Energy-efficient ski resort

Improved energy efficiency at ski resorts

Ski resorts use a significant amount of energy, and purchasing this energy is a considerable expense for the companies in the sector. It is estimated that the energy-saving potential at the largest ski resorts could be hundreds of megawatt-hours, corresponding to tens of thousands of euros each year.

In Finland, there are an estimated 1.2 million downhill ski enthusiasts, 0.9 million of whom had at least one skiing day during the season (TNS Gallup, Finnish Skier Study 2010). The number of visitors to a ski resort is calculated on the basis of so-called skier days. At the Finnish ski resorts, there were three million skier days and the total estimated number of ski lift rides was 50 million.

The energy consumption of one person's skier day is approximately 20 kilowatt-hours, which is in the same league with, for example, one day at a spa or two weeks' energy consumption of a fridge-freezer. The energy consumption of a ski resort includes the energy consumption of snowmaking and maintenance of the slopes, ski lifts and lighting, as well as the maintenance and service buildings in slope operations. However, the energy consumption of catering and accommodation services in connection with the ski resorts has not been dealt with in this report.

Why improve energy efficiency?

Improving energy efficiency is sensible management of company finances, because lower energy consumption corresponds to lower running costs. A number of measures are free for enterprises: for example, changes in the operating times and working methods of equipment may achieve savings even without investments. Improving energy efficiency also promotes sustainable development in accordance with the national climate and energy strategy.

Achieving Finland's emissions reduction targets requires goal-oriented measures by enterprises, the public sector and households. The Energy Efficiency Agreements 2008-2016 aim for improved energy efficiency through voluntary measures in accordance with the Energy Services Directive. It is sensible to adopt energy efficiency as one of the starting points when developing services, creating operating instructions, advising new staff or deciding on the acquisition and replacement of equipment at ski resorts.

The Energy Efficiency Agreements 2008-2016 aim for improved energy efficiency through voluntary measures in accordance with the Energy Services Directive.

ENERGY EFFICIENCY agreements

Current situation

Improving energy efficiency starts from the metering of energy consumption. The more accurate information is available for each set of equipment, the easier it is to pinpoint appropriate areas of energy saving. The information obtained from each individual ski resort can be compared with the consumption data from specific ski resorts acquired in the project.

Ski resorts are unique service companies with a common goal: providing customers with good slope conditions and supplementary services required at a ski resort. The individual energy consumption profile is created, for example, on the basis of the location of the resort, the size and shape of the slopes, the selection of services, and certain technical solutions.

Energy is a necessary production factor for ski resorts. However, it is possible and profitable to improve its use. It is a good starting point to know how energy consumption is distributed as accurately as possible and compare it with researched information about the impacts of various technical solutions and operating methods on energy consumption. The seven member companies of the Finnish Ski Area Association took part in the project entitled Energy-Efficient Slope Operations, examining the energy consumption and saving potential of ski resorts. Information about the investigated ski resorts is presented in the table on the next spread.

Ski resorts are major electricity users

The energy consumption of slope services at ski resorts mainly consists of the use of electricity. The majority of electricity is used in lifts, lighting and snowmaking, which consumes most of the electricity used for slope services almost without exception. Their proportion in the total energy consumption is reduced if the ski resort is responsible for several electrically heated buildings with a large building volume. In addition to

Consumption data from the web?

Several electricity distribution companies offer consumption monitoring even on an hourly basis as an online service for customers with hourly metering. If you are one of these customers, you can request for the online passwords.

electricity use, ski resorts use a lot of fuel in slope upkeep and in the machinery and vehicles needed in maintenance work. Fuels may account for up to one-third of the total consumption of all electricity and fuel.

Specific consumption, one of the meters of energy efficiency

The specific electricity consumption of various services or functions is a handy tool for monitoring changes in electricity consumption and estimating the implementation of energy efficiency at ski resorts.

Specific consumption expresses the energy used for the production of a product or service. At a ski resort, this may be, for example, the specific consumption of electricity in slope services estimated per one skier day, or the energy efficiency of snowmaking per certain area or the time spent in snowmaking.

However, it is not possible to use specific consumption for comparing electricity consumption between different ski resorts.

Changes in specific consumption between ski resorts are explained by different weather conditions, the effects of local conditions on technical solutions, such as the snowmaking system, and the time of opening the slopes. Different opening times also mean different times for using the lifts and lighting.

At the resorts included in the project, the average specific electricity consumption of slope services amounts to approximately 34.6 megawatt-hours, or almost €3,000* per year per one hectare of total slope area. For snowmaking, the corresponding average consumption per one hectare of snowed slope is approximately 24.1 megawatt-hours, with the costs amounting to some €2,000* (*calculated according to €85/MWh).

Metering produces monitoring data

It is possible to acquire accurate and comparable consumption data only if the electricity consumption metering used at various sites is reliable. However, the electricity systems of the ski resorts are often complicated, and detailed consumption data is not always available.

At ski resorts, there are often a number of power supplies and subcentres for distributing electricity for various needs. It is difficult to divide consumption, for example, between lifts, lighting, snowmaking and heating of the buildings even if the subcentres were equipped with submetering of electricity.

Metering and regular consumption monitoring increase the operational security of systems: unexpected changes in consumption may reveal faulty equipment or parts. The gathered information is also valuable when planning and dimensioning new systems.

Basic information about the studied ski resorts, 2008

	Himos	Talma	Messilä	Tahko	Ruka	Levi	Iso-Ylläs
Slope area, ha	70	9	21	73	71	102	83
Snowed slope area, ha	70	9	21	50	71	33	29
Skier days, number/a	162,040	45,547	121,419	210,567	391,514	447,352	143,000
Opening days per year, d/a	150	140	135	154	220-250	194	170
Lifts, number	18	7	9	13	19	24	12
Lifts, total capacity, kW	996	99	447	1,002	1,442	2,600	1,504
Slope lighting, total capacity, kW	251	36	104	66	600	1,050	194
Fan guns, number	15	9	18	19	20	27*	8
Hybrid cannons, number	75	-	-	72	65	130*	15
Snowmaking hours per year, h/a	800-1,000	400-700	700-1,000	500-800	1,000	700-1,000	500-600
Pumping capacity, m^3/h	700	250	231	730	1,590	1,500	250
Buildings, rm^3	18, 622		33,086	1,500	35, 338	16,589	22,000
Lift ascends, number/a	3 148,000	1,792,000	1,855,000	3,210,000	5,813,000	5,585,000	1,885,709

*year 2009

Monitor the consumption

In addition to snowmaking, it is worth monitoring the consumption levels of various sites with, for example, the following specific consumptions:

- the electricity consumption of lighting in relation to the illuminated slope area (MWh/ha, kWh/m^3)
- the total electricity consumption of the ski resort in relation to the slope area (MWh/ha, kWh/m^3)
- in buildings, the relation of heating energy to the building volume (kWh/m^3)

An example of estimating the efficiency of snowmaking

1. Establish the efficiency of pumping: electricity consumption of pumping in relation to the volume of water pumped (kWh/m^3).
2. Calculate the produced amount of snow: the generally used coefficient is 1 m^3 of water = 2.5 m^3 of snow.
3. Establish the electricity consumption of air compressors (kWh/m^3).
4. Items 1-3 cover approximately 70-80% of the electricity consumed in snowmaking. 20-30% is consumed by fan guns, the metering of which is difficult due to several subcentres.
5. When the electricity consumed in snowmaking has been established, it can be compared, for example, with the amount of snow produced or the time spent in snowmaking.

Key metering areas at a ski resort:

- electricity consumption of pumping stations
- electricity consumption of air compressor
- electricity consumption of snow cannons (according to the number of power supplies)
- electricity consumption of the electric heating of larger buildings
- volume of snowmaking water with the water meter

How is metering implemented?

If the ski resort has a building automation or automated snowmaking system, the meters can be connected directly to the system. It is most advantageous to acquire the metering together with the system, but the meters can also be installed at a later date. Metering connected to a centralised automation system reduces extra work incurred from meter reading.

Metering acquires a sufficient amount of information about the functioning and consumption of various systems, and especially about the variations of consumption.

An electricity meter is installed separately in each monitoring area. The consumption data is read on the meters or transferred by cable or wirelessly into the automation system. The total costs are affected by the number of meters, their distances and the desired technical solution.

Energy metering services are provided by, for example, electricity companies, consulting companies specialised in energy efficiency, and companies manufacturing meters and metering systems. The most recommended meter type is a meter with a bus output, which is more accurate than a pulse meter in terms of its measuring accuracy.

A glance at the efficiency of the snowmaking system

It is possible to examine the efficiency and costs of snowmaking by metering or estimating the electricity consumption of pumping, fan guns and any compressors, and by metering the amount of water used in snowmaking. When the consumption of various components is known, it can be compared, for example, with the hours of snowmaking or the volume of snow produced.

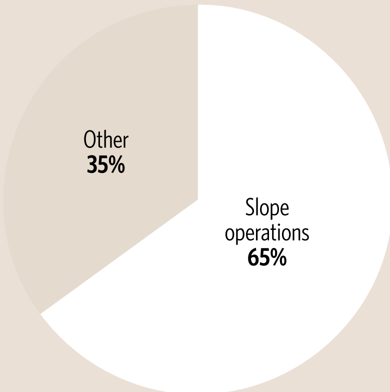
Using several different key figures ensures that all sections of snowmaking are covered by monitoring:

- the amount of electricity consumed in relation to the volume of snow produced (kWh/m^3)*
- the amount of electricity consumed in relation to the snowmaking hours (MWh/h)
- the relation of costs to snowmaking hours (€/h)
- the amount of electricity consumed in relation to the snowed slope area (MWh/ha)
- the amount of electricity consumed in pumping in relation to the volume of water pumped (kWh/m^3)*
- consumption of water used in snowmaking in relation to the snowed slope area (m^3/m^2)

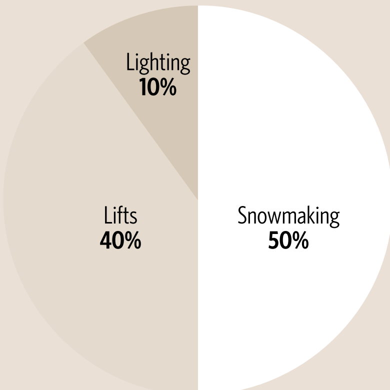
*2.5 m^3 of snow requires 1 m^3 of water

It is possible to connect appliance-specific measurements of power and the volume of snowmaking water to the snowmaking automation system. The data will produce an accurate system-specific distribution of electricity consumption.

Distribution of electricity consumption at ski resorts, %



Distribution of electricity consumption in slope maintenance and use, %



Source: Energy-Efficient Slope Operations Project Report (available only in Finnish).

Electricity procurement

Optimisation of electricity procurement costs requires thorough knowledge of the ski resort's electricity distribution network and drawing up a strategy for electricity purchases suitable for the electricity consumption at the resort.

An electricity bill consists of two elements: electricity transmission and electricity sales. In both of these, billing is usually based on a fixed basic charge (€/month) and the energy charge based on consumption (c/kWh). As major electricity users, ski resorts usually choose between tariffs based on either time or peak-load.

The transmission service includes the distribution costs, meter reading and balance settlement between electricity suppliers, as well as electricity tax and the supply security fee. The proportion of the electricity bill that is subject to competitive bidding consists of the purchase of the actual commodity, i.e. electricity. Its price is affected by production costs.

The electricity transmission service must be purchased from the local distribution system operator. However, electric energy can be bought from any company.

Electricity transmission

The transmission costs are composed in accordance with the transmission tariff of the local system operator, and the customer chooses the suitable tariff from the electricity company's selection. In support of the decision, it is worth making metering site-specific calculations in order to find the most advantageous alternative.

The customer can often choose from different tariff alternatives according to the fuse size of the metering point, or from low-, medium- or high-voltage connections based on the power. The energy charge is composed on the basis of a general, seasonal or night-time electricity contract. Electricity companies provide further information about various connection and tariff alternatives.

In terms of accrual of costs and consumption monitoring, it is problematic that electricity is needed over a wide area at ski resorts. As a result of this, several subcentres are established, each of which has its own basic charge. Connection of metering points may also bring savings in the energy charge.

It pays to carefully optimise the main fuse size to the needs of the area of operations because in the fuse-based tariff overdimensioning will increase the basic charge unnecessarily. It is possible to reduce billing based on actual consumption by regulating the operating times of electrical appliances. However, this requires constant power metering and an alarm function.

Electricity sales, the proportion subject to competitive bidding

Usually, the major part of an electricity bill is subject to competitive bidding, i.e. electricity sales. In this, the main stress of the costs is on consumption-based energy charge (c/kWh), but the tariffs may also include a small basic charge. Energy purchases are usually determined by single or two-rate metering.

The price of electric energy is based on the price of the Nordic electricity exchange, Nord Pool, almost without exception, in which case the electricity company will add its own margin. The companies offer various pricing methods and it is possible to draw up fixed-term contracts or contracts valid until further notice.

The price risk of electricity can be balanced by tying parts of the acquisition to various electricity products in the same way as in the fund and stock markets. Electricity portfolio management services are provided by consulting companies. Ski resorts can also carry out acquisition co-operation and arrange competitive bidding for their electricity portfolio management.

Compare the price level of a ski resort's electricity contract with the general electricity exchange level. If the electricity contract is of a fixed term, be prepared to learn in advance about the alternatives, arranging for competitive bidding and purchasing any electricity portfolio consulting services.

At the ski resorts included in the study, the total price of electricity varied between €81 and €141 per MWh (0% VAT). Only some of the resorts have arranged for competitive bidding on the price of electricity.

Inform customers of energy-efficient snowmaking practices and factors related to the start-up of snowmaking. This will reduce external pressures for premature snowmaking and improve the ski resort's image as a responsible operator.

Reliable weather forecasts help to forecast favourable snowmaking conditions, when snow can be produced efficiently and quickly.

Unexpected savings with snow fences
At one ski resort, the specific consumption of snowmaking is 21 MWh/ha and the average area of one slope is 3.5 hectares. If the snow for the slope can be gathered fully with snow fences, it would provide annual savings of 74 megawatt-hours in energy consumption. This means savings of €6,300 when the price of electricity is €85/MWh.

Grooming and maintenance of slopes

Slope operations, i.e. the operation of lifts and the snowmaking, lighting and maintenance of slopes, consume the majority of energy used by ski resorts

Snowmaking systems

Snowmaking is the biggest individual electricity consumer at ski resorts. The average specific electricity consumption of a snowmaking system is 34.6 megawatt-hours per one hectare of slope. It is possible to improve energy efficiency through careful planning of snowmaking practices and forecasting and making use of good conditions.

The snowmaking system consists of a pump house, cannons, water and air pipelines, an electricity network and, if necessary, a compressor station. At some ski resorts, separate cooling for the snowmaking water is also required.

The equipment of the snowmaking system includes:

- the pumps, automation and control system in the feedwater/booster pump house
- in the compressor station, air compressors operated by electricity or combustion engine
- snowmaking cannons

Ski resorts are still partly using fairly old technology because the lifecycle of snow cannons is up to twenty years. Wear and tear of the appliances has an impact on their effectiveness despite regular maintenance. Old technology is not necessarily very efficient in terms of snow production and the consumed energy.

It is always worth paying attention to energy efficiency when assessing new appliance acquisitions.

Automation increases the efficiency of snowmaking and often provides savings in energy costs. Usually, fully automated systems are economically justified only in the largest ski resorts due to their high acquisition costs.

Measures to boost the energy efficiency of snowmaking:

- replacing old snow making equipment with modern technology and automation
- automation of pump stations and compressed air production
- a fully automated snowmaking system

Low temperature boosts snowmaking

Snowmaking is most energy efficient at sufficiently low temperatures when snow production in relation to the amount of electricity consumed is at its highest. Large amounts of snow should only be produced in optimal conditions once the temperature falls to approximately -6 °C. As the resorts want to open the slopes as early as possible, it may not be possible to wait for the optimal snowmaking conditions.

The amount of snow produced depends on the air temperature and humidity, as well as on the temperature of the water used for making snow. The poorer the weather conditions are for snowmaking, the more important it is to make sure that the water temperature is as low as possible, however, without causing a risk of freezing in the appliances.

Good planning is worthwhile

Effective and quick snowmaking under good conditions is successful when it is preceded by advance preparation and careful planning. Information from previous years and knowledge of the local conditions are used in the planning. Critical assessment of established snowmaking practices may also bring up needs for a change related to energy consumption.

Deciding on the order of producing snow for the slopes is important in terms of the start of the skiing season. Usually, the main slopes are the main priority, as the resorts want to open them first. However, the conditions may vary in different parts of the ski resort, in which case it may be possible to start snowmaking earlier if the order of snowmaking is rearranged.

By moving the equipment in place in good time, it is possible to start snowmaking as soon as the conditions permit. Forecasting the wind conditions helps to position the cannons in favourable places on the slopes. Snow fences can also be used for creating banks of natural snow for later use, thus reducing the use of artificial snow. Comparison of the amount of snow produced over several years may reveal that sometimes an unnecessary amount of snow has been produced. In such a case, it is also likely that more energy has been consumed than would have been necessary.

Automation to the rescue

Supplementing a manually operated snowmaking system with automation accelerates the start of snowmaking in good conditions because the equipment is controlled from a single computer monitor. A fully automated system can also be programmed to start up by itself when the conditions entered in the program are met.

All parts of the snowmaking system are connected to the fully automated system, and the cannons are replaced with automated ones. The system is expensive and it is suitable in the Finnish conditions mainly in the largest ski resorts.

In semi-automated systems the water pumps are controlled, and in centralised production of compressed air the compressors are controlled – either both or only one or the other in accordance with the solutions. The personnel are responsible for controlling the system and regulating the operation of the cannons according to the conditions. Meterings and controls related to pumping can be connected to the system. The semi-automated system is clearly more favourably priced than the fully automated snowmaking system.

The benefit of the automated system is its speed and reduced maintenance runs, which also brings savings in fuel consumption. Also, utilisation of optimal snowmaking conditions will reduce the time spent in snowmaking and improve its production, resulting in smaller electricity consumption.

Snow guns and cannons

The selection of snow guns is affected by the prevailing weather conditions, the type of terrain and the width of the slope.

Fan guns

A fan gun mixes the water coming out of the nozzle with the compressed air produced with the gun's own compressor, and then blows the mixture into the air. The fan, compressor and heating are operated by electricity.

With a fan gun, snowmaking can be started when the temperature falls below freezing. It is the most energy-efficient alternative when snow is produced at a temperature of 0...–5 °C. Snow production and the amount of water used by the gun increase as the temperature falls.

If too much water is fed in relation to the conditions, it will not freeze. The excess water pumped to the slope will impair the snow quality and reduce energy efficiency.

Positioning on the slope

With respect to snow production, the correct positioning of cannons on the slope is important. The production is affected, for example, by the wind conditions and the throw distance, in which case water freezes into snow flakes.

Production improves when cannons are positioned on top of a small mound of snow and the snow is projected to the lower slope. Cannons can also be positioned on top of a fixed tower, which further improves snow quality and the operational security of cannons in windy conditions.

Nozzles

In different cannon models, nozzles are on the cannon ring either in groups of rings or on a single ring in nozzle pairs. The nozzles are heated with an electric cable to prevent freezing. The heating is more efficient in cannons with nozzle pairs because the heating cable travels inside the nozzle insulation and the required power is smaller.

The compressed air of hybrid cannons can be disconnected in snowmaking when the temperature falls below -15 °C. Thus, it must be ensured that the non-return valves are working and water cannot enter the compressed air network.

Reducing the power of nozzle heating from 5 kW to 1 kW will accumulate into great savings. The heating of 50 fan guns for one hundred hours at a ski resort will cost €2,000 with old technology. With new technology, the heating costs will fall to one-fifth of this, i.e. to €400.

In the latest models, the heating of the nozzles can be controlled according to the nozzles used, whereas in the older models the heating is switched on simultaneously in all nozzles. Heating is not required during snowmaking because the flowing water prevents the nozzles from freezing.

Reduction in the heating power considerably improves the energy efficiency of the fan guns. Moreover, the snowmaking capacity of the nozzles has improved with modern technology and they do not require as much maintenance and cleaning as the older models.

Automation

Automated fan guns contain a weather station, which can measure, for example, air humidity, temperature and wind. When the desired snow quality has been selected on the gun, it will control the functions to produce as much snow as possible under the prevailing conditions. These features will be most beneficial in variable conditions.

Some manually controlled fan guns may also have their own weather station for measuring air humidity and temperature. The controls will direct the user to regulate the gun's functions in the best possible way in relation to the conditions.

The reliability of the weather stations in the automated guns should be closely monitored. Variable conditions may result in incorrect measurement results and inaccuracy in snowmaking controls.

Hybrid cannons

Hybrid cannons are energy efficient, but their weakness lies in their low start-up temperature. In practice, snowmaking cannot be started until at a temperature of -3 °C, and the best result is not achieved until the air temperature has fallen to -9 °C or below.

In very cold conditions, the energy need of hybrid cannons in relation to the produced amount of snow is smaller than with fan guns because they have no separate electrically operated heating or fans. Hybrid cannons also operate better, for example, in humid conditions.

Most hybrid cannons are installed in place as stationary equipment. For this reason, knowledge of the wind conditions in the place of use is important in order to be able to position the equipment correctly. If the wind conditions are variable, it is worth considering positioning the cannons on either side of the slope.

Compressed air effectively

With hybrid cannons, the velocity time required for the freezing of the water droplets is achieved with compressed air or by positioning the nozzles high on top of a pole. Hybrid cannons need a water supply, but do not require an electricity connection. Compressed air is usually produced in a compressor station and the cannons are connected to the common compressed air network.

Compressed air and water are mixed either outside or inside the nozzle depending on the model.

Effectiveness of snow cannons

	0–3 C°*	**< -9 C° ***	**High wind**
Fan gun	Reasonable	Reasonable	Good
Hybrid, tower	Poor	Excellent	Poor
Hybrid, high-pressure	Poor	Reasonable	Good

* wet-bulb temperature

Fan gun	**Hybrid, tower**	**Hybrid, high-pressure**
+ energy efficient in high temperature + suitable for wide slopes requiring a lot of snow + produces snow in all snowmaking conditions - relatively expensive - freezes easily in very humid and windy conditions	+ energy efficient + best production at -9 °C and below + suitable for narrow slopes that are opened later - poor wind resistance - poor snow spreading ability, snow has to be spread with slope groomers	+ operates well in all conditions and is suitable for most places + snow is dispersed over a wide area + wind conditions have no impact - poor efficiency due to high compressed air requirement

A one-degree increase in the water temperature diminishes the efficiency of snow production by 2-3 %.

Water pumping and cooling

The pumping of water for snowmaking consumes a lot of electricity. It is worth keeping the temperature of the water used for snowmaking as low as possible.

Water pumping

The pumping of the snowmaking water is affected considerably by the fact how high on the upper parts of the slope the water is pumped. The pumping efficiency is affected by the correct selection and dimensioning of pumps.

Water flow from the pump to the snow cannons must be able to be controlled in order to obtain the correct volume of water for snowmaking. Excess water will diminish the quality and efficiency of snowmaking because extra water will only dampen the slope.

Methods of water flow controls in the pumps:

- throttling control
- rotation speed control
- return flow control

The rotation speed control with a frequency converter is the most energy-efficient way of controlling the flow, but the profitability of the investment depends on the number of operating hours and the amount of control that is needed in terms of time and flow volumes. Throttling control is not as energy efficient as a control method, but it can be implemented easily and at a lower cost. In the case of fewer operating hours, throttling control is usually the most profitable control alternative. Bypass flow control is the least effective way of controlling the flow, and its use should be avoided.

Water impurities

The snow cannon nozzles or the filters in the cannon feed may become blocked if the snowmaking water contains a lot of impurities. This will impair the effectiveness of snowmaking and increase maintenance breaks and visits to the cannon.

Separate water filters can be replaced with a central filter installed in the pump house. Automatically cleaned filter equipment is best suited for snowmaking purposes.

Water cooling

The temperature of the water used for snowmaking should be as low as possible, however, without causing a risk of freezing. The cooler the water coming out of the cannon is, the faster the water droplets will freeze when falling on the ground and the better the snow production in relation to the volume of water will be.

If necessary, the correct temperature can be ensured with a water cooling system. This will make sure that snow can be produced even in poorer snowmaking conditions.

Mechanical cooling is rarely needed because usually the temperature of water taken from the environment is already fairly low. In Finland, a few ski resorts are using water from the municipal water supply. In the municipal water supply network, the water temperature is 6–8 °C, in which case cooling plays a key role in the operation and energy efficiency of snowmaking.

Dimension the need for pumps correctly and distribute pumping between several pumps

The pumps operate energy-efficiently close to their best efficiency point. The method requires an automated system in pumping, controlling the pumping and directing the order of starting the pumps according to the load of the snowmaking system.

Compressed air

Rationalising the production of compressed air saves money and energy.

Centralised production of compressed air is used especially in sites that use hybrid cannons. Compressed air is produced in the compressor station, and its need varies at ski resorts between 500 and 1,000 hours per year.

The cost-effectiveness of acquiring air compressors controlled by frequency controllers should be examined when planning new systems.

In terms of energy efficiency, it is sensible to manage the heat recovery of the compressor centre. The cooling air of the compressor can be either blown directly to the heated space or recovery can be implemented as a water-circulated system, in which case heat can be directed to the heating of tap water, indoor space or ventilation.

Repairing leaks in the compressed air network is a good area for saving, but it may require a separate leak assessment. In the worst case, 20–30% of the compressed air produced by the compressor goes to waste as leaks. If the compressed air consumes 200 MWh of electricity a year, this means a waste bill of approximately €3,400 per year (price of electricity €85/MWh).

Ski lifts

The best time to have an impact on the energy efficiency of the operating machinery of ski lifts is during the planning stage. Before making the acquisition decision, it is worth drawing up a case-specific calculation, also examining maintenance and electrical cables.

The ski lift motors are moderately large, but their average operating hours are only 500–1,000 hours per year. During the planning stage, it is worth asking the lift supplier to establish the impact of the efficiency rate of the lift motor on the costs and energy efficiency.

These days, the lift motor is equipped with a frequency converter almost without an exception, directing the lift speed, for example, in demanding wind conditions. The frequency converter also starts up the electric motor gently, which protects the motor against wear and tear.

Speed control is a simple way of improving the energy efficiency of lifts, and it is used at some ski resorts. It is a challenge to find the correct balance between energy efficiency and customers' waiting time.

Ski lift efficiency can be monitored by comparing the number of ascends with the capacity and estimating the effects of changes in various functions on efficiency. Efficiency monitoring may result in improved lift operations – and that way improved customer satisfaction. For example, upgrading the areas where customers get on and off the lift will make it easier and faster to use the lift.

Slope lighting

Use part power in lighting correctly

in work lighting, for improving customer safety and as advertising light. For the quietest hours of the night, it is worth switching off the lights altogether, because just two hours will achieve a saving of €300 per slope per season.

Slope lighting consumes 5–10 per cent of all electricity used at a ski resort. Lighting often involves waste consumption, which is an easy area for saving.

At several resorts, lighting has not been designed as such, but light poles have been positioned according to need. This may result in over-lighting in some parts of the slope and in insufficient lighting elsewhere.

When working on the slopes in the summer, lighting must be taken into account. Bringing extra earth to the slope may have an impact on the height and lighting angle of the light poles.

Light with part power

Usually, light poles are positioned on the slope at intervals of approximately 40 metres. Based on experience, three 400-watt light fittings should be installed in the poles to achieve sufficient lighting for the width of the entire slope.

The most feasible solution is to install one yellow high-pressure sodium light and two metal halide lights. When adjusting the angle of the lights, light glare should be avoided and efforts should be made to minimise diffused illumination.

Light fittings are designed so that lighting can be directed to part power in stages, if necessary. Usually the high-pressure sodium light is directed to part power as it is used for work lighting outside the opening hours and, for safety reasons, highlighting the shape of the snow during the day.

From manual operation to a time or twilight switch

The lighting of the slopes can be controlled effectively by automated lighting. Moreover, a lighting sensor can be used for switching on full slope lighting at dusk. Appropriate lighting controls can also be created for yellow light.

If automation is not successful, for example, due to the slope type, advising the users in energy-efficient lighting is the most essential saving opportunity. Lighting is often connected manually from the lift station, in which case lights may be switched on unnecessarily early, before the slopes are opened, and left on at full power after closing time to wait for slope maintenance.

Saving measure	Investment/slope	Saving/year	Note
Introduction of part lighting for snowmaking	€200/slope	5-10 %	Lights must already be switched on earlier in stages. Suitable for both large and small resorts.
Automated lighting control	€100-500/ slope	5-20 %	Requires good planning, suitable for large and small resorts.
LED lighting in snowmaking use	Approx. €5,000/ slope	50 % *	Can also be used as energy-efficient 'advertising lighting'.
Switching off the slope lighting when carrying out maintenance on the slopes		2-5 %	According to some drivers, it is better to drive without slope lighting. Suitable for all resorts.

*comparison with currently used lights

Master planning

Good planning promotes energy efficiency.

When planning new slopes, the objective is to achieve a slope with a suitable profile in the desired location. Conditions that are known to be good may also become the starting point: if the area's conditions are ideal with respect to snowfall and snow retention, snowmaking can be started early and the slope can be opened in good time.

The requirements of care and maintenance should also be taken into account when planning the slopes and lift lines. This will ensure correct location of the equipment and easy snowmaking and slope maintenance. It will also promote general efficiency.

Slope maintenance and shaping carried out in the summer will reduce the need for snowmaking and maintenance tasks in the winter and the related energy consumption. For example, ski bumps and other snow structures are shaped and larger holes are levelled with earth.

Snowmobiles

The technical development of four-stroke snowmobiles has turned them into a noteworthy alternative to traditional two-stroke engines. However, as a result of their different capacities, it is justified to use both models at ski resorts.

Four-stroke snowmobiles are about 30 per cent more expensive. If a replacement of snowmobiles is necessary in any case, it is worth making calculations from the viewpoint of overall costs. Savings in fuel consumption may amount to up to a quarter of that of the cost of old two-stroke snowmobiles.

Two-stroke snowmobiles

+ lower acquisition cost
+ development of the fuel feeding system has diminished consumption
+ better steerability
– blending of engine oil and fuel creates exhaust fumes, and acquisition costs are higher

Four-stroke snowmobiles

+ efficient fuel economy: saves up to 25 % of fuel compared with the old two-stroke snowmobile. Benefit an average of 5–10 %
+ no need to blend engine oil with the fuel, which reduces exhaust fumes
– about 30 % higher acquisition price
– old snowmobiles are heavier and their engine power in relation to weight is smaller

Fewer maintenance runs mean less wear and tear of the slopes

It is possible to have less frequent slope maintenance times outside the season without compromising over safety and quality.

Grooming machines equipped with a hybrid engine are being tested

In the machines, electricity is obtained from an electric generator installed in connection with a diesel engine. The brake energy of the engine is recovered for the use of the other devices of the slope machine. According to preliminary studies, average consumption falls by 5 litres an hour.

Grooming machines

The life cycle of grooming machines is 5–7 years, depending on the driving hours. For this reason, ski resorts are using relatively modern technology with up-to-date consumption. The frequency of replacing the machines is mainly due to high repair costs.

The development of fuel feed and output restriction systems has steadily diminished the fuel consumption of grooming machinery. Average consumption of the latest machines is 20–25 litres per hour.

A grooming machine suitable for its purpose of use helps to control energy consumption. The higher the output, the higher the consumption. Using a winch, it is possible for a slope machine to push snow back even up the steepest of slopes. This will reduce the need for snowmaking and the electricity consumed in the operation.

Economical driving

An economical driving method is one of the key factors having an influence on the fuel consumption of slope machines. This includes, for example, avoiding unnecessary idle running and planning of maintenance measures to save time and driving. Machine manufacturers organise courses in economical driving.

The impacts of changes in the driving method can easily be monitored by recording the amount of fuel spent and the driving hours in the driver's logbook and transferring it from there to consumption monitoring in a spreadsheet programme.

The specific fuel consumption of grooming machinery and snowmobiles can be examined with the following meters:

- relation of annual consumption to slope area (m^3/h)
- relation of annual consumption to driving hours (m^3/h)

There are also ready monitoring consumption programmes available on the market, and it is possible to install a real-time driving monitor operated by a satellite connection. However, the acquisition costs are high in relation to the benefits gained in the scale of Finnish ski resorts.

Buildings

The energy consumption of slope service buildings used for the maintenance and repair needs of slopes is low with respect to the overall energy consumption of a ski resort. However, it is possible to increase their energy use as well, even with small measures.

Slope service buildings include:
- lift stations
- maintenance and machine workshops for slope machinery
- pump stations, production buildings for electricity distribution and compressed air

The slope restaurants, equipment rental shops and other customer service buildings are not included in the buildings examined in this context. However, the same development and saving proposals also apply to them.

Heating systems

Direct electric heating is the most common heating method in slope buildings. Especially in medium-sized buildings, it can be fairly easy and productive to partly replace it with an air source heat pump.

Rewarding alternatives to oil heating include pellet heating or geothermal heat, which utilise preproduced water-circulated heat distribution.

A geothermal heating system is a greater investment than an air source heat pump, requiring accurate information about the building's heating energy needs. The heat distribution of the buildings is converted to water circulation, and the heat collection pipes are installed in the lake, ground or drill wells.

Joining a district heating or block heating network is worth considering whenever possible. New buildings would benefit from a water-circulated heating system, which means that the heating method can be easily changed at a later date.

If compressed air is used for snowmaking at a ski resort, the waste heat from the cooling of the compressors and the compressed air station can be utilised in the heating of buildings. It is most beneficial to find out the possibilities of heat recovery already in the construction stage.

Ventilation

New buildings are designed with mechanical supply and exhaust air ventilation, equipped with heat recovery. The system can also be added to the ventilation machine at a later date.

In old buildings, energy can be saved, for example:
- by controlling the ventilation operating times

- by overhauling or improving the heat recovery system
- with frequency converter controls

In the energy audits of buildings, the greatest savings without investments have been achieved by reducing the ventilation power when the premises are not being used. For example, it is usually highly worthwhile to reduce ventilation at night.

Indoor lighting

In indoor lighting, the easiest way to save energy is to switch off unnecessary lighting. It is worth using pre-timed controls or motion detectors in the lighting controls if they are suitable for the purpose and times of use in the building.

Replacing incandescent and halogen light fittings with more effective solutions will diminish the energy consumption of lighting. It is possible to boost traditional fluorescent tube lighting with electronic ballasts. It is sensible to make more extensive changes to lighting in connection with the lighting renovation or general redecoration of the building.

Outdoor lighting

Energy-efficient passage lighting outside buildings and in car parks and caravan areas is implemented with lighting controls. With a timer control, lighting can be switched off completely or partially, taking safety into consideration. In the 2010s, regulations about the energy efficiency of outdoor lighting will be tightened and old technology will be replaced with new.

Caravan areas

The electricity consumed by caravans can amount to up to 5–10 per cent of the total electricity consumption of a ski resort. Caravan pitches are usually metered, and consumption is billed directly to the occupier of the caravan pitch. Providing information about the targets of improved energy efficiency may have an impact on the customers' consumption habits and improve the ski resort's reputation as an environmentally responsible operator.

A suitable temperature for the lift station

is almost always 16–18 °C because outdoor clothes are usually worn in these facilities. Further savings are gained if night-time heat is reduced with a timer switch. A reduction of one degree in the indoor temperature can cut the energy bill by 5 %.

Investment support for acquisition of renewable energy

The carbon dioxide emissions of the heating system can be reduced by replacing a water-circulated oil or electric heating with geothermal heat or pellets. In Finland it is possible to receive investment support granted by the government for renewable energy forms.

Motiva has compiled this guide for improving the energy efficiency of ski resorts. The guide supports the implementation of the Energy Efficiency Agreement in the commercial sector in the field of hospitality.

The information in the guide has been compiled in the Energy-efficient slope operations project, in which separate guidelines for energy audits for ski resorts were developed and the special needs of metering the energy consumption in ski resorts were examined.

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