IIHF ICE RINK GUIDE

INTERNATIONAL ICE HOCKEY FEDERATION

April 2016

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GUIDE

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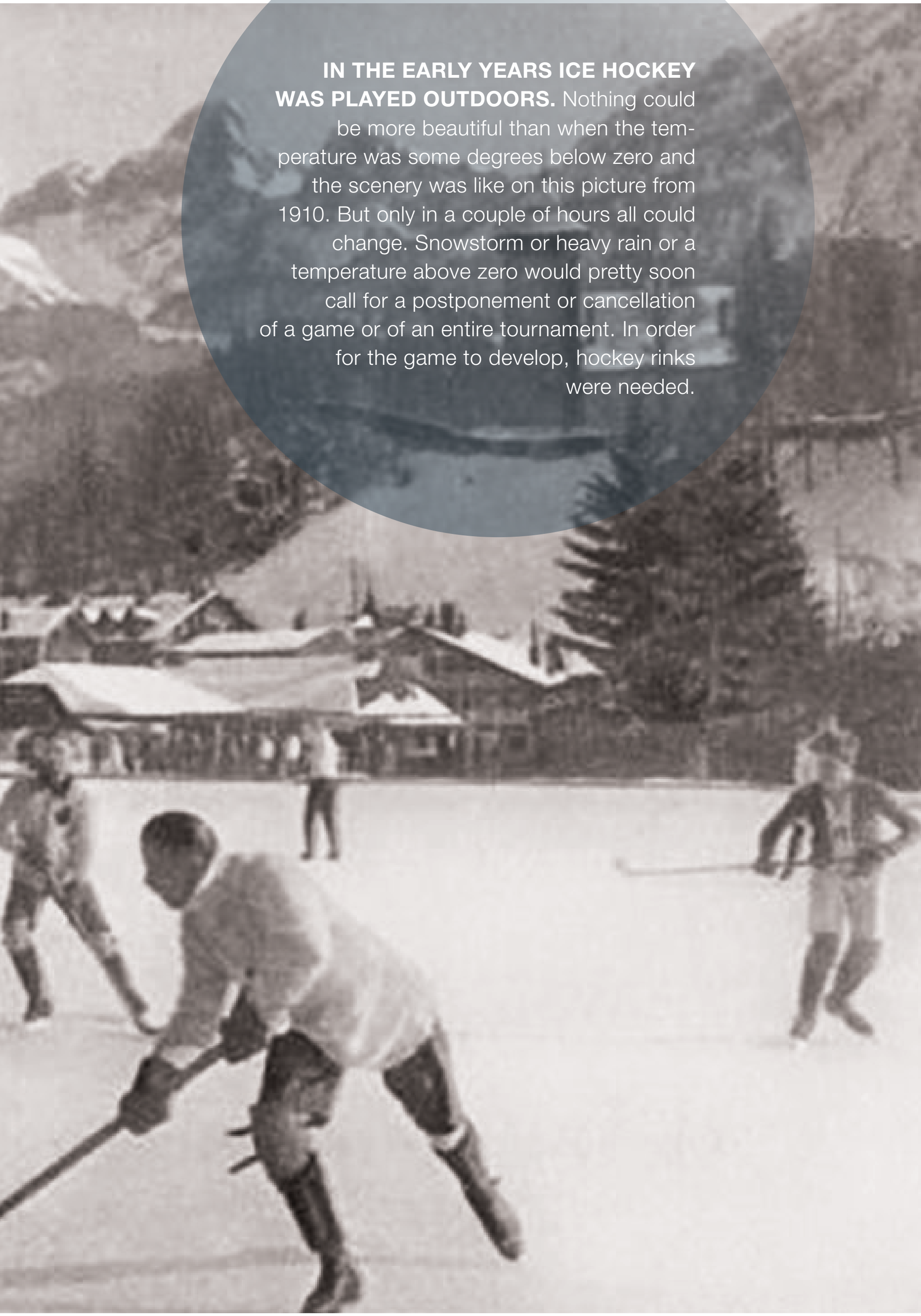
FEDERATION

Photo: National Archives of Canada

IN THE EARLY YEARS ICE HOCKEY WAS PLAYED OUTDOORS. Nothing could be more beautiful than when the temperature was some degrees below zero and the scenery was like on this picture from 1910. But only in a couple of hours all could change. Snowstorm or heavy rain or a temperature above zero would pretty soon call for a postponement or cancellation of a game or of an entire tournament. In order for the game to develop, hockey rinks were needed.



IMPRINT

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EVER THOUGHT OF BUILDING AN ICE RINK?

The rink is the key to all hockey development

In the beginning, ice hockey had certain clearly defined limits. It could only be played in places where you had natural ice from December until at the latest March. And those were the long seasons.

This is why North America, Scandinavia, the former Soviet Union and a handful of other countries had an early jump in this game.

Today, the International Ice Hockey Federation has 74 member associations. Our beloved sport is represented in nearly all corners of the globe.

The reason, of course, is rinks with artificial ice. These can be built anywhere, even in the desert south of the equator.

The problems associated with building artificial ice rinks could be summarized in these two questions:
1. How do we start?
2. Isn't it far too expensive?

In order to show communities all over the planet that an ice rink is not a prohibitively expensive nor a hugely difficult venture to undertake, the IIHF decided to put a group of expert together to create a rink guide. The goal of the guide is to help communities and hockey enthusiasts to build ice rinks in their neighborhoods, at reasonable costs.

This guide targets ice hockey clubs with an ambition to build a community rink, the decision makers within communities or municipalities, and construction entrepreneurs.

As the President of the International Ice Hockey Federation I am proud to present this guide: "Ever thought of building an ice rink?" This is the first guide of its kind in regards to ice rinks.

Dr. René Fasel
IIHF President

HE SHOOTS…
HE SCORES. Ice Hockey is about skill and speed – the fastest game on earth

IIHF NEW ARENA PROJECT

An ice rink brings joy to the entire community
The excitement of gliding on a naturally frozen surface has fascinated mankind since prehistoric times and through the centuries. In recent times, different ice sports, and particularly ice hockey, were developed and enjoyed by more and more men, women and children.

The development of refrigeration technologies at the end of the 19th century has offered many people the opportunity to skate on artificial ice surfaces. Nowadays, through more advanced techniques and better insulation materials, which results in more efficient energy use, it is possible for any country in the world to develop ice sports.

Our working group, appointed by the International Ice Hockey Federation Council, is composed of experts from different countries that are involved in various aspects of the development of ice sports. Contractors, engineers, sports facilities experts, administrators, operators, sportsmen and media, all participated in the working group.

This guide has been prepared in order to help the different Federations affiliated with the IIHF or future members, to achieve simple and affordable projects to build ice rinks. This will allow them to develop wider programs to promote ice hockey, the world's fastest team sport as well as other international ice sports.

The goal is to provide the information and explanations, which should be utilized by the various groups who are involved or interested in the different aspects of ice rink planning, construction, maintenance and management operations.

An ice rink is a special building that has to be studied with particular care. The project should involve advice from experienced construction companies and engineering firms as well as maintenance and management professional advice to make it viable.

The philosophy behind this project was to provide the know-how and hopefully to inspire a community or group to build an ice rink. This guide should also help rink projects to avoid some common mistakes.

Through the description of an ice rink prototype, which combines a good economic figure with a standard architectural design and a complete installation for social enjoyment, the purpose of this guide is to reflect:

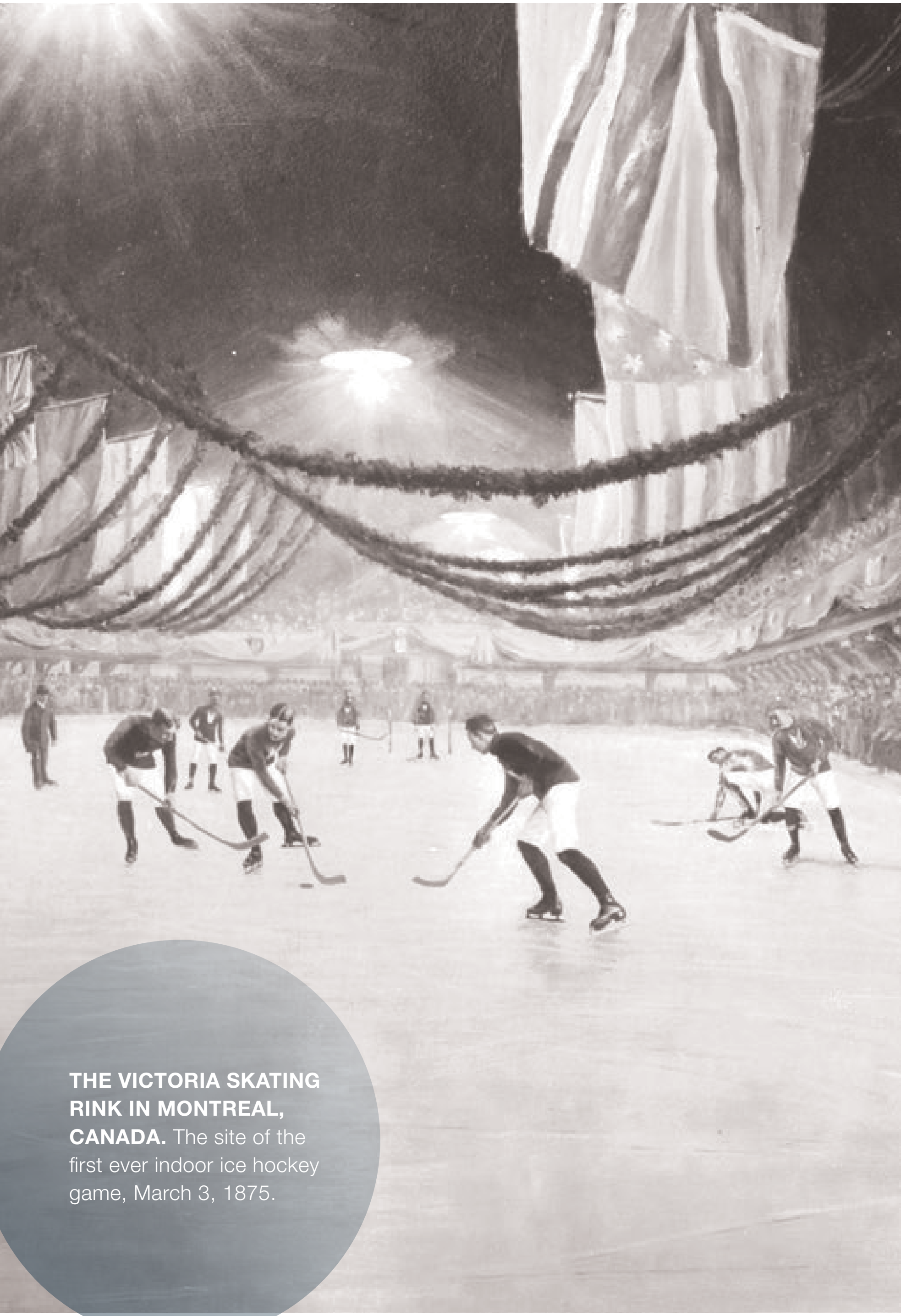
- That an ice rink will create a great social interest for ice hockey and other ice sports within a community.
- That building an ice rink is simply possible anywhere in the world.
- How to successfully construct, manage, and operate an ice rink.
- That building, maintaining and operating an ice rink is financially feasible, provided that the technical concept has been carefully studied.

We sincerely hope that this guide will give the reader some of the information necessary to help understand the technical and financial aspects of building an ice rink. This will also show how the interest of building an ice rink could be to the benefit of a wide range of users. Men and women of any age will be able to enjoy the fun of ice hockey and other ice sports in their community.

Frank Gonzalez
IIHF Facilities Committee Chairman
IIHF Council Member

BUILD ICE RINKS ANYWHERE

CHAPTER 1



THE VICTORIA SKATING RINK IN MONTREAL, CANADA. The site of the first ever indoor ice hockey game, March 3, 1875.

1. BUILD ICE RINK ANYWHERE

1.1 INTRODUCTION AND IIHF PROTOTYPE RINK

The International Ice Hockey Federation will, in this guide, show that it is possible to construct an ice rink anywhere in the world. The target groups are ice sport clubs and leisure organizations who wanted to take their ice hockey development programs to a higher level. We will show them how to successfully construct, manage and operate an ice rink. Decision makers and politicians will find countless researched ideas and become inspired to build a financially viable ice rink in their communities.

In many communities the ice rink is the center of social life where countless activities take place. Other ice sports, public skating, fairs, exhibitions, minor conventions and coaching clinics, to name but a few, are attractions warmly welcomed by the majority in winter. In the summer months the ice sheet is removed or covered and the rink is transformed into an appealing indoor sports arena where basketball, indoor soccer, handball and inline hockey are enjoyed.

In this guide we will introduce a cost friendly prototype that offers modern comfort to both active and passive visitors, by utilizing modern ice rink construction and operating techniques. The rink must be an inviting place attracting potential visitors. It has to be a safe and comfortable venue where visitors are able to enjoy their stay, whether it's on the ice, in the restaurant, on the stands or in the dressing rooms. The rink should be easy to maintain, with low overheads and investment costs.

The first recorded indoor ice hockey game took place at the Victoria Skating Rink in Montreal, Canada, way back in 1875. From these modest beginnings, the game evolved into a major modern indoor sport. The impact of enclosed arenas on the game cannot be underestimated. Technology has recently afforded the sport of ice hockey substantial opportunities to expand globally. Current facility construction enables ice hockey and ice sports to be accommodated anywhere in the world.

It has been historically documented that a contained covered rink increases community spirit. Social gatherings still play an important role in today's society, allowing people with similar interests to get together for the purpose of social interaction and entertainment. From a business perspective, an indoor arena provides the potential to generate revenue because games can be played year round, regardless of the weather.

Furthermore, top class events can be planned without weather risk, thus providing a guarantee to sponsors, spectators and all media sectors. It is therefore not surprising that the appeal of the game extends beyond the participants. Ice hockey is an extremely popular spectator sport, whether it is viewed in person or via a television broadcast. Both men and women of all ages enjoy the fast paced action of a typical ice hockey game.

Because of its mass appeal, the game of ice hockey is highly marketable. Corporations benefit by their association with this dynamic sport and brand their products and services via the game. The demographics of ice hockey, despite variations from country to country, reveal that most arena patrons definitely notice advertising in and around rinks and arenas and typically have a higher than average income. A perfect combination for the implementation of successful marketing strategies, particularly when coupled with an exciting product on the ice.

Traditionally a skating facility was primarily regarded as part of a community's infrastructure, much like a park or a library. Today's arena projects are evaluated in economic terms with avenues of revenue and expenses at the forefront. Naming rights, private boxes, concessions, revenues, TV rights along with innovative advertising opportunities are indeed the order of the day.

Prototype of an IIHF rink in Jaca, Spain

Picture shows the Pelham Civic Complex in Alabama

SOCIAL DIMENSIONS OF AN ICE RINK

CHAPTER 2

2. SOCIAL DIMENSIONS OF AN ICE RINK

2.1 INTEREST OF THE COMMUNITY

Sport For All is one of the rising concepts in the global field of sport and physical education.

Ice sports come particularly close to the ideals of the **Sport For All** concept enhancing promoting health and sociocultural development for all ages. A rink creates opportunities for the community to enjoy a variety of ice sports such as recreational skating, figure skating, ice hockey, short track and curling.

An ice rink attracts communities, athletes, schools and clubs. As long as it is supported by well-organized utilization programs and has patron friendly operating hours, an ice rink arouses curiosity and attracts the community. Schools and clubs are the main entry-level motivators often initiating an interest in skating beyond the level of basic skills.

From here, development can progress into recreational sports as a life-long athletic pastime or to competitive sports in another may take the enthusiast to competitive sports in an ice hockey or skating club. Ice rinks are attractive sports and recreational facilities promoting health and sociocultural activity as a key to a good way of life. Experienced physicians, pedagogues and social scientists, future-oriented local politicians, and others involved in the world of sport have underlined this.

The public interest in ice sports has evolved to such an extent that today they are no longer regarded as exclusive athletic activities. However, all-weather facilities available during 6 – 9 months of the year are usually in short supply. Natural outdoor ice surfaces, with their dependence on local climate are equally unsuitable for continuous wide scale recreational use as they are for regular training, competitions, or figure skating events. Artificial ice rinks have therefore become indispensable in today's increasingly sports-related recreational environment.

During the ice-free months of the year, these facilities are ideal sites for musicals, theatre, fairs and of course indoor sports. The possibility of round-the-year use is a necessity. High capacity utilization will warrant the investment and offset the recurring annual operational costs.

2.2 ACTIVITY PROGRAMS AND SERVICES

Youth and adult ice hockey programs will usually provide the greatest number of users of a facility. It is vital to the success of the rink to schedule as many hours of daily usage as possible. Scheduling youth programs to utilize as many early evening, and weekend hours, as possible will leave late night times to be filled with adult hockey programs.

A typical youth hockey program will use the rink ice surface from approximately 4.30 to 9.00 pm on weekdays and most of Saturday and Sunday from the early morning to the evening. Depending on the country or/and on the time of the year, youth hockey players may also be able to skate during daytime on weekdays or public holidays.

Another popular program is recreational or pick-up hockey as players register is reserved and players register individually for each session. Sessions are typically either 60 or 90 minutes. Late Friday and Saturday nights, weekday early morning or “lunch time” sessions and also Sunday mornings have been found to be successful. It is also possible to rent ice time to adult hockey groups, who may fill the odd vacant hours at the facility.

Learn to Skate & Learn to Play Hockey programs
The **Learn to Skate** & **Learn to Play Hockey** programs are the foundation of a successful facility. In these programs, casual participants can be turned into regular patrons who return to the facility three to four times a week. If children can demonstrate minimal proficiency on the ice, it becomes more enjoyable to return to the rink and develop as athletes.

These grass roots development programs are vital to keep skaters returning to the rink. The **Learn to Skate** & **Learn to Play Hockey** programs, targeting 5 to 12 year old children, will constantly provide new skaters for the more advanced programs. Classes can also be offered to pre-schoolers i.e. 3 to 5 year olds, during weekday mornings. Again, this provides the rink with another program to fill those quiet hours.

Learn to Skate classes will also provide a feeder program for classes for older children. An advantage of the **Learn to Skate** & **Learn to Play Hockey** programs is that as many as 8 different groups, with approximately 10 children each can use the ice simultaneously.

For these programs to generate revenue, one weekday afternoon session and a Saturday morning or afternoon session should be offered as a minimum. The weekday sessions will serve as an after school activity, and could be operated from 4 to 6 pm. Depending on the community, this time frame could be very popular.

Saturday sessions provide the opportunity for all family members to participate. Parents and family members may have a better chance of attending weekend sessions which should be offered immediately before or after public skating sessions to encourage patrons to spend more time at the facility.

Once a skater progresses through the Learn to Skate and Learn to Play programs, they can choose the sport that they will concentrate on: either figure skating or hockey. It is vital for rinks to have a balance of both programs in order to maximize the ice usage at the facility. In a single ice sheet facility it is difficult to accommodate the needs of all the user groups, but it is important to create an environment where all can participate.

Public skating

In many countries, especially in regions where hockey is not part of their sports culture, public skating is vital when operating a successful ice facility. A public skating session is ice time set aside so that any individual may, for a fee, skate at the rink. A public skating session is usually an inexpensive way to introduce new clients to your facility.

Public skating also allows the rink management to introduce customers to other, structured programs that are offered at the facility. Most public skating sessions average two hours. In many rinks weekend evening sessions on Friday or Saturday nights have become standard. Starting at 7 or 8 pm and lasting until 10 or 11 pm youth and adults can skate and socialize. As an added bonus, a “theme night” program might be instituted. Rock or popular music Fridays may attract crowds.

Weekend afternoon sessions are popular with families as parents are able to skate with their children. Many facilities also offer birthday party programs that are connected to afternoon public skating sessions.

Other public sessions that have proved to be successful include:
- Early Sunday evenings. This session, from 6 to 8 pm could become a family, or “End of the Weekend” event.
- Weekday mornings. Make these sessions available for school groups, adult or senior citizen groups.
- Weekday afternoons. An after school skate, from 3 to 5 pm with music that caters to the 10 to 14-year-old group.
- A weeknight session. This session, 7 to 9 pm, will work around your Learn to Skate classes, thereby encouraging more adults to use the facility.

Usually other ice sport programs use the ice time that hockey programs cannot, or will not, utilize. Early morning, mid- and late afternoon hours have become standard for most figure skaters.

As figure skaters develop and become more advanced, they spend more time on ice. Synchronized team skating is gaining popularity around the world and should be received with open arms by the rink industry. A synchronized skating team can put 15 to 20 skaters on the ice for a practice session, incorporating more skaters into a program.

Figure skating clubs happily welcome skaters coming from the Learn to Skate program. They can also take care of marketing and promotion of figure skating programs and events for the facility. Devoted skaters will not hesitate to skate on weekday mornings before school, from 6 to 9 am.

It is useful to schedule figure skating afternoons around the Learn to Skate and Learn to Play programs. This way the beginners can view the more advanced programs, and get an idea of the next level of participation.

Other ice sports

There are other ice sports that may or may not fit within a given facility or community. Short Track and curling are activities that can complement a rink.

Community programs

There are several programs which rink management can introduce to attract a wider public to the rink.

School field trips, coffee mornings, or ice themed celebrations and fairs, for example, can be very popular and provide rinks with ideal opportunities to advertise and market their programs to potential participants. Corporations and other organizations may also be interested in skating at the rink. It is important for the rink management to seek out as many of these opportunities as possible. The rink management should explore these options thoroughly.

TECHNICAL GUIDELINES OF AN ICE RINK
CHAPTER 3

3. TECHNICAL GUIDELINES OF AN ICE RINK

3.1 GENERAL INTRODUCTION

Ice rink facilities share the same concerns: energy & operationg cost and indoor climate. Ice rink designs and operations are unique and differ in many ways from standard buildings. Thermal conditions vary from – 5 ºC on the ice surface to + 10 – 20 ºC in the stand and over + 20 ºC in dressing rooms and offices. High air humidity indoors brings on corroding problems with steel structures, decay in wooden structures and indoor air quality problems like fungi and mold. Advanced technology can reduce energy consumption considerably and thus decrease operating costs in existing and proposed ice rink facilities while improving the indoor climate at the same time. Energy cost and concern about the environment today set high demands for the technical solutions, and without effective solutions the operational (energy, maintenance, replacement) cost will increase. Considerable savings can be made if the facilities are operating energy-efficiently. This will require investment in energy-saving technology and in raising energy awareness on the part of ice rink operators.

The basic technical elements of a well-working facility are:
– Insulated walls and ceiling (envelope)
– Efficient refrigeration plant
– Mechanical ventilation
– Efficient heating system incl. heat recovery
– Air de-humidification
– Proper lighting

1. Insulated walls and ceilings

Insulated walls and ceiling make it possible to control the indoor climate regardless of the outdoor climate. In an open-air rink the operation is affected by the weather (temperature, sun, rain, wind) and the running costs are high. Depending of the surroundings there might also be noise problems with the open-air rink – traffic noise may trouble the training or the slamming of the pucks against the boards may cause noise nuisance to the neighborhood. Ceiling-only construction helps to handle sun and rain problems but may bring about maintenance problems in the form of "indoor rain": humid air will condensate on the cold inner surface of the ceiling and create dripping. The ceiling is cold because of the radiant heat transfer between the ice and the ceiling i.e. the ice cools down the inner surface of the ceiling. Though there are technical solutions to minimize the indoor rain problem (e. g. low emissive coatings) the ceiling covered rink is still subjected to weather conditions and high running cost.

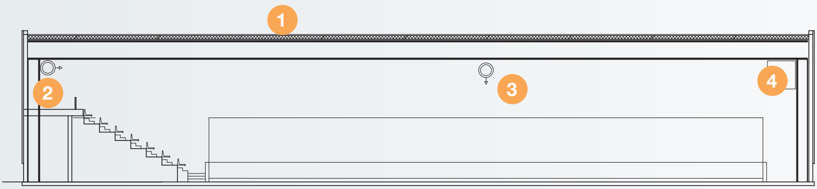
2. Efficient refrigeration plant

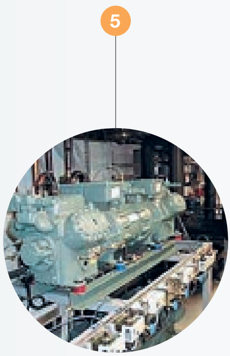
The refrigeration plant is needed to make and maintain ice on the rink.

A refrigeration plant includes the compressor(s), the condenser(s), the evaporator(s), and rink piping. The heat from the condenser can be used to heat the facility and thus save energy and money. The refrigeration plant is the main energy consumer in the ice rink facility. Compressors, pumps and fans needed in the refrigeration system are normally operated by electricity, consuming over 50 % of the total electricity used.

THE CONSTRUCTION, PLANT SYSTEM AND OPERATION DEFINE ENERGY CONSUMPTION OF AN ICE RINK

Figure 1





1 Insulated exterior envelope

– Enables to build an ice rink anywhere in the world
– Air tight envelope to avoid moisture problems

2 Heating

– Maintains acceptable thermal conditions
– Use heat recovered from the refrigeration plant (condenser heat) as much as possible

3 Mechanical ventilation

– Provides good indoor air conditions
– Demand-controlled ventilation saves money and energy

4 Dehumidification

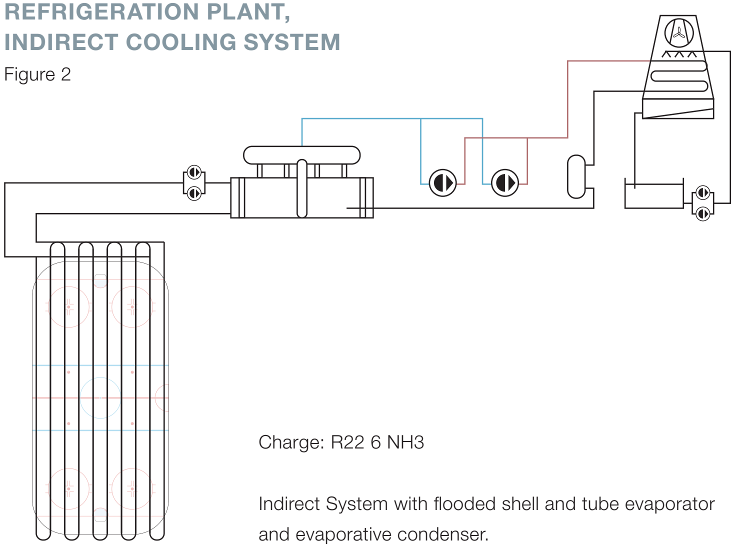
– Dehumidification prevents moisture problems (fog, soft ice, damages to the building)
– Dry ventilation air before entering the building

5 Refrigeration plant

– Needed to make and maintain ice
– Pay attention to the energy efficiency of the plant (high COP)

REFRIGERATION PLANT, INDIRECT COOLING SYSTEM

Figure 2



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Indirect System with flooded shell and tube evaporator and evaporative condenser.

3. Mechanical ventilation

Mechanical ventilation is necessary in order to control the indoor air quality and thermal as well as humidity conditions inside the ice rink. Ventilation is needed both in public spaces (dressing rooms, cafeteria, etc.) and in the hall. If you ever have visited a dressing room when the ventilation is off you will realize the necessity of proper ventilation as the odour of the players' outfit i unpleasant. Inadequate ventilation can also cause health problems in the facility.

To be energy efficient air conditioning must be well controlled. This means that the ice rink envelope should be air tight with no uncontrolled air infiltration through openings (doors etc.) and roof-to-wall joints. Air infiltration will increase energy consumption during the warm and humid seasons related to refrigeration and dehumidification and during the cold seasons the problem is associated with space heating. This leads us to the fourth basic demand: **the ice rink facility must be heated.** An unheated ice rink is freezing cold even in warm climates and humidity control of the air becomes difficult.

4. Efficient heating system

Ventilation also offers a means to heat the ice rink. Heating the ice rink with air necessitates the use of re-circulated air and that thve ventilation unit is equipped with heating coil(s). Remarkable energy-savings can be achieved when using waste heat from the refrigeration process to warm up the air.

5. Air de-humidification

The de-humidification plant is needed to dry the rink air. Excess moisture in indoor air will cause corrosion of metal structures, rotting of wooden structures, fungi and mold growth, increased energy consumption and certainly ice quality problems.

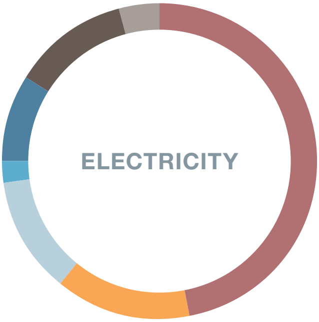
Energy consumption holds a key role when speaking of the life cycle costs and above all the environmental load of the facility during its life cycle. Efficient utilization of the energy resources in new as well as in retrofit and refurbishment projects is in the consciousness of the energy-sinks and the various parameters affecting the energy consumption.

The building's construction, plant system and day-to-day operation define the energy consumption of an ice rink. The construction characteristics are the heat and moisture transfer properties of the roof and walls, as well as air infiltration through cracks and openings in the building envelope. The structure of the floor is also important from the energy point of view. Plant characteristics include the refrigeration, ventilation, dehumidification, heating, lighting and ice maintenance systems. The operational characteristics are the length of the skating season, air temperature and humidity, ice temperature, supply air temperature and fresh air intake of the air-handling unit as well as the control- and adjustment parameters of the appliances. Figure 3 shows the energy spectrums of typical training rinks and figure 4A and 4B illustrates the energy flows of a typical small ice rink.

Ideally, the heating demand of the ice rink is fully covered by recovered heat from the refrigeration process. In practice extra heat is still needed to cover the needs of hot tap water and heating peaks. Moreover a backup heating system is needed to meet the heating demands when the compressors are not running for example during dry floor events (concerts, shows, meetings, etc.).

MAIN ELECTRICITY AND HEAT CONSUMPTION COMPONENTS OF A TYPICAL TRAINING FACILITY

Figure 3



- Compressor, 47 %
- Brine pumps and condenser fans, 14 %
- Ice-surface lighting, 12 %
- Lighting, 2 %
- HVAC appliances (pumps, fans, controllers, etc.), 9 %
- Other consumption (cafe, cleaning, outdoor lights, etc.), 12 %
- Dehumidification, 4 %

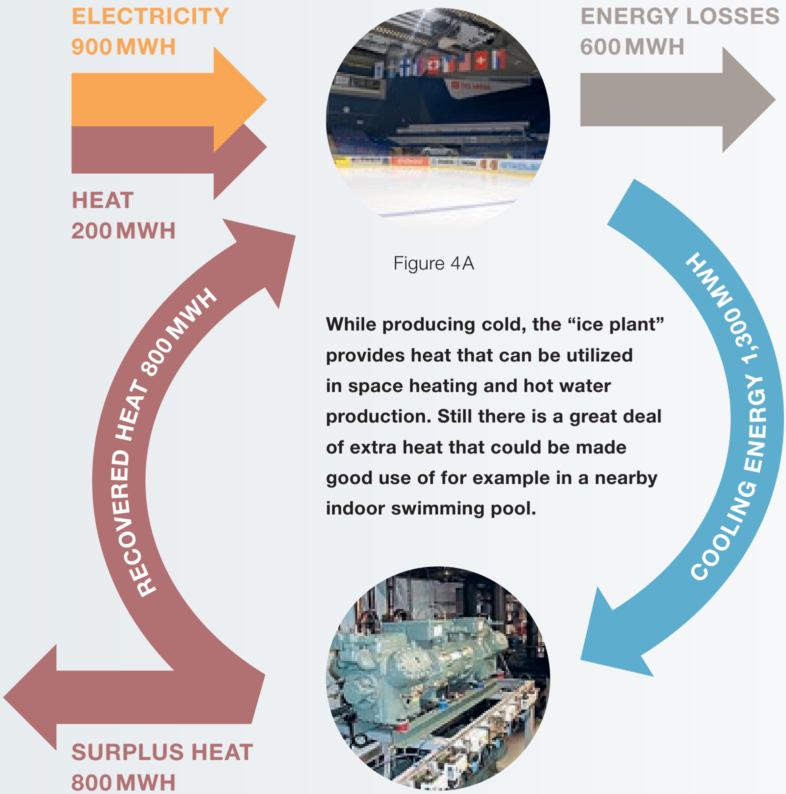
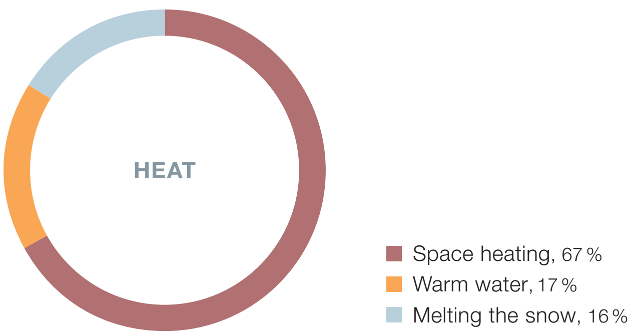


Figure 4A

While producing cold, the “ice plant” provides heat that can be utilized in space heating and hot water production. Still there is a great deal of extra heat that could be made good use of for example in a nearby indoor swimming pool.

Figure 4B



3.2 SIZING THE ICE RINKS

There are several ways to classify ice sport venues; in this guide the definition will be based on fixed seating capacity, the size of the catering operation and the multi-purpose use possibilities.
Thus ice sport venues are/can be divided into three categories as follow:

- Small ice rinks with seating capacity up to 1,000
- Medium size ice arenas between 2,000 and 6,000 seats with some multi-purpose features (seating from 2,000 to 4,000 on 2 or 4 sides of the rink on one level).
- Modern multi-purpose ice arenas with over 6,000 fixed seats with a wide scale catering operation, 4 sides of the rink over several levels.

Small ice rinks can be built without any fixed seating or any catering service although the modern small ice rinks are usually also concentrating on obtaining additional revenues through special hospitality programs.

The first studies for a new ice rink should be done on a so called modular base, which allows later optional enlargements. These later modifications could be e. g. an additional ice pad, enlarged spectator stand or a restaurant.

In order to make the optional features possible for later realization, the designer team should take into consideration some technical features such as:

- Capacity of the refrigeration unit
- Main structural support system, where for example the columns and foundations on one side of the building could be planned to take on extra load from additional structures
- Envelope structure, such as external walls, should be at least partly removable

In this guide we are focusing on a small ice rink by defining an IIHF prototype ice rink with about 1,000 fixed seating and a small restaurant.

Small ice rink, capacity less than 2,000 seats.

Multi-purpose arena, capacity over 8,000 seats.

3.3 IIHF PROTOTYPE DEFINITION

Minimum required space, IIHF prototype ice rink

In the IIHF prototype ice rink space is needed for following use:

- at least one standard IIHF ice pad, size of 26 – 30 m × 56 – 60 m surrounded by a dasher board and glass protection with 1,5 m minimum space outside of the dasher board. The recommendation of 30 × 60 is based on the fact that the ice rink should be used by other sports like short track and figure skating.
- six dressing rooms incl. toilets, showers and lockers for personal items
- two coach rooms
- referees and linesmen dressing room incl. toilet and shower
- four to ten drying rooms
- entrance hall, ticketing
- medical room
- team equipment service room (skate sharpening, stick storage etc.)
- general storage space
- technical room for mechanical and electrical system
- tribune for 1,000 spectators
- public toilets
- small restaurant / Vending zone
- Rental skates zone
- Commercial zone
- Staff room

3.4 CONSTRUCTION MATERIAL AND STRUCTURAL SYSTEMS FOR AN ICE RINK

It is essential to understand that ice rinks cannot be compared to any other type of buildings. This is due to:

- high indoor temperature differences in same indoor climate from – 4 °C to + 24 °C, where at the same time these internal climate zones must be controlled and maintained stable
- differences in indoor climate also cause humidity problems that must be under control
- air tightness is a more important feature of the building envelope than thermal insulation
- large glazing of the facade should be avoided due to energy loss and the most optimized ice rink could be composed by a fully closed casing.

However as in all other kind of buildings, there are structural possibilities for almost all kinds of systems with numerous materials. The main structural alternatives for ice rinks and arenas are:

- Arched girders
- Grids with mast columns
- Framework

HERE WE WILL PRESENT A FEW EXAMPLES OF SMALL RINKS

Hartwall Jaffa Arena Training Rink Eura, Finland

Facts

- Building year: 2000
- Building area: 2,520 m^2 (70 × 36 m)
- Ice pad size: 58 × 28 m
- Seats: 400
- Skating season: 8 months (August – March)
- Personnel: 2
- Heating consumption: 710 MWh/year
- Electricity consumption: 710 MWh/year
- Water consumption: 2,200 m/year

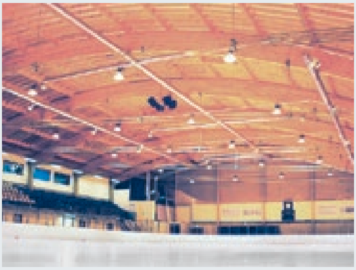
Layout

The layout of the rink is simple, the stands and the players benches are on the opposite sides of the rink. Four dressing rooms are at the end of the hall. On top of the dressing rooms there are office rooms, a lecture room and a cafeteria. The space under the spectator seats is used as storage. Technical room is placed in a separate container outside of the rink.

Structures

The rigid frame structure of the rink is made of glue laminated timber. The roofing and the walls are made of polyurethane elements. In order to improve the energy efficiency of the rink the air tight polyurethane elements are equipped with low emissivity coating laminated on the indoor surface of the elements. The elements have also an acoustic dressing which improves the acoustic atmosphere of the rink. The facades are made of bricks and profiled metal sheets.

Training Rink Hämeekyrö, Finland



Facts

- Building year: 1997
- Building area: 2,590 m^2 (68 × 38 m)
- Ice pad size: 58 × 28 m
- Seats: 600
- Skating season: 8,5 months
- Personnel: 1–2
- Heating consumption: 395 MWh/year
- Electricity consumption: 490 MWh/year
- Water consumption: 1,100 m/year

Layout

The four dressing rooms with showers are under the seating area alongside the hall. At the other end of the hall there is a cafeteria and a training room.

Structures

The arched girder structure of the rink is made of glue laminated timber. The roofing and the walls are made of polyurethane elements. To improve the energy efficiency of the rink the air tight polyurethane elements are equipped with low emissivity coating laminated on the indoor surface of the elements. The elements also have acoustic dressing which improves the acoustic atmosphere of the rink. The facades are made of profiled metal sheets, clapboard and lime bricks.

Monrepos Arena Training Rink Savonlinna, Finland

Facts

- Building year: 1999
- Building area: 2,420 m^2 (67 × 36 m)
- Ice pad size: 58 × 28 m
- Seats: 400
- Skating season: 12 months
- Personnel: 3
- Heating consumption: 760 MWh/year (76 m^3 oil)
- Electricity consumption: 720 MWh/year
- Water consumption: 3,500 m/year

Layout

Four of the six dressing rooms with showers are under the seats along the long side of the hall and the other two dressing rooms at the end of the hall. On top of these two dressing rooms there are office rooms, lecture room, cafeteria, TV stand and air conditioner. Technical room (refrigeration unit) is placed in a separate container outside of the rink.

Structures

The mast-supported grid constructer of the rink is made of glue laminated timber. The roofing and the walls are made of polyurethane elements. To improve the energy efficiency of the rink the air tight polyurethane elements are equipped with low emissivity coating laminated on the indoor surface of the elements. The elements have also acoustic dressing which improves the acoustic atmosphere of the rink. The facades are made of profiled metal sheets.

3.4.1 STRUCTURAL SYSTEM AS USED IN THE IIHF PROTOTYPE

The roof structure consists of steel trusses each supported by two columns. At the support points the bottom boom of the truss bears on an elastomeric bearing pad bolted to the supporting concrete column. The whole roof structure of steel (see roofing 3.3.2) is floating on top of the framework. The columns are mounted ridged to the concrete foundations.

Depending on the geographical region of the planned new ice rink, the horizontal loads of the roof structure (snow) are highly affecting the choice of the most economical structural system. If the snow loads are not remarkable, the steel trusses could easily and cost efficiently be spanned over the spectator stand and the dasher board using span lengths like 40 to 45 meters and concrete column rasters of 6 to 8 meters. A minimum free space between the ice surface and the bottom of steel trusses should be at least 5 – 7 meters. Depending on structural and tribune formats. **In order to avoid serious problems with humidity, like corrosion etc. the building must be equipped with a dehumidifier system.**

3.4.2 ENVELOPE, ROOFING

The main function of an ice rink envelope is air tightness and not parti-cularly thermal insulation. The envelope structure should be done most efficiently to fulfill only that one main characteristic.

MATERIALS AND STRUCTURAL SYSTEM – PROS AND CONS

Table 1

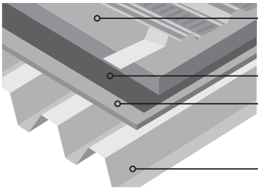
Steel support	**Wood support**	**Reinforced concrete**	**Mix material combinations**
+ long span length	+ long span length	+ global availability	+ long span length
+ global availability	+ non corroding	+ non corroding	+ fire protection
+ pre-fab system	+ pre-fab system	+ pre-fab system	+ pre-fab system
+ cost	+ fire protection	+ fire protection	+ cost
– corroding	– global availability	– cost	– corroding
– fire protection	– cost	– beam span length	– decaying
– maintenance	– maintenance	– acoustic feature	– cost
	– decaying	– flexibility in use	– maintenance

In the design phase all structural possibilities for later enlargement of the building should be defined considering the size of the plot, the traffic situation and possible changes in the surroundings.

Most used roofing structures consist of the following layers:
- Profiled, load bearing steel sheets
- Vapour barrier
- Thermal insulation (10 cm to 15 cm rock wool)
- Water insulation (cover)

TYPICAL ROOF STRUCTURE

Figure 5



3.4.3 ENVELOPE, WALLS

The exterior wall structure of an ice rink is commonly based on the idea of air tightness and the simplest walling is done by using different metal sheet panels. These panels are simple, pre-fabricated sandwich elements, that have an inside core of thermal insulation and both sides covered with metal sheets.

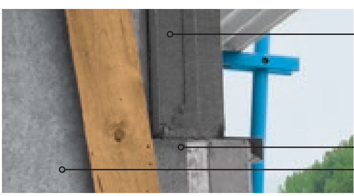
These panels also allow later changes of the envelope very easily and with rather low additional cost.

These metal sheet panels are manufactured in sizes up to 12 meters each, in various colors and surface treatment. A problem with these metal sheet panels is a rather poor resistance against mechanical exertion like hits of the hockey pucks inside (protective netting recommended) or vandalism outside.

Outside it is recommended to use wall concrete panels on the lower parts and metal sheet panels higher up the walls.

TYPICAL WALL STRUCTURE

Figure 6



3.4.4 ICE PAD STRUCTURE

Perhaps the most special structure in an ice rink is the ice pad. The ice pad consists of ground layers below the pad, thermal insulation, piping and the pad itself. New technologies have made possible the use of new materials and technical solutions in these structures, where at the same time the energy efficiency and construction cost can be optimized.

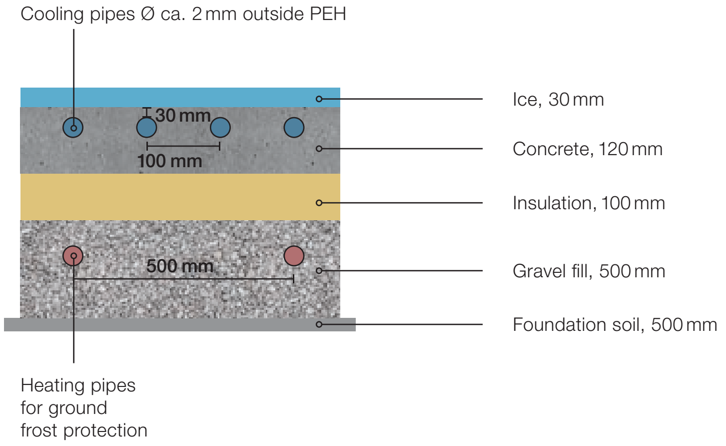
The most common surfacing material is:

- Concrete

Sand surface is cheapest and fairly energy efficient due to the good heat transfer characteristics but the usability is limited to ice sports. Asphalt surfaces are suitable for some special needs, for example in the case that the facility is used for tennis in the off-ice sport season. Asphalt is cheaper than concrete but the refrigeration energy requirement is higher.

TYPICAL ICE PAD CONSTRUCTION

Figure 7



3.5 MECHANICAL AND ELECTRICAL PLANT

The effective utilization of the energy resources has become an important aspect in the design of new facilities. There are many different energy conservation measures that can be incorporated in the planning stage. In planning the hardware configuration and construction of an ice rink one should consider the types of activities, special requirements and interest of the various user groups in question. Table 2 summarizes the main indoor air design values, which can be used in designing technical building services. It is important to set these values already in the pre-design stage in order to control the demands.

INDOOR AIR DESIGN VALUES FOR SMALL ICE RINK (RINK SPACE)

Table 2, see also table 5 on page 44

Action	Air temperature of the rink space °C		Ice temperature, °C	Max. relative humidityof the rink space (%)	Min. fresh air intake l/s/occupant
	Rink (at 1,5 m height)	Tribune (operative)			
Hockey					
game	+6	+10 – +15	–5	70	4–8 / spectator
training	+6	+6 – +15	–3	70	12 / player
Figure					
competition	+12	+10 – +15	–4	70	4–8 / spectator
training	+6	+6 – +15	–3	70	12 / skater
Other	+18	+18	–	–	8 / person

3.5.1 THE REFRIGERATION PLANT

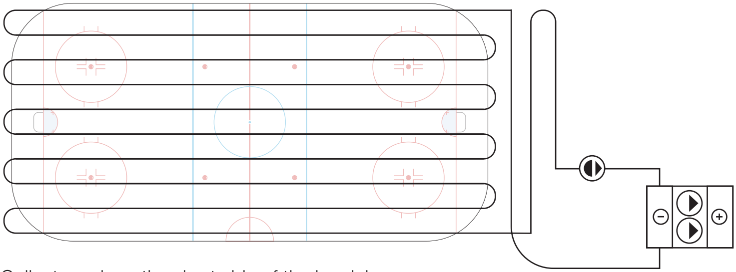
The refrigeration plant is fundamental to the ice-rink facility. A frequently used phrase is that the refrigeration unit is the heart of the ice rink. Almost all of the energy flows are connected to the refrigeration process in one way or another. It is quite normal that the electricity consumption of the refrigeration system accounts for over 50 % of the total electricity consumption and the heat loss of the ice can be over 60 % of the total heating demand of an ice rink.

In the design stage, when choosing the refrigeration unit one has to consider the economics, energy usage, environment, operation, maintenance and safety.

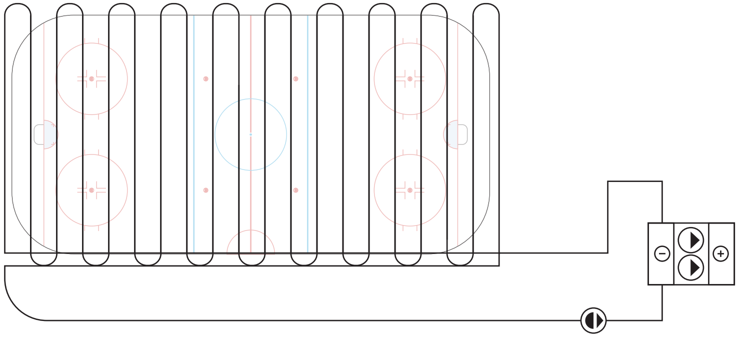
Plastic rink piping connections to the distribution and the collection mains (thermally insulated).

DIFFERENT COLLECTORS ALONG THE ICE RINK

Figure 8



Collectors along the short side of the ice rink.



Collectors along the long side of the ice rink. (not recommended)

FEATURES OF DIRECT AND INDIRECT REFRIGERATION PLANT

Table 3

Direct system	**Indirect system**
+ Energy efficiency + Simple + Suitable to any refrigerant	+ Use of factory made refrigeration units + Small refrigerant filling (environmentally positive)
– Not possible with certain refrigerants (ammonia) – Installation costs – Need of professional skills in design and in installing	– Lower energy efficiency than with direct system

The design of the refrigeration plant can be either so-called direct or indirect system. In a direct system the rink piping works as the evaporator, whereas an indirect system is comprised of separate evaporator (heat exchanger) and the ice pad is indirectly cooled by special coolant in a closed circulation loop. The energy efficiency of the direct system is in general better than the efficiency of the indirect system. On the other hand the first cost of the direct system is higher than that of the indirect system. Moreover indirect systems can't be used with for example ammonia in several countries because of health risks in the case of refrigerant leaks. Table 3 summarizes the advantages and disadvantages of the different systems.

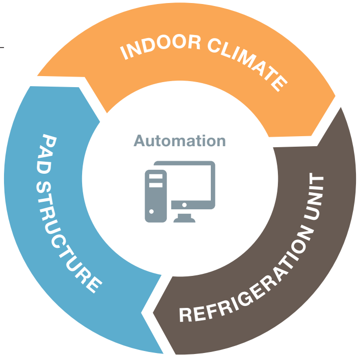
In most cases the refrigeration plant refrigerates an indirect system i.e. the floor by a closed brine circuit rather than directly. The refrigerant used in the compressor loop should be environmentally accepted. The tendency is to favor in natural substances of HFCs. In choosing the refrigerant the country-specific regulations must be taken into account. The operational aspect is to equip the compressor with reasonable automation, which enables demand-controlled running of the system. In addition, the safety factors should be incorporated in the design of the machine room. **Please always contact the local safety- and environment authorities in regard to this.**

From the energy point of view it is of course essential that the compressor unit should be as efficient as possible, not only in the design point but also under part-load conditions.

When estimating the energy economy of the system it is essential to focus on the entire system and not only on one component alone. The refrigeration plant is an integral part of the ice rink, Figure 9.

REFRIGERATION UNIT AND RELATED ENERGY FLOWS

Figure 9



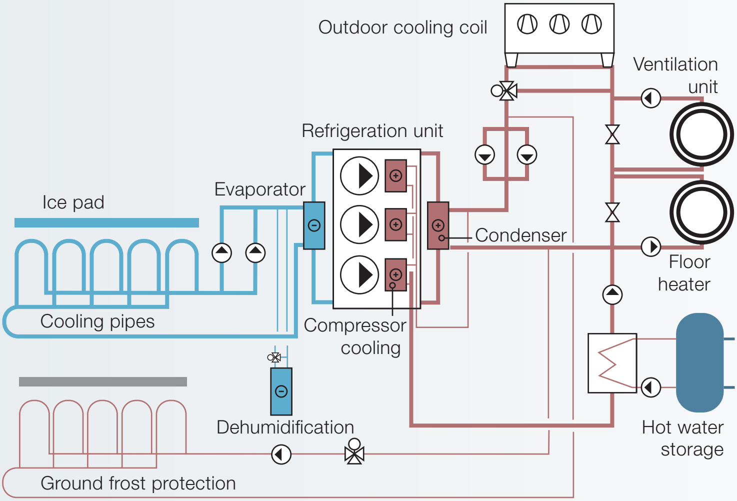
Indoor climate
- air temperature
- ceiling temperature and material
- air humidity
- ice temperature

Pad structure
- ice thickness
- slab thickness and thermal properties
- pipe material and sizing
- cooling liquid properties
- frost insulation
- frost protection heating

Refrigeration unit
- evaporating and condensing temperatures
- efficiency
- compressor type
- sizing
- refrigerant

REFRIGERATION PLANT WITH HEAT RECOVERY: PREHEATING OF HOT WATER, FLOOR HEATING AND AIR HEATING

Figure 10



Design and dimensioning aspects

The refrigeration plant is dimensioned according to cooling load and the required evaporation and condenser temperatures. For a standard single ice rink approximately 300–350 kW of refrigeration capacity is adequate.

The refrigeration capacity is normally sized according to the heat loads during the ice making process. The dimensioning cooling load during the freezing period is comprised of the following components:

- Cooling the ice pad construction down to the operating temperature in required time.
- Needed cooling capacity depends on the temperature of the structures at the beginning of the freezing process and the required freezing time (normally 48 hours).
- Cooling the temperature of the flooded water to the freezing temperature (0 °C) and then freezing the water to form the ice and to cool the temperature of the ice to the operating temperature. The freezing capacity depends on the temperature of the water, the operating temperature of the ice and the required freezing time (48 hours).
- Heat radiation between the rink surface and the surrounding surfaces. The cooling capacity depends on the surface temperatures during the freezing period.

- Convective heat load between the rink surface and the air. Cooling capacity depends on the air and rink surface temperatures as well as the air stream velocity along the rink surface during the freezing period.
- Latent heat of the condensing water vapor from the air to the rink depends on the air humidity (water vapor pressure) and the surface temperature of the rink during the freezing period
- Radiation heat load on rink surface during the freezing period (lights ect.)
- Pump-work of the coolant pump.

3.5.1.1 REFRIGERATION UNIT

Refrigeration unit is comprised of many components: compressor(s), evaporator, condenser, and expansion valve and control system.

The function of the compressor is to keep the pressure and temperature in the evaporator low enough for the liquid refrigerant to boil off at a temperature below that of the medium surrounding the evaporator so that heat is absorbed. In the compressor the vapor is raised to high pressure and high enough temperature to be above that of the cooling medium so that heat can be rejected in the condenser. After the condensation the liquid refrigerant is throttled in the expansion valve back to the pressure of the evaporator. In other words the compressor pumps consists normally of at least 2 compressors to guarantee flexible and economical use of the unit.

Two screw compressors

3.5.1.2 ICE PAD

Another interesting aspect in the energy chain is the heat resistance between the ice and the brine, which affects the energy consumption. The underlying energy-thinking in the heat resistance is: the bigger the resistance is – the lower the brine and evaporation temperature of the compressor should be in order to produce the same cooling effect as with smaller resistance. The lower the evaporation temperature is the bigger the power need of the compressor. Heat resistance consists of five different parameters:

1. The so called surface resistance of the ice surface, which is a combination of ceiling radiation and convection.
2. Heat resistance of the ice, mainly dependent on the ice thickness.
3. The ice, the concrete slab or any other surfacing material constitutes heat resistance based on the thickness of the layer and the heat conductivity of the material involved.

4. Pipe material and pipe spacing in the floor.
5. Surface resistance between the pipe and fluid.

The function of secondary coolants is to transfer heat from the rink to the evaporator in the refrigeration unit. The perfect coolant is environmentally friendly, non-toxic, has low pumping cost and high efficiency. It must also be non-corressive, cheap and practical. A variaty of collants are in use, table 4 summarizes a few of them.

SECONDARY COOLANTS

Table 4

Secondary coolant	Remarks
Glycols – Ethylene glycol – Freezium contains a 20–50 % calsiumformats	High pumping costs, low efficiency, easy to handle
Salts – calcium chloride ($CaCl_2$)	Low pumping costs, high efficiency, unpractical
Formats – Potassium formats – Potassium acetates	Low pumping costs, high efficiency, corrosive, expensive

In the construction of the ice pad the ground frost insulation and in some cases ground heating is compulsory (con provids denser waste-heat can be used for heating). Ground frost will build up also in warm climates where frost normally is not a problem. If the ground is frost-susceptible then the frost may cause uneven frost heave of the ice pad. The pad will be damaged by the frost and frost heave makes it more difficult to maintain the ice and will impede the utilization of the facility to other sports (tennis, basketball) over the ice-free period. Moreover, a non-insulated pad increases energy consumption of the refrigeration.

3.5.2 AIR CONDITIONING

It is highly recommended to use mechanical ventilation in ice rink facilities to ensure healthy and safe indoor air conditions. The air-handling unit(s) provide(s) fresh air to the ice rink and other premises and it is also used for heating purposes and even to dehumidify the ice rink air. Fresh air intake is necessary to maintain good air quality. Air quality is affected by the emissions caused by people, the building materials and the ice resurfacer especially when the resurfacer is run by combustion engine (gas or gasoline).

The building is divided into two thermal zones: the ice rink and the public areas. The simplest and safe way is to equip the facility with two ventilation units, one for the rink area and one for the public areas.

The energy-saving factor in ventilation can be found in the demand-controlled fresh-air intake and in optimizing the airflow rates according to the needs for minimizing the fan power.

3.5.3 DE-HUMIDIFICATION

The moisture loads are influenced by the occupants (skaters, audience), outdoor air moisture, evaporating floodwater of the ice resurfacing and combustion driven ice resurfacer. The biggest moisture load is the water content of the outdoor air which enters the ice rink through ventilation and as uncontrolled air infiltration leakage through openings (doors, windows), cracks and interstices in constructions caused by pressure effects during operation.

Excess air humidity increases the risk of rot growth on wooden structures and corrosion risk of metals thus shortening the service lifetime of the construction components and materials, resulting in increased maintenance costs. High humidity levels cause indoor air problems through the growth of mold and fungus on the surfaces of the building structures.

In the following tables maximum allowable ice rink air humidity rates are presented to avoid indoor air problems and depraving of constructions.

There are two primary ways to remove moisture from the air: cool the air below its dew point to condense the water vapor, or pass the air over a material that absorbs (chemical dehumidification) water.

AIR TEMPERATURE AND HUMIDITY CRITERIA TO AVOID FOG

Table 5

Ice rink air temperature, °C	Maximum relative airhumidity, %
5	90
10	80
15	70
20	60

AIR TEMPERATURE AND HUMIDITY CRITERIA FOR ROT AND MOULD DAMAGES OF WOODEN STRUCTURES

Table 6

	Temperature, °C	Relative humidity, %
Rot	50 – 5	> 90 – 95
Mould	55 – 0	> 75 – 95

CORROSION CRITERIA FOR METALS

Table 7

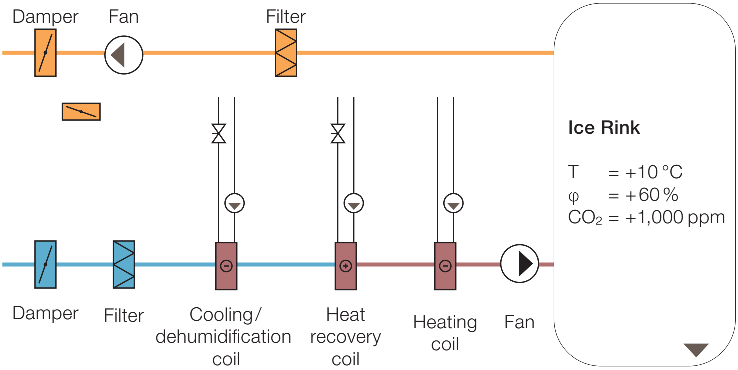
Temperature, °C	Relative humidity, %
>0	> 80

Systems that cool the air below its dew point normally use mechanical refrigeration. Air is passed over a cooling coil causing a portion of the moisture in the air to condense on the coils' surface and drop out of the airflow. Cooling coil can also be integrated in the ventilation unit and in the ice refrigeration circuit.

Chemical dehumidification is carried out through the use of absorbent materials, which are either solids or liquids with the ability to extract moisture from the air and hold it.

SCHEMATIC DIAGRAM OF AN ICE RINK AIR-CONDITIONING SYSTEM WITH DEHUMIDIFICATION AND HEAT RECOVERY COILS

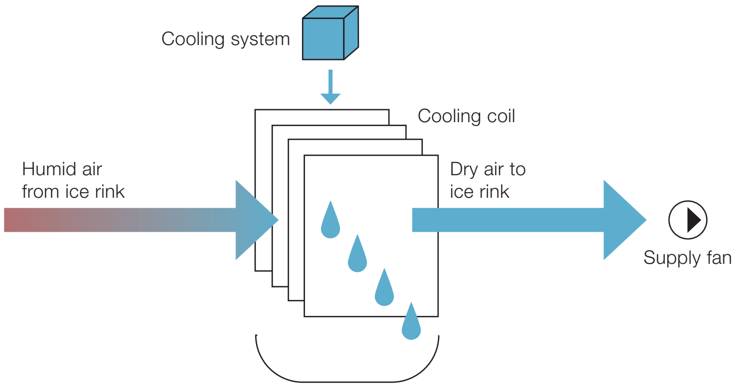
Figure 11



The desiccant dehumidification system, figure 10 on page 41 or 13 on page 46, consists of a slowly rotating disk, drum or wheel that is coated or filled with an absorbent (often silica gel). Moist air is drawn into the facility and passed across one portion of the wheel where the desiccant absorbs moisture from the air. As the wheel slowly rotates, it passes through a second heated air stream. Moisture that was absorbed by the desiccant is released into the heated air, reactivating the desiccant. The warm moist air is then exhausted from the facility.

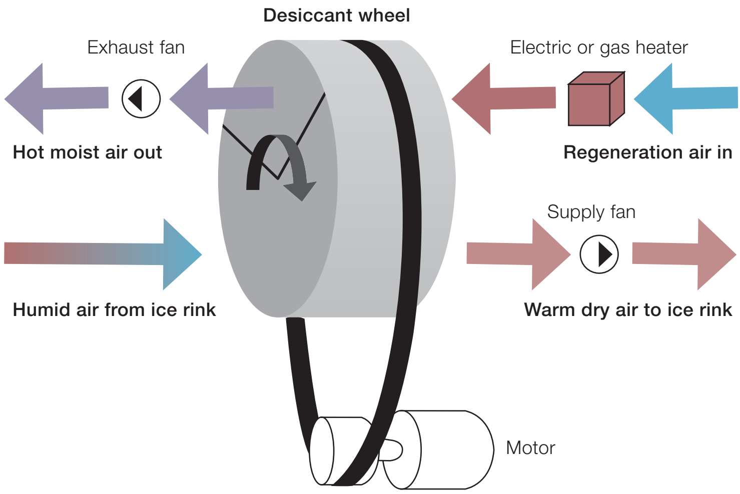
CONDENSING DEHUMIDIFICATION PROCESS

Figure 12



DESICCANT DEHUMIDIFICATION PROCESS

Figure 13



3.5.4 HEATING

A proper heating system is needed to maintain comfortable thermal conditions for both the players and the audience. Heating is also important in controlling the humidity of the ice rink in order to avoid fog and ceiling dripping problems. Moreover heat is needed for hot water (ice resurfacing, showers), and in some cases for melting waste-ice from the ice resurfacing process.

Waste-heat recovery

Waste-heat recovered from the compressor can supply almost all of the heating demand of a training rink in most cases. When designing the heat recovery system, the relatively low temperature level should be taken into account. The temperature level of the waste heat is normally around 30–35 °C and a small portion of the waste heat, the so-called super heat, can be utilized at a higher temperature level. Waste heat can be utilized in the heating of the resurfacing water as well as the rink, the fresh air, to pre-heat the tap water and to melt the snow and ice slush of the resurfacing process.

3.5.5 ELECTRIC SYSTEM

Electrical installations are comprised of a distribution and transformer center, if necessary. Emergency lighting and guide lights must work in the event of power cuts. Emergency power can be supplied by diesel operated generators or by battery back-up systems. In most cases it is worthwhile avoiding the reactive power by capacitive compensation.

LIGHTING EXAMPLE

Table 8

Building Area/Activity	Lux
Recreational Hockey (IES)	500
Recreational Skating (IES)	300
Dressing Rooms	300
Common Areas	300

LED lighting reducing energy costs by up to 70–80 % and eliminate maintenance fees, while increasing your lighting quality and the use of different colors for different purposes, are advisable. The distribution of the lamps in the ice rink should be done according to the specific lamp models used and the height of the arena ceiling.

LIGHTING COMPARISON FOR COMPARABLE LIGHT SOURCES (400W MH EQUIVALENT)

Table 9

	Metal Halide	HPS	Fluorescent T8	Fluorescent T5	Induction	LED
Life Span (hrs)	12,000–20,000	15,000–25,000	20,000–40,000	20,000–40,000	60,000–100,000	50,000–200,000
Instant-on	No	No	Yes	Yes	Yes	Yes
Instant Hot-restrike	No	No	Yes	Yes	Yes	Yes
Lumen Depreciation	35–45 %	40–50 %	10–15 %	5–10 %	25–30 %	5–30 % at 100,000 hrs
Efficacy	65–125 lm/W	60–150 lm/W	80–100 lm/W	85–105 lm/W	70–90 lm/W	70–90 lm/W
CRI	65	20	> 80	> 80	>80	>80
Dimmable	No	No	Yes	Yes	No	No
Mercury Content	Yes	Yes	Yes	Yes	Yes	Yes
Upfront Cost	N/A	N/A	Low	Low	Medium	Medium
Maintenance Cost	High	High	Medium	Medium	Low	Low
Energy Cost	High	High	Medium	Medium	Medium	Medium

3.5.6 ACOUSTICS AND NOISE CONTROL

The sound system of an ice rink should enable clear good quality of speech and music. Therefore environmental acoustics must be included in the design process. The importance of the acoustics is emphasized in multi-purpose rinks. The most significant acoustical parameter is the reverberation time, which should be low enough (< 3 s). High background noise level caused by ventilation and compressors (inside) or traffic (outside) has negative effects on the acoustical indoor environment. In some cases it is necessary to take into account the noise caused by the ice rink facility to its surroundings. Outdoor condenser fans and even the sounds of an ice hockey game may cause disturbing noise.

3.5.7 BUILDING AUTOMATION AND INFORMATION SYSTEMS

Modern automation systems enable demand-controlled operation of different systems, such as ventilation rates, ice rink air temperature and humidity, ice temperature, etc. An automation system enables functional and economical use of the different systems of the ice rink. Beside these traditional benefits of the building energy management system, there are other functions such as information and security systems that can be emphasized.

Currently worldwide management of energy is a major concern and the development and planning of the automation system is an integral part of this project.

Efficient automation for energy management of an ice rink must take into consideration all parameters of the building including external parameters as well as parameters of aggression of the ice. This will ensure a good quality of ice and enhance the credibility and quality of your project.

3.5.8 WATER AND SEWER SYSTEM

Water is needed in showers, toilets, and cafeterias, for cleaning and as flood and ice resurfacing water etc. The warm water system must be equipped with re-circulation to ensure short waiting times of warm water and to prohibit the risk of bacterial growth. Because of the legion Ella risk the hot water must be heated at least up to +55 ºC. Waste-heat from the refrigeration plant can be utilized to heat the resurfacing water and to pre-heat the hot water.

The sewer system of an ice rink need separate systems for the rink melted water drainage and the melting pit of waste-ice. Surface water drains for melted water from ice defrosting are required outside and around the rink.

3.6 ENERGY CONSUMPTION

Energy consumption is very different from one arena to another. Energy consumption of the refrigeration unit is subjected to the heat loads of the ice. Ceiling radiation is generally the largest single component of the heat loads. Other ice heat load components are: the convective heat load of the ice rink air temperature, lighting, ice maintenance, ground heat, humidity condensing from the air onto the ice, and pump-work of the cooling pipe network. The amount of heat radiated to the ice is controlled by the temperatures of the ceiling and ice surface and by a proportionality factor called emissive. Materials that are perfect radiators of heat would have an emissive of 1, while materials that radiate no heat would have an emissive of 0. In new facilities, using low-emissive material in the surface of the ceiling can reduce the ceiling radiation. Most building materials have an emissive rate near 0.9. The most common low-emissive material used in ice rinks is aluminum foil. It is the low emissive property (emissive as low as 0.05) of the aluminum foil facing the ice that makes this system so effective. Moreover, the low-emissive surface reduces heating demand and improves the lighting conditions of the rink.

The temperature level of the ice rink air has a significant effect on both the electricity consumption of the refrigeration unit and on the heating energy need. The higher the air temperature, the warmer the ceiling will be, which increases the ceiling radiation as well as the convective heat load of the ice. The convective heat load is relative to the temperature difference between the air temperature and ice-surface temperature and the air velocity above the ice. The most effective way to reduce convective heat load is to keep the ice temperature as high as possible and the air temperature as low as possible.

The other operational parameters, besides the rink air temperature, which affects the electricity consumption of the compressor and the heating energy consumption are the ice temperature and ice thickness. Rising of 1°C of the ice temperature gives 40–60 MWh savings in electricity and 70–90 MWh savings in heating per year in year-round operation. The thickness of the ice tends to increase over time. Increasing ice thickness brings about higher electricity consumption of the refrigeration unit and makes the maintenance of the ice more difficult. Recommended ice thickness is 2,5 to 3,0 cm. The thickness and the even levels of the ice must be controlled weekly in order to maintain it optimal.

After ceiling radiation and convection, ice resurfacing creates one of the highest heat loads in the arena, This load, imposed by the resurfacing of the ice sheet with flood water, in the range of 30 °C to 60 °C and 0.4 to 0.8 m^3 of water per one operation, can account for as much as 15 % of the total refrigeration requirements. A lower floodwater volume and temperature should be used to reduce the refrigeration and water cost.

The humidity of the ice rink air tends to condense on the cold ice surface. This phenomenon is mainly dependent on the outdoor air conditions and can be overcome by dehumidification of the ice rink air. Humidity problems may occur from a dripping ceiling or as fog above the ice. Humidity problems are one indication of possible moisture damage in the structures and thus must be taken seriously.

Lighting forms a radioactive heat load on the ice, which is relative to the luminous efficacy of the lamps.

Warm soil under the floor is a minor heat load on the refrigeration and can be handled with sufficient insulation between the soil and the cooling pipes.

The system pump-work is a heat load on the refrigeration system due to the friction in the cooling pipes and in the evaporator. Pump-work is affected by the cooling liquid used (there are several alternatives), pipe material and hydraulic sizing of the pipe network and the evaporator.

3.6.1 CASE STUDIES OF ENERGY CONSUMPTION

Energy consumption of a standard small ice rink depends mainly on the thermal conditions both inside (air and ice temperature) and outside (climate). In the following the effect of climatic conditions on the energy consumption of a standard ice rink facility is studied. The differences of the energy consumption, both electricity and heating, between the same prototype ice rink is studied in three locations: **Helsinki** (Finland), **Munich** (Germany) and **Miami** (USA). The technical description of the prototype ice rink is given in the previous section

1. Electric energy consumption

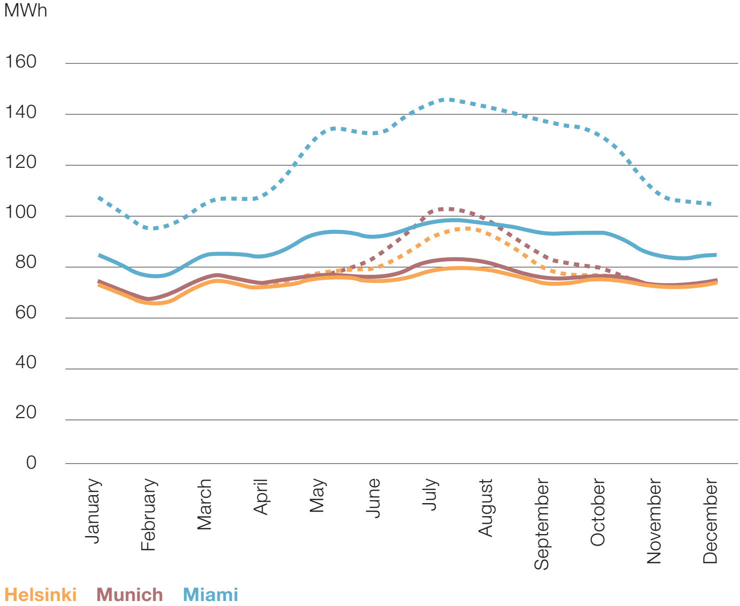
The electric energy consumption of the ice rink consists of ice refrigeration, rink lighting, air conditioning and heating systems (fans and pumps), public space lighting, different appliances, cleaning etc.

The refrigeration process consumes some half of the total electricity use of a small ice rink. In warm and humid conditions the dehumidification of the rink air also plays a big role in the energy consumption. The electricity consumption of the dehumidification system depends on the selected system: desiccant dehumidifiers consume mainly heat energy, which can be produced with gas or some other fuel but also electricity is possible, mechanical dehumidifiers (separate heat pump or ice refrigeration system) usually use electricity.

ELECTRIC ENERGY CONSUMPTION OF THE ICE RINK FACILITY

with (dashed lines) and without dehumidification

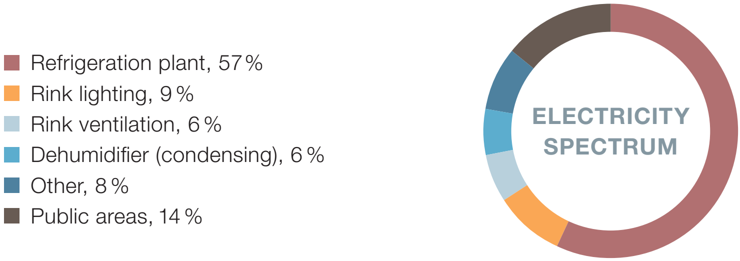
Figure 14



In the case of the dehumidification the ice refrigeration system is supposed to be used for the dehumidification.

ELECTRIC CONSUMPTION SPECTRUM OF THE PROTOTYPE ICE RINK IN MUNICH

Figure 15



Annual electricity consumption is 960 MWh with mechanical dehumidification (900 MWh without dehumidification).

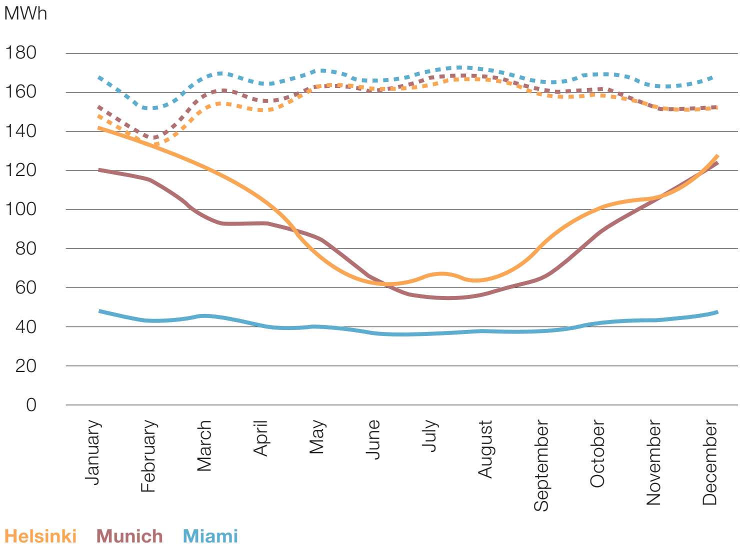
2. Heating energy consumption

Heating energy need is the sum of the heating need of the ventilation and infiltration air as well as the cooling effect of the ice and the conductive heat flows through the exterior envelope. The heat loads of the occupants, lights and other equipment are taken into account when determining the heating energy need of the ice arena. In many cases the waste ice (slush) of the ice resurfacing process must be melted in a special melting pit before draining it and melting requires heating. In some cases the slush can be dumped outdoors or even be re-used for building ski tracks. Depending of the climatic conditions the heat flows can be either negative or positive. For example in Miami the outdoor climate is so hot all year that the ventilation, air infiltration and conductive heat flows heat the ice rink space and actually the only cooling load is the ice. The cooling effect of the ice is still bigger than the heat loads and thus the rink must be heated even in Miami. The ice refrigeration process continously produces large amounts of heat. This heat can be utilized directly to space heating and supply air heating, pre-heating of hot water for ice resurfacing and showers, slush melting, ground heating (frost protection) under the ice pad and in the dehumidification processes. Condenser energy can save a great portion of the annual heating costs.

HEATING ENERGY NEED OF THE ICE RINK AND HEAT FROM THE REFRIGERATION CONDENSERS

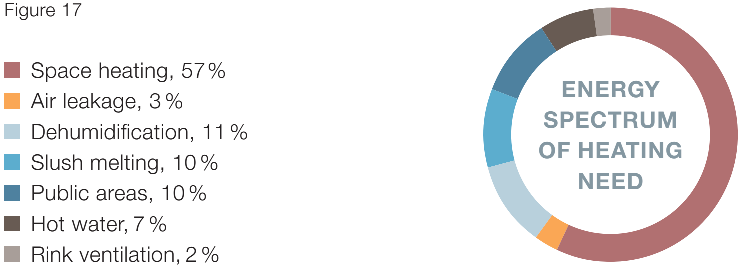
Condenser heat (dashed lines)

Figure 16



SPECTRUM OF HEATING ENERGY NEED OF THE PROTOTYPE ICE RINK IN MUNICH

Figure 17



The annual heating need is 1,100 MWh. Most of the heating need can be covered by free condenser heat of the ice refrigeration.

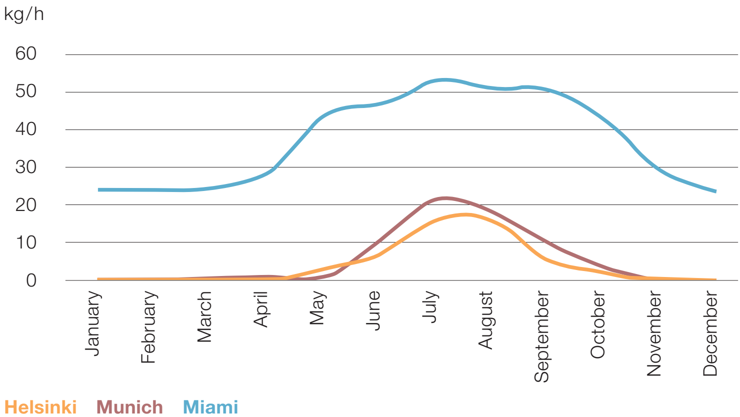
3. Dehumidification

The local weather conditions determine the dehumidification requirement which in turn affects the energy use of the facility. This can be seen in figure 18, showing that moisture removal requirements are much higher in Miami where the climate is hot and humid compared to the colder and drier climates in Munich and Helsinki. The dehumidification need is also affected by the ventilation need, air tightness of the building envelope and moisture load of the occupants.

MOISTURE REMOVAL OF THE DEHUMIDIFICATION SYSTEM IN ORDER TO MAINTAIN THE REQUIRED INDOOR AIR CONDITIONS

Figure 18

Temperature +10° and relative humidity 65 %

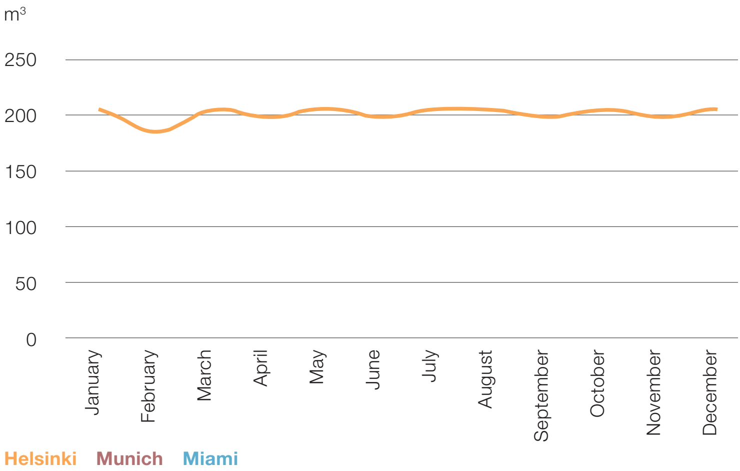


4. Water consumption

Water consumption consists of the ice resurfacing water and the sanitary water. Shower and toilet use dominate sanitary water consumption. In some cases treated water is used for cooling the condensers of the ice refrigeration plant. This is the case especially during the summer operation even in cold climates. Direct use of treated water should be avoided as far as possible for this purpose because of high operation costs.

WATER CONSUMPTION INCLUDING THE ICE RESURFACING WATER AND SANITARY WATER WITHOUT THE POSSIBLE CONDENSER FLUSH WATER OF THE ICE REFRIGERATION

Figure 19



The water consumption rate is the same for all the studied three cases.
Annual water consumption is 2,500 m^3.

3.7 ENVIRONMENTAL EFFECTS

Most of the environmental loads and impacts of an ice rink during it's life cycle are caused by travel to and from the rink, energy (electricity and heat) and water use. It is impossible to give exact or general figures of the loads because of the variety of energy production profiles in each case. In the following some results of the environmental load calculations in Finland are given.

In the analyzed case 91 % of the greenhouse gas emissions and 74 % of the acidifying emissions were due to energy usage during the life cycle (50 years).[1]

ENVIRONMENTAL LOADS OF AN ICE RINK IN FINLAND BASED BY LIFE CYCLE ANALYSIS (LCA) OF THE RINK (50 YEARS) EXCLUDING TRANSPORT.[1]

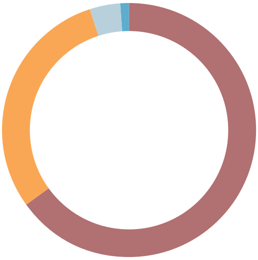
Table 10

Greenhouse gas emissions g/m², CO_2 esq	**Acidifying emissions g/m², CO_2 esq**
3,000,000	7,500

[1] Vaahterus T., Saari A. Environmental Loads of a Finnish indoor training ice-skating rink in the Context of LCA. Helsinki University of Technology, Publications 194, Espoo 2001. ISBN 951-22-5465-4, ISSN 1456-9329. (In Finnish).

AN EXAMPLE OF THE USE OF THE NATURAL RESOURCES OF A JUNIOR ICE HOCKEY TEAM IN FINLAND BASED ON MIPS CALCULATION

Figure 20



- Transport by cars, 65 %
- Energy and water, 30 %
- Construction, 4 %
- Equipment of the players, 1 %

MIPS – material input per service, kg/active skating hour.[2]

[2] Kiekko-Nikkarit Ry

The ecology of an ice rink can be improved by
- Using reusable and renewable materials and components in construction
- Minimizing the energy use (heat recovery, efficient appliances, renewable energy sources)
- Minimizing the distance between the rink and the users (town planning)
- Enabling public transport (storerooms for the equipment by the rink)

ECONOMIC PROFILE OF THE IIHF ICE RINK PROTOTYPE
CHAPTER 4

4. ECONOMIC PROFILE OF THE IIHF ICE RINK PROTOTYPE

4.1 INTRODUCTION

Ice rinks are unique buildings and should be accepted as such. Unfortunately, there are still plenty of new ice rinks and arenas being constructed without proper input by experts. In these projects, the potential for major problems is huge, both during the process of construction and when operational. To have a proper cost and operational structure for a new ice rink project, the special features required must be known, understood and taken care of.

A modern ice rink requires the correct tools to control the indoor climate, particularly the temperature and humidity factors which cannot be compared to regular buildings. If these elements are not taken into

consideration major problems arise soon, within 2 to 3 years. High indoor humidity causes serious corroding problems in steel structures and decay in wooden structures.

Saving costs in incorrect areas leads to serious damage in a short period of time. Some wood framed ice rinks have suffered major decay damage just 4 years after their completion, due to ignoring the humidification issue.

The ever increasing public demand for warmth and comfort in the stands lead to higher standard requirements to ensure the quality of the ice rink indoor climate. Having the temperature, just above the ice surface, at –4 degrees centigrade and at +15 degrees centigrade a few meters away behind the dasher boards on the first seating row, are usual requirements in modern ice rinks and arenas.

Simplified technical solutions more often than not, result in extremely high operational costs. Advanced technology reduces energy consumption and operating costs by up to 50 per cent in existing and proposed arena facilities, while simultaneously improving the indoor climate for customers.

High energy costs create the necessity to strive for energy efficiency. The combination of a clever design, correct technical features and skilled maintenance staff reduce operating costs remarkably.

The purpose of this guide is to offer technical and financial guidelines for the construction of a small modern ice rink.

This prototype is a customer-oriented facility that gives operators and investors the opportunity to provide their communities with an economically successful facility.

The IIHF prototype ice rink provides a variety services for on ice and dry floor activities that are summarized in Chapter 2. As in major multi-purpose arenas, it is quick and easy to change into a dry-floor facility.

4.2 CONSTRUCTION COSTS

The structural solutions, materials and equipment for building have great impact on the construction costs. The IIHF working group made the decision to design an IIHF ice rink prototype. The result of this decision is that the technical features are chosen as well as the structure, layout and volume of the facility. The technical features are described in chapters 3.3, 3.4 and 3.5 of this guide.

Construction costs are inevitably going to vary from country to country, even when we use the same technical definitions. The cost estimate shown in the excel is based on a location in Western Europe.

Lower labor costs in some countries, in comparison with the cost level in Europe, might result in substantial savings. The cost of the land and the utilities are not included in the summary.

The IIHF Facilities Committee has created an Excel Worksheet in order to help you to calculate the cost of this Ice rink prototype in your country.

This calculation gives you a fairly accurate indication of the cost of a small ice rink.

4.3 OPERATIONAL BUDGET

4.3.1 EXPENSES

The major utilities required in an ice rink operation are electricity, gas, and water. Also monthly fees related to the external financing (see chapter 5) for example mortgage payments, should be evaluated individually.

Maintaining a sheet of ice is a 24/7 commitment. The owners cannot simply turn off the electricity to the refrigeration plant when the building is closed because of ice quality and ventilation consequences.

It is therefore advisable to work with the local utility companies to establish favorable agreements for the facility. A common way to reduce the fixed costs is to negotiate partnership agreements with a local energy company or garbage disposal company or any other similar companies.

When preparing the budget for the operational costs one should take into consideration the tasks that could be fulfilled by volunteers. This would improve cost reduction. The tasks could be:

- Maintenance of the facility
- Cleaning
- Ice resurfacing maintenance

Mechanical service contracts have to be included for specialized work undertaken by professionals in their fields.

List of monthly expenses

- Financing costs
- Utilities – electricity
- Utilities – gas
- Utilities – water, sewer
- Insurance – Liability and Property
- Real estate taxes
- Other taxes licenses and fees

- Telephone
- Office expenses
- Cleaning supplies
- Trash removal
- Facility maintenance
- Personnel cost

Personnel

All ice facilities require competent, well-trained staff to ensure a successful enterprise. As previously mentioned, the costs of opening an ice facility are substantial. It is important to employ staff that understand the ice business and can operate the facility at maximum efficiency and profitability. Because a single sheet facility may operate for 18 hours a day, 7 days a week, the facility will need related man-hours to cover the operation.

In some countries, it is possible to utilize volunteer staff to cover many of the hours. However one should be aware that volunteer work ethics and expertise might be lacking. For a successful operation, the total number of staff can be adjusted. With larger public sessions or special events, more staff will be needed.

The rink manager is the key to a successful operation. The Manager oversees the entire spectrum of activities and services and should operate a customer-based operation.

The duties of the manager in a single sheet operation include, but are not limited to, the following areas:

- Personnel Administration
- Human Resource Management
- Ice Scheduling
- Ice Contracts
- Marketing
- Facility Maintenance
- Budgeting

It is necessary to employ at least two assistant rink managers (rink technicians). The assistant rink managers are typically responsible for the evening and weekend shift at the facility. It is their responsibility to schedule part time staff, maintain the facility, and serve as the main customer service person for the public. They are also responsible for ice maintenance and resurfacing.

An ice rink facility needs a full time multitalented and multitasking secretary in the role of receptionist, registrar and accountant, to name a few. This person must be aware of all the activities offered at the rink in order to be able to answer questions from the general public.

In addition, a single sheet facility may employ 2 to 3 additional part time operational staff to drive the ice resurfacer, work evening or weekend shifts, maintain the building and keep it clean.

As the ice rink industry evolves and changes, it is important to keep staff up-to-date on the latest advancements in the industry. With a plan for staff training and education, rink operators will have the opportunity to learn more efficient and cost effective methods of running an ice rink. A budget should be created to cover training course registrations and expenses.

In many areas of the world, the user groups such as the hockey or figure skating clubs will take responsibility for the programs on the ice. In other parts of the world, depending on the type of rink operation and its regional location, there are several other positions that may be added to the full time staff. A skating director would handle all Learn to Skate and figure skating programs in the facility.

This person would serve, as a teaching professional in the Learn to Skate program, would hire other skating coaches, and coordinate all skating programs. A hockey director would operate in a similar manner to manage the hockey operations at the facility. If necessary, a marketing director may be hired to promote the facility and the many programs that are offered to the community.

If the rink expands to include a concession stand or a pro shop, both a concession manager and a pro shop manager would be required.

Personnel list
- Rink Manager
- Technical Staff (2)
- Office Secretary
- Part-time operations staff (2–3)
- Part time maintenance staff

It should be noted that an ice rink with two ice pads can be operated with the same number of staff as the single ice surface rinks. Other expenses, such as energy, can be reduced, in comparison with the doubled use of the facility.

4.3.2 INCOME

To operate successfully, ice rink facilities must offer activities and programs for everyone in the community. The more potential users the facility has, the greater its chances of long term success. There are many program ideas that help rinks to prosper, but actual incomes vary greatly due to the local community, area or socioeconomic environment.

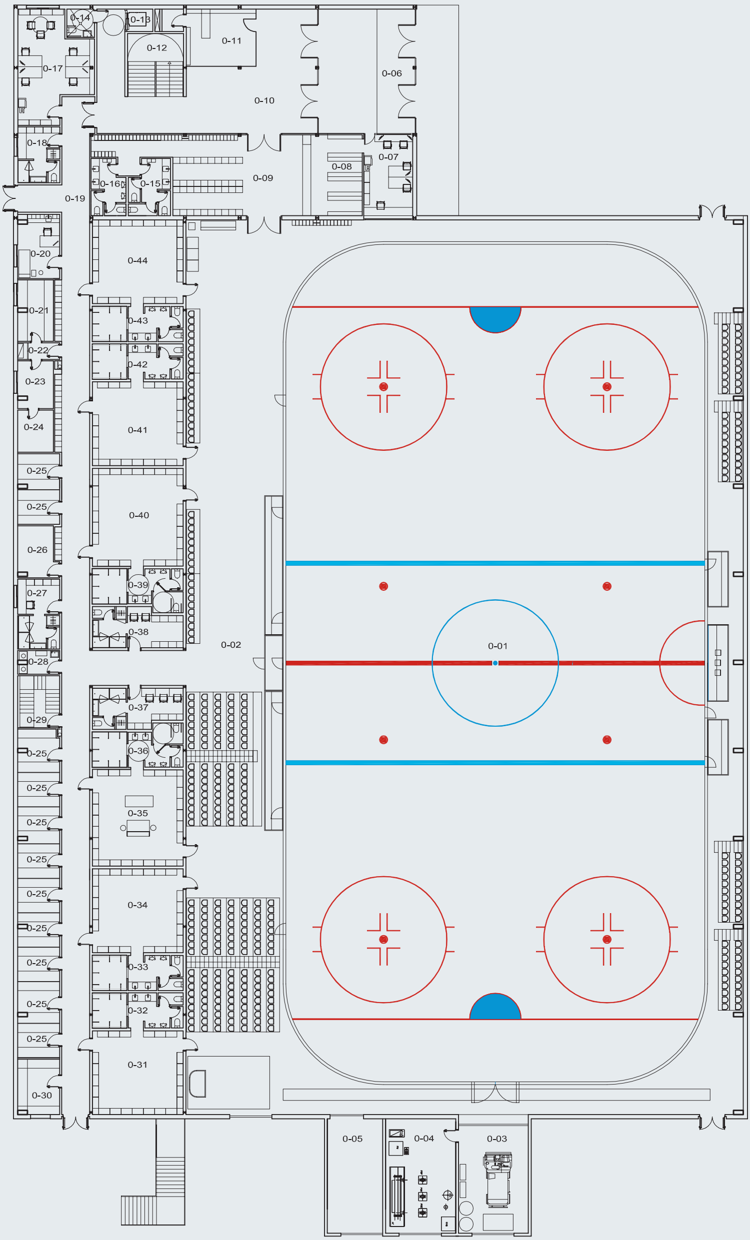
Another key to success is to offer programs that will allow your customers to use your facility for a lifetime. A lifetime customer would, for example, enter your facility as someone interested in skating, start in learn to skate lessons, decide to concentrate on hockey or other ice sports, compete as a youth participant in their chosen sport, then remain with your facility in adult recreational programs in the future.

Income categories

- Youth Hockey Programs
- Adult Hockey Programs
- Group Skating Lessons
- Public Skating
- Schools
- Contract Ice Rental
- Figure Skating
- Curling
- Camps/Clinics
- Parties/Special Events
- Fairs, exhibitions
- Advertising

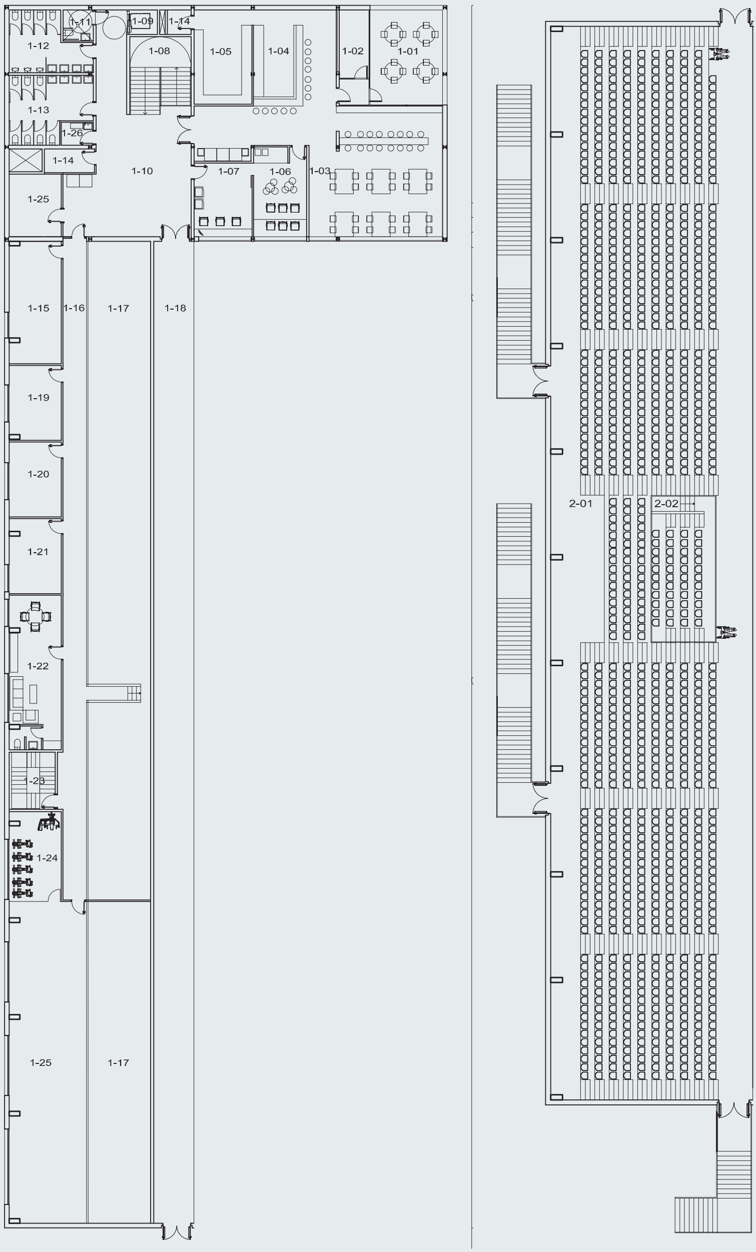
It is also important to schedule your ice usage for success. There are several examples of "best practices" to be followed, and suggested time frames are noted with each programming option.

IIHF ICE RINK PROTOTYPE, GROUND FLOOR



	ROOMS	m²
	GROUND FLOOR	**3,959.75**
0–01	ICE PAD	1,791.50
0–02	MAIN HALL	795.80
0–03	ICE RESURFER	47.00
0–04	MECHANICAL ROOM (COMPRESSORS)	45.50
0–05	STORAGE (GOALS AND SHORT TRACK)	36.30
0–06	ENTRANCE	64.80
0–07	TICKETING, ARENA OFFICE & CONTROL AREA	23.60
0–08	RENTAL SKATES COUNTER	26.90
0–09	PUBLIC SKATING DRESSING ROOM	71.00
0–10	LOBBY	95.00
0–11	SHOP	26.60
0–12	STAIRS	20.20
0–13	LIFT	4.10
0–14	LAVATORY (DISABLED)	5.60
0–15	PUBLIC SKATING LAVATORY FEMALE	13.00
0–16	PUBLIC SKATING LAVATORY MALE	10.80
0–17	CLUB OFFICE	40.60
0–18	STAFF LOCKER ROOM	14.70
0–19	CORRIDOR	171.65
0–20	MEDICAL/FIRST AID ROOM	16.35
0–21	SKATES AND MAINTENANCE ROOM	15.90
0–22	ELECTRICAL CONTROL ROOM	4.15
0–23	FIRE EXTINGUISH ROOM	12.10
0–24	PLUMBING ROOM	10.80
0–25	DRYING ROOMS (11 un)	102.55
0–26	FIGURE SKATING STORAGE ROOM	12.85
0–27	FIGURE SKATING COACHES ROOM	17.60
0–28	LAUNDRY & CLEANING ROOM	6.20
0–29	INNER STAIRS	13.55
0–30	ICE HOCKEY EQUIPMENT ROOM	15.05
0–31	DRESSING ROOM HOCKEY 1	43.50
0–32	SHOWERS & LAVATORY HOCKEY 1	19.30
0–33	SHOWERS & LAVATORY HOCKEY 2	19.30
0–34	DRESSING ROOM HOCKEY 2	42.00
0–35	DRESSING ROOM HOCKEY HOME TEAM	48.45
0–36	SHOWERS & LAVATORY HOCKEY HOME TEAM	20.90
0–37	DRESSING ROOM REFEREES	20.80
0–38	DRESSING ROOM HOCKEY COACHES	20.80
0–39	SHOWERS & LAVATORY HOCKEY VISITOR TEAM	20.95
0–40	DRESSING ROOM HOCKEY VISITOR TEAM	49.00
0–41	DRESSING ROOM FIGURE SKATING MALE	42.10
0–42	SHOWERS & LAVATORY FIGURE SKATING MALE	19.30
0–43	SHOWERS & LAVATORY FIGURE SKATING FEMALE	19.30
0–44	DRESSING ROOM FEMALE FIGURE SKATING	42.30

IIHF ICE RINK PROTOTYPE, FIRST FLOOR



	ROOMS	m²
	FIRST FLOOR	**1,239.05**
1–01	TERRACE	36.95
1–02	SMOKING AREA	9.30
1–03	RESTAURANT	92.65
1–04	CAFÉ	48.10
1–05	KITCHEN	30.95
1–06	VIP BOX	23.05
1–07	GAME SUPERVISOR & TIMING BOX	20.55
1–08	STAIRS	20.20
1–09	LIFT	4.40
1–10	SPECTATORS LOBBY	76.30
1–11	LAVATORY (DISABLED)	5.60
1–12	SPECTATORS LAVATORY MALE	21.20
1–13	SPECTATORS LAVATORY FEMALE	24.40
1–14	RESTAURANT STORAGE	5.50
1–15	TEAM MEATING ROOM	30.45
1–16	CORRIDOR	70.95
1–17	UNDER SEATS ZONE (HEIGHT MINUS 2,50)	279.15
1–18	SPECTATORS PASSAGE	168.35
1–19	FIGURE SKATING OFFICE	19.00
1–20	SHORT TRACK OFFICE	19.00
1–21	ICE HOCKEY OFFICE	19.00
1–22	VIP RECEPTION & CATERING ROOM	39.40
1–23	INNER STAIRS	12.05
1–24	GYM	22.90
1–25	WARM-UP & STRECHING ZONE	114.00
1–25	MECHANICAL ROOM (AIR)	21.30
1–26	CLEANING ROOM	4.35
	SECOND FLOOR	**749.94**
2–01	EMERGENCY EXIT ZONE	147.40
2–02	SPECTATORS ZONE	602.54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FINANCING
CHAPTER 5

5. FINANCING

5.1 CONSTRUCTION COSTS/INVESTMENT COSTS

The construction of ice sports facilities in countries with an ice sports tradition were in earlier times financed by local authority institutions. These institutions were frequently supported by means of construction grants from local, regional or central governments.

Today, the economic situation of the public sector in most countries has changed dramatically. The role of the government is continuously debated and tasks that were usually appointed to these governments are now the responsibility of the private sector. The shifting from governmental financing and operation to other organizations changed the management philosophy of sports facilities remarkably, as will be discussed in 5.2.

The private sector has emerged as a provider of ice sports. Investors have been found as a source of finance that, rather than having their profits skimmed off by the tax authorities have enjoyed high tax write-offs (loss allocation). This type of financial assistance takes the weight off the investment budget. Low interest rates and loan repayment installments have yielded a lower burden on the current budget for facility operation.

Modern ice sports facilities make use of entirely different forms of financing, many of which fall within the concept of public-private partnership (PPP). This is where the public sector and commercial industry search jointly for sources of financing. In this context, sports clubs can also act as private partners by providing either funding or manpower for construction and equipment. There are nevertheless limits to the latter, because work performed by the sports club on a building with sophisticated engineering, such as an ice sports facility, is generally only feasible for a small number of construction and technical tasks.

On PPP projects, the private sector is put in a more profitable position than was possible in the past, through the free provision of building land by the local authority (or by the payment of a token fee). If the design and construction of the building is controlled by a commercial operator, certain legal obstacles can be evaded, e. g. the guidelines (regulations) for State-awarded contracts. If the construction and engineering services are correctly designed and specified, construction costs can be reduced without any loss of quality. This reduces overall project expenditure, the interest and repayment installments are lower, and the operating costs are less heavily burdened year after year.

The preparation of a public-private construction project does not differ qualitatively from earlier forms of project financing and realization at all.

The analyses of demand for such a facility, and of the required space and rooms are the same as before. The design and tendering procedures require the same attention (see above) and the companies for construction and interior decorating must be selected according to the same criteria as in the past. For the public partner, it is important to reach user-friendly agreements early on with the private partner concerning opening hours and socially acceptable pricing. Of course, the private partner will not enter into agreements that put the achievement of a surplus in facility operations at risk.

A special form of Public-Private-Partnership is the leasing of a property for a period of time with an option of renewing the agreement or purchasing the property. Given favorable terms and reliable partners, a leasing agreement also ensures that the ice sports facility remains in immaculate structural and technical condition throughout the term of the lease.

5.2 OPERATIONAL COSTS

Chapter 4.2 and 4.3 described the main construction and annual costs of the IIHF Prototype Ice Rink with a standard ca.30 x 60 m ice pad. The expenditure side depends on the structural and technical quality of the facility, the level of labor costs, and the various energy, water and disposal charges. The income side is affected by such factors as location, population density, awareness rating and interest in ice sports, admission pricing, opening hours and number of users.

The successful operation of the facility in the long term can only be ensured if the revenue surplus covers the interest and repayment installments as well as sufficient upkeep of the building and its installations.

THE DATA ORIGINS FROM 12 RINKS IN EUROPE AND NORTH AMERICA

in €	January	February	March	April	May	June
Incomes						
Sports	27,370	26,270	28,325	26,575	28,035	27,355
Advertising	8,000					
Public rentals	52,178	46,733	45,248	50,518	49,890	47,975
Rentals	5,700	5,700	5,700	5,700	5,700	5,700
Other Incomes						3,500
Total	**93,248**	**78,703**	**79,273**	**82,793**	**83,625**	**84,530**
Expenses						
Salaries & Social Security	16,000	16,000	16,000	16,000	16,000	16,000
Accounting services	330	330	330	330	330	330
Cleaning Services	1,300	1,300	1,300	1,300	1,300	1,300
Maintenance Services	1,500	1,500	1,500	1,500	1,500	1,500
Insurances	1,250	1,250	1,250	1,250	1,250	1,250
Security Services	350	350	350	350	350	350
Utilities	10,255	9,545	11,228	12,009	14,155	14,371
Marketing	300	300	300	300	300	300
Bank Costs	550	550	550	550	550	550
Repair & Maintenance Supplies	1,700	1,700	1,700	1,700	1,700	1,700
Supplies	1,600	1,600	1,600	1,600	1,600	1,600
Other running costs	850	850	850	850	850	850
Ice Pad Painting						
Subscriptions & Memberships	1,440					
Quality Control / Training	1,350					
Cooling Fluids						
Local Taxes				2,500		2,500
Activity Taxes				1,250		
Annuity Depreciation						
Loans	25,550	25,550	25,550	25,550	25,550	25,550
Total	**64,324**	**60,825**	**62,507**	**67,038**	**65,434**	**68,151**
Result						
Profit	**28,923**	**17,878**	**16,765**	**15,754**	**18,191**	**16,379**
Profit after Taxes						

July	August	September	October	November	December	Total
27,370	0	26,420	27,960	27,355	27,215	300,250
		21,700				29,700
52,490	0	50,325	50,523	48,225	54,240	548,343
5,700	0	5,700	5,700	5,700	5,700	62,700
		10,000				13,500
85,560	**0**	**114,145**	**84,183**	**81,280**	**87,155**	**954,493**
16,000	16,000	16,000	16,000	16,000	16,000	192,000
330	330	330	330	330	330	3,960
1,300	700	1,300	1,300	1,300	1,300	15,000
1,500	1,500	1,500	1,500	1,500	1,500	18,000
1,250	1,250	1,250	1,250	1,250	1,250	15,000
350	350	350	350	350	350	4,200
14,448	7,418	17,301	16,227	12,601	10,437	149,994
300	300	300	300	300	300	3,600
550	550	550	550	550	550	6,600
1,700	1,700	1,700	1,700	1,700	1,700	20,400
1,600	400	1,600	1,600	1,600	1,600	18,000
850	250	850	850	850	850	9,600
	3,500					3,500
						1,440
						1,350
	1,600					1,600
					2,500	7,500
	1,250				1,250	3,750
25,550	25,550	25,550	25,550	25,550	25,550	306,595
65,728	**62,648**	**68,580**	**67,507**	**63,880**	**65,467**	**782,089**
19,832	**–62,648**	**45,565**	**16,676**	**17,400**	**21,688**	**172,403**
			TAXES	**25%**	**43,101**	**129,303**
		LOAN	**6,667,209**		**Percentage**	**1.94%**

Although the latter will be negligible in the first few years, initially low reserves should be set aside from the outset.

A continuous theme is that of the quality of the work performed by the various tradesmen. At this point, it is important to highlight the effect that appropriate (not excessive) quality can have on a building's life span. Usually it can be assumed that 20 % of the costs arise through construction and 80 % through operation and maintenance. If, instead, only 4 % more is spent on the initial investment, operating and maintenance costs are reduced to 70 %. This represents an appreciable cut in annually occurring costs.

The possibility of intense year-round use is necessary to consider in the planning process. Only high capacity utilization rates can warrant the investment and recurring annual overheads and maintenance costs associated with an adequately staffed, state-of- the-art facility of this type.

The construction of an ice rink should be considered wherever the following basic prerequisites are met: In moderate climate zones, such as Central Europe, indoor ice rinks with artificial ice should be implanted in communities with between 20,000 and 50,000 inhabitants, depending on the tradition of ice sports in that particular region. The population density per square kilometer should be at least 150 within a 12-kilometer radius.

IIHF RULES
FOR ICE RINKS

These are the specifications of
the IIHF Rule Book.

DEFINITION OF THE RINK

Ice hockey is played on an enclosed sheet of ice with markings specific to the rules of play. The rink must be made fair and safe for players and set up in a way which also considers spectator safety to be of paramount importance. The only markings allowed on any and all parts of the rink are those outlined in these rules or in the IIHF's Marketing Regulations.
Any deviations from these requirements for any IIHF competition require IIHF approval. For arena guidelines and facility requirements, see relevant manuals.

ICE SURFACE/FIT TO PLAY

i. Ice hockey must be played on a white ice surface known as a rink. It must be of a quality deemed fit to play by the on-ice officials in charge of the game.
ii. The ice surface must be prepared with water and chemicals to a consistent quality in all areas and must be properly frozen by either a reliable system of refrigeration to ensure stable temperature and density or by natural causes.
iii. If, prior to or during the playing of a game, any section of the ice or rink becomes damaged, the on-ice officials will immediately stop the game and ensure the necessary repairs are made before game action resumes.
iv. If the repairs delay the game unduly, the referee has the option to send the teams to their respective dressing rooms until the rink is deemed fit to play. If the problem cannot be solved in a short period of time or if any section of the ice or rink is of a quality that makes playing the game dangerous, the referee has the right to postpone the game until such a time as the ice or rink can be properly made fit to play.
v. If any lengthy delay occurs within five minutes of the end of a period, the referee has the option to send the teams to their respective dressing rooms to begin the intermission immediately. The rest of the period will be played after the repairs and resurfacing of the ice has been completed and the full intermission time has elapsed. When play resumes, teams will defend the same goal as before play was postponed, and at the end of the period they will change ends and begin playing the ensuing period without delay.
vi. If the playing area is affected by fog or other opaque air, the referee will not permit game action to take place until the air in the arena is suitably clear for players and fans to experience a safe environment.

PLAYERS' BENCHES

i. Although the players' benches are not a part of the ice surface, they are considered a part of the rink and are subject to all rules pertaining to the ice surface.

ii. The only people allowed on or at the players’ benches are the dressed players and not more than eight team officials.
iii. Both players’ benches must be of the same dimensions and quality, offering advantage to neither team in any manner.
iv. Each players’ bench must start 2.0 metres (6' 6 ¾") from the centre red line and be 10 metres (32' 9 ¾") wide and 1.5 metres (5') deep.
v. Each players’ bench must have two doors, one at either end.
vi. The players’ benches must be located on the same side of the rink, opposite their respective penalty boxes and the scorekeeper’s bench.
vii. Teams must use the same bench for the duration of a game.
viii. Players’ benches must be enclosed on all three sides from spectators, the only open-air side being the one with direct access to the ice for the players themselves.
ix. The designated home team is entitled to its choice of players’ bench.

PENALTY BOXES

i. A penalty box, one for each team, must be situated on either side of the scorekeeper’s bench and across from their respective players’ benches. Each box must be of the same size and quality, offering advantage to neither team in any manner.
ii. Teams must use the penalty box opposite their players’ bench and must use the same penalty box for the duration of a game.
iii. Each penalty box must have only one door for both entry and exit and must be operated only by the penalty-box attendant.
iv. Only the penalty-box attendant, penalized skaters, and game officials are allowed access to the penalty boxes.
v. Both penalty boxes must be situated in the neutral zone.

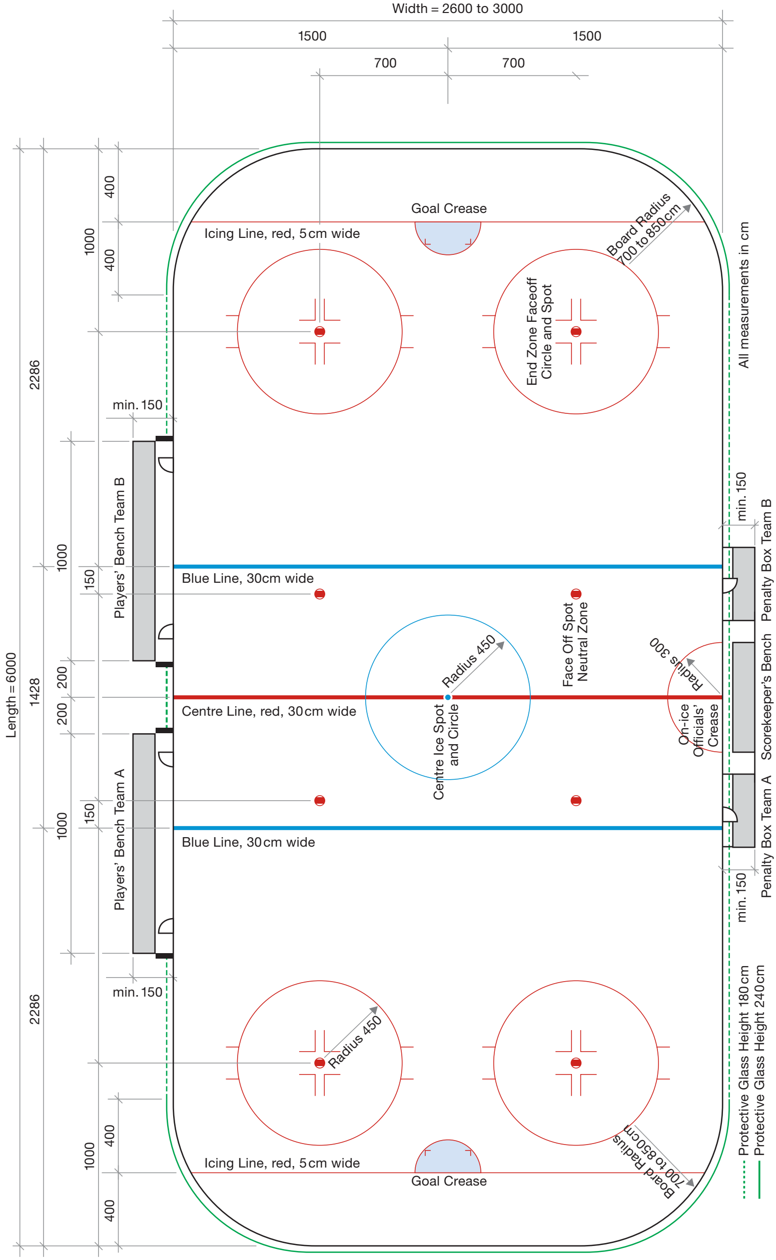
OBJECTS ON ICE

i. The ice surface is intended only for players and on-ice officials. Any objects on the ice that are not directly related to them or their equipment, or the puck, are strictly forbidden. Any damage to the playing facilities by any means will result in the immediate stoppage of game action. Play will not resume until the ice is clear of these objects and the playing area ready for game action.

STANDARD DIMENSIONS OF RINK

i. For top-level IIHF competitions, the recommended dimensions of the rink are 60 metres (197') long and 25–30 metres wide (82'–98' 5").
ii. The corners of the rink must be rounded in the arc of a circle with a radius of 7.0 to 8.5 metres (23'–28').
iii. In countries where the standards set out in Rules 12-i and 12-ii are not possible, other dimensions are allowed so long as they are approved by the IIHF before the competition or game is played.

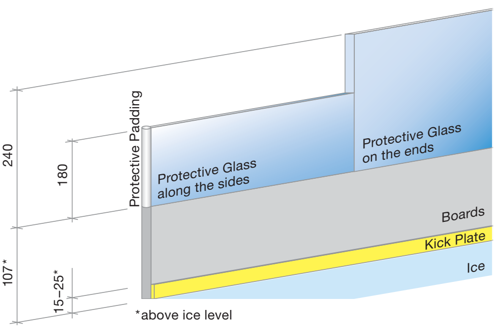
iv. For IIHF World Championship tournaments, the official dimensions must be 60 metres (197') long and 30 metres (98'5") wide.



RINK BOARDS

i. The rink must be contained within an enclosure known as boards which are made out of sections of wood or plastic and be painted white.
ii. The space between the panels which comprise the boards should be no more than 3 mm (⅛").
iii. The boards must be constructed in such a manner that the surface facing the ice must be smooth and free of any obstruction that could cause injury to players or unnaturally alter the course of a puck.
iv. The height of the boards should be 107 cm (42") from the ice surface.
v. Affixed to the bottom of the boards must be a yellow kick plate which extends around the entire circumference along the ice. It should be 15–25 cm (6"–10") high.
vi. Affixed to the top of the boards must be a blue dasher which extends around the entire circumference of the boards and marks the area where the boards end and the protective glass begins. The dasher should be 110 cm (43 5⁄16") from the concrete flooring under the ice.

PROTECTIVE GLASS



All measurements in cm

i. Panes of Plexiglas or similar acrylic material that are 12 mm–15 mm (½"–⅝") thick and both transparent and of high durability must be inserted into and affixed to the top of the boards. The glass must be aligned using stanchions which allow the sections to be flexible. This is an obligatory component for IIHF competitions.
ii. The protective glass must be 2.4 metres (7' 10 ½") high behind the goals and must extend at least 4.0 metres (13' 1 ½") from the icing line towards the blue line. The glass must be 1.8 metres (5' 11") high along the sides except in front of the players' benches.
iii. There is no protective glass permitted in front of the players' benches, but there must be protective glass of similar height outlined in 14-ii behind and along the sides of the players' benches and penalty boxes. Where the glass deviates from the boards there must be protective padding extending its full height.

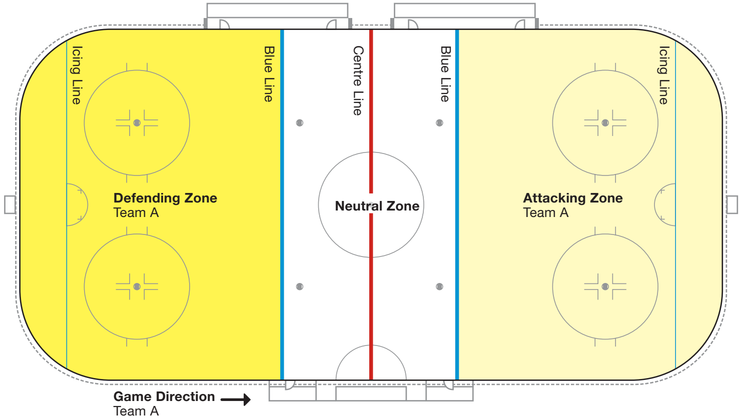
iv. The protective glass and fixtures used to hold the boards in position must be mounted on the side away from the playing surface.
v. The gaps between the panels of protective glass must not be more than 5 mm (3⁄16").
vi. No openings or holes are allowed anywhere along the full circumference of the protective glass with the exception of a round hole 10 cm (4") in width in front of the scorekeeper's bench.
vii. The protective glass must be installed in such a way that one sheet can be replaced without compromising the integrity of any others.

PROTECTIVE NETTING
i. Protective netting of a suitable height must be suspended above the end-zone protective glass behind both goals and must extend around the rink at least to where the icing line meets the boards.
ii. Protective netting behind both goals is an obligatory component for IIHF competitions.

DOORS
i. All doors allowing access to the ice surface must swing inwards, towards the spectator area.
ii. The gaps between the doors and the boards must not be more than 5 mm (3⁄16").

ICE SURFACE MARKINGS/ZONES
i. The ice surface must be divided lengthwise by five lines marked on the ice surface, extending completely across and continuing vertically up the boards to the dasher: icing line, blue line, centre red line, blue line, icing line.
ii. The middle three lines mark the three zones of the rink and are referred to as the defending zone, the neutral zone, and the attacking zone. The zones will be established as such: icing line to blue line, blue line to blue line, blue line to icing line, as measured from the middle of each line.
iii. The centre red line divides the length of the rink exactly equally. It must be 30 cm (12") wide and extend up the kick plate and up the full height of the boards to the dasher. In case of advertising allowed on the boards, the lines must be marked at least on the kick plate.
iv. The two icing lines must be marked 4.0 metres (13' 1 ½") from the flat and middle sections of the end boards (i.e., not the curved sections) at both ends of the rink and must be 5 cm (2") wide.
v. The blue lines must be 22.86 metres (75') from the flat and middle sections of the end boards at both ends of the rink and be 30 cm (12") wide. They must extend up the kick plate and onto the boards. In case of advertising allowed on the boards, the lines must be marked at least on the kick plate.

vi. For open air rinks, all lines must be 5 cm (2") wide.



ICE SURFACE MARKINGS/FACEOFF CIRCLES AND SPOTS

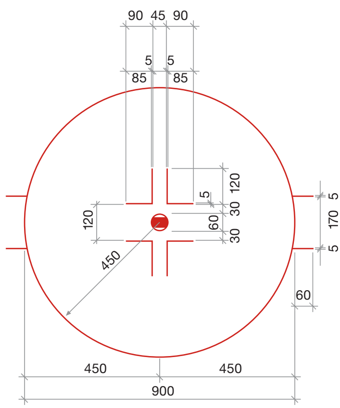
i. There must be nine faceoff spots on the ice. These are only places at which an on-ice official can drop the puck to begin game action.

ii. All faceoff spots must be red except for the one at centre ice which must be blue.

iii. A circular spot 30 cm (12") in diameter must be marked exactly in the centre of the ice surface. With this spot as a centre, a circle with a radius of 4.5 metres (14' 9 ¼") must be marked with a blue line 5 cm (2") wide. This constitutes the centre faceoff circle.

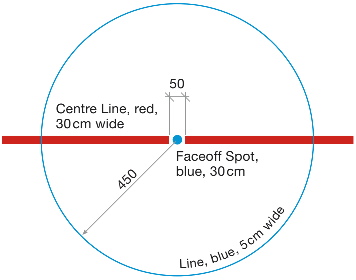
iv. A total of four faceoff spots 60 cm (24") in diameter must be marked in the neutral zone. There must be two such spots 1.5 metres (5') from each blue line. These faceoff spots should be the same distance from an imaginary straight line running from the centre of both goal lines as the end-zone faceoff spots.

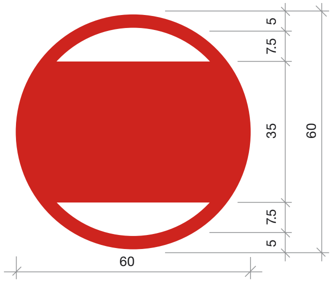
v. A total of four faceoff spots 60 cm (24") in diameter and red circles 5 cm (2") wide with a radius of 4.5 metres (14' 9 ¼") from the centre of the faceoff spot must be marked on the ice in both end zones and on both sides of each goal. On either side of the end zone faceoff spots must be marked a double “L”.



All measurements in cm

vi. The location of the end zone faceoff spots must be fixed along a line 6 metres (19' 8 ½") from each icing line. Parallel to this, mark two points 7 metres (23') on both sides of a straight line drawn from the centre of one goal line to the other. Each point will be the centre of the end faceoff spot.



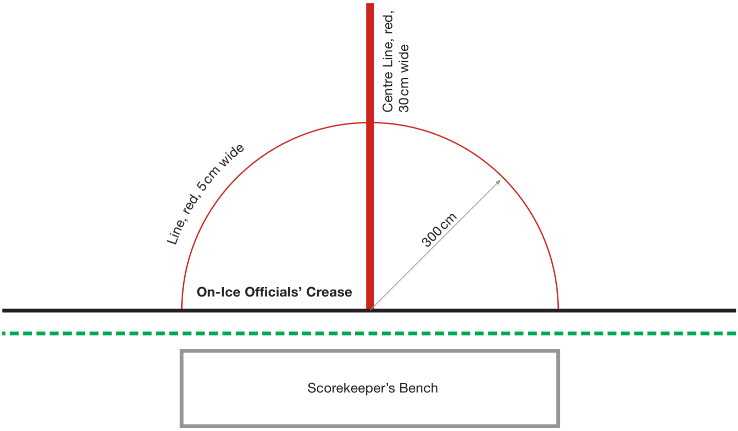


All measurements in cm

ICE SURFACE MARKINGS/CREASES

i. There are three creases on the ice: one for each goaltender in front of either goal net and one at the boards by the scorekeeper's bench for on-ice officials.

ii. The red, on-ice officials' crease must be marked on the ice in a semi-circle 5 cm (2") wide with a radius of 3.0 metres (9' 10") immediately in front of the scorekeeper's bench. Players are not allowed in this area during stoppages of play when on-ice officials are in consultation with each other or reporting to off-ice officials.



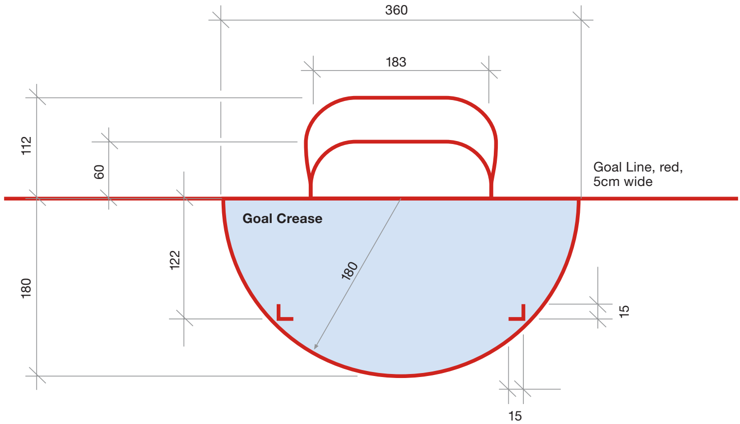
iii. In front of each goal net a goal-crease area must be marked by a red line, 5 cm (2") wide.

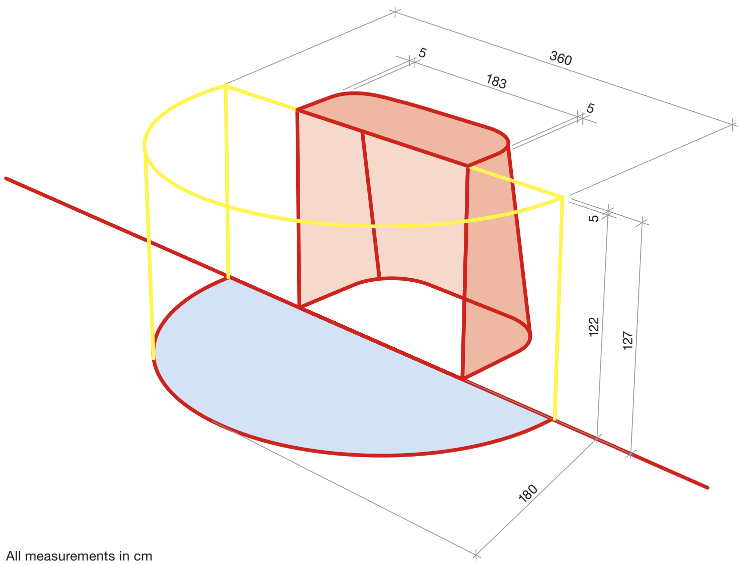
iv. The goal-crease area must be painted light blue, but inside the goal-net area from the goal line to the back of the goal net must be white.

v. The goal crease is a three-dimensional space and includes the air above the markings on ice up to the top of the crossbar.

vi. The goal crease must be marked as follows:
   1. A red semi-circle 180 cm (71") in radius and 5 cm (2") in width must be drawn using the centre of the goal line as the centre point;
   2. A red, “L”-shaped marking of 15 cm (6") in length (each line) must be added at each front corner;
   3. The location of the “L” is measured by drawing an imaginary line 122 cm (48') from the goal line to the edge of the semi-circle.

vii. The measurements of all creases must be taken from the outside edge of the lines such that the full thickness of the lines is considered part of the crease.





All measurements in cm

GOAL NET

i. Each rink must have two goal nets, one at either end of the rink.

ii. The goal net is comprised of a goal frame and netting.

iii. The open end of the goal net must face centre ice.

iv. Each goal net must be located in the centre of the icing line at either end and must be installed in such manner as to remain stationary during the progress of the game. For top-level IIHF competitions, flexible goal pegs to hold the goal frame in place but which displace the goal net from its moorings upon significant contact are mandatory. These are strongly recommended for other competitions. The holes for the goal pegs must be located exactly on the icing line.

v. The goal posts must extend vertically 1.22 metres (4') above the ice surface and be 1.83 metres (6') apart (internal measurements). The goal posts and crossbar that form the tubular steel goal frame must be of a specified design with a diameter of 5 cm (2").

vi. The goal posts and crossbar must be red. All other parts of the net and frame must be white.

vii. The goal posts and crossbar must be completed by a white frame inside the base of the goal frame along the ice and top extending from post to post towards the end boards and supporting the netting, the deepest point of which must be 0.60–1.12 metres (2'–3'8").

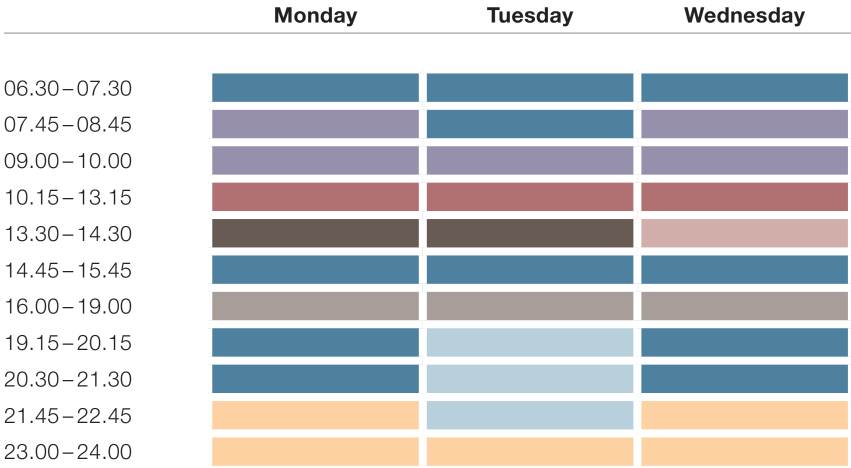
viii. A netting of durable white nylon cord must be attached securely over the entire back of the goal frame in such a manner as to trap the puck in the goal net after it has entered and to prevent the puck from entering the goal net in any way other than in front.

ix. On-ice officials are required to check the netting before the start of each period of play. If they find any damage to the netting, game action cannot begin until the necessary repairs have been made.

x. The inside parts of the supports of the white frame, other than the goal posts and the crossbar, must be covered by white padding. The padding of the base frame must start not less than 10 cm (4") from the goal post and must be attached in a manner that does not restrict the puck from completely crossing the goal line.

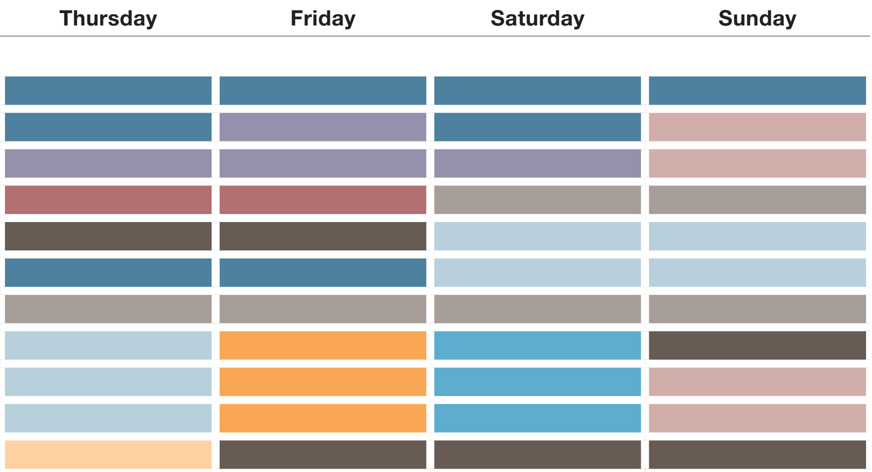
SAMPLE WEEKLY SCHEDULE, ICE RINKS THROUGHOUT THE WORLD, LIST OF EQUIPMENT

SAMPLE WEEKLY SCHEDULE



- Youth Hockey, 10 hours
- Adult Hockey, 6 hours
- Senior Hockey, 5 hours
- Figure Skating, 19 hours
- Short-Track, 9 hours
- Public Skating Schools, 15 hours

	%	**Total** hours	**January**	**February**	**March**	**April**
	100.00	**5,006**	**465**	**435**	**449**	**450**
Ice Hockey	19.95	999	92	86	95	86
Figure Skating	18.10	906	81	80	86	81
Short-Track	8.57	429	39	38	40	38
Public Skating Schools	14.26	714	63	63	69	63
Competitions	2.88	144	15	12	12	15
Private Rental	7.65	383	37	33	34	35
Public Skating Schools	25.59	1,281	123	111	101	117
Disco Skating	3.00	150	15	12	12	15



- Competitions, 3 hours
- Private Rental, 8 hours
- Public Skating, 27 hours
- Disco Skating, 3 hours

May	June	July	August	September	October	November	December
465	**450**	**465**		**447**	**465**	**450**	**465**
96	91	92		86	94	91	90
84	83	81		81	83	83	83
39	39	39		39	39	39	40
66	66	63		66	63	66	66
12	12	15		12	15	12	12
36	33	37		33	36	33	36
120	114	123		115	123	114	120
12	12	15		15	12	12	18

ICE RINKS THROUGHOUT THE WORLD

COUNTRY	RINKS In-door	RINKS Out-door
Andorra	1	0
Argentina	0	1
Armenia	3	4
Australia	10	0
Austria	47	72
Belarus	31	3
Belgium	16	0
Bosnia & Herzegovina	1	0
Brazil	4	0
Bulgaria	5	4
Canada	2,631	5,000
Chile	1	0
China	48	64
Chinese Taipei	4	0
Croatia	2	4
Czech Republic	21	148
Denmark	26	0
DPR Korea	3	12
Estonia	6	4
Finland	260	24
France	135	9
FYR Macedonia	1	3
Georgia	4	1
Germany	202	45
Great Britain	63	0
Greece	0	0
Hong Kong	4	0
Hungary	24	13
Iceland	3	0
India	10	4
Ireland	0	5
Israel	3	0
Italy	45	24
Japan	34	123
Kazakhstan	19	128
Korea	38	4
Kuwait	2	0
Kyrgyzstan	3	2
Latvia	19	0
Liechtenstein	0	0
Lithuania	8	4

COUNTRY	RINKS In-door	RINKS Out-door
Luxembourg	3	1
Macau	1	0
Malaysia	1	0
Mexico	23	0
Mongolia	0	13
Morocco	2	0
Netherlands	26	2
New Zealand	6	3
Norway	45	1
Oman	1	0
Poland	35	6
Qatar	3	0
Romania	6	15
Russia	450	2,553
Serbia	3	1
Singapore	2	0
Slovakia	64	17
Slovenia	7	0
South Africa	5	1
Spain	16	0
Sweden	358	136
Switzerland	159	30
Thailand	13	0
Turkey	8	20
Turkmenistan	4	0
Ukraine	26	7
United Arab Emirates	9	0
United States	1,900	500

LIST OF EQUIPMENT

Arena
- dasher board with plexiglas
- safety nets
- water hose(s)
- ice resurfacer
- edger
- snow scrapers
- equipment trolley for tools
- tools (drilling machine, pipe tongs, adjustable spanners, screwdrivers etc.)
- goals (4)
- lifter (to change bulbs)
- timer + scoreboard
- clock
- sound system
- stretcher + first aid supplies
- benches (players boxes, penalty boxes, timers box)
- ice coverings (for off-ice events)
- rubber mattings

Locker rooms
- benches
- lockers/clothes hooks or rails
- stick stands
- mirrors
- waste baskets
- rubber mattings

Public skate
- rental skates + shelving
- lockers
- racks
- rubber mattings
- skate-sharpening machine

Cleaning
- brushes
- floor mops
- pressure cleaner
- vacuum cleaner
- floor washing machine
- waxing machine
- laundry machine

Cafeteria
- oven
- refrigerator freezer
- microwave oven
- counter
- tables
- seats
- sets (plates, forks, spoons etc.)

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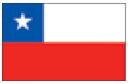

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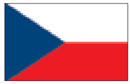

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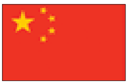

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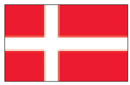

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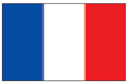

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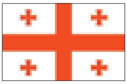

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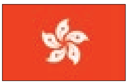

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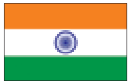

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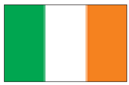

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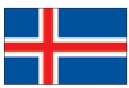

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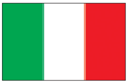

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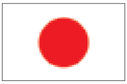

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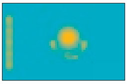

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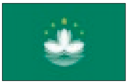

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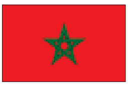

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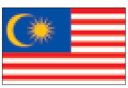

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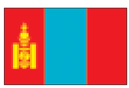

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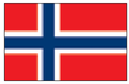

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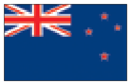

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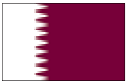

Qatar Ice Hockey Federation (QAT)
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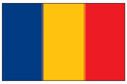
wsc@olympic.qa



Romanian Ice Hockey Federation (ROU)
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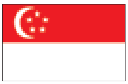

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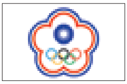

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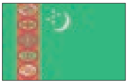

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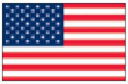

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