CHAPTER 8
LIFT OPERATIONS

Whether you're operating an existing lift system (nationwide, there is a growing inventory of lifts that are over 20 years old) or thinking about buying a new lift, several opportunities exist to improve lift design and operations from an environmental management standpoint. The chart below will help you navigate the various opportunities described throughout this chapter. Case studies are used to illustrate how resorts have implemented the various opportunities described in the rest of this chapter.

In addition to the topics covered in this chapter, review Chapter 7, Vehicle Maintenance, for overlapping environmental management opportunities. Specifically, the following topics discussed in Chapter 7 also apply to lift operations:

- Aqueous cleaning
- Refillable spray bottles
- Re-refined oil (for backup diesel engines)

Are you involved in lift operations? Be sure to check out Chapter 7 on "Vehicle Maintenance" for overlapping opportunities.

Applicable Sections	Operating Existing Lifts?	Designing New Lifts?
8.1 Top-Drive Lifts		✓
8.2 Harmonics Filtering	✓	✓
8.3 Rate Structure and Peak Shaving	✓	✓
8.4 Energy Efficient Motor Selection		✓
8.5 Heating and Lighting in Lift Houses	✓	✓
8.6 Sheave Liner Recycling	✓	
8.7 High-Altitude Brushes	✓	✓
8.8 Paint Selection for Towers and Terminals	✓	✓

8.1 TOP-DRIVE LIFTS[1]

A top-drive lift is a lift system with its motor located at the uphill terminal. A top-drive lift pulls from the uphill (loaded) side of the cable. A bottom-drive lift is a lift system with its motor located at the bottom terminal. A bottom-drive lift pulls from the downhill (unloaded) side of the cable. Because it pulls from the loaded side of the cable, a top-drive lift is able to obtain the required cable tension by means of system dynamics alone, whereas a bottom-drive lift requires a higher-tension cable to achieve the same effect.

> Top-drive lifts can achieve 10 to 15 percent more carrying capacity than bottom drive lifts using the same equipment.

The higher-tension cable causes bigger loads on the towers and throughout the system. Because of this difference in system dynamics, estimates indicate that a top-drive lift can achieve 10 to 15 percent more carrying capacity than a bottom-drive using the same equipment. Conversely, to achieve the same carrying capacity as a top-drive lift, a bottom-drive lift would require 10 to 15 percent more power from the driving motor. In addition, a bottom-drive lift requires:

- An additional hold-down tower at the bottom of the lift
- Larger cable and an increase in torque and horsepower because of the increased tension in the cable
- Stronger structural frames and more concrete in the foundations

The additional equipment could cause a bottom-drive lift to cost 10 to 20 percent more than a top-drive lift. The larger the lift and the rougher the terrain profile, the more pronounced the potential savings associated with a top-drive lift become.

> Bottom-drive lifts can be more convenient to install and operate.

Installation of a top-drive lift depends on the availability of electric power and vehicle access at the top of the lift. It could be expensive to provide power if it is not available near the top of the lift. Furthermore, an operator needs to be at the top of the lift at startup and shutdown, and heavy components may need to be transported to and from the top of the lift during installation and motor maintenance. These factors may require that a road to the top of the lift be built or improved and maintained. Despite these possible drawbacks, a top-drive lift is worth investigating because of the potential cost savings over the life of the lift.

CASE STUDY: A-BASIN LENAWEE LIFT

At Arapahoe Basin (A-Basin), a ski lift replacement was planned for the Lenawee lift. Because of the midmountain location of the lift, a bottom-drive lift would be more convenient to access during startup and maintenance than a top-drive lift. However, A-Basin was interested in comparing the costs and environmental impacts of the two types of lifts.

At First Glance – What's the Potential Cost Savings?

The design for the new Lenawee lift called for a bottom-drive lift at a total project cost, including installation, of approximately $1,200,000. As stated above, a top-drive lift is estimated to cost 10 to

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[1] John Dalton. "Top or Bottom-drive?" Poma of America (Poma). September 1992.

20 percent, or in this case \$120,000 to \$240,000, less than a bottom-drive lift in terms of initial material and equipment costs.

The design for the bottom-drive lift required 238 horsepower (hp) and was supplied 300 hp, whereas a top-drive lift would require 10 to 15 percent less power, as described above.

At 10% less $HPTD = HPBD \text{ x } 0.90 = 214 \text{ hp}$

At 15% less $HPTD = HPBD \text{ x } 0.85 = 202 \text{ hp}$

where

$HPTD$ = Horsepower required for top-drive lift, hp

$HPBD$ = Horsepower required for bottom-drive lift, hp

A quick analysis shows that A-Basin could save up to \$26,800 over 10 years.

The operating cost savings (OCS) for a 10 and 15 percent reduction in horsepower over 175 days when the lift runs 8 hours a day and the energy cost is \$0.07134 per kWh would be as follows:

At 10% less

$$\text{OCS} = (\text{HPBD} - \text{HPTD}) \text{ x } (1 \text{ kilowatt} / 1.341 \text{ hp}) \text{ x } (8 \text{ hours} / \text{day}) \text{ x } (175 \text{ days} / \text{year}) \text{ x } (\$0.07134 / \text{kWh})$$

$$\text{OCS} = (238 - 214) \text{ x } 74.479 = \$1{,}787.49 / \text{year}$$

At 15% less

$$\text{OCS} = (\text{HPBD} - \text{HPTD}) \text{ x } (1 \text{ kilowatt} / 1.341 \text{ hp}) \text{ x } (8 \text{ hours} / \text{day}) \text{ x } (175 \text{ days} / \text{year}) \text{ x } (\$0.07134 / \text{kWh})$$

$$\text{OCS} = (238 - 202) \text{ X } 74.479 = \$2{,}681.23/\text{year}$$

With the reduction in on-mountain energy use, emissions at the electric power plant would be reduced by over 25 tons of CO_2 per year.

For this case study, the \$0.07134/kWh value was obtained from A-Basin's 1999 energy baseline, which computed an average \$/kWh that includes both demand charges and kWh consumption charges.

In addition to the cost savings, the reduced energy consumption would translate into avoided emissions at the electric power plant. Based on average conversions for Colorado utilities, the estimated reduction in carbon dioxide (CO_2) emissions would be 25 to 37 tons per year.

In summary, based on the estimated industry standard[2] of 10 to 20 percent savings, A-Basin might have saved between \$120,000 and \$240,000 by purchasing a top-drive lift and realize an additional operating cost savings of \$1,800 to \$2,700 per year.

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[2] John Dalton. "Top or Bottom-drive?" Poma. September 1992.

These numbers do not take into account the cost to run power to a top-drive lift from the bottom of the lift area in the case of the Lenawee lift, which was estimated by A-Basin electricity provider to be at least $100,000. The cost to build a road or to rebuild and maintain an existing road was not considered and would need to be analyzed further in order to completely understand the cost benefits and environmental impacts of each type of ski lift.

Upon Closer Inspection – It Doesn't Make Sense This Time

The results of the preliminary analysis based on industry averages for savings associated with top-drive lifts[2] presented a strong case for investigating a top-drive design in more detail. However, when the specifics of this case were examined, the top-drive lift would save less than industry averages because of its relatively small size. Table 8.1 highlights the results of the design comparison.

TABLE 8.1 LENAWEE FIXED-GRIP TRIPLE CHAIR:
BOTTOM-DRIVE VERSUS TOP-DRIVE LIFT

Design Specification	Bottom-Drive Lift	Top-Drive Lift
Required hp	238	233
Supplied hp	300	250
Towers	13	13
Sheaves	174	172
Terminal concrete	130	140
Contract price	$1,177,400	$1,175,610

Although the top-drive lift would be slightly less expensive to install and operate, A-Basin has selected a bottom-drive lift for more convenient access to the lift motor during operation and maintenance.

8.2 HARMONICS FILTERING

This section describes sources of harmonic distortion, its negative effects on energy efficiency, and strategies for reducing harmonic distortion.

Sources of Harmonic Distortion

Harmonic distortion is defined as voltage and current frequencies in the power system that are either above or below the normal 60-hertz (Hz) power provided by utilities in the U.S.[3] For buildings, the most common sources of harmonic distortion are computers, other electronic equipment, and high-efficiency electronic light ballasts.

Large DC drives and AC motors with adjustable-speed drives are the biggest sources of harmonic distortion for ski areas.

For ski areas, the greatest sources of harmonic distortion are large, direct current (DC) drives and alternating current (AC), adjustable-speed drives used to power lifts and snowmaking systems.

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[3] Technology Atlas Series. Volume IV, Chapter 13, "Drive Power." Page 13.2.4. 1997.

Negative Effects of Harmonic Distortion

Harmonic distortion can be thought of as energy consumption that doesn't do any useful work.

In a sense, harmonic distortion can be thought of as energy consumption that doesn't do any useful work.[4] If an electrical system is not sized to accommodate increased energy consumption, numerous problems can occur, including:[5]

- Overheating of transformers, motors, and conductors, which decreases component life
- Capacitor cell and capacitor fuse failures
- Malfunctions of sensitive electronic controls
- Drive instability

These problems increase operating costs through increased utility bills, downtime, and maintenance for labor and parts.

Solutions to Harmonic Distortion

Filtering requires a capital investment, but the payback is reasonable for ski areas with power factor charges imposed by their electric utility.

Harmonics filters can be installed to mitigate the negative effects of harmonic distortion. Computer modeling of an overall electrical system and the sources of harmonic distortion provides insight into the most strategic locations and sizes for filters.

Harmonics filters are estimated to reduce energy consumption by 5%.

In addition to cleaning voltage distortions, harmonics filtering has the added advantage of increasing the power factor.[6] Electric induction motors require a reactive or magnetizing current that does no useful work. This reactive power takes up space in the distribution lines but does not appear on a demand meter. The power factor is the ratio between the active power that a facility uses (in kilowatts [kW]) and the apparent power that the utility provides (in kilovolt-amperes [kVA]). To ensure that customers are charged for their full power use, many utilities include a power factor charge when the measured power factor is more than ±5 percent of unity. Large, DC lift motors in particular tend to have low power factors. For a large DC drive (400 to 1,200 hp), the power factor typically ranges between 0.50 and 0.78. This is partially due to the gearbox ratio, which prevents the DC motor from operating at its rated nameplate speed.

Although harmonics filtering requires a significant capital investment, the payback is reasonable for ski areas with power factor charges imposed by their electric utility. For example, in the case of Vail, installation of eight filters cost approximately $500,000, but the payback period in terms of power factor charges alone was only 6 years. Taking into account reduced energy consumption, the payback period was only 4.4 years.[7]

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[4] Rocky Mountain Lift Association 29th Conference and Trade Show. Grand Junction, Colorado. Session E-10, "Drive Harmonics and Filtering." May 2000.

[5] VAR+Technologies Background Paper on Harmonics. P.O. Box 564, Whitmore Lake, MI 48189, wmrent@ismi.nte, (810) 231-4461.

[6] Steve Hyland, and William McConnell. "Are Your Lifts Driving You (and Your Neighbors) Crazy?" *Ski Area Management*. May 1994.

[7] Study Performed for Vail by Vaughn DeCrausaz, Starboard Electric, (970) 949-1882, starbrd@vail.net.

CASE STUDY: ASPEN SKIING COMPANY (ASC) INSTALLS HARMONICS FILTERS

Example of a harmonics filtering system installed by VAR+Technologies at Keystone

In 1990, Holy Cross Energy (Holy Cross) began receiving customer complaints about power supply instability caused by harmonic distortion. Vail Resorts and ASC are Holy Cross' two largest customers, and their large-hp lifts were suspected to be the problem. After studying the problem, Holy Cross executives devised a plan to finance the installation of harmonics filters on Vail and Aspen lifts. The ski areas would repay the implementation cost to Holy Cross with savings from improving power factors. Seven DC lifts on Snowmass Mountain were selected for harmonics filtering. The power factor savings were estimated based on utility bills issued before filter installation. The energy reduction was estimated to be 5 percent and was also derived from utility bills. The values for Snowmass Mountain shown in Table 8.2 below are estimates of the actual savings realized, whereas the values for the other three mountains estimate the savings that ASC would realize if it were to install harmonics filters.

TABLE 8.2 ECONOMIC AND ENVIRONMENTAL BENEFITS OF HARMONICS FILTERING FOR LIFTS

Item	Cost Savings ($/year)	Power Savings (kWh/year)	eCO_2 Reduction (tons/year)
Snowmass Mountain filters (power factor)	$31,097	0	0
Snowmass Mountain filters (energy reduction)	$4,855	97,100	65.0
Other 3 mountains (power factor)	$5,361	0	0
Other 3 mountains (energy reduction)	$268	5,361	3.6
Total	**$41,581**	**102,461**	**68.6**

In this case, the cost to install the filters on Snowmass Mountain was approximately $250,000. The implementation cost was paid by Holy Cross and was repaid to the utility by ASC in monthly amounts equivalent to the reductions in its energy bills. Given the savings shown in Table 8.2, the payback period for Holy Cross was approximately 7 years. However, this simple analysis doesn't consider the intangible savings to ASC cited by lift maintenance personnel and filter manufacturers, such as extended equipment life.

8.3 RATE STRUCTURE AND PEAK SHAVING

Electric rates typically have at least two components – consumption and demand. The consumption charge is proportional to the amount of energy used in kWh and is analogous to paying for the miles driven in a car as shown on the odometer during a given month. The demand charge is the rate at which energy is used in kW and is analogous to paying for an engine of the size required to attain the maximum speed on the car's speedometer. It costs the utility more to provide the capability of using power at a faster rate. The monthly bill is based on the maximum demand, or "peak demand," reading for that month, typically monitored over 5- to 30-minute intervals. For lifts, the peak demand charges for electricity can dwarf consumption charges because lifts must perform at peak capacity for only 8 hours per day during the ski season. For the rest of the time, the utility must be able to provide peak capacity while the lifts lie idle.

In addition to consumption (kWh) and demand (kW) charges, some lifts may be charged for electricity based on a rate structure that includes a "coincident peak" charge. At the end of the month, the utility determines when its total system peak occurred during the month and charges customers a premium rate for the demand during that total system peak. This provides an incentive for customers to monitor their energy use, compare it to total system activity, and shift loads whenever possible to avoid excess charges.

What is Peak Shaving?

"Peak shaving" refers to actions taken to reduce the maximum demand on a meter over a billing cycle (typically 1 month). Depending on the rate structure for lifts, there may be an added incentive to reduce the coincident peak (coincident peak shaving). Other terms that are synonymous with peak shaving include "load management" and "load shedding."

Vail estimates that it saves $100,000 each month by peak shaving.

In the case of lifts, there is little opportunity to reduce the peak demand during ski season because the lifts must operate to transport skiers uphill. Slight demand reduction might be achieved through minor adjustments of existing systems such as lighting or through heater upgrades (see Section 8.6). However, if there is a coincident peak charge, the ski area has an incentive to ensure that it is not operating electric lift motors when the system peak occurs. Backup diesel engines can be used during these episodes, saving the ski area thousands of dollars in electricity bills.

To make effective use of backup diesel engines, a ski area needs computers tied to the electric utility, where real-time information is available on how the overall power system is operating. It takes experience to recognize when monthly system peaks are building and therefore when the ski area needs to act in order to minimize its own peak. Using backup diesel engines to minimize coincident peak charges is becoming increasingly common in the industry. If diesels are used in non-emergency situations, the ski area should checked the state and federal air permitting requirements.

Another form of peak shaving is to manage multiple loads on the same meter. During the off-season, ski areas can pay up to five times more per kWh than during the ski season because they operate lifts sporadically, kicking in full demand charges but incurring comparatively small consumption charges. If two or more lifts are coupled on one meter, this provides a strong incentive to avoid simultaneous operation of the lifts during the off-season. Likewise, using backup diesel engines instead of primary electric motors in summer can save on electricity costs.

Does Peak Shaving Have Environmental Benefits?

There is some debate about whether peak shaving is strictly a cost saving strategy or whether it has some environmental benefits. Such benefits are not directly realized by a ski area but are realized by the electric utility in terms of reduced air emissions at its generating facilities. The main environmental benefits of peak shaving occur because electric utilities prioritize which generating facilities to operate at any given time. Utility companies generally operate the most efficient (and typically the least polluting) plants first to meet their base load, only bringing the least efficient (and typically the most polluting) generating facilities on line as needed to meet system peaks. Furthermore, by reducing the overall system peak, a utility can postpone the need to invest in costly and resource-intensive construction of new generating plants.

Peak shaving reduces the occasions when a utility must operate its least efficient and most polluting plants and postpones the need for construction of new generating facilities.

CASE STUDY: REDUCING COINCIDENT PEAK CHARGES FOR SNOWMASS MOUNTAIN LIFTS

ASC partnered with Holy Cross to purchase “smart” meters for 14 large lifts. As part of the deal, ASC adopted a new rate structure that included a coincident peak charge where there previously was none. The new rate structure saved ASC money without any changes in demand or kWh usage. In addition, it provided ASC with incentive to monitor Holy Cross’ system and to avoid coincident peak charges. In the first year, ASC operated backup diesel engines for isolated lifts three times during February and March. The estimated cost savings associated with both the new rate structure and peak shaving for the first year are summarized in Table 8.3. For all the mountains identified in the table, the rate structure savings are actual savings based on utility bills. For peak shaving, the avoided costs were estimated for the three episodes when backup diesel engines were operated on Snowmass Mountain (SM). The load shedding for Aspen Mountain (AM), Aspen Highlands (AH), and Buttermilk Mountain (BM) was estimated based on current coincident peak charges and the potential for reduction in these charges.

TABLE 8.3 COST AND ENERGY SAVINGS AT ASC

Item	Cost Savings	Energy Savings (kWh)
SM rate structure	$30,301	0
SM peak shaving	$45,798	6,136
AM, AH, BM rate structure	$39,518	0
AM, AH, BM peak shaving	$38,289	765,775
Total	**$153,906**	**771,911**

CASE STUDY: REDUCING DEMAND CHARGES FOR A-BASIN LIFTS

A-Basin can reduce its total electricity costs by 4.5 percent by implementing a simple administrative policy.

As shown in Chapter 3, A-Basin spends about $4,500 (of the $100,000 total yearly electric bill) to run the lifts from July through October, but the average energy costs with demand are $0.36/kWh during that time compared to an annual average cost of $0.07/kWh. Overall, the summer electric bills are lower than the winter bills, but the increased cost/kWh in summer indicate an opportunity for cost savings by reducing peak electric demand. After surveying its electric meters, A-Basin found that four lifts were coupled together in pairs on two meters. By implementing a management policy never to operate two lifts coupled together on the same meter simultaneously in the summer, it is estimated that A-Basin can save about $ $700 per year, with no significant implementation cost.

8.4 ENERGY EFFICIENT MOTOR SELECTION

You can't pay extra for a "premium efficiency" motor for a ski lift as you can in many industrial settings.

Upgrading to "premium-efficiency" motors has the greatest potential in the 1- to 20-hp range for motors that are operated at least 4,000 hours per year. However, neither of these criteria fits the typical lift motor. Lift motors are very large in comparison to those used in industrial settings and are operated for fewer hours per year. A lift motor represents a large capital investment, with the motor typically being semi-custom-designed to meet specific application needs. In fact, motors of more than 200 hp are already considered to be relatively energy efficient without upgrading to a more efficient grade.[8] However, there are a few energy efficiency opportunities to consider for new lift systems. These opportunities involve regenerative drives, AC and DC lift motors, and direct-drive motors and are further discussed below.

Regenerative Drives

A regenerative drive actually produces energy when a lift is slowing down.

A lift system contains enormous potential energy from pulling such a significant load uphill. When a lift needs to slow down, a regenerative drive converts the potential energy to electrical energy and puts the energy produced back on the power grid. The regenerative cycle is of such short duration and so sporadic that electric utilities do not credit customers for energy put back on the grid. Furthermore, the energy may need to be filtered before it is returned to the grid because of high harmonic distortion levels. Therefore, regenerative drives are not cost-saving devices for a ski area, despite the fact that they conserve total system energy. The main reason that ski areas use regenerative drives on lift motors is the improved control of lift operation that the drives offer. Regenerative drives are becoming more common as their prices fall. Most new lifts installed since the early 1990s have regenerative drives.[9] In fact, about one-third of the ski lifts in Colorado have regenerative drives.[10]

AC Versus DC Lift Motors

Which is more energy efficient, an AC motor with a variable-frequency (adjustable-speed) drive or a DC motor with a silicon control rectifier? Each allows speed control so that the motor is working only as hard as needed to meet the demand load. In many applications, AC motors are considered to

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[8] Rutgers University. "Modern Industrial Assessments; A Training Manual." www.Rutgers.edu

[9] Interview with Larry Smith, Colorado Tramway Board.

[10] Aerial Tramway Public Database.

be more efficient, but for the ski industry, this is true only in certain power ranges, typically less than 300 HP. Larger AC motors have two additional drawbacks:

- Regenerative drives have only become available on AC motors relatively recently, and they can be more complicated to operate than DC counterparts.
- If harmonics filtering is needed, which is often the case for larger-hp motors (greater than 200 hp), filtering tends to overcorrect the power factors, such that the AC motor has a leading power factor after filtering.[11]

In practice, energy efficiency is seldom involved in the design decision of which type of motor to use. Rather, the cost, the state of the technology, and the particular application at hand are the deciding factors affecting energy efficiency of lift motors.

Direct-Drive Motors

Poma estimates that A-Basin's new Lenawee lift is 88 percent efficient. Some direct-drive electric motors that could be used in this application would raise the efficiency as high as 95 percent. However, there are drawbacks to this approach. First, direct-drive motors are very expensive. Poma estimates that such a motor would add $80,000 to $90,000 to the cost of a lift. Based on average electricity rates for A-Basin, the annual cost savings from the existing increase in energy efficiency would be only $2,200 per year, and thus the payback period would be 36 years. Furthermore, a direct-drive motor is difficult to implement for a retrofit project because it is large and may not fit in the existing motor room. Despite the drawbacks, there may be cases where direct-drive motors are cost-effective, such as for larger lifts in regions where utility rates are high. There are no direct-drive lifts in the U.S., but Leitner recently installed a direct-drive motor on a lift in Italy.

Direct-drive motors can increase system efficiency by up to 13 percent.

8.5 HEATING AND LIGHTING IN LIFT HOUSES

Although lift motor houses and operator houses are relatively small structures (usually less than 250 square feet), the energy principles discussed in Chapter 10, Buildings, apply to these types of buildings as well. Lift house heating and lighting create relatively small electric loads compared to the lift motor itself. However, the efficiency of the lift motor is relatively fixed without major capital investment. In contrast, heaters and lighting offer lower-cost areas of opportunity to reduce demand and consumption costs. The economic and environmental benefits may not be large for a single lift house, but there can be significant cumulative benefits over time if energy conservation principles are applied to routine upgrades of existing houses as well as installation of new lifts.

CASE STUDY: TIMERS ON ELECTRIC HEATERS AT SNOWMASS MOUNTAIN

To reduce both electricity consumption and demand charges, Snowmass Mountain installed Grasslin timers (www.grasslin.com) on all electric heaters used to provide heat for lift related structures. The timers made it possible to operate heaters only when needed. For operator houses, the heaters are run 9 hours per day, only 5 hours per day for motor rooms and return terminals. Previously, all heaters were running 24 hours per day.

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[11] Interview with Vaughn DeCrausaz, Starboard Electric.

Timers are a particular source of cost savings in the motor houses for larger, detachable lifts. These motor houses have the largest heating load (40 kW) lift-related structures, and they are on meters with a coincident peak demand charge. For a lift motor to be started each morning, the equipment must be maintained at a certain temperature. Before the timers were installed on the heaters in the motor houses, the heaters operated all night so that motor startup could begin as soon as the crews arrived in the morning. Timers are now programmed to activate the heaters 3 to 4 hours before scheduled startup time.

Table 8.4 summarizes the locations and numbers of timers installed, heater ratings, numbers of hours the heaters are now operating after timer installation, and electricity rate charges for the heaters.

Grasslin timer installed on Snowmass Mountain

TABLE 8.4 SUMMARY OF TIMERS ON ELECTRIC HEATERS ON SNOWMASS MOUNTAIN

Location of Heaters	Number of Heaters	Heater Rating (kW)	Hours of Operation with Timer (hours/day)	Electric Consumption Charge ($/kWh)	Demand Charge ($/kW)	Coincident Demand Charge ($/kW)
Operator houses not on peak meters	27	2.5	9	0.05	4.00	NA
Motor houses not on peak meters	7	5	5	0.05	4.00	NA
Operator houses on peak meters	7	2.5	9	0.018	5.75	10.63
Motor houses on peak meters	14	10	5	0.018	5.75	10.63

The total electricity and cost savings associated with the use of the timers can be calculated as follows:

$$ES = N \times HPR \times AUT \times C$$
$$ECS = ES \times EC$$

where

ES = Electricity savings, kWh/year
N = Number of electric heaters
HPR = Electric power rating of heaters, kW
AUT = Avoided usage time, hours/day
C = Constant, 160 days/season
ECS = Electricity cost savings, $/year
EC = Cost of electricity, $/kWh

Based on the data in Table 8.4, the total electricity and cost savings associated with the use of the timers are presented in Table 8.5.

TABLE 8.5 ELECTRIC AND COST SAVINGS FROM TIMERS ON SNOWMASS MOUNTAIN

Locations of heaters	N	HPR (kW)	AUT (hours/day)	C (160 days/season)	ES (kWh/year)	EC ($/kWh)	ECS ($/year)
Operator houses not on peak meters	27	2.5	15	160	162,000	$0.050	$8,100
Motor houses not on peak meters	7	5	19	160	106,400	$0.050	$5,320
Operator houses on peak meters	7	2.5	15	160	42,000	$0.018	$756
Motor houses on peak meters	14	10	19	160	425,600	$0.018	$7,660
Total	55				736,000		$21,837

Electric Demand Savings

Although the electric consumption cost savings are significant in themselves, additional savings are realized from reducing coincident peak demand charges. Based on historical data, ASC knows that the Holy Cross system peak typically occurs in the evening when the heaters are not likely to be running. During the 2000/2001 ski season, there were only two occasions when the system peak occurred during the morning. Previously, the heaters were certain to be running during system peak because they were operating 24 hours per day. Now, the heater timers are set in the motor houses and return equipment rooms to avoid both morning and evening peaks.

The reduced coincident peak demand charges can be calculated as follows:

$$DS = N \times HPR \times DUF$$
$$DCS = DS \times DEC$$

where

DS = Electric demand savings, kW/year
N = Number of electric heaters
HPR = Electric power rating of heaters, kW
DUF = Demand usage factor percent
DCS = Demand cost savings, \$/season
EDC = Electric demand cost, \$/kW

The demand usage factor is the estimated probability that the heaters will not be running when the peak electric demand occurs. Because the heater timers are set to avoid both morning and evening peaks, the demand usage factor is estimated to be 100 percent. It is assumed that the ski season begins in November and ends in April. Although November and April are seven months a part, they would be subject to the same savings because the system peak is likely to occur during the season.

Based on data provided by Snowmass Mountain personnel and application of the equations and variables defined above, the cost savings associated with reduced coincident peak charges are presented in Table 8.6.

TABLE 8.6 ELECTRIC DEMAND COST SAVINGS

Locations of Heaters	N	HPR (kW)	DUF (%)	EDC ($/kW)	DS (kW/year)	DCS ($/season)
Operator houses on peak meters	7	2.5	100	$10.63	17.5	$186
Motor houses on peak meters	14	10	100	$10.63	140	$1,488
Total	21					$1,674

The estimated cost savings associated with installing timers is $23,511 ($21,837 in electrical cost savings plus $1,674 in demand cost savings). The cost per timer was $43, which represents a capital investment of only $2,365 for the 55 timers installed at Snowmass Mountain. Not including labor costs, the simple payback period for this project was less than 6 weeks. One matter that should be considered by anyone installing timers is to use timers with a battery backup to avoid timer disruption during power outages, which can result in heaters turned on at the wrong time.

CASE STUDY: REDUCING THE NUMBER OF HEATERS IN RETURN TERMINAL HOUSES

In addition to installing timers on electric heaters, Snowmass Mountain personnel reduced the number of heaters in return terminal houses on peak meters from four 10-kW heaters to two 10-kW heaters. A total a fourteen 10-kW heaters were turned off. The cost savings associated with this equipment change can be calculated as follows:

$$ES = N \times RER \times UT \times C$$
$$ECS = (ES \times EC) + (N \times \mathrm{RER} \times \mathrm{DC}) + (N \times CDC \times RER \times DUF)$$

where

ES = Electricity savings, kWh/year
N = Number of electric heaters
RER = Reduced electric power rating of heaters, kW
UT = Usage time of heaters, hours
C = Constant, 160 days/season
ECS = Electricity cost savings, $/year
EC = Cost of electricity, $/kWh
DC = Demand charge, $/kW
CDC = Coincident demand charge, $/kW
DUF = Demand usage factor, percent

Thus, Snowmass Mountain's savings are calculated as follows:

$$\mathrm{ES} = 14 \times 10\mathrm{kW} \times 5\mathrm{hr}/\mathrm{day} \times 160\mathrm{day}/\mathrm{year} = 112{,}000\mathrm{kWh}/\mathrm{year}$$
$$\mathrm{ECS} = (112{,}000\mathrm{kWh}/\mathrm{yr} \times \$0.018/\mathrm{kWh}) + (14 \times 10\mathrm{kW} \times \$5.75/\mathrm{kW}) + (14 \times 10\mathrm{kW} \times \$10.63/\mathrm{kW} \times 67\%)$$
$$= \$4{,}309/\mathrm{yr}$$

Environmental Benefits

Whenever the amount of electricity used can be reduced or applied more efficiently, the environment benefits. Although electricity is a cleaner source of energy at the point of use than gas, the production of electricity is far from being a clean and efficient process. For example, the estimated CO_2 reduction in emissions at the generating plant associated with timer installation and reducing the number of return reduction in terminal heaters hours is estimated to be 568 tons per year.

CASE STUDY: LIGHTING SELECTION FOR NEW LENAWEE LIFT AT A-BASIN

A-Basin's design for its new Lenawee lift was developed by Poma and specified the lighting fixtures and lamps indicated in Table 8.7.

TABLE 8.7 LENAWEE LIFTLIGHTING SPECIFICATIONS

Building	Lighting Specification	Description
Terminal	4 Lithonia UN248PG120, 4 feet	Channel fixture with two 4-foot-long T12 lamps; lamps are very high output (VHO) rated at 110 watts (W) each
Operator house	1 Lithonia WA296A-120, 8 feet	Wrap-around fluorescent fixture with two 8-foot-long lamps; lamps are 75W T12 Slimline

A T12 lamp at 0°F generates only 20 percent of its maximum output under normal conditions.

As part of the CDPHE project, alternative lighting fixtures and lamps were researched. At first glance, the lighting appeared to be overdesigned, employing relatively inefficient components. A typical energy efficient lamp system for the structure involved would use T8 instead of T12 ballasts and would use 32W instead of 100W lamps. However, most fluorescent lamps are designed to operate at 70 to 90°F, with the performance dropping off dramatically below 50°F. For example, a regular T12 lamp at 0°F generates only 20 percent of its maximum output under normal conditions. This explains why Poma specified such high-wattage lamps – to obtain the necessary lumen output under cold conditions. Furthermore, although T8 lamps are more energy efficient in most applications, they are more susceptible to reduced output under cold conditions; hence, T12 lamps were specified for the Lenawee lift.

However, after further research and discussions with a Denver-based lighting vendor,[12] the lighting alternatives indicated in Table 8.8 were identified for both the terminal and operator house.

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[12] Bob Hawkins of The Lighting Agency, (303) 445-1012.

TABLE 8.8 LENAWEE LIFT LIGHTING ALTERNATIVES

Building	Lighting Alternatives	Differences From Current Specification
Terminal	Lithonia DM 248 HO, 4 feet	Rated high output (HO) instead of VHO; 60W instead of 110W
Operator house	Lithonia WA-296A-120	Rated HO instead of VHO; 60W instead of 75W

The purchase cost of the alternative equipment is slightly lower for both the terminal and operator house. Also, because of the reduced lamp wattage, less energy would be used by the alternative equipment, reducing electricity bills. However, because so few fixtures and lamps were involved, the projected cost savings were negligible, as shown in Table 8.9.

TABLE 8.9 LIGHTING COST SAVINGS

Building	Fixture Cost Savings	Reduced Operating Cost
Terminal	\$120	24 kWh/year = \$1.62/year
Operator house	\$5	7 kWh/year = \$0.49/year

Although the cost savings are negligible, the lighting alternatives would slightly reduce energy use over the life of the equipment. And as indicated above, the cumulative benefits are greater when efficient lighting is applied to all lifts operated by a ski area.

8.6 SHEAVE LINER RECYCLING

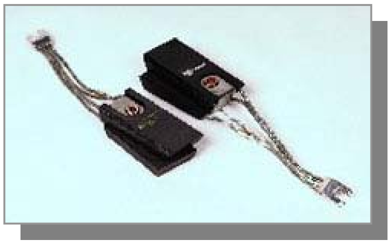
Sheave liners are circular rings that guide and pull a ski lift cable. In high-speed quad lifts, many ski areas use Semperit sheave liners. Semperit high-speed quad sheave liners have the following constituents: Polymer SBR (50 percent), black carbon filler (40 percent), mineral oil plasticiser (6 percent), and a sulphur-containing crosslinking system (4 percent). The rubber in these sheave liners contains no halogens. Most (if not all) ski areas send sheave liners to landfills for disposal. According to representatives from a Denver tire recycling company and Colorado Recycles, there is little market for high quality rubber found in sheave liners, which contain no metal and little fabric. Rubber recycling programs generally collect used tires exclusively. The tire recycling company representative estimated that the recycling market would mature in the next 5 years, creating a demand for the high-quality, metal-free sheave liners. Nevertheless, ski areas should contact local rubber recycling facilities and ask whether they can recycle sheave liners rather than sending them to landfills.

8.7 HIGH-ALTITUDE BRUSHES

Low-humidity motor brushes cost 50 to 60 percent more but last twice as long.

For lift motors, selecting the right brush is important for long commutator life, maximum brush life, and optimal motor performance. When correctly applied, brushes can reduce downtime and maintenance costs by improving motor reliability and availability. At low temperatures and low humidity, standard motor brushes exhibit higher wear rates. Special low-humidity brushes should be used when the humidity level is less than 20 percent. Within the ski industry, low-humidity brushes are sometimes called "high-altitude" brushes because the high altitudes where lifts are located are typically low-temperature, low-humidity environments. Low-humidity brushes have a resin applied that reduces wear, increasing their lives. Contrary to some beliefs, low-humidity brushes have no effect on the energy efficiency of a motor.

At low temperatures and low humidity, standard motor brushes exhibit higher wear rates.



However, using low-humidity brushes on lift motors is a prudent practice with environmental benefits. Increased brush life saves on purchase costs for new brushes, disposal costs for worn brushes, and labor costs for replacing brushes. Proper brush selection also avoids damage to the commutator, where the brushes ride in the motor. Such damage can be very costly to re-machine.

Because of the relatively small demand, low-humidity brushes cost about 50 of 60 percent more than standard brushes. However, at a humidity less than 20 percent, low-humidity brushes have twice the lives of standard counterparts. Thus, low-humidity brushes offer a net cost savings despite a higher purchase price.

In contrast, at a humidity of more than 60 percent, low-humidity brushes exhibit greater wear than standard brushes. As a result, some vendors may advise that low-humidity brushes be replaced with standard brushes during the summer months.

For more information about high altitude brushes, visit www.reliance.com or call Reliance Electric at (440) 646-5550.

8.8 PAINT SELECTION FOR TOWERS AND TERMINALS

Chapter 10, Buildings, discusses appropriate exterior paints for buildings and exterior strucures. For new lift systems, the environmentally preferable choice is to install dark, galvanized lift towers and cross arms. Dark, galvanized towers blend better with the environment than bright, galvanized towers and are thus preferred by the U.S. Forest Service. Galvanized towers never require paint, and thus their use avoids purchase costs for paint; labor costs for maintaining painted surfaces; and disposal costs for paint and paint-related waste, which may be classified as hazardous waste. Although most new lift systems have dark, galvanized towers, vendors indicate that some ski areas still prefer painted towers if such towers are perceived as providing a unique identity for the ski areas. Rather than practicing business as usual, ski areas should consider the life-cycle cost impacts of using painted towers as well as the benefits of projecting a new, more environmentally sound look to skiers.