separate pulse card and a separate pulser connected to it appliance and the thus obtained consumption data read by means of remote reading.

5.1.2 Wastewater heat recovery

Information found on the swimming pool portal and the Energy Efficiency Agreement period of the municipal sector according to the 2017-2015 list of measures, there is some ver ran waste water heat recovery systems. Wastewater is used as a liquid, from use water to be removed. In swimming pools, there are possibilities for waste water heat recovery large ones, because they generate a lot of warm waste water, for example from the washing of filters of drinking water and users washing in the shower, when thermal energy would be possible the list captures and utilizes.

The efficiency of the waste water heat recovery system is affected by, among other things temperature of waste water in swimming pools, temperature of heated water, water flow rate and heat transfer method. Wastewater heat recovery systems can be connected using I do either a passive hot water preheating connection or an active heat pump connection to fly In picture 10, JVLTO, Kokkola Swimming Center in Vesiveijari, preheater is connected to measure the thermal energy of pool and shower water using new hot service water giaa.

Figure 10. Kokkola Swimming Pool Vesiveijari's waste water heat recovery system (https:// www.ecowec.com/ uimahallit-ja-kylpylat/ uintikeskus-vesiveijari-kokkola/)

5.1.3 Exhaust air heat recovery

Information found on the swimming pool portal and the energy efficiency contract period of the municipal sector according to the list of measures for 2017-2025, some Finnish swimming pools have exhaust air heat recovery systems. In swimming pools, in the exhaust air of the pool section there is a huge amount of thermal energy that could be harnessed. Heat recovery off from the air can be realized with heat exchangers or exhaust air heat pumps (PILP). Ny kyaical exhaust air Heat recovery systems are efficient, but the suitability for the objects must always be checked on a case-by-case basis. It is also important to consider how the recovered energy is utilized.

In swimming pools, the ventilation rates are high, which requires heating the incoming air a large amount of energy. The share of energy needed to heat the supply air can be can be reduced by preheating the air using a heat recovery system. Others applications for the energy recovered from the exhaust air in swimming pools are, for example hot water production and pool water heating.

5.1.4 Optimizing usage

In the buildings, building technology and lighting are sized according to peak needs. Ra however, the kennels are not in peak use all the time, so if possible, partial power is used to save energy consumption. Often even with lighter ones big savings can be achieved with maintenance measures and system adjustments in energy consumption and costs. In the municipal energy efficiency agreement for the period 2017-2025, the list of measures included operating technology for swimming halls those measures and also in the media, due to the topicality of the topic, have been on display different energy saving measures that have been implemented in swimming pools, for example there are saunas excluded from use and/or use restricted.

Regarding swimming pools, use optimization could also be done with, for example, the following in energy-saving ways:

- Covering pools to prevent water evaporation. Covering pools can I think it would be done at night or at times when there are no users in the hall.
- Sauna heaters use electricity. In quieter times, the saunas can be closed closed (or if there are several saunas, only some would be in use and the others closed), thus saving on electricity consumption.
- In premises where it is possible, a presence sensor would be used for lighting thyme. The intensity of the lighting can also be adjusted as needed and considering natural light. In many swimming pools, the window surface of the pool areas the fields are large, so intelligent lighting control could affect energy to giate efficiency.
- Ventilation control as needed, i.e. use of ventilation machines in swimming to suit the premises and conditions of the hall. Circumstance goals for ventilation can can be, for example, a certain moisture content, carbon dioxide content and/or temperature.

5.1.5 Framework

According to the information received from the swimming pool portal, more than a hundred swimming pools have had some kind of renovation decoration. There is no more detailed information on the scope and type of renovation on the portal.

However, the end result of renovations is often to improve the building as well energy efficiency.

In swimming pools, the indoor conditions are different compared to other buildings. The usual because in buildings, heat is transferred through their structures from September to May. Swimming pools are exceptional because of their high internal temperature transfers heat from the inside to the outside almost all year round. Because of this, also heat loss is greater than in normal buildings.

However, by improving the heat insulation of the sheath, for example, it can be achieved significant savings in energy consumption. Due to cost efficiency, the structure additional changes should, however, be scheduled for existing swimming pools mostly in connection with the renovation of the hall.

5.1.6 Energy saving measures found in inspections

In Finland, energy audits have been carried out for more than 80 swimming pools and spas. Motiva website the most common views of the 32 viewed swimming pools are summarized in picture 11 found on the jacket the energy saving measures observed in The picture shows how many swims out of the 32 halls viewed, measures have been proposed, as well as measures average cost savings, investments and payback periods. Procedures the calculated average payback times for the swimming pools of the viewing sites varied between 0.1 and 5.5 years.

Yleisimmät uimahallien katselmuksissa havaitut energiansäästötoimet

Havaitut energiansäästötoimet*	Ehdotettu energiansäästötoimeksi yhteensä, krt	Keskimääräinen kustannussäästö, €/a	Keskimääräinen investointi, €	Keskimääräinen takaisinmaksuaika, a
Sisä- ja ulkovalaistus	33	400	2 100	5,0
Ilmanvaihdon käyntiajat	31	2 300	300	0,1
Muut energiansäästömahdollisuudet (mm. allasveden lämpötilan alentaminen, allastilan olosuhteiden muutokset yms.)	23	2 100	3 100	1,5
Vesikalusteiden virtaaman rajoitus	22	2 700	500	0,2
Ilmavirran puolittaminen tai pienentäminen	15	3 200	2 000	0,6
Ilmanvaihdon lämmityksen säätötavat	14	2 100	1 400	0,7
Muut sähkölaitteet	13	500	400	0,7
Tariffin ja jännitetason tarkistus ja loistehon kompensointi	11	3 700	700	0,2
Lämmöntuotto - kaukolämmön sopimusteho	11	2 400	300	0,1
Lämmöntalteenottomahdollisuudet	10	2 100	11 400	5,5

*Katselmoiduissa 32 uimahallissa.
Kaikkiaan Suomessa on katselmoitu yli 80 uimahallia ja kylpylää.

Figure 11. The most common energy-saving measures observed in inspections of swimming pools (https:// www.motiva.fi/ ratkaisut/ energiakatselmustoiminta/ tem_n_tukemat_energia inspections/ in inspections_observed_pollution possibilities/ swimming pools)

The average observed energy saving potential of those views was 6% for electricity, 11% for heat and 4% for water. In relation to those presented in chapter 5, swimming this would reduce the energy consumption of the hallportaal sites by 9,924.0 MWh of electricity, 34,304.3 MWh of heat and 119,545.1 m3 of water per year . Energy and water the savings in annual costs would be significant at the national level.

5.2 Example: waste water heat recovery

The development project piloted the automatic reading of energy and water consumption data for Tesoma's swimming pool, which will be discussed in more detail in chapter 6. The project also looked at the energy saving potential if a waste water heat recovery system were installed in Tesoma's swimming pool. According to information from the swimming pool portal, there is no JVLTO system there is no in the swimming hall in question. In this chapter, li of that system has been examined in terms of energy saving.

In 2019, the number of visitors to Tesoma's swimming hall was 112,751. By default, pi that one visitor to the swimming hall consumes 80 liters of warm water when washing (if the water flow of the showers is, for example, 18 l/min, so that would mean that every visitor would be in the shower for approx. 4.5 minutes per pool visit), in which case the visitors would be wasted around 9020.1 m³ of warm water in the Tesoma swimming pool during 2019.

Figure 12 shows the temperature of one operator's waste water heat recovery systems saving in household consumption (kWh/a) in relation to the amount of waste water (m³/a). If you energize in order to improve the heat, the heat room in question would be installed in Tesoma's swimming hall tea extraction system to recover the thermal energy contained in the wash water for beneficial use to heat the new hot water, then looking at the picture, the saving in heat consumption would be about 50MWh/a, if the heat was recovered with a passive hot water with the preheating connection. The image can also be used to see how much heat consumption would be saved if the system were connected together with a heat pump.

If the price of district heating is, for example, around €60/ MWh (VAT 0%), then the benefit of the waste water heat recovery system in heating costs would be around €3,000/ a (VAT 0%).

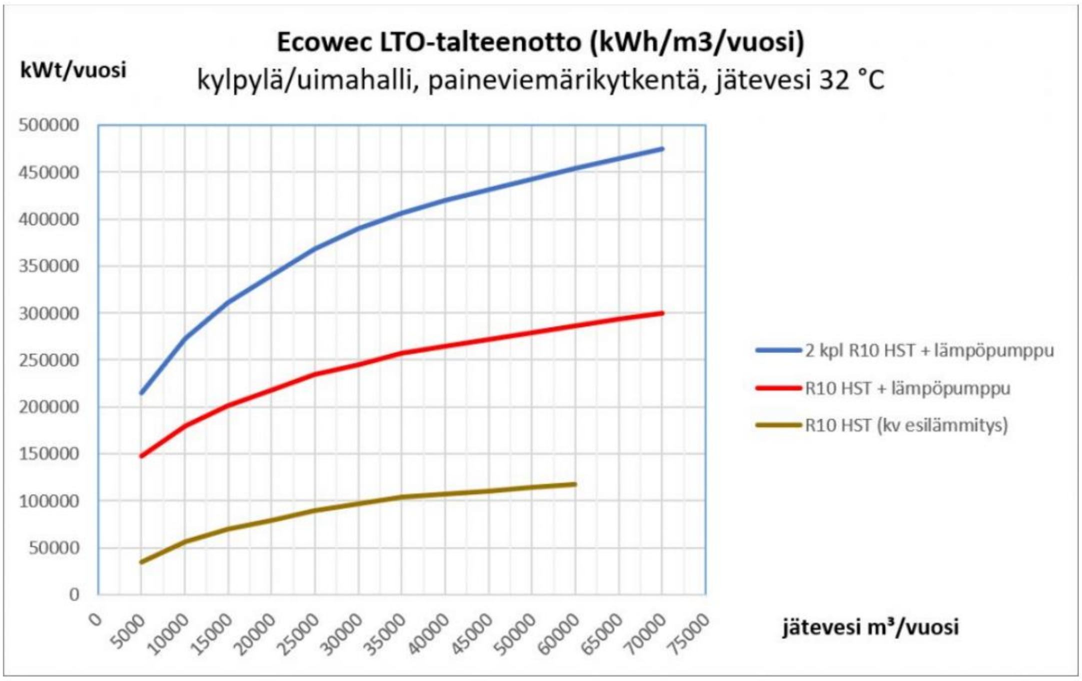


Figure 12. Ecowec waste water heat recovery system savings in relation to waste water to the amount (https:// www.ecowec.com/ ecowec-r10-hst-kyllypavaihdin/)

6 Tesoma's swimming hall as a pilot site

Users currently enter energy and water consumption data into the swimming pool portal at the yearly level. For this, electricity, heat and water meters have to be physically measured to read on the spot. In some locations, the problem has become different liability limits. End users are not necessarily responsible for technical entities and thus inputting the necessary readings becomes more difficult. That's why energy consumption information the comparability of swimming pools weakens on a national level, when some swimming pools' there are no problems with entering the readings into the portal and the readings of some objects is not entered there at all.

As a proposed solution to this problem, an automatic energy consumption information system was piloted implementation of the lecture in the selected swimming hall. Automatic energy flow reading information supports the basic idea of a reliable, free information source and not in the future, time would also be spent on maintaining up-to-date energy consumption data in the same way.

6.1 Tesoma swimming hall

The city of Tampere, located in Tampere, was selected as the project's pilot site owned by Tesoma swimming pool, Tuomarinkatu 7, 33310 Tampere. The swimming pool is Tampe the newest of ree's swimming halls and completed in 1998.

The swimming pool has a six-lane 25-meter main pool, a children's pool, a whirlpool, and a cold water area las and a diving pool with a three-meter diving board. Fitness and jumping pool are steel tanks. The more precise water surfaces, volumes and temperatures of the pools are observed listed in Table 5.

	Vesipinta-ala, m²	Altaan tilavuus, m³	Veden lämpötila, °C
Pääallas	380	608	27
Lastenallas	92	65	28
Hyppyallas	77	285	28
Poreallas	12	20	30
Kylmäallas	1	1	12
Yhteensä	562	979	

Table 5. Water surface areas, volumes and temperatures of Tesoma's swimming pool pools

There are a total of 180 lockers in the swimming pool and the meeting rooms are gender neutral. There are a total of 24 showers (12 for women and 12 for men in the shower rooms) and there are a total of 4 saunas in the swimming hall (2 for women and 2 for men on the side of). There are 1 water massage points in the Tesoma swimming hall.

According to the information available from the swimming pool portal, the energy consumption of Tesoma's swimming pool is was in 2019 before the restrictions caused by the corona pandemic:

- Heat 1854 MWh
- Electricity 795 MWh
- Vesi 12 524 m3

There have been 112,751 visitors in 2019. If we compare the number of visitors to the numbers in 2020 (72,000) and 2021 (67,945), when various restrictions have been in place due to the corona pandemic, then the number of visitors in the Tesoma swimming pool has been around 35–40% less during those years.

Within the framework of the development project, we were also in contact with the maintenance side of Tesoma's swimming hall, surveying the renovations made in recent years. Surface and tile repairs have been made to the end wall and floor of the pool area, the paneling of the saunas is maintained at regular intervals, and the back wall of the sauna heaters has been tinned to make it more durable. The hall's water treatment automation was updated in 2019, and in 2021, the equalization pool was renovated. The filter compounds of the sand pressure filters in Tesoma's swimming hall have been replaced once in a while. The lockers in the dressing room have been renewed and other lock updates have also been made to the hall.

As one larger measure affecting the energy efficiency of Tesoma's swimming hall it also became clear within the framework of the contact, which was not, for example, from the information on the swimming pool portal found. The exhaust side of the pool ventilation machine has a heat recovery system and the heat energy recovered from it is used primarily by ventilation machines for heating the supply air. If possible, heat obtained from the exhaust air the energy is also used to heat the water in the children's pool.

6.2 Current consumption monitoring and its challenges

In the swimming pool portal, the energy consumption data for Tesoma's swimming pool is recorded for the year from 2001 (excluding the years 2008-2010, for which there is no consumption data stored in the portal). The swimming pool's energy consumption data for the years 2001-2021 for heat, for electricity and water is illustrated in figure 1, 2, and 3.

Looking at heat consumption from 2016-2018, their share is quite small compared to other years, especially 2016 and 2017. The 2020-2021 pie the faster heating energy consumption can be explained by the restrictions set due to the pandemic. It was not known that there had been any renovation in the swimming hall between 2016 and During 2018, or anything else that could explain the consumption of swimming in these years in the hall portal. In the same years, electricity and water consumption have also been discussed for this swimming hall at a normal level and the number of visitors in line with other years.

The input heat consumption for the years 2016-2018 was analyzed in connection with the project and it turned out that apparently there was an error when entering the consumption data, and there is no consumption level checked after saving.

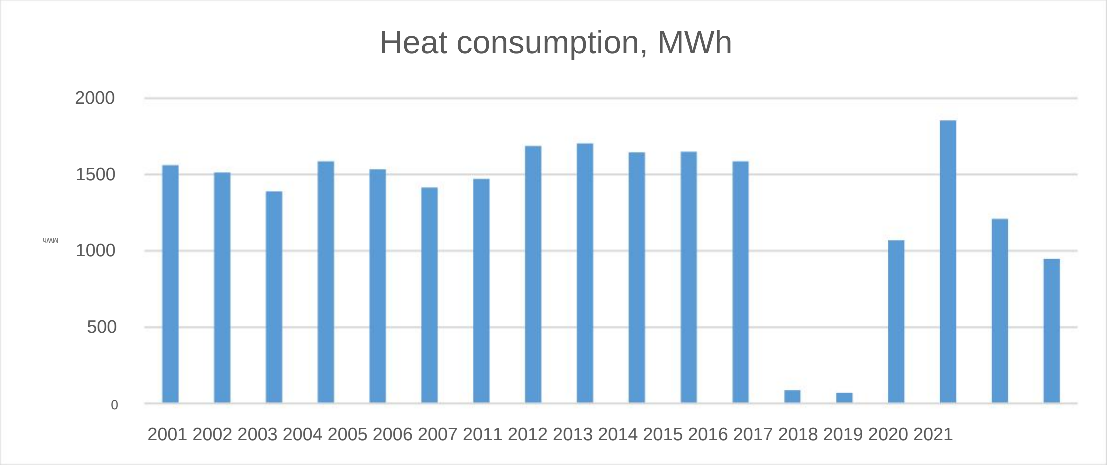


Figure 1. Tesoma's swimming pool heat consumption from 2001-2021 in the swimming pool portal

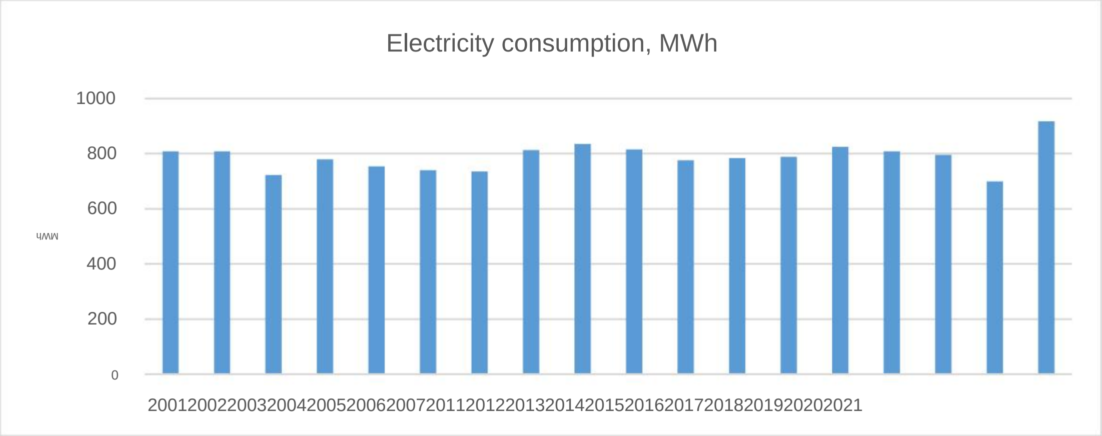


Figure 2. Tesoma's swimming pool electricity consumption from 2001-2021 in the swimming pool portal

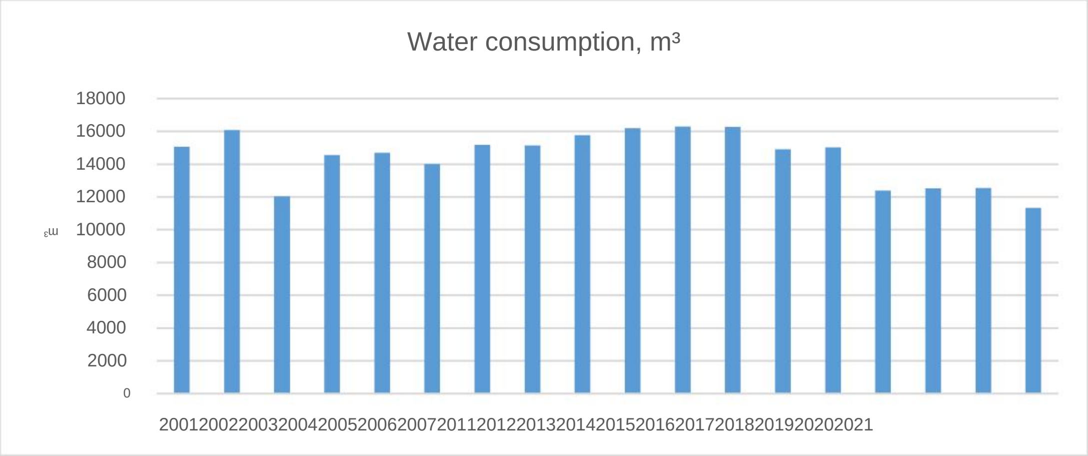


Figure 3. Tesoma's swimming pool water consumption from 2001-2021 in the swimming pool portal

6.3 Implementation of automatic monitoring of consumption data

The purpose of the pilot was to automatically import Tesoma's swimming pool energy and water consumption data into the swimming pool portal. This chapter describes the path, how consumption data was brought to the portal.

Heat, electricity and water consumption data were automatically imported into the swimming pool portal as level consumption data. A power of attorney from the operator is required to import consumption data who manages/owns the building in question. A power of attorney authorizes a power of attorney to receive electricity, heat and water consumption data from the authorizing building from nus's energy and water meters.

The heat consumption information is received from the regional energy company as a message transfer. You regarding the soma swimming pool, the information was obtained from the Tampere electricity company.

Electricity consumption data can be retrieved from Fingrid's Data, which came into use in 2022 through the hub system. Fingrid's system works nationwide, so Tesoman in addition to the consumption data of the swimming pool, the electricity consumption of other swimming pools would also be obtained there bug information.

The main water meter of Tesoma's swimming hall already had a separate reader installed before the project sea, from which water consumption data could also be retrieved via a separate interface. Water implementing the automatic transfer of consumption data from the main water meter requires at least another secondly, in a large part of the buildings, a separate device, as previously in chapter 5.1.1 sidestepped the issue.

Diagram 1 illustrates how the implementation of automatic monitoring of consumption data to the pilot site was implemented.

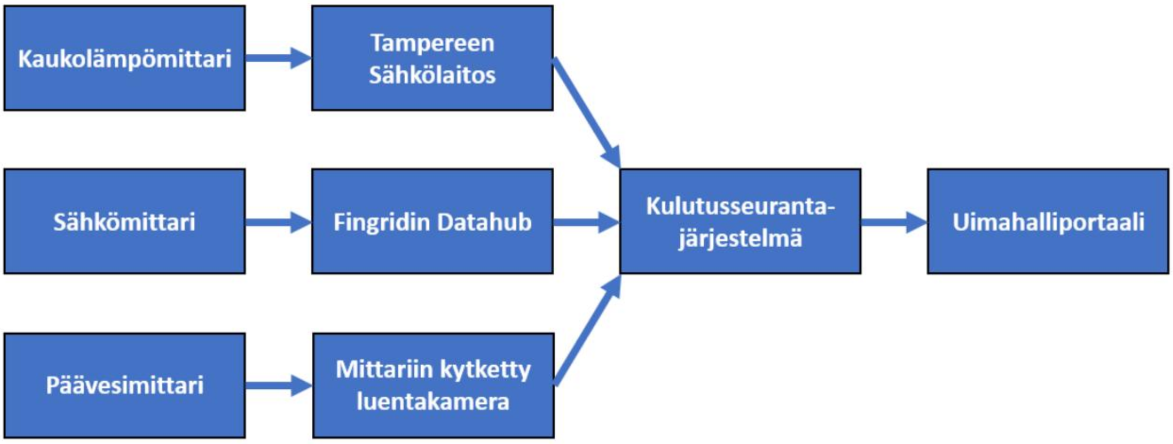


Diagram 1. Process diagram of the path from energy and water meters to the portal.

7 Summary

The purpose of the development project was to count the objects found in the swimming pool and ice rink portal energy consumption and carbon dioxide emissions. Energy consumption data from portals was found very varied. In some items, the information was very up to date, but unfortunately flaws were found in a large part of the supplement, which turned out to be a challenge in collecting consumption data counting and counting. In order to make the calculated result more reliable, a step should be taken to add and/or update the information of existing objects.

Carbon dioxide emissions were calculated using city-specific energy method calculations tuja district heating emission coefficients and Finland's average electricity production output work factor (average of statistical years 2018-2020). In the calculation, the targets were assumed as a form of heating, district heating, if no more detailed information was found on the portals or it could not be concluded from the entered consumption data (in the case of ice rinks, some of the objects assumed to be electrically heated). For this reason, the result of the calculation can only be taken for granted to be given, because for a more accurate calculation, for example, you should find out each one heating mode of the object. However, the results of the calculations illustrate well the mouth for the energy and water consumption of rose-class swimming pool and ice rink portal sites and for carbon dioxide emissions, a summary of the results is shown in table 6.

	Lämpö, GWh	Sähkö, GWh	Vesi, m^3
Jäähallit	114	209	730 614
Uimahallit	312	165	2 988 629
Yhteensä	426	374	3 719 243
Yhteenlasketut hiilidioksidipäästöt 88 kt CO2			

Table 6. Summary of energy and water consumption and carbon dioxide emissions

The total energy of the participants in the municipal energy efficiency agreement consumption for 2021 was 7,133 GWh. The objects of the swimming pool and ice rink portals have been calculated the energy consumption estimate is about 11% of this, which can be considered a fairly significant percentage you. However, it must be taken into account that not all municipalities in Finland have joined KETS nat, so in reality the percentage is somewhat lower compared to if all Finnish municipalities had joined the energy efficiency agreement in question there. Also worth noting is the fact that municipal affiliates generally do not report Energy consumption of the city's residential buildings to KETS.

Savings suggested in mapping and for energy audits of swimming pools measures emerged as typical measures to improve energy efficiency among other things, the various operational technical measures of the halls and the heat recovery system the systems. From the point of view of monitoring energy consumption, the swimming pool portal can be this also as one way. Consumption data should be up-to-date for all items as well as the monitoring carried out on an annual level in more precise values, so that from the portal its potential would be fully exploited.

In addition, the project piloted Tesoma's automatic reading of energy consumption data regarding the swimming pool, to the swimming pool portal and illustrated for the same site Energi savings if a waste water heat recovery system were installed there. Energy the number of visitors from 2019 was used and evaluated when illustrating the savings based on how much hot domestic water they have used during the year for washing not in the swimming pool. Using the table as a help, ar was obtained from this amount of waste water to fail in terms of energy-saving heating of about 50MWh/a, which would make annual heating costs about €3,000 (VAT 0%), while the price of district heating is about €60/ MWh (VAT 0%).

Automation of Tesoma's swimming hall energy consumption data directly to the swimming hall portal succeeded in the development project. It would be easy to expand the model in question to other sites as well, as long as the initial information is in order, i.e. for example the necessary credentials from the right people and the situation of the sites' main water meters has been mapped in order to choose the right type of remote water reading.

7.1 Development ideas

The figures entered into the swimming pool and ice rink portals are currently partially incomplete and honest, which weakens their national comparability and makes it difficult for individuals monitoring the energy and water consumption of the sites and through this also the carbon dioc calculation of side emissions.

As a solution to this problem, remote reading of energy and water consumption would support the idea from a reliable and free source of information in the portals and at the same time would reduce the work find out what it takes to read the meters and enter the data into the portals. Consumption getting data to the portals using remote reading requires the sel. of the measurements of the objects fiddling and deciding which measurements of the target would be desired for remote reading. In the process times, it would also be reasonable to find out the information missing from the portals of the destinations (such as etc such as heating type, surface area and building volume) and update these there.

In appendices 1 and 2 of the report, you can see which sites have the biggest deficiencies in energy in gas and water consumption and destination information. Especially the way of the ice rink portal destinations there would be room for improvement with a more detailed audit of energy and water consumption bone.

From hourly consumption data, where the consumption data is automatically updated regularly information, for example, we get information about the effect of possible implemented energy use on the effects of the measures on energy consumption faster than on an annual basis of recorded consumption data. Hourly consumption information is also useful information on the distribution of energy and water use and temporal variations.

Based on up-to-date and correct data, more accurate calculations could be made carbon dioxide emissions of swimming pool and ice rink portals, and possible mouth for the automatic calculation of carbon dioxide emissions using the system.

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29.12.2022

Attachments

APPENDIX 1. Ice rinks, energy consumption and consumption estimates

APPENDIX 2. Swimming pools, energy consumption and consumption estimates