IIHF INTERNATIONAL ICE HOCKEY FEDERATION

OFFICIAL ICE ARENA GUIDE

2024

INTERNATIONAL
ICE HOCKEY
FEDERATION

IIHF December 2024 edition

Foreword by the President

The ice arena is the key to all hockey development.

When we look to the past, hockey was limited to outdoor rinks. Communities and teams playing only between December to March at the longest, and only in the coldest of places. The game of hockey flourished i.e. in North America and in Scandinavia, while other countries could only dream of the game.

Fast forward to today, where hockey is alive and expanding globally. The International Ice Hockey Federation consists of 82 Member National Associations, including many countries from all parts of the world.

And there are many reasons for this success, but most important factor has always been facilities where ice hockey can be played – rinks and arenas!

Many questions arise when bridging the topic of artificial ice; “Isn’t it expensive? How do you build an ice arena when it’s summer year-round?” but these questions aren’t as difficult to answer as one might think.

This guide is your key to understanding how to bring hockey and artificial ice to your community. It was created in cooperation with global experts and aims to give you a foundation of knowledge that will help grow the game while keeping it affordable and accessible.

As the President of the International Ice Hockey Federation, I have the pleasure of watching ice hockey reach new people every year. I hope you will use this guide as a starting point to inspire, encourage and expand the ice hockey family in your community.

Luc Tardif

IIHF President
International Ice Hockey Federation

Welcome

IIHF Ice Arena Guide

Dear members of the hockey community,

We are excited to present the second updated edition of the IIHF Ice Arena Guide. Building on the success of the first edition, this guide has been meticulously revised to address the evolving landscape of ice hockey facilities over the past years.

In this ever-changing environment, we have faced new challenges related to rising energy costs and the availability of innovative ice arena technologies. Therefore, it is imperative to provide you with the most up-to-date and comprehensive resource to navigate these developments.

Our commitment to sustainability has led us to explore various interactions between all systems within ice hockey arenas from an environmental perspective. We have compiled this valuable information in a separate document, the "Guide to Sustainable Ice Arenas," to further support the environmentally responsible management of ice sports facilities.

The Facilities Committee of the IIHF has been at the forefront of these advancements. In addition to these documents, our committee has actively hosted workshops, virtual conferences, webinars, ice-making seminars, and one-on-one meetings with Member National Associations (MNAs), arenas, and clubs.

Our role and aim are clear: to serve as a guiding light for our members and stakeholders, harnessing the extensive knowledge and expertise accumulated by our committee members and experts over the years.

Our network of collaborators spans the vast geography of our planet. This global reach allows us to continuously gather new insights and explore a multitude of options to address the challenges within our industry.

Our partnership also extends beyond IIHF office members. We have been fortunate to receive invaluable help and assistance from a diverse group of stakeholders, all united by their unwavering passion for the sport. Their dedication has been instrumental in driving innovation and improving our understanding of the ever-evolving landscape of ice hockey facilities.

With this document presented to you in its virtual form, the Facilities Committee reaffirms its commitment to excellence. We will remain diligent in our efforts to absorb best practices and gather fresh insights from producers, engineers, and esteemed academic members. Through this ongoing collaboration, we aim to keep pushing the boundaries of what is possible within the realm of ice hockey facilities.

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Together, we are shaping the future of the sport, drawing inspiration from a global network of experts, and ensuring that the passion for hockey continues to burn brightly across all corners of the world.

Work of IIHF Facilities committee and its reflection in the IIHF Ice Arena Guide can be divided into two main areas:

Retrofitting and Consultation for Existing Arenas:

- This aspect of work involves suggesting expert consultation and assistance to existing ice arenas to address various challenges, including:
- Increased costs: helping arenas manage rising expenses related to energy consumption, employment wages, and maintenance costs by implementing cost-effective solutions.
- Aging infrastructure: advising on strategies to renovate and modernize older arenas to improve efficiency, safety, and functionality while preserving historical or architectural significance.
- Sustainability initiatives: introducing sustainable practices and technologies to reduce environmental impact, such as energy-efficient refrigeration, heating, dehumidification, ventilation and lighting (BIG 5) systems.
- Operational efficiency: offering guidance on optimizing operations to streamline processes, minimize downtime, and maximize revenue generation while maintaining high standards of quality and service.

Guidance and Consultation for New Arenas:

- This aspect focuses on assisting in concept development, planning, design, and construction of new ice arenas by providing comprehensive guidance on:
- New technologies: introducing cutting-edge technologies and innovations in ice arena design and management to enhance performance, energy efficiency, and user experience.
- Logistics optimization: advising on the layout, configuration, and logistics within arenas to optimize space utilization, traffic flow, and accessibility for players, spectators, and staff.

Welcome

- Sustainability integration: incorporating sustainable design principles from the outset to minimize environmental impact, reduce operating costs, and enhance long-term viability.
- Safety and compliance: ensuring compliance with relevant regulations, standards, and best practices related to building codes, safety protocols, accessibility requirements, and environmental regulations.

By focusing on these two main areas, the IIHF Ice Arena Guide effectively addresses the diverse needs of both existing and new ice rinks, helping our MNA's and stakeholders to navigate challenges, adopt best practices, and thrive in a continuously evolving landscape.

We believe that this updated Ice Arena Guide, combined with our commitment to sustainability and active involvement in the hockey community, will continue to contribute to the growth and success of ice hockey facilities worldwide. Thank you for being a part of our hockey family, and we look forward to your continued support and collaboration.

Viesturs Koziols

IIHF Council member
Facilities Committee Chairman
International Ice Hockey Federation

IIHF Arena Online Guide

In 2011 the IIHF launched its new digital IIHF Arena Online Guide. The first-ever online-only version of the IIHF's Guide to Building an Ice Hockey Arena was a complete rework and reinterpretation of the old IIHF Arena Manual. The guide features drawings, images, technical details, and facts for each of four types of arena projects, ranging from "Small" to "XL". Through this online platform, the user will also be able to access latest news and information, and to view updates in technology and building techniques for ice hockey arenas.

Who is this guide for?

It is for everyone involved in compliance in our member associations and the partnerships, as well as other sporting bodies, as we continue to play our part to inspire the global sport compliance community.

It is an interactive tool designed to support compliance in our member associations and the confederations. We want to help our compliance community with strategies, ideas, and advice while sharing best practices to help you create a compliance program that works for you.

The ICE ARENA GUIDE can be downloaded in the download section of the corporate website IIHF.com.

Credentials

Imprint and Publisher

Revised Edition – IIHF Ice Rink Guide is based on the IIHF Ice Rink Manual, originated by the 2002 Facilities Committee chaired by Philippe Lacarrière; Copyright 2002 by the IIHF Publisher International Ice Hockey Federation; and the IIHF Ice Rink Guide updated by the 2016 IIHF Facilities Committee chaired by Frank Gonzalez; Copyright 2016 by the IIHF Publisher International Ice Hockey Federation. International Ice Hockey Federation

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IN THE EARLY YEARS ICE HOCKEY WAS PLAYED OUTDOORS

In the early days of hockey, nothing was more captivating than stepping onto the ice under a clear sky, with the temperature below zero and a pristine, snow-covered landscape reminiscent of a scene from 1910. But in those times, the weather could shift dramatically in just a few hours. A sudden snowstorm, heavy rain, or a rise in temperature could bring the excitement to a halt, forcing the postponement or cancellation of games or entire tournaments. These unpredictable conditions highlighted the need for dedicated hockey rinks, ensuring that the sport could thrive regardless of the weather, allowing players to refine their skills and communities to continue enjoying the game uninterrupted and played globally.

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BUILDING ICE ARENAS ANYWHERE

1 Building Ice Arenas Anywhere

1.1. Introduction

The International Ice Hockey Federation will, in this guide, show that it is possible to construct an ice arena anywhere in the world. The target groups are hockey clubs, municipalities 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 arena. Decision-makers and politicians will discover a wealth of thoroughly researched ideas that inspire the creation of financially viable ice rinks within their communities. By doing so, they can fulfill their critical social mission of promoting a healthier, more organized society and fostering excellence in community activities.

In many communities the ice arena is the center of social life where a number of activities take place. Other ice sports like public skating, fairs, exhibitions, conventions, and coaching clinics are attractions warmly welcomed by the majority in winter. During the summer months, the ice sheet is either removed or covered, transforming the rink into a versatile indoor sports arena for basketball, indoor soccer, handball, and inline hockey. However, due to the increasing demand and rising popularity of hockey, many rinks now remain open even in the warmer months. This guide offers valuable solutions for minimizing costs while keeping the rinks operational during these periods.

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

And we always need to remember – Ice Arenas are safest places for kids to be.

The first recorded indoor ice hockey game took place at the Victoria Skating Rink in Montreal, Canada 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 arena construction enables ice hockey and ice sports to be accommodated anywhere in the world.

It has been historically documented and witnessed that a contained and covered ice arena 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 and attract large number of visitors.

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. Business 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 are highly aware of advertising in and around 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.

In today's world, new social trends and the rise of social networking and the gaming industry are increasingly competing for the attention of kids and youth. These trends are shaping new habits and routines, often pulling young people away from physical activity. Ice rinks provide a vital space where kids and youth can engage in active sports like hockey, fostering both physical fitness and teamwork. Maintaining their involvement in such activities helps develop discipline, resilience, and a sense of community, offering a valuable alternative to the passive consumption of digital content. Encouraging engagement in hockey helps ensure a healthy, balanced lifestyle, countering the sedentary tendencies of modern digital trends.

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 each offer scalable revenue streams.

Adirondack Bank Center in Utica, New York, USA.

1.2. Where to start build Arena

We – The IIHF Facilities Committee - recommend addressing and discussing the following questions before beginning the planning process. This will help identify the best business concept, functionality, and potentially ideal cost and income structure to maximize the efficiency of the arena's operations.

Purpose of Arena, goals for owners – why to build Arena
(OBJECTIVES FOR OWNERS OR OPERATORS)

- Business approach- make it profitable for investors and owners
- Social and community approach- make hockey more accessible for kids, players, community members
- Build it and donate it to hockey community
- Promote hockey and grow the game with help of local municipality, sponsors
- Legacy for next generations

Functionality of Arena

- Single sport (hockey) use
- How many ice pads in one
- Roof-only Arena (in countries where climate allows)
- Ice hockey sports use (which ones)
- Multi sports use
- Multifunctional purpose and use (with much more functionality and rooms, sqm.)
- Part of shopping mall entertainment, additional services to visitors
- Functionality inside Arena (number and size of dressing rooms, gym, meeting facilities, cafeteria, coaches' room, hockey equipment shop, etc.)

Design of Arena

- Simple arena vs super modern and technology driven (lights, sounds, LED, etc.)
- Simple architecture vs Iconic project
- Atmosphere for spectators (comfortable seats, VIP zone, lounge area, kids' area, cafeteria) or ascetic and simple
- Additional elements of design outside Arena (lights or facade)
- Additional elements of innovative design inside Arena (LED screens, cafeteria, etc.)

Research and due diligence of similar buildings, concepts

- Arenas nearby vs demand for ice sports
- Local governments policies related to ice sports (from very supportive to negative)

- How to maximize ice time- cooperation with figure skating, speed skating, etc.
- Winter- summer situation (energy costs during summer- roller skating, team sport games, puck shooting, plastic ice)
- Best practices from functionality, energy savings, modern design, etc. point of view

Location

- City downtown
- Municipal center
- Outskirts of city
- Regional and/or country landmark
- Destination place
- Added value exist- shopping malls, hotels, transportation, etc. OR
- Added value must be created- shopping malls, office buildings, hotels, etc.
- Catalyst for regional/local development- real estate value increase for depreciated areas

Shareholders structure

- Private individuals, commercial partnership
- Clubs
- Municipality
- Government
- Federations/Associations
- Mixed

Operating options

- Experienced manager
- Main/anchor tenant representative
- International tender for director
- Large and multipurpose Arenas can join international associations, for example https://www.europeanarenas.com/

Social aspects of Arena

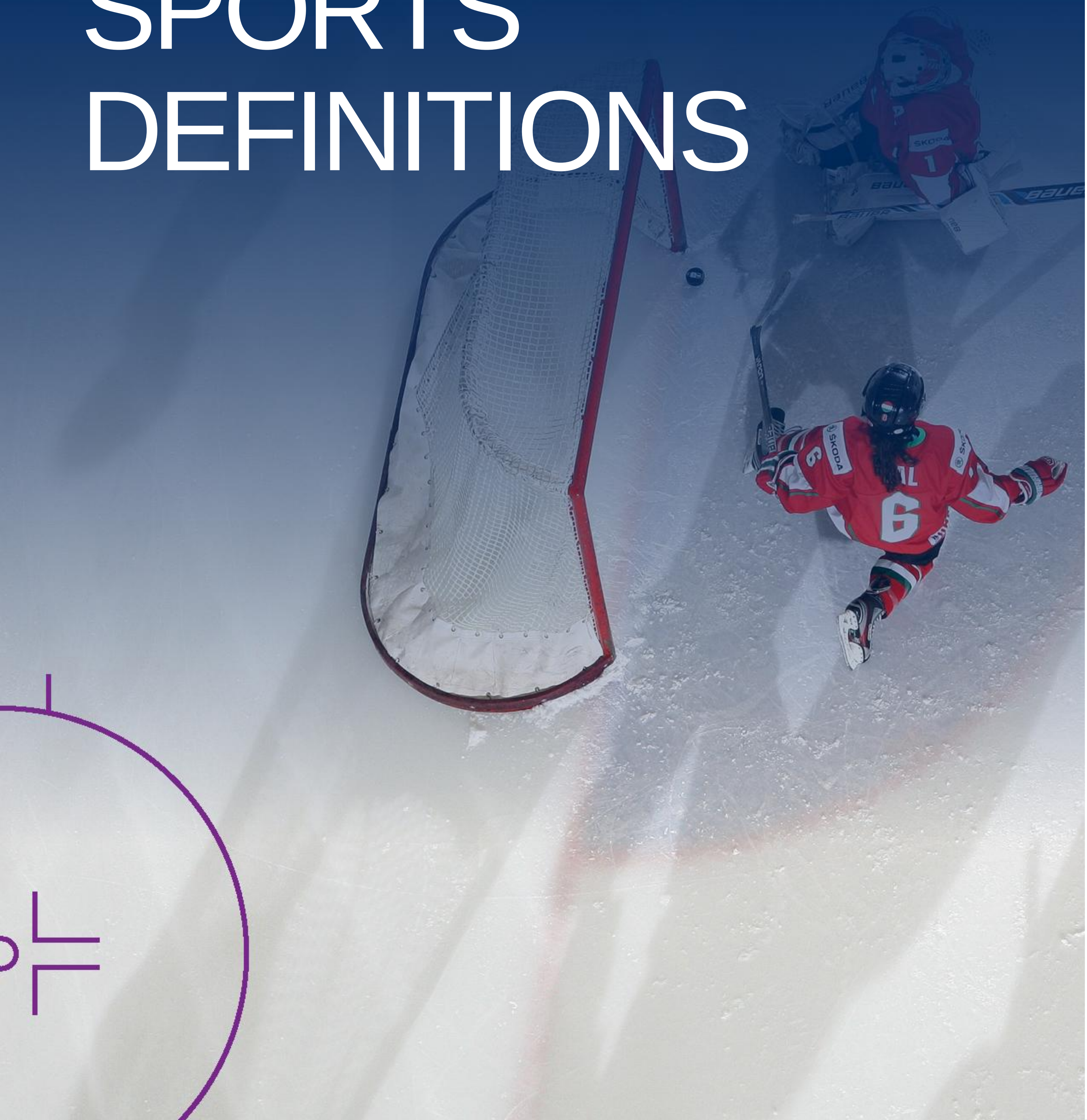
- Sustainability aspects (water recycling, solar panels, geothermal heat, waste solutions, etc.)
- Energy efficiency aspects- most advanced systems and solutions
- CO_2 emissions and solutions

Financing of Arena

- Own equity and bank loan ratio
- Municipality/state
- Advance payments for ice rent from municipality
- Naming rights for Arena, skyboxes presale
- Crowd financing
- Best examples from other projects
- Business plan for shareholders

CHAPTER 2

SPORTS DEFINITIONS



2 Sports Definitions

For exact measurements and more information please refer to Section 01 and Appendix VI in the Official IIHF Rulebook found on the IIHF website (Sports & Development / Rules & Regulations):

https://blob.iihf.com/iihf-media/iihfmvc/media/downloads/rule%20book/220721_iihf_rulebook_v22.pdf

All rules and regulations mentioned in this Arena Guide are applicable to all IIHF Competitions and any deviations from these are only allowed on written permission from the IIHF.
For play under MNA/Other jurisdiction, the MNA/Proper Authorities can make deviations.

2.1. Rink

Games under jurisdiction of the IIHF shall be played on an ice surface known as the "**Rink**" and must adhere to the dimensions and specifications prescribed by the IIHF and the applicable rules. For any IIHF Competition, no ice markings shall be permitted except those provided for under these rules unless express written permission has been obtained from the IIHF. On-ice logos must not interfere with any official ice markings provided for the proper playing of the game.

2.2. Dimensions

For IIHF top level championships, the official size of the Rink shall be 60 m long and 26 m to 30 m wide. The corners shall be rounded in the arc of a circle with a radius of 7.0 m to 8.50 m. Non IIHF championship level ice hockey may be played on a Rink of different dimensions.

2.3. Boards And Protective Glass

The Rink shall be surrounded by a wall known as the "**Boards**".
The ideal height of the boards above the ice surface shall be 1.07 m.

Except for the official markings provided for in these rules, the entire playing surface and the Boards shall be white in color except the "Kick Plate" at the bottom of the Boards, which shall be light yellow in color.

Any variations from any of the foregoing dimensions shall require official authorization by the IIHF for any IIHF competition.

The Boards shall be constructed in such a manner that the surface facing the ice shall be smooth and free of any obstruction or any object that could cause injury to Players.

Affixed to the Boards and extending vertically shall be an approved “**Protective Glass**” construction.

The height above the Boards behind the Goals must be 2.4 m and must extend at least 4.0 m from the “Goal Line” towards the Blue Line.

The height above the Boards along the sides must be 1.8 m, except in front of the Players’ Benches. Protective Glass shall be required in front of the Penalty Boxes.

The Protective Glass – which shall be of a flexible nature - and gear to hold them in position shall be properly padded or protected and mounted on the Boards on the side away from the playing surface including the “Protective Netting”.

Protective Netting

Protective Netting shall be hung in the ends of the Arena, of a height, type, and in a manner approved by the IIHF. The Protective Netting must be suspended above the “End-zone” Protective Glass behind both Goals and must extend around the Rink at least to where the Goal Line meets the Boards.

The Protective Netting is to be installed in such a way that it protects the top bench row viewer. Thus, the height of the Protective Netting is determined by the height of the Rink and the settings of the top row of benches.

Lines

Goal Lines: A red line, 5 cm wide, shall be drawn across the entire width of the ice surface, 4.0 m from each end of the ice surface and continued vertically along the side of the Boards. This line shall be referred to as the "Goal Line". The Goal posts and nets shall be set in such a manner as to remain stationary during the process of the game.

Goal Crease: In front of each Goal, an area shall be marked by a red line 5 cm wide, named as the “Goal Crease”.

On-ice Official Crease: In front of the Official Scorekeepers’ Box, a semi-circular area is marked on the ice surface, called the "On-ice Officials Crease". A 5 cm wide red line with a radius of 3.0 m marks this crease area.

Blue Lines: The ice surface between the Goals shall be divided into three (3) zones by lines, 30 cm in width, and blue in color, and extended completely across the Rink, parallel with the Goal Lines, and continued vertically up the side of the Boards, named as the “Blue Lines”. In case advertising is allowed on the Boards, the lines must be marked at least on the Kick Plate.

Centre Line: Another line, 30 cm in width and red in color, drawn completely across the Rink on Centre ice, parallel with the Goal Lines and continued vertically up the side of the Boards, named as the “Centre Line”. In case advertising is allowed on the Boards, the lines must be marked at least on the Kick Plate.

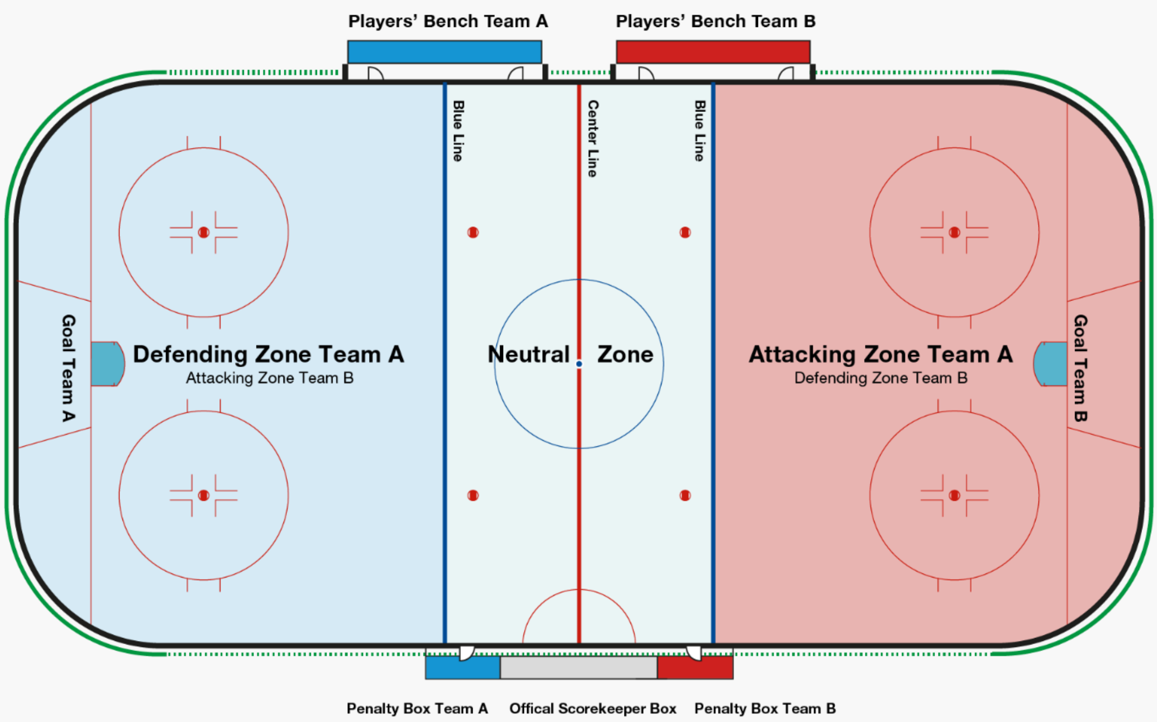
Goalkeeper’s Restricted Area: Behind each goal, a trapezoidal area is marked on the ice surface, called the "Goalkeeper Restricted Area". The two 5 cm wide red lines mark the restricted area between the Goal Line and the Boards behind the Goal. The outside dimension of the marking along the Goal Line is 6.80 m and along the Boards is 8.60 m, and the lines continue vertically on the Kick Plate.

On-ice Official Crease: In front of the Official Scorekeepers’ Box, a semi-circular area is marked on the ice surface, called the "On-ice Officials Crease". A 5 cm wide red line with a radius of 3.0 m marks this crease area.

Division of Ice Surface

Defending Zone: The portion of the ice surface in which the Goal is situated shall be called the “Defending Zone” of the Team defending that goal.

Neutral Zone: The central portion shall be known as the “Neutral Zone”.
Attacking Zone: The portion farthest from the defended Goal shall be the “Attacking Zone”.



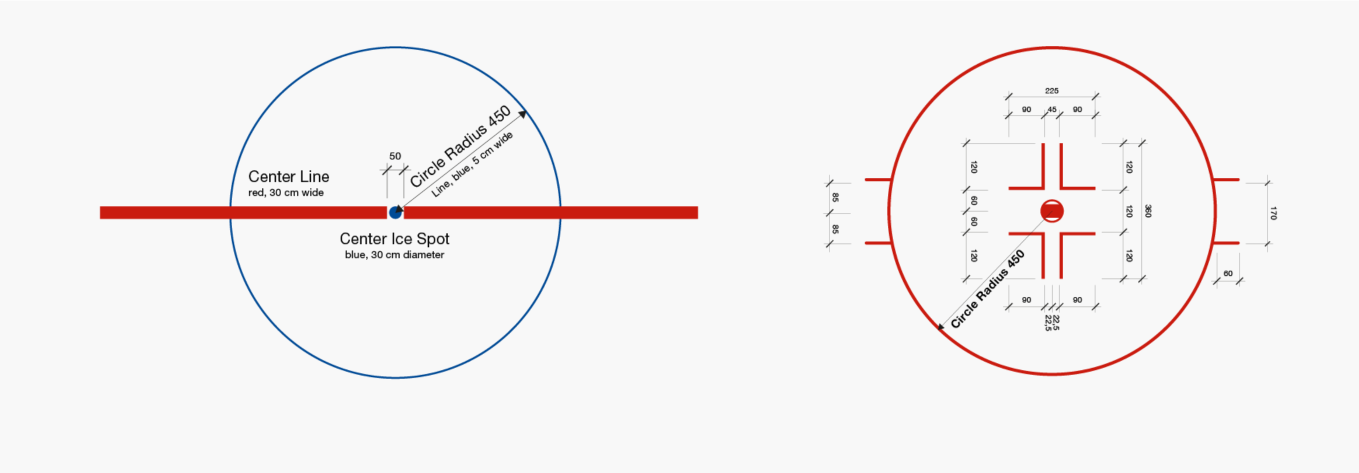
Face-off Spots and Circles

Face-off Spot and Circle at Centre Ice: A circular blue spot, 30 cm in diameter, shall be marked exactly in the centre of the Rink. This spot shall be referred to as the "Centre Ice Face-off Spot". With this point is the center, a circle with a radius of 4.50 m must be marked with a blue line 5 cm wide, so that the boundary line measured from the outer edge of the radius is placed inside the radius.

Face-off Spots in the Neutral Zone: Two (2) red spots, 60 cm in diameter, shall be marked on the ice in the Neutral Zone 1.50 m from each Blue Line. These four (4) spots shall be referred to as the "Neutral-zone Face-off Spots". Within the Face-off Spot, draw two parallel lines 8 cm from the top and bottom of the spot. The area within the two lines shall be painted red, the remainder shall be painted white. The spots shall be 14.0 m apart and each shall be a uniform distance from the adjacent Boards.

Face-off Spots and Circles in the End-Zones (Attacking and Defending Zone): In both End-zones and on both sides of each goal, red Face-off Spots and circles shall be marked on the ice. The Face-off Spots shall be 60 cm in diameter. These four (4) spots shall be referred to as the "End-zone Face-off Spots". Within the Face-off Spot, draw two parallel lines 8 cm from the top and bottom of the spot. The area within the two lines shall be painted red, the remainder shall be painted white. The circles shall be marked with a red line 5 cm wide with a radius of 4.50 m from the centre of the Face-off Spots. At the outer edge of both sides of each Face-off Circle and parallel to the “Goal Line”, two red lines 5 cm wide and 60 cm in length and 1.70 m apart shall be marked.

30 cm away from the outer edge of the Face-off Spot, two red lines 5 cm wide shall be drawn parallel with the Side Boards that shall be 1.20 m in length and 45 cm apart. Parallel to the End Boards, commencing at the end of the line nearest to the Face-off Spot, a red line 5 cm wide shall extend 90 cm in length.



Goal posts and nets

Each Rink must have two (2) “Goal Nets”, one at either end of the Rink. The “Goal Net” is comprised of a Goal frame and netting.

The open end of the goal net must face Centre ice. Each Goal Net must be on the center of the Goal Line at either end or must be installed in such manner as to remain stationary during the progress of the game. The Goal posts must be kept in position by means of flexible pegs affixed in the ice or floor, but which displace the Goal Net from its moorings upon significant contact.

The holes for the goal pegs must be located exactly on the Goal Line.

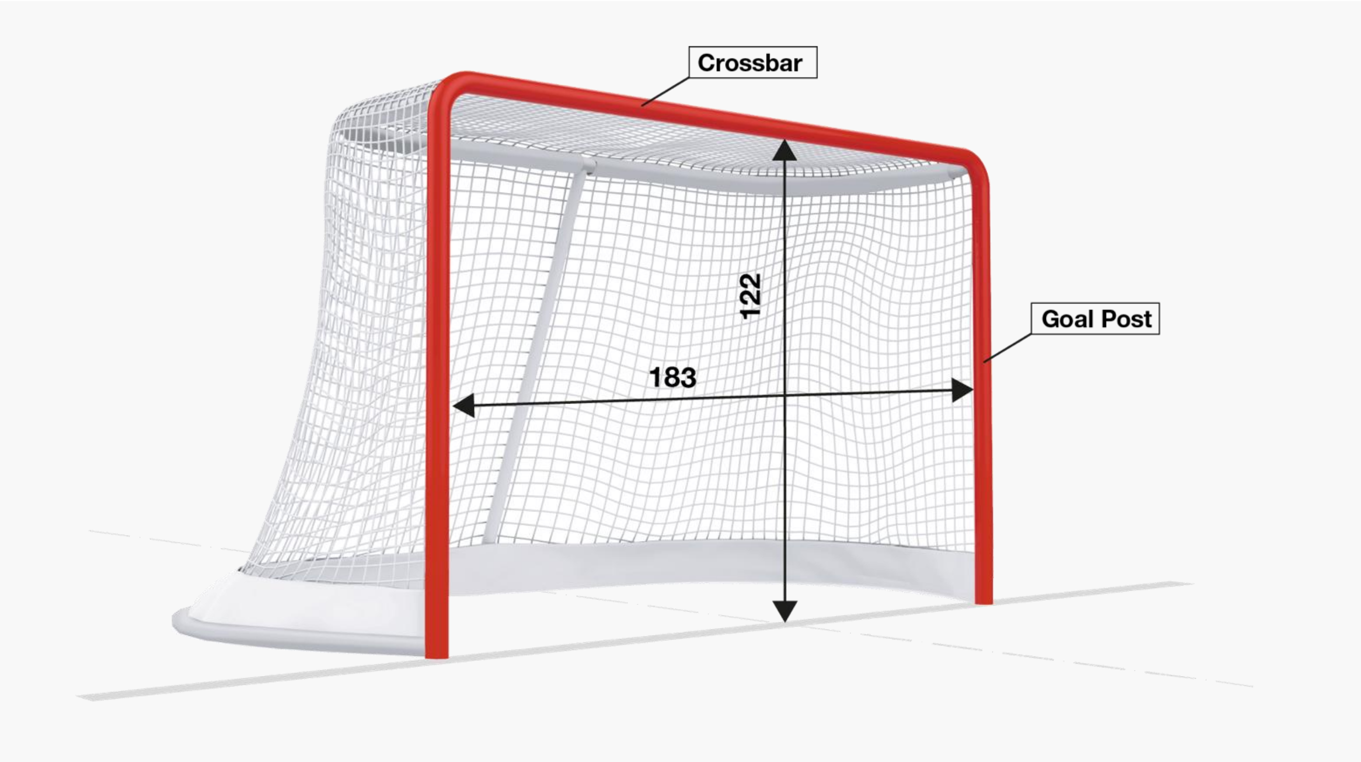
The Goal posts shall be of an approved design and material, extending vertically 1.22 m above the surface of the ice and set 1.83 m apart measured from the inside of the posts. A crossbar of the same material as the Goal posts shall extend from the top of one post to the top of the other.

The Goal posts and crossbar shall be painted in red color and all other exterior surfaces shall be painted in white color.

Goal nets

A net of an approved design shall be attached to each Goal frame and made of white nylon cord, which shall be draped in such a manner as to prevent the puck coming to rest on the outside of it yet strung in a manner that will keep the puck in the net. A skirt of heavy white nylon fabric or heavyweight white canvas shall be laced around the base plate of the goal frame in such a way as to protect the Goal net from being cut or broken.

This protective padding must be attached in a manner that will not restrict the puck from completely crossing the Goal Line. This padding must be set back 15 cm from the inside of the Goal post. This skirt shall not project more than 2.5 cm above the base plate. The frame of the Goal shall be draped with a nylon mesh net to completely enclose the back of the frame.



Benches

Players’ benches

Each Rink shall be provided with seats or benches for the use by Players of both Teams. The only people allowed on or at the Players’ Benches are the dressed Players and not more than eight (8) persons, including Coach and team personnel. Teams must use the same Player’s Bench for the duration of a game. The accommodations provided, including benches and doors, must be uniform for both Teams.

The Players’ Benches shall be placed immediately alongside the ice as near to the centre of the Rink as possible. Two (2) doors for each Players’ Bench must be uniform in location and size and as conveniently close to the Dressing Rooms as possible. Each Players’ Bench should be 10m in length and 1.50m in width and when situated in the spectator area, shall be separated from the spectators by a Protective Glass to afford the necessary protection for the Players and Team Personnel.

The Players’ Benches shall be on the same side of the playing surface opposite the Penalty Box and should be separated by a substantial distance, if possible.

Penalty Box

Each Rink must be provided with benches or seats to be known as the “Penalty Box”.

Separate Penalty Boxes shall be provided for each team, and they shall be situated on the opposite sides directly across the ice from their Players' Benches. Teams must use the “Penalty Box” opposite their Players’ Bench and must use the same “Penalty Box” for the duration of a game.

Each “Penalty Box” should be at least 4.0m in length and 1.50m in width and shall be separated from the spectators by a Protective Glass to afford the necessary protection for the Players.

Each Penalty Box must be of the same size and quality, offering no advantage to either Team in any manner and must have only one door for both entry and exit.

Signal and Timing Devices

Signal Devices

Each Rink must be provided with a suitable sound device that will sound automatically at the conclusion of each period of play. Should the sound device fail to sound automatically when time expires, the determining factor as to whether the period has ended shall be the Game Clock.

Each Rink shall be provided with some form of electronic game clock for the purpose of keeping the spectators, Players, Team Personnel and Game Officials accurately informed as to all time elements at all stages of the game including the time remaining to be played in any period and the time remaining to be served by penalized Players on each Team.

Time recording for both game time and penalty time shall show time remaining to be played or served.

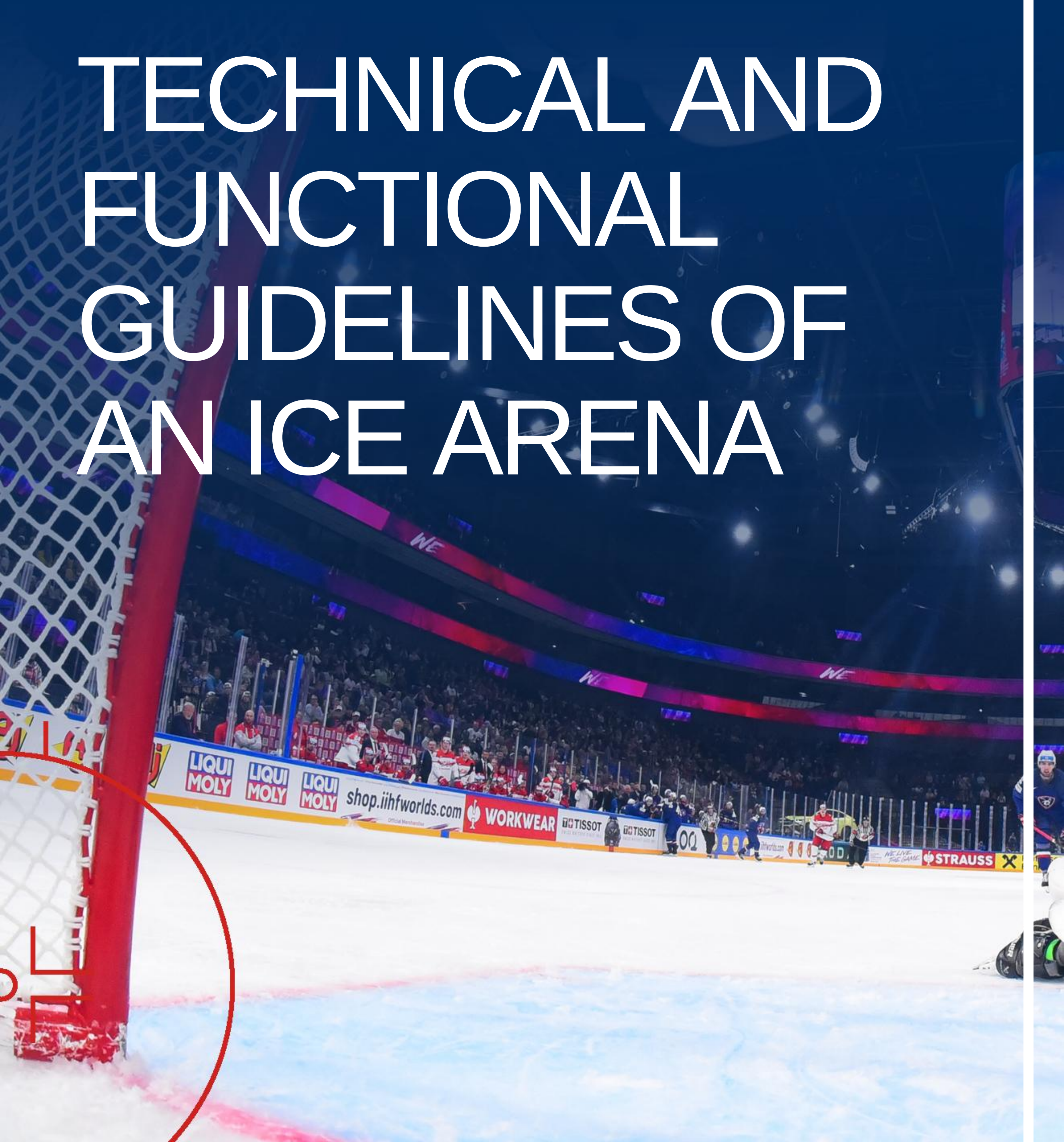
The Game Time Clock shall measure the time remaining in tenths (1/10) of a second during the last minute of each period.

For more information of IIHF Technology Codes & Regulations the IIHF Rulebook:

https://blob.iihf.com/iihf-media/iihfmvc/media/downloads/rule%20book/220721_iihf_rulebook_v22.pdf

CHAPTER 3

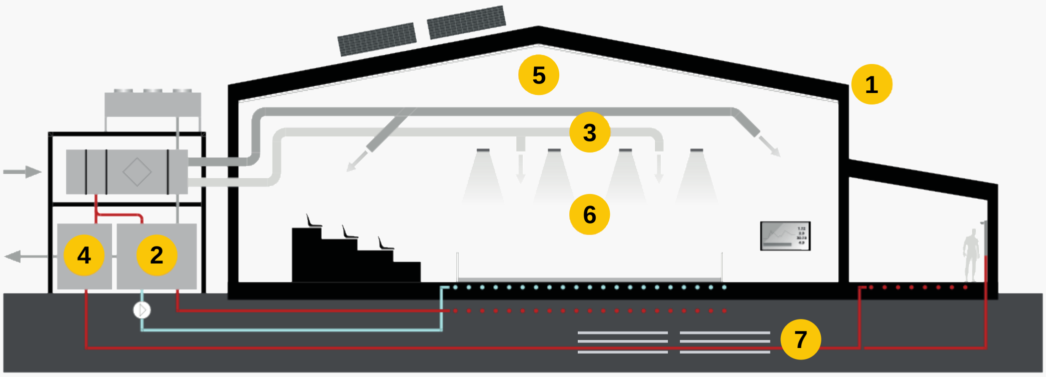
TECHNICAL AND FUNCTIONAL GUIDELINES OF AN ICE ARENA



3 Technical & Functional Guidelines Of An Ice Arena

3.1. General Introduction

All ice arenas share the same concerns: energy & operating costs and indoor climate. Ice arena designs and operations are unique and differ in many ways from standard buildings. Thermal conditions can vary from –3° C on the ice surface to +10-18° C in the stands and over +20° C in dressing rooms and offices. High air humidity indoors can create corrosion problems with steel structures leading to decay in wooden structures and indoor air quality problems like fungi and mould. Advanced technology can reduce energy consumption considerably and thus decrease operating costs in existing and proposed ice arena facilities while simultaneously improving the indoor climate. Energy costs and concerns about the environment today set high demands for the technical solutions and without effective solutions the operating costs (energy, maintenance, replacement) will increase. Considerable savings can be done if the facilities are operating energy-efficiently. This will require investment in energy-saving technology and in raising energy awareness together with ice arena operators.



The basic technical elements of a well-functioning arena are:

1 Insulated walls and ceiling (envelope)
2 Efficient refrigeration plant
3 Mechanical ventilation
4 Efficient heating system incl. heat recovery
5 Air de-humidification
6 Proper lighting
7 Alternative energy sources (solar, wind, ground heat, etc.) and storage possibility for excess heat, energy.

3.2. Sizing The Ice Arena

The goal is to determine the appropriate quality level and operating cost level of the ice arena based on the needs of the intended programming and user groups. The ice arena's business plan is based on its operating concept as a practice arena, competition arena, or multi-purpose arena. In all cases, it is possible to achieve sufficient profitability to enable ice sports activities. However, a large multi-purpose arena is usually economically viable only in areas where the population base enables the organization of large public events continually.

Around 80 – 90% of project implementation costs are determined during the ice arena planning phase, so it is important that the project is led by a qualified project manager and a team of experts familiar with the functionality and design of ice arena. In terms of life cycle costs, the most significant decisions are also made at the very beginning of the planning process. An ice arena is a demanding construction project due to the indoor conditions, large equipment investments and the high energy consumption of the refrigeration machines. Therefore, the building's energy efficiency and life cycle costs must be carefully considered.

Before starting the planning, a project feasibility study should be conducted to determine the viability of building the arena. Following the feasibility study will be the arena concept plan which defines the business objectives, requirements and necessary functions.

There are several ways to classify ice arenas; 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 arenas are/can be divided into five categories as follows:

1. Small practice arena with seating capacity 0 - 300 (can also be standing places only)
2. Small competition arena with seating capacity 300 - 1,500
3. Large competition arena with seating capacity between 1,500 and 5,000, including some multi-purpose features
4. Modern multi-purpose arena with over 5,000 fixed seats with a wide-ranging catering operation, 4 sides of the rink over several levels
5. Shopping mall skating rinks

TYPE: Modern Multi-Purpose Arena

TYPE: Large Competition Arena

TYPE: Small Competition Arena

TYPE: Small Practice Arena

TYPE: Shopping Mall Skating Rink

3.3. The Main Design Principles of An Ice Arena

This Ice Arena Guide focuses on ice arenas, which create year-round recreational opportunities for ice sports in a manner that is as economically and environmentally friendly as possible. The goal is to have a simple, functional ice arena that is sustainable and economical in terms of construction and operating costs, and that meets the needs of the region, while also anticipating future needs for expansion of the building due to the development of ice sports in the region.

The main principles of cost-effective and functional ice arena design:

- The building's gross area is optimized. Primarily, only auxiliary spaces required by ice sports will be built. Other ancillary spaces will be built if there is a business rationale for them.
- The surface area and volume of the semi-warm ice rink space must be optimized. Efforts are made to avoid unnecessary floor area and interior height, which also makes it easier and most cost effective to manage ice conditions.
- The load-bearing frame of the arena is designed to be structurally simple and modular (if possible), so that it is possible to expand the arena later.

- The spans of the beams or trusses supporting the roof of the arena are designed to be as short as possible.
- The thermally insulated wall line between rooms with normal temperature and the semi-warm space is to be clearly delineated.
- Exterior windows are not usually planned in the ice rink space of the arena due to heat load and glare disadvantages. Natural light is used only in public lobbies and auxiliary user spaces.
- The main entrance of the arena and the service yard with the service spaces are placed on opposite sides of the building for safety reasons.
- Auxiliary spaces are mainly planned at the ends of the arena, leaving the long sides of the space free, for external rainwater drainage and snow removal from the roof.
- In the arena, efforts should be made to separate the spaces intended for the public, users, and maintenance, as well as the related passage routes.
- The passage route of the ice resurfacer to the rink space and maintenance areas must be separated from public and user traffic for safety reasons.
- Efforts should be made to separate passage in outdoor shoes from passage in ice skates. The team dressing rooms are designed to be passable.
- The space required by the ice rink's opening technical channel is used as a corridor for skaters' passage to the dressing rooms.
- The small spectator stands of the arena are placed above the skater passage areas at field level, so they do not increase the volume of the hall or the span of the roof supports.
- The latest accessibility standards must be applied in the design.
- The spaces serving spectators are usually located on the second floor next to the stands. In this case, an elevator connection to the premises must be planned. If there is a significant amount of public skating in the arena, services should also be placed on the ice rink space level.
- Spaces serving the surrounding outdoor sports area are also often placed in the arena.
- Any ancillary training spaces, such as a gym or small exercise room, are usually placed on the second floor above the team dressing rooms.
- The ventilation machine room is usually placed on the second floor above the team dressing rooms.

- The free height above the rink is at least 5m for practice arenas and at least 7m for competition arenas.
- The ice rink's refrigeration machines can be integrated into the arena, but often they are brought to the construction site as a ready-to-install refrigeration container, which is placed outside the arena.
- Also, the ventilation equipment of the ice rink space is often implemented as ready-to-install unit, which is installed on top of or next to the refrigeration container.
- Possible future expansion must be considered when planning the layout of the arena's spaces and the shape of the roof.

Ice Arena Spaces:

Entrance & Lobby

The main entrance should be made large enough to accommodate the rated occupancy of the arena.

It is common in competition arenas and multi-purpose arenas to have a separate entrance for professional team players, staff, equipment managers to not interfere with the public.

There must be enough space for both users and spectators in the arena lobby. The size of the lobby space is strongly dependent on the number of seats in the spectator area and whether equipment rental for recreational ice skating is available in the arena.

Washrooms

There must be enough public washrooms in the lobby, spectator area, and other public spaces to accommodate the rated occupancy of the arena.

Food Service

The sizing of the restaurant premises depends on the planned service level. In competition ice arenas, the number of serving points is determined according to the spectator seats. It is recommended that there be at least one point of service per 400 spectator seats.

Storage

Dedicated spaces for storage of cleaning and maintenance supplies, small equipment, tools, and other supplies should be included in the arena design.

Ice Resurfacer

The area of the space must be large enough to park the ice resurfacer and perform routine maintenance and repairs. The space should be both heated and ventilated. The space should include a cold and hot water supply for filling the ice resurfacer ice making and wash water tanks. The ceiling height should allow for the ice resurfacer snow bin to be raised to its maximum height. The space should also include a pit designed for holding and melting ice shavings collected in the ice resurfacer snow bin. The space should also include a door for personnel to exit the room to the outside of the arena in an emergency. Finally, a door should be included large enough to move the ice resurfacer to the outside the arena if needed.

Refrigeration System

A dedicated space near the ice rink for the refrigeration compressors, evaporators, pumps, and motors. For safety reasons, this space should not be accessible by the public. The space should be large enough to perform routine maintenance and repairs. The room should be heated and ventilated and include a refrigerant leak detection system with alarm. The space should also include a door for personnel to exit the room to the outside of the arena in an emergency.

Mechanical & Electrical

Dedicated spaces must be considered in the arena design for electrical panels, water heaters & boilers, fire suppression systems, computer, phone, audio & video equipment.

Offices

Dedicated spaces for arena management and other personnel.

Ice Rink

The size of the ice rink space is based on the selected rink size, the number of spectator seats, the placement of the players boxes in the rink and the width of the free passageways.

Dressing Rooms

The number and size of dressing room spaces are determined by the type of ice arena and the extent of the adjacent training spaces. The minimum number of dressing rooms per rink is four. Competition ice arenas will also have designated dressing rooms for the representative teams. When planning dressing rooms, it is important to consider teams with players of both genders. In this case, it is good to include separate dressing room spaces (for girls up to 18 year of age). Smaller dressing rooms for coaches, and on-ice game officials should also be built in a sufficient quantity.

Hockey team dressing rooms should be designed for at least 25 people. Dressing room seating in practice ice arenas are usually implemented as wall-mounted continuous bench structures (at least 0.5 m/person). The dressing room seating in competition ice arenas are often implemented as player-specific furniture units with a width of at least 0.8 m.

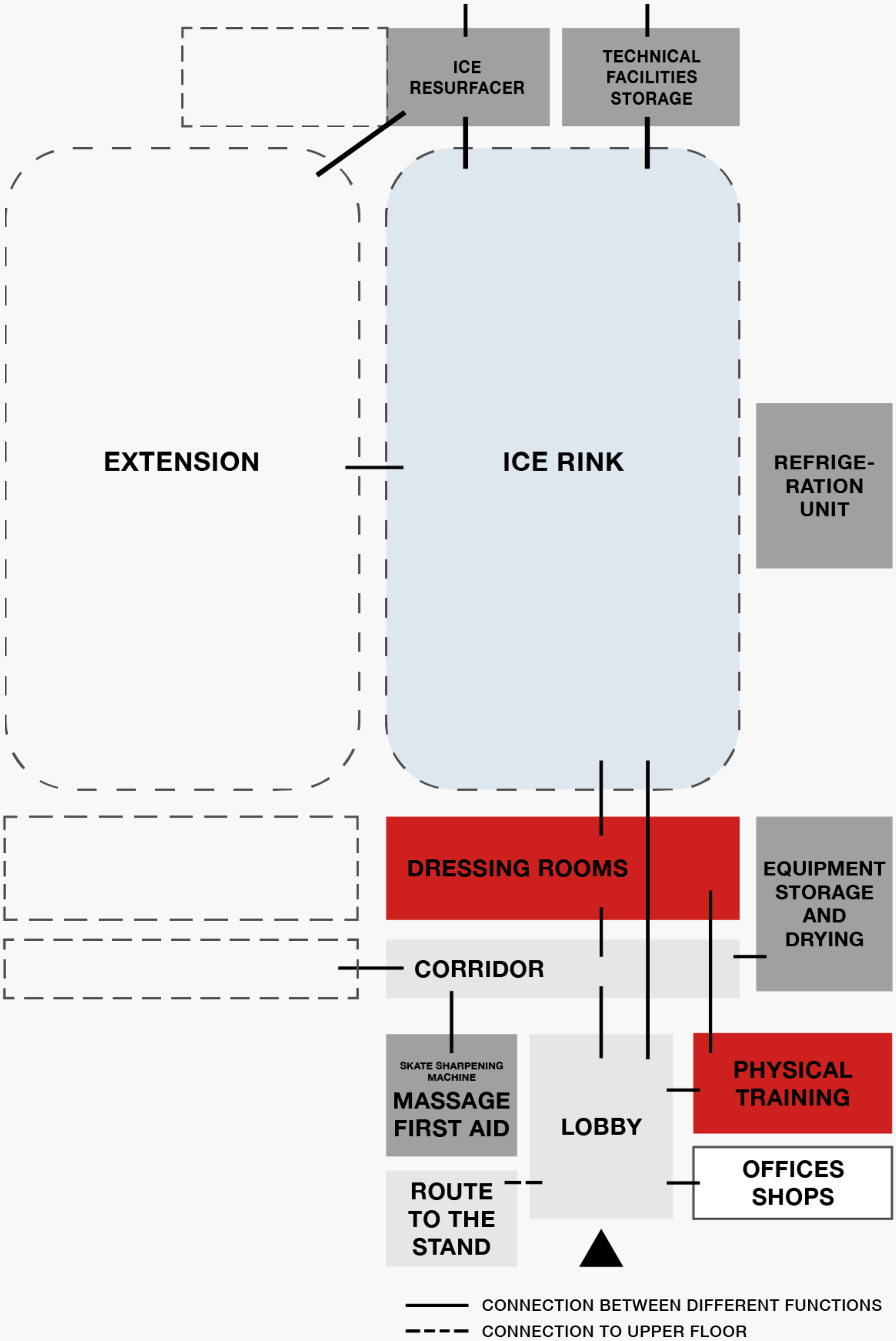
The team washrooms in practice ice arenas are usually designed in such a way that one washroom serves two dressing rooms that are used at different times (arriving/leaving team).

Spaces for storing and drying the teams' clothing and equipment is also common in team dressing rooms to reduce the transportation of equipment between the home and the arena.

Media

The space needs of the media are assessed according to the scope of the ice arena operations. In a competition ice arena, media operations must be considered in the planning in terms of television/video recording, radio broadcasting and the press.

Example layouts of ice hockey arenas


ICE RESURFACER
TECHNICAL FACILITIES STORAGE
EXTENSION
ICE RINK
REFRIGE-RATION UNIT
DRESSING ROOMS
EQUIPMENT STORAGE AND DRYING
CORRIDOR
SKATE SHARPENING MACHINE
MASSAGE FIRST AID
LOBBY
PHYSICAL TRAINING
OFFICES SHOPS
ROUTE TO THE STAND
CONNECTION BETWEEN DIFFERENT FUNCTIONS
CONNECTION TO UPPER FLOOR

Example of an arena space plan

FACILITIES	SMALL PRACTICE ARENA	SMALL COMPETITION ARENA
Hall		
Single rink	2.000 m^2	2.200 m^2
Size of an ice rink	28 m x 58 m	30 m x 60 m
Spectators		
Stands	100 standing places	1000 seats
Sky Boxes / VIP suites	-	50 m^2
Lobby	30 m^2	300 m^2
Ticket office	-	3 m^2
Clothing storage	-	-
Public toilets	12 m^2	30 m^2
Retail and sales area	1	4
Cafe / restaurant	30 m^2	200 m^2
Users		
Dressing rooms	4 x 40 m^2	4 x 40 m^2 2 x 60 m^2
- Benches for 25 people 0,5 m / person	Normal locker room	Normal locker room
- Benches for 25 people 0,8 m / person		representative team locker room
Washrooms	4 x 15 m^2	4 x 15 m^2 2 x 20 m^2
Toilets	15 m^2	27 m^2
Sauna* regional variances	-	12 m^2
Clothing maintenance	8 m^2	2 x 8 m^2
Sharpening	7 m^2	2 x 8 m^2
Hockey stick maintenance	7 m^2	2 x 8 m^2
Medical / first aid (massage)	12 m^2	15 m^2
Doping testing	-	10 m^2
Coaches' rooms	2 x 10 m^2	4 x 10 m^2

FACILITIES	SMALL PRACTICE ARENA	SMALL COMPETITION ARENA
Dressing rooms / referees / teachers	2 x 12 m^2	2 x 12 m^2
Drying and storage	12 x 6 m^2	12 x 6 m^2 2 x 15 m^2
Club offices	20 m^2	50 m^2
Training classroom	-	100 m^2
Staff		
Locker room, washroom, and toilet	12 m^2	2 x 16 m^2
Toilets	7 m^2	10 m^2
Control room	12 m^2	15 m^2
Office	12 m^2	2 x 16 m^2
Maintenance and technical facilities		
Refrigeration units	80 m^2	80 m^2
Converter	15 m^2	20 m^2
Electrical main centre	10 m^2	15 m^2
Heat distribution room	14 m^2	20 m^2
Ventilation room	60 m^2	120 m^2
Sprinkler centre	6 m2	6 m^2
Management of presentation and information technology	-	in control room
Ice resurfacer	60 m^2	60 m^2
Workshop	-	20 m^2
Storage of property maintenance	20 m^2	30 m^2
Cleaning room	8 m^2	1 x 8 m^2 and 1 x 4 m^2
Media facilities		
Presenter	-	6 m^2
Host speaker	-	x
Camera positions	-	x
Press facilities at stand	-	x

FACILITIES	SMALL PRACTICE ARENA	SMALL COMPETITION ARENA
Press	-	x
Interview room	-	x
Other facilities		
Gym	-	120 m^2
Locker rooms	-	40 m^2
Washrooms	-	20 m^2
Toilets	-	11 m^2

Entrance & Lobby

The main entrance should be made large enough to accommodate the rated occupancy of the facility.

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The latest trends in newly constructed ice rinks and arenas focus on creating larger areas for ice resurfacers to efficiently reuse the snow collected from the ice surface. These facilities are equipped with melting pits and specialized filters that enable the rapid recycling of used ice, promoting sustainability and reducing waste

Refrigeration System

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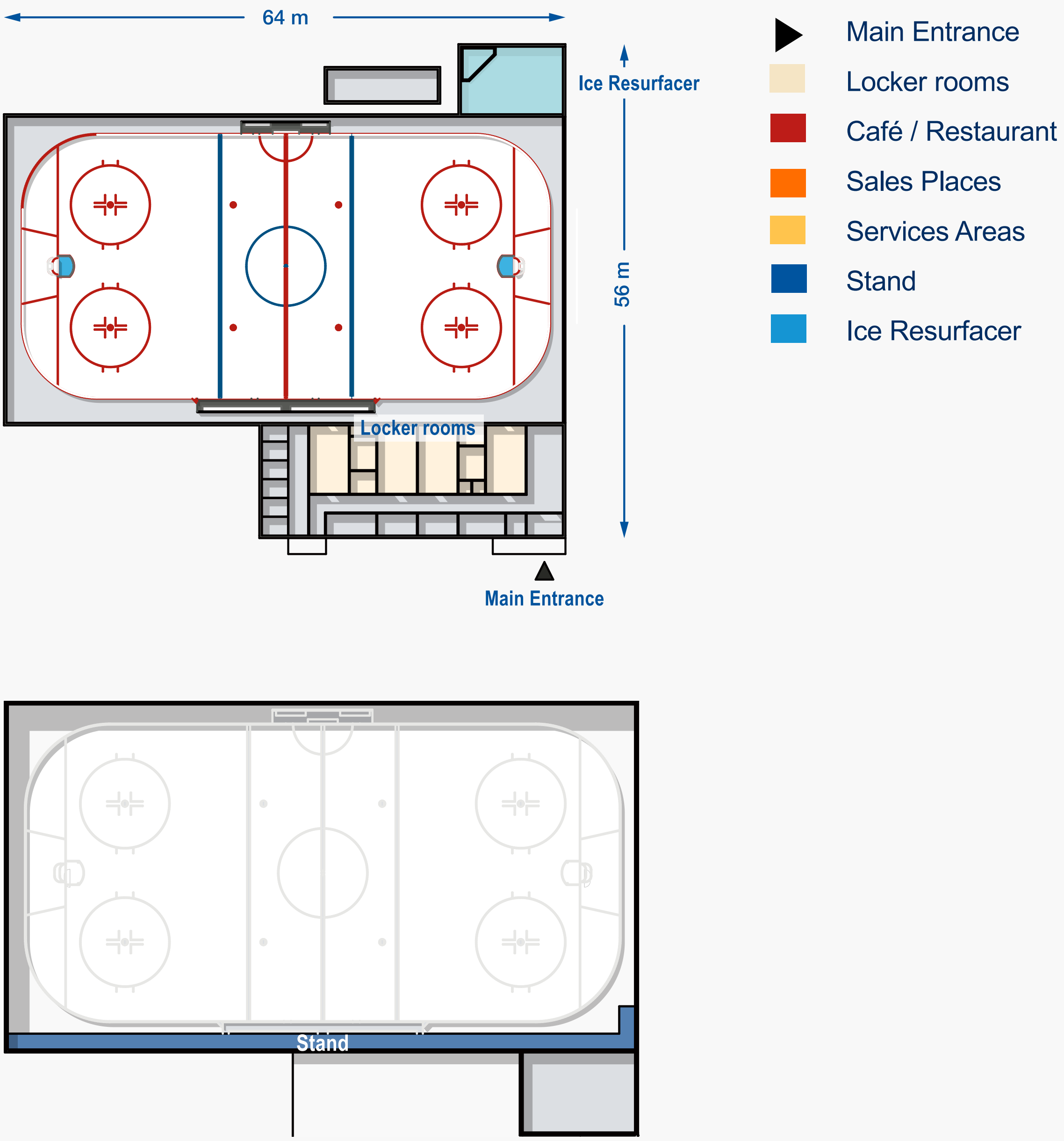
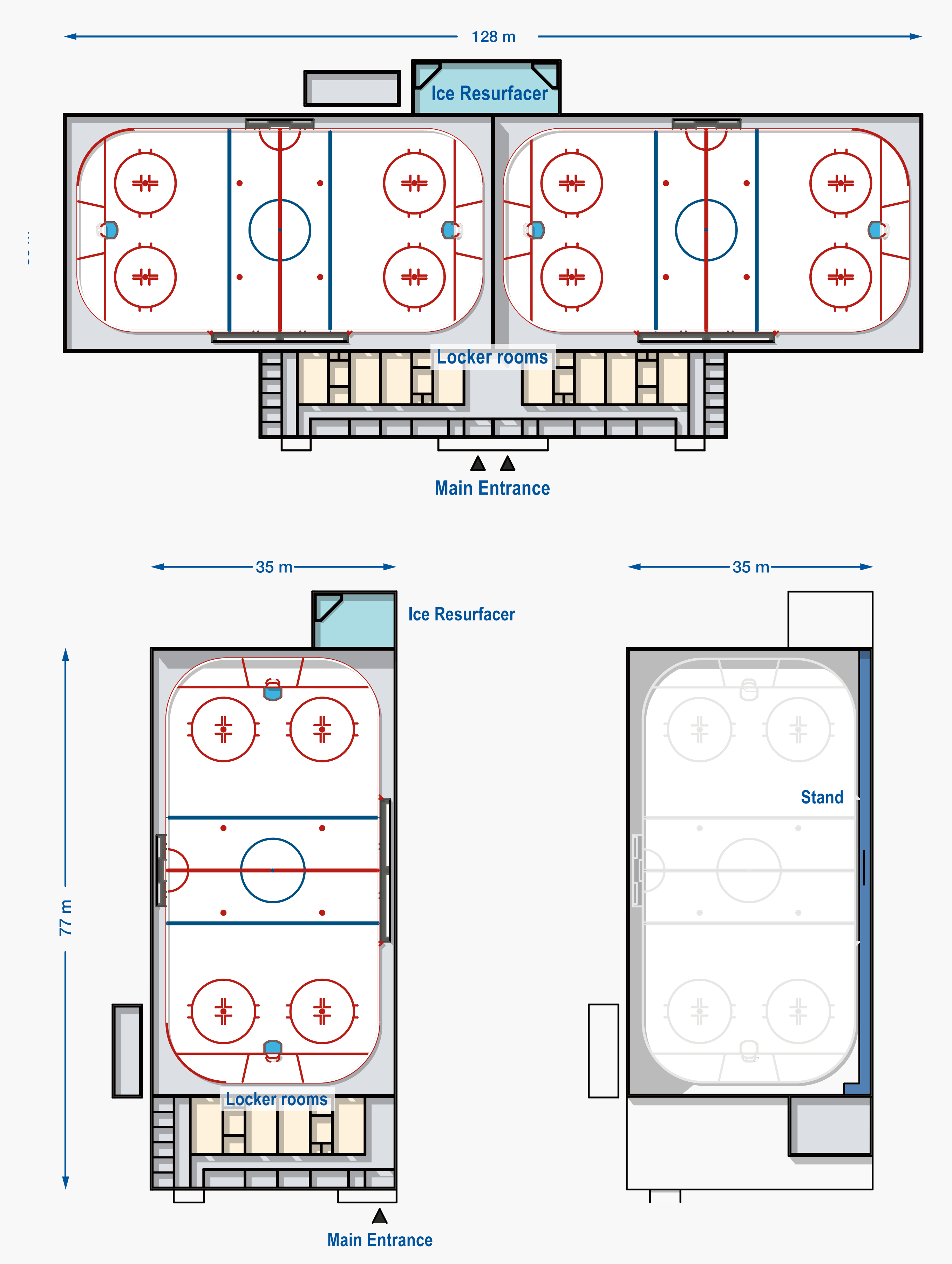
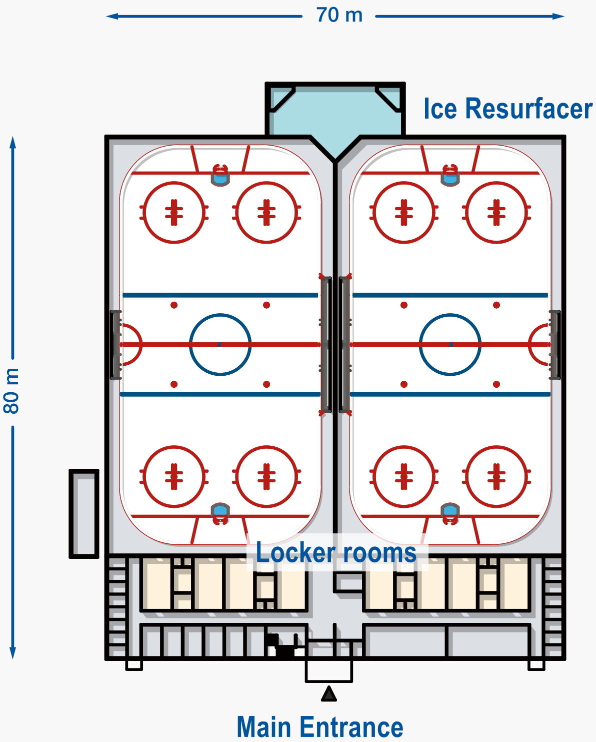
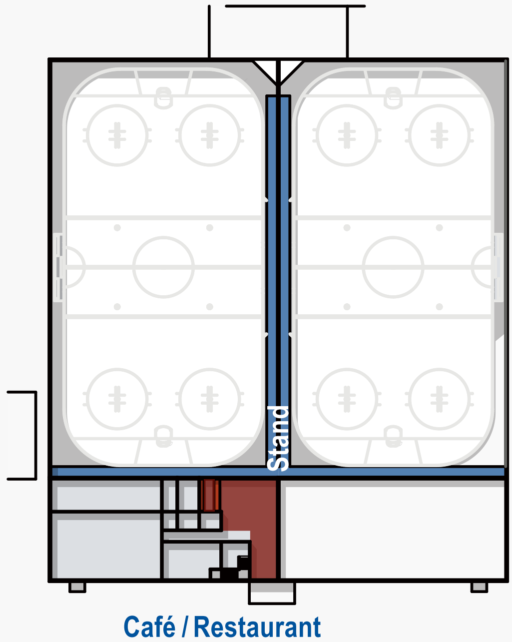
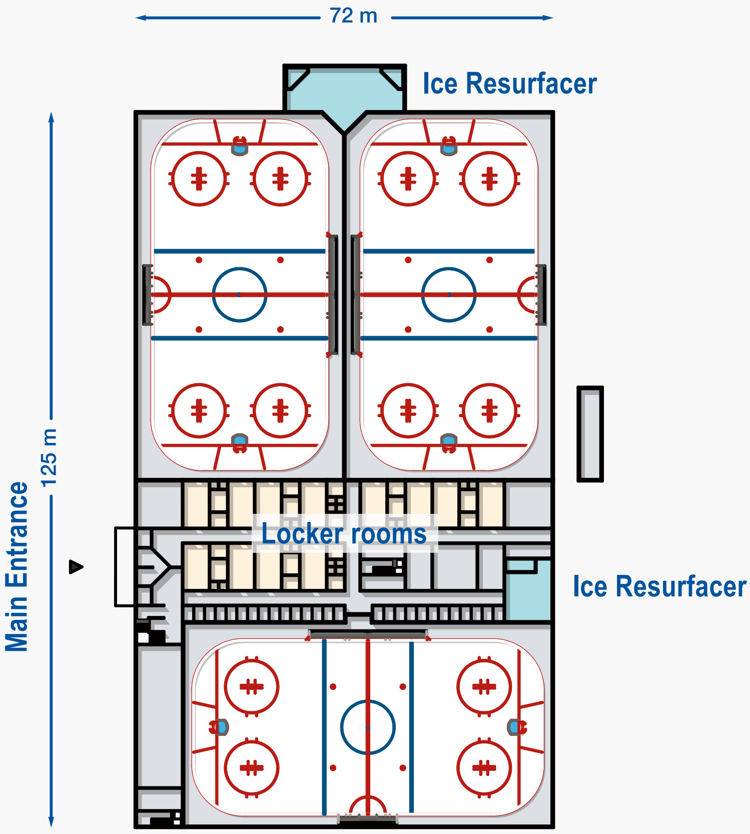
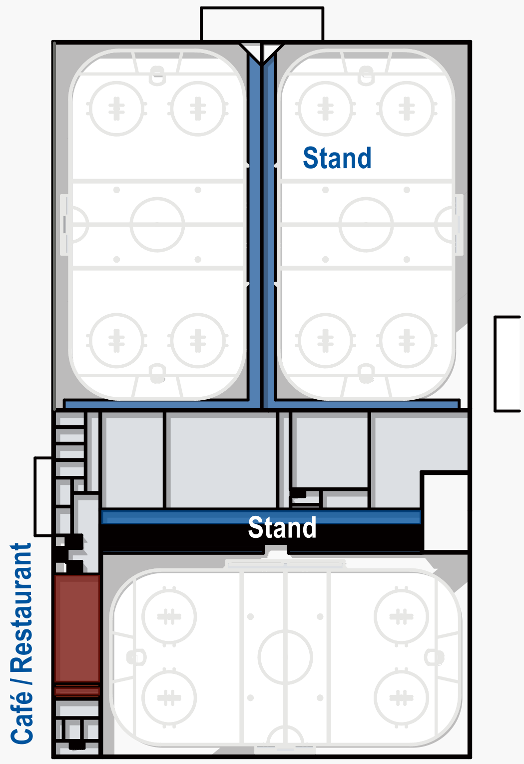


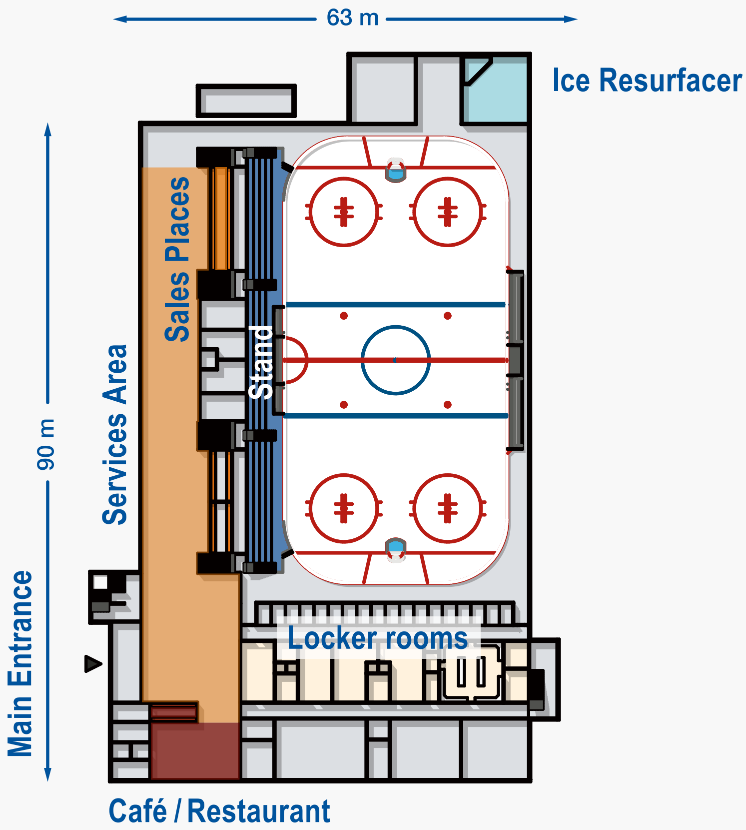

128 m
Ice Resurfacer
Locker rooms
Main Entrance
35 m
35 m
Ice Resurfacer
77 m
Stand
Locker rooms
Main Entrance

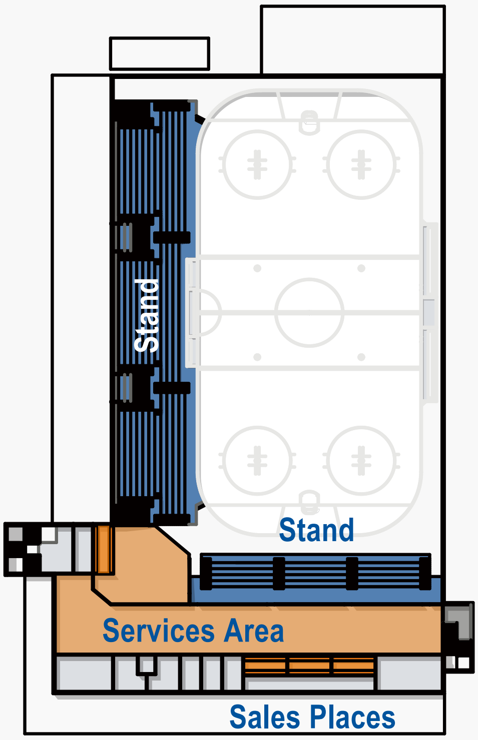

70 m
80 m
Ice Resurfacer
Locker rooms
Main Entrance

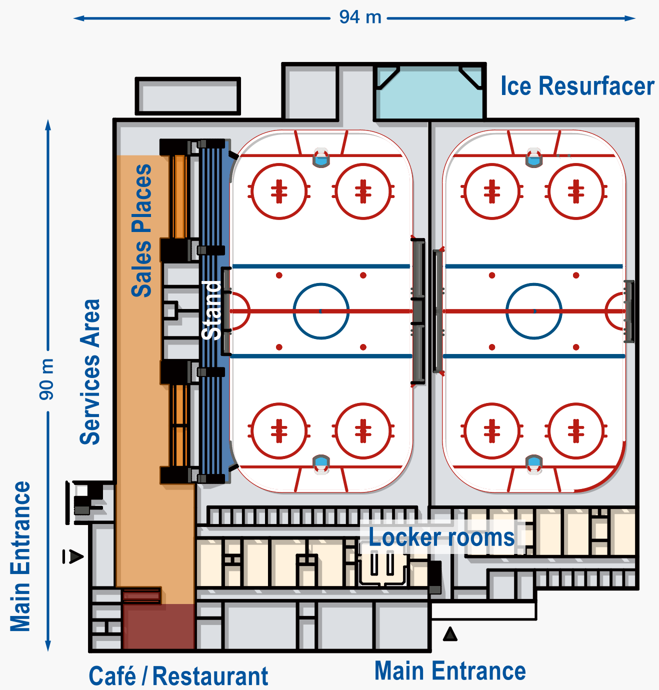

Stand
Café / Restaurant

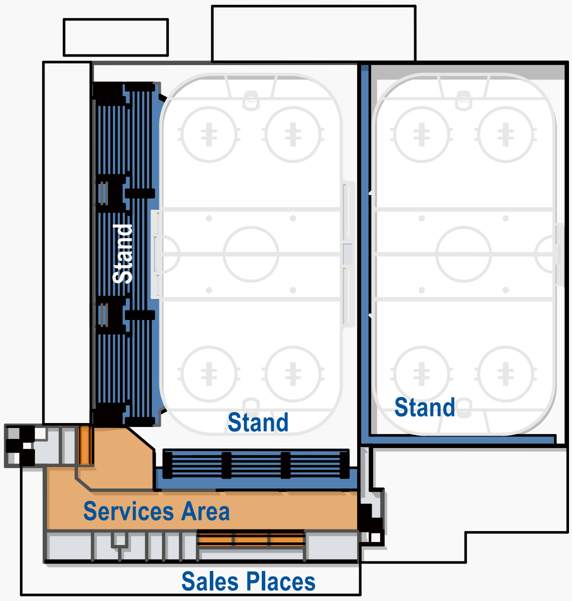

72 m
125 m
Main Entrance
Ice Resurfacer
Locker rooms
Ice Resurfacer


Stand
Stand
Café / Restaurant

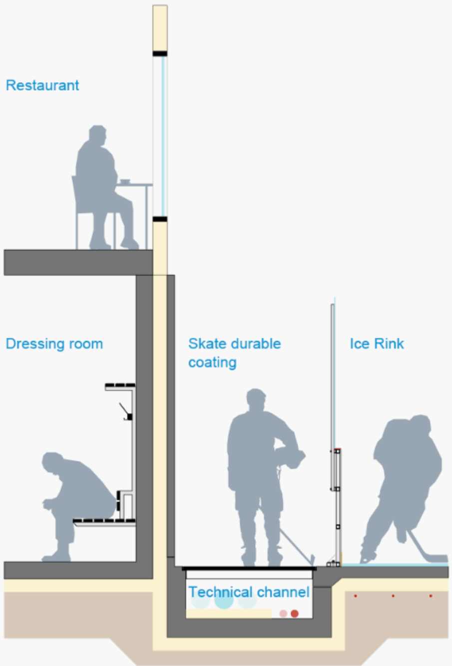

63 m
Ice Resurfacer
90 m
Main Entrance
Services Area
Sales Places
Stand
Locker rooms
Café / Restaurant


Stand
Stand
Services Area
Sales Places

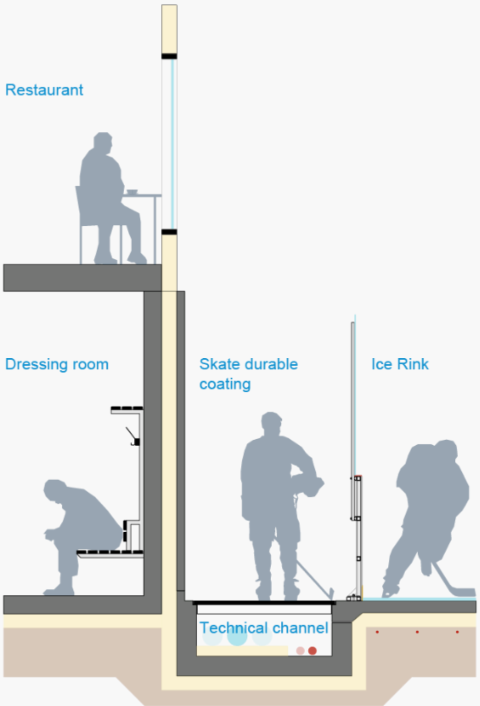

94 m
Ice Resurfacer
90 m
Main Entrance
Services Area
Sales Places
Stand
Locker rooms
Café / Restaurant
Main Entrance


Stand
Stand
Stand
Services Area
Sales Places

Examples of small spectators stands



Small stand on second floor with 300 seats and 100 standing places.



Upper stand between ice rink on the long side of the ice rink.

3.4. Ice Arena Structural System and Envelope

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

- High indoor temperature differences in same indoor climate from –3°C to +18°C, where at the same time these internal climate zones must be controlled and kept stable.
- Differences in indoor climate also cause humidity problems that must be kept 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 arena could be composed by a fully closed casing.

FRAME TYPES:

The frame of the ice rink space is usually made as a lattice or ring structure. In a practice ice arena where there are no large seating areas extending the free span of the ice rink space, beam structures can also be used cost effectively.

Concrete, steel, wood, and combinations of these can be used as materials for the supporting frame of the ice rink space.

The aim of the frame design is clarity and optimal module dimensioning. In the design phase all structural possibilities for later enlargement of the arena should be defined considering the size of the plot, the traffic situation, and possible changes in the surroundings.

Ice arenas can also be built as air-supported structures (air dome), in which case the arena does not have a fixed frame. The arena envelope is then a single structure that stays in place with the help of air pressure. Construction costs are lower, but there are some risks related to the durability of the structure if there are strong winds or heavy snow loads in the area.


LANXESS arena


ROGERS PLACE


5050 $66180

Materials of structural system – PROS and CONS:

STEEL SUPPORT	WOOD SUPPORT	REINFORCED CONCRETE	MIX MATERIAL COMBINATION
long span length	long span length	beam span length	long span length
global availability	global availability	global availability	-
corroding	non-corroding	non-corroding	corroding
fire protection	fire protection	fire protection	fire protection
prefab system	prefab system	prefab system	prefab system
maintenance	maintenance	maintenance	maintenance
		flexibility in use	
		acoustic feature	
	decaying		decaying

Building envelope:

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 and elements and the running costs are high. Depending on surroundings there might also be noise problems with an open-air rink – traffic noise may be an issue for 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. 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 costs.

The main function of an ice arena envelope is air tightness. Thermal insulation of the envelope is also necessary to control indoor conditions. The optimal level of thermal insulation depends on the location of the planned ice arena. In conditions where the outside temperature is sometimes colder than the inside temperature and sometimes warmer, the risk of water condensing in the envelope is high. The structures of the envelope must function properly in terms of humidity throughout the year.

In structures, attention should also be paid to their fault tolerance in abnormal conditions. There must be no unventilated cavities in the envelope structures. There may be a risk of condensation on them when the outside temperature changes. Also, in the structures between the warm rooms and the cold hall, thermal insulation, vapor barrier and the possibility of condensation at the cold bridges must be considered.

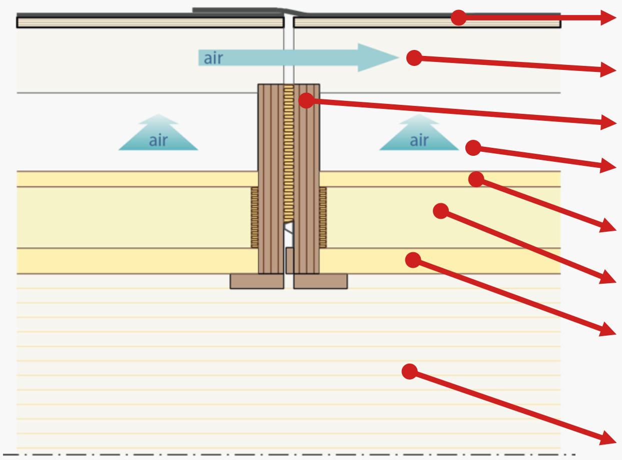
Examples of roof structure:

A light color of the roofing and a high level of reflection substantially reduce the thermal load and the harm caused by it.

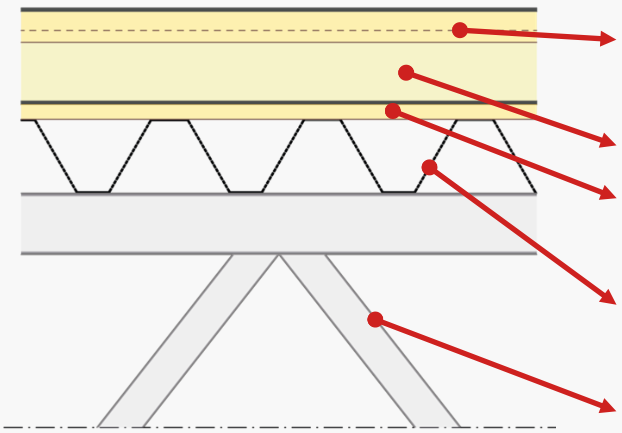
Picture from ozone ice rink in Bracknell, UK

When designing ventilated envelope structures, their moisture-technical functioning is verified by calculation. After the building is completed, the functionality of the structure is monitored with internal measuring sensors.

With the help of the low-emissivity (aluminum surface) inner ceiling, significant energy savings are achieved, regardless of the thickness of the envelope's thermal insulation. The higher the temperature is in the hall, the more benefit the coating brings. The feasibility of dry hold during construction is considered in the roof structures of the wide-framed building.



- Waterproofing cover, light color, pine plywood
- Secondary bracket / air passage
- Glu laminated wood
- Air passage
- Non-combustible thermal insulation
- Secondary bracket / thermal insulation
- Non-combustible acoustic material with aluminum surface
- Load-bearing beam or lattice



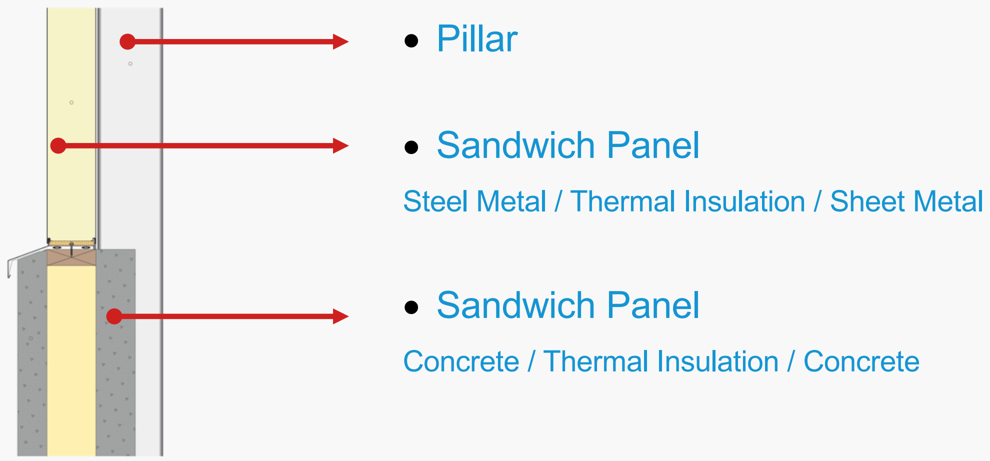
- Waterproofing cover, light colour, Grooved non-combustible thermal insulation
- Thermal insulation
- Vapor barrier, non-combustible thermal insulation
- Load-bearing sheet metal profile with acoustic perforation
- Load-bearing beam or lattice

The infographics show two commonly used roof structures. A wood roof element and an on-site built roof structure with a load-bearing steel profile plate. Element structures can reduce moisture damage caused by rainwater and snow, because it is difficult to protect large roof surfaces built on site and the building time is longer.

Example of wall structure:

The exterior wall structure of an ice arena is commonly based on the idea of air tightness and the simplest walling is made using different metal sheet panels. These panels are simple, prefabricated sandwich elements that have an inside core of thermal insulation and both sides covered with metal sheets. These panels also very easily allow later changes of the envelope and with rather low additional cost.

These metal sheet panels are manufactured in sizes up to 12m each, in various colors and surface treatments. 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 ice pad structure:

Perhaps the most special structure in an ice arena 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 the use of new materials and technical solutions in these structures possible, while simultaneously optimizing energy efficiency and construction costs.

The ice pad is set up in such a way that no harmful subsidence can occur. For cost reasons, the aim is to make the ice pad primarily based on the ground (slab-on-grade).

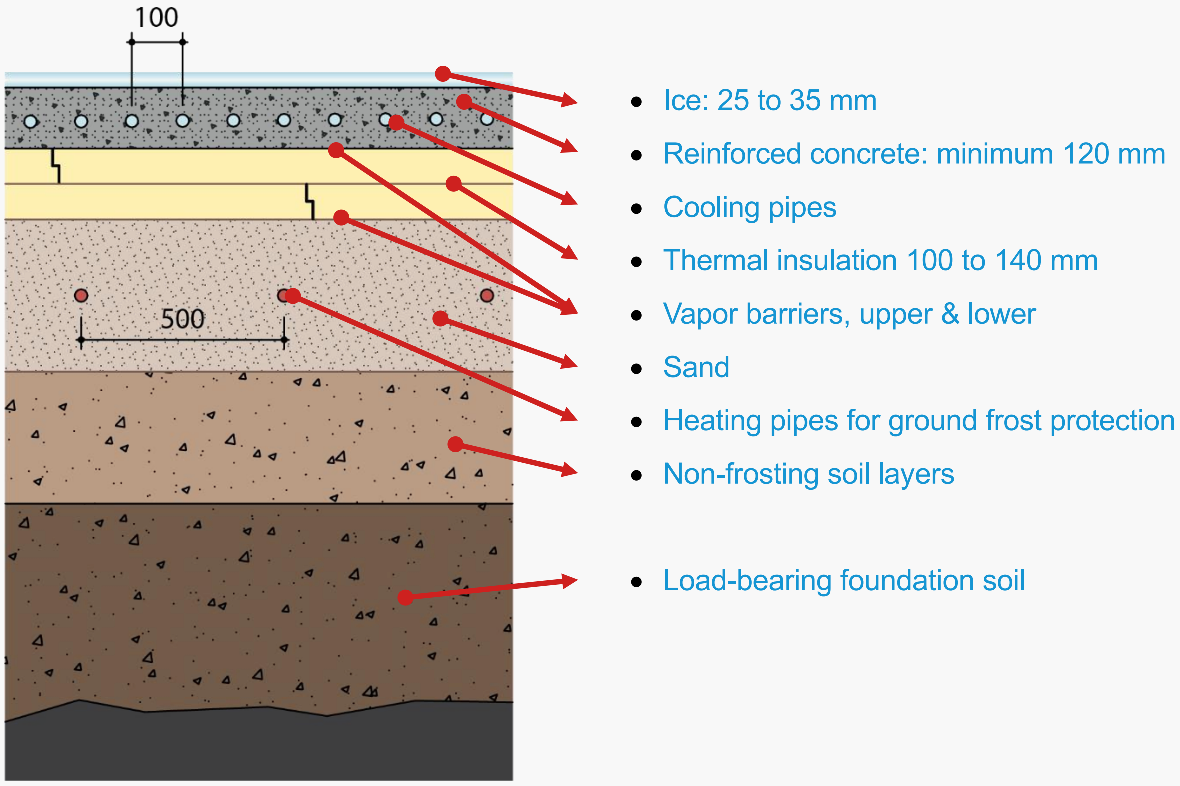
The ice pad surface is usually a reinforced concrete slab, which is a thermally good solution and, as it is wear-resistant, also best suited for multi-purpose use. The reinforced concrete slab is made with a thickness of at least 120 mm.

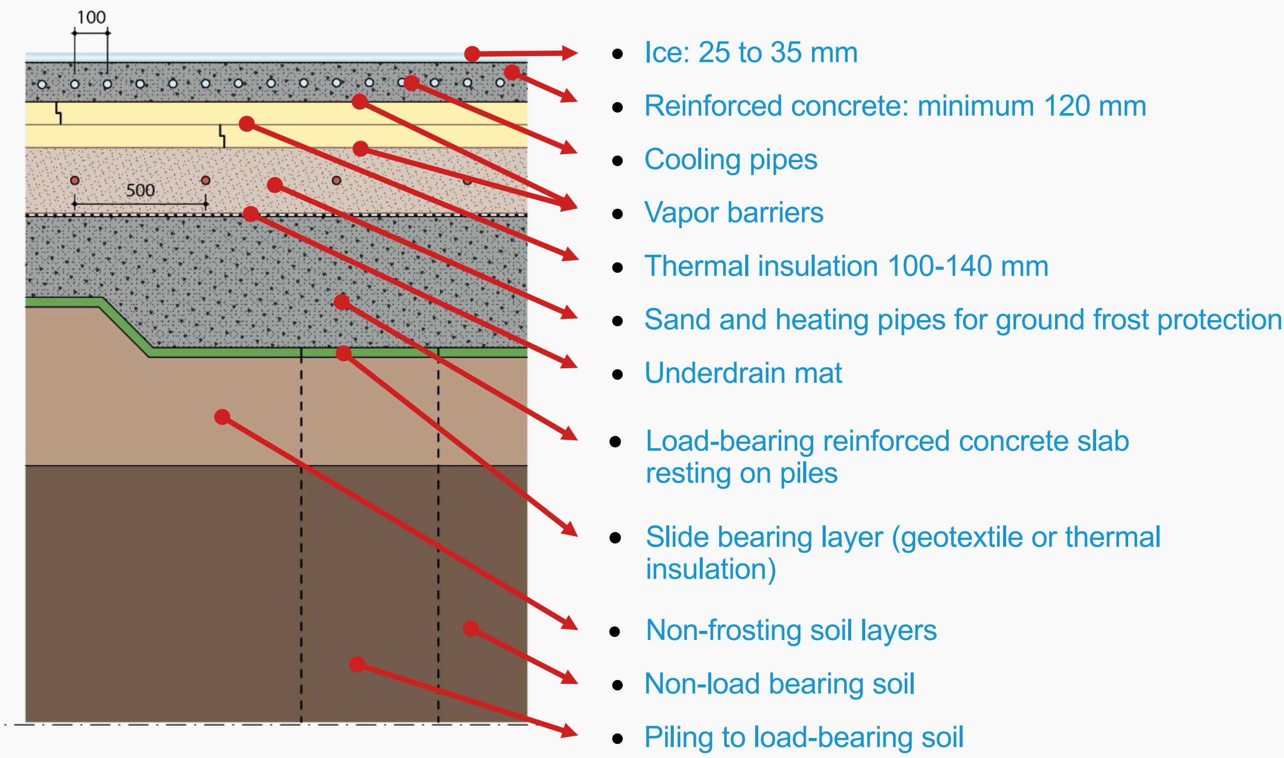
A sand ice pad surface is the cheapest and fairly energy efficient due to the good heat transfer characteristics, but its usability is limited to ice sports only, unless covered with a ice cover.

Plastic or steel cooling pipes are usually installed every 100 mm between the upper and lower reinforcement nets of the concrete slab.

The purpose of the thermal insulation layer of the cold slab is to prevent the transfer of heat from the soil layers below to the cold slab and, accordingly, to prevent freezing of the soil layers below. The thermal insulation must also withstand the loads placed on the concrete slab and the freezing and thawing stresses of the structures.
Below the cold slab and its frost insulation, heating pipes for ground frost protection and measuring sensors are planned, which will help always keep the temperature in the foundation structures above 0° C.

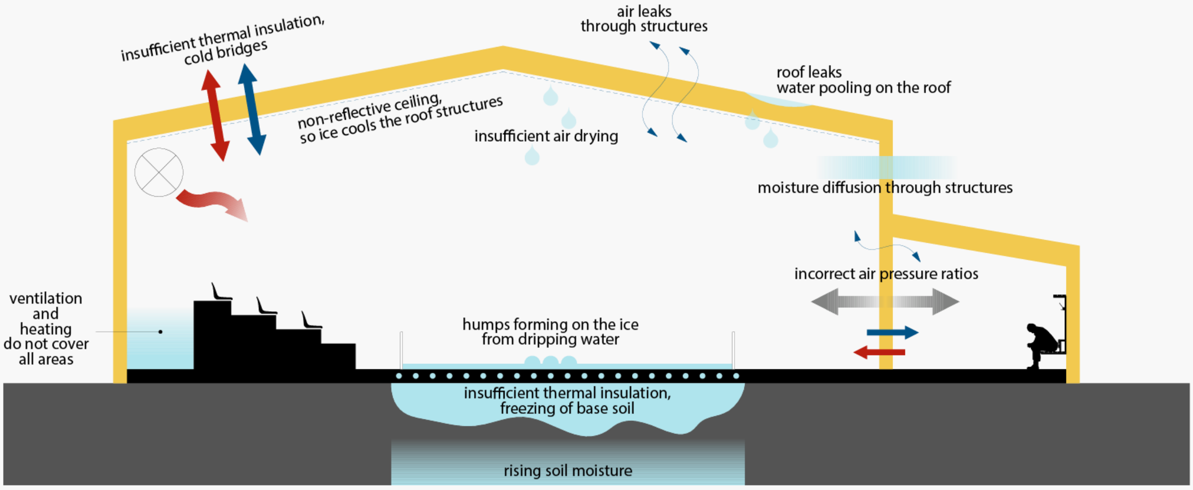
If the base soil is not load-bearing, a separate piled load bearing reinforced concrete slab must be built under the ice pad. Load-bearing pile foundations transmit loads through the soil onto a layer that can bear the load of the concrete slab.


100
500
Ice: 25 to 35 mm
Reinforced concrete: minimum 120 mm
Cooling pipes
Thermal insulation 100 to 140 mm
Vapor barriers, upper & lower
Sand
Heating pipes for ground frost protection
Non-frosting soil layers
Load-bearing foundation soil

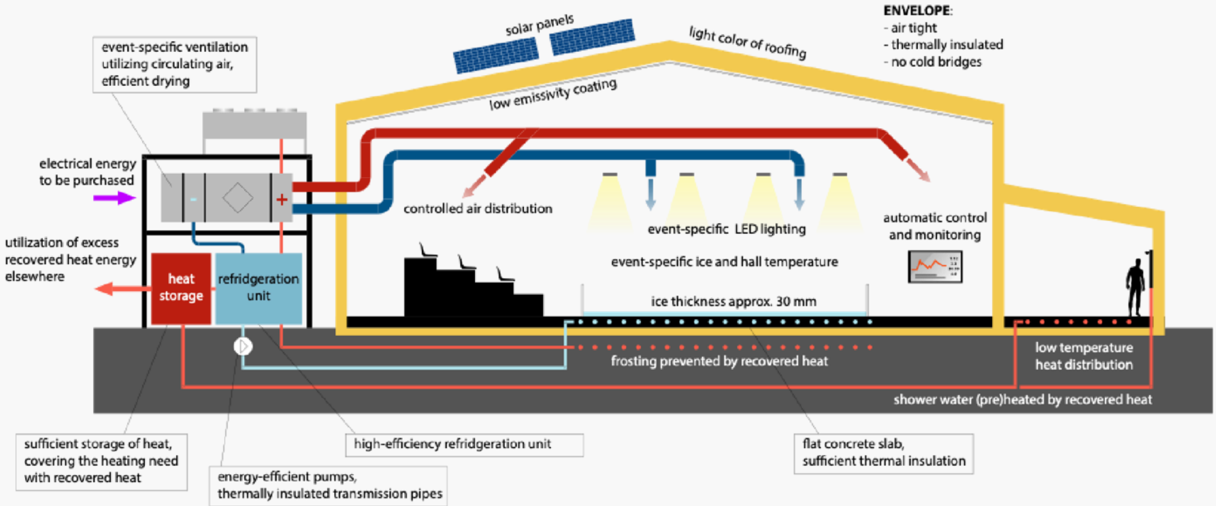

100
500
Ice: 25 to 35 mm
Reinforced concrete: minimum 120 mm
Cooling pipes
Vapor barriers
Thermal insulation 100-140 mm
Sand and heating pipes for ground frost protection
Underdrain mat
Load-bearing reinforced concrete slab resting on piles
Slide bearing layer (geotextile or thermal insulation)
Non-frosting soil layers
Non-load bearing soil
Piling to load-bearing soil

3.5. Structural Points of View And Technical Principles

Typical Mistakes that lead to Energy-Inefficiency



Best-Practice: Energy-efficient Ice Arena



3.6. Acoustics And Noise Control

Ice arena technology such as outdoor condensing fans cause noise that, depending on the location of the building, can be disturbing to the environment. The permitted noise levels must always be determined in the planning phase and the noise levels of the equipment must be scaled accordingly.

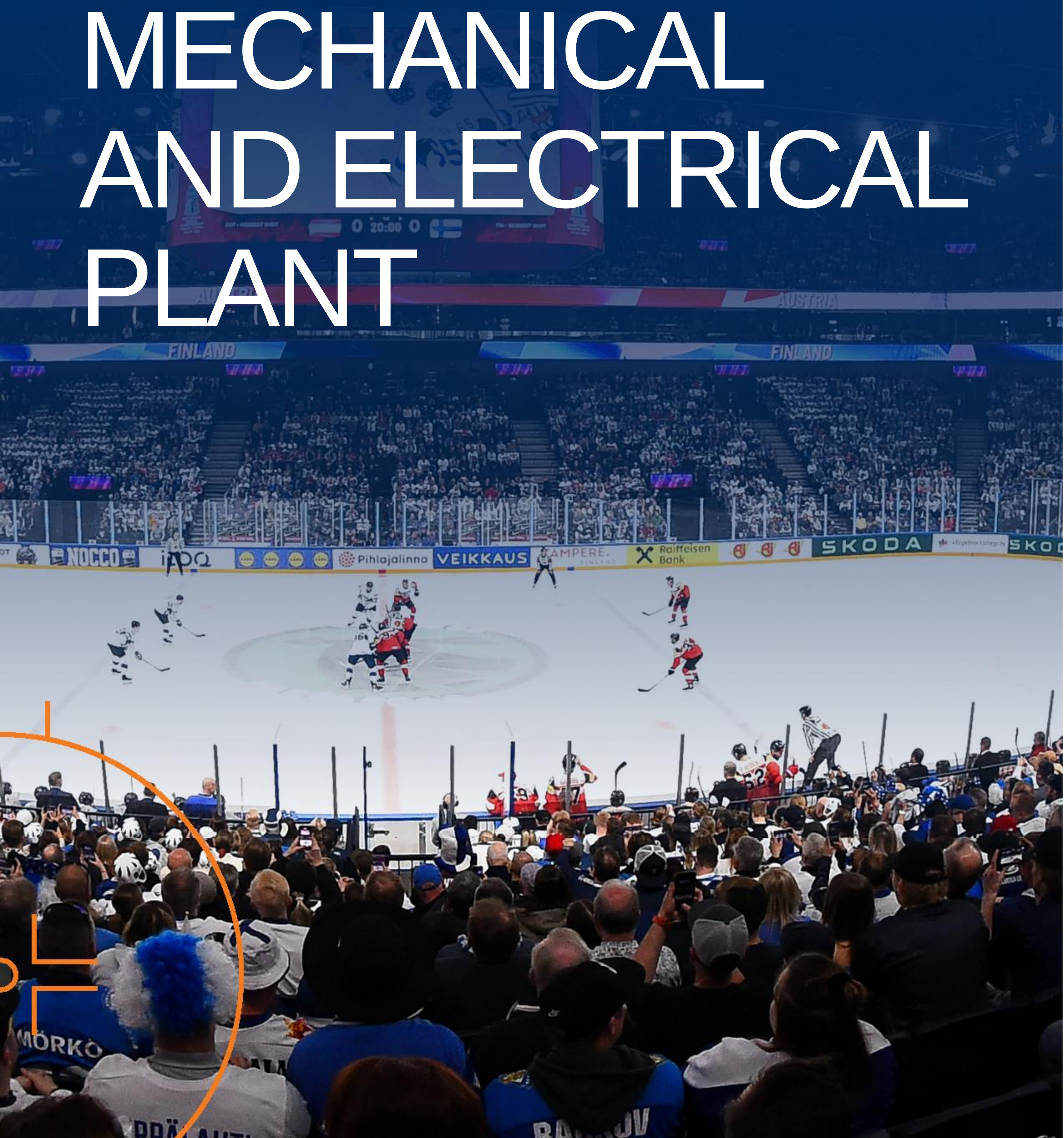
In practice ice arenas, the reverberation time is often too long, more than 3 seconds. The hall has a lot of hard surfaces, which increases the importance of the acoustic design. Sound reduction has practical benefits, especially in training situations and in the use of electronic sound reproduction, as well as in terms of quality - for example, in the intelligibility of announcements and in the possible use of the hall for other purposes and events.

In ice arenas with several ice pads, the aim is to place each of them in their own separate hall spaces, so that the sounds of simultaneous games or practices do not disturb each other. If the ice pads are side by side in the same hall space, sound absorbing structures should be placed between them.

When using and placing acoustic materials in the hall, the risks of mold and the mechanical stress caused by bouncing pucks must be considered.

CHAPTER 4

MECHANICAL AND ELECTRICAL PLANT



4 Mechanical And Electric Plant

4.1. Introduction

To operate an ice arena there are generally five basic energy systems required:

Refrigeration

- The refrigeration system keeps the ice pad cold and freezes ice-resurfacing water.

Heating

- The heating system keeps the indoor air temperatures on a comfortable level, both in the hall and in the other facilities.
- The heating system produces hot water for washing, ice resurfacing and other needs.

Dehumidification

- The dehumidification system keeps the indoor air humidity level appropriate. Excess moisture causes problems to the structures, increased energy consumption and ice quality problems.

Ventilation

- The ventilation system moves fresh air to the arena when it is needed and maintains good indoor air quality. Ventilation machines can also be used for heating purposes.

Lighting

- Lighting is needed to achieve comfortable and safe visual conditions.

These systems are often called the “big five”, because they typically account for more than 90% of the energy used in the ice arena. Systems are often integrated with each other; for example, the same ventilation unit can cover ventilation, heating and dehumidification needs for a small practice arena. Even if the systems are totally separated, they always interact by impacting each other’s energy usage.

Energy efficiency of the ice arena is strongly dependent on how its systems are designed and maintained. However, it is important to understand that the desired indoor conditions (temperatures, humidity levels) also play a significant role in how much energy is used. In planning the systems and construction of an ice arena, one should consider the types of activities, special requirements and interests of the various user groups. Table 4.1 summarizes the main indoor air design values, which can be used in designing technical systems. The values are guidelines, and they must be considered case by case. It is important to set these values already in the pre-design stage, to guide the system design and sizing.

Type of ice rink	Activity	Air temperature of the rink space °C		Ice surface temperature °C	Max relative humidity of the rink space (%)	Min. fresh air intake l/s/occupant
		Rink at 1m:n operative	Tribune			
arena Practice	**Hockey**					
	Game	+8…+10	+10	-4…-5	60	6 / spectator 20 / player
	Training	+6…+8	-	-4…-5	60	20 / player
	Figure skating					
	Competition	+9…+11	+10	-3…-4	60	6 / spectator 20 / skater
	Training	+9…+10	-	-3…-4	60	20 / skater
	Public skating	+6…+8	-	-3…-4	60	10 / skater
Small competition arena	**Hockey**					
	Game	+8…+10	+15	-4,5...-5,5	60	6 / spectator 20 / player
	Training	+6…+8	-	-4…-5	60	20 / player
	Figure skating					
	Competition	+9…+12	+15	-3,5…-4,5	60	6 / spectator 20 / skater
	Training	+9…+11	-	-3…-4	60	20 / skater
	Other	+18	+18	-	-	6 / person

TABLE 4.1: Indoor air design values for Practice arena and small competition arena (rink space)

In addition to the desired indoor conditions at the arena, it is very important to consider the surrounding environment and how it affects to the system design and sizing. One of the main factors is the weather conditions of the area since warm weather generates both heat and moisture load to the rink space. Other important factor is the seating capacity of the rink since spectators generate both heat and humidity to the space as well.

It is quite common that ice rinks are placed into buildings that are not primarily designed for ice rink purposes. One example of these are the mainly recreational skating rinks at the shopping and entertainment malls. This environment needs a significant cooling capacity for the rink because the indoor temperature can be high and warm air frequently enters freely from the surroundings to the rink area. To achieve a good ice quality, it is always recommended that ice rink space is separated from the surrounding spaces by walls or windows. This allows the use of independent ventilation and dehumidification system and control for the ice rink space.

4.2. The Refrigeration System

The refrigeration system is needed to make and maintain the ice on the rink slab, and therefore is fundamental for the ice arena. A frequently used phrase is also that the refrigeration unit is the heart of the ice arena. 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 arena.

Ice arena refrigeration systems naturally produce excess heat as a byproduct, which can be harnessed to heat the facility, significantly reducing energy costs. With modern technology, this heat can be captured more efficiently and used for various purposes, including heating water, warming seating areas, or even preheating ventilation systems. In some advanced setups, the surplus heat can be transferred to geothermal wells for long-term storage or sold to nearby facilities, making the arena more energy-efficient and creating an additional revenue stream. This approach not only conserves energy but also contributes to a more sustainable and environmentally friendly operation.

In the design stage, when choosing the refrigeration unit, one must consider the economics, energy usage, environment, operation, maintenance, and safety. When estimating the energy economy of the system, it is essential to focus on the entire system and not on only one component alone. The refrigeration plant is an integral part of the ice arena, as is shown in FIGURE 4.1.

Refrigeration unit and Related Energy Flows

INDOOR CLIMATE

- Air temperature
- Ceiling temperature and material
- Ice temperature

PAID 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

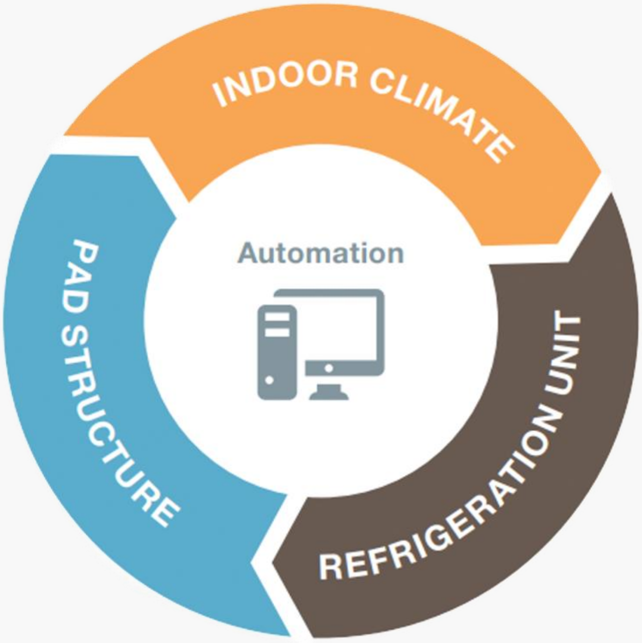


FIGURE 4.1: Factors affecting to the design, dimensioning, and energy use of the refrigeration system.

A refrigeration system includes the compressor(s), the condenser(s), the evaporator(s), and rink piping. 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. Indirect systems have become the most common system type of new ice rinks, but direct systems are also built when carbon dioxide is used as a refrigerant. FIGURE 4.2 shows the simplified schematics of the direct and indirect system.

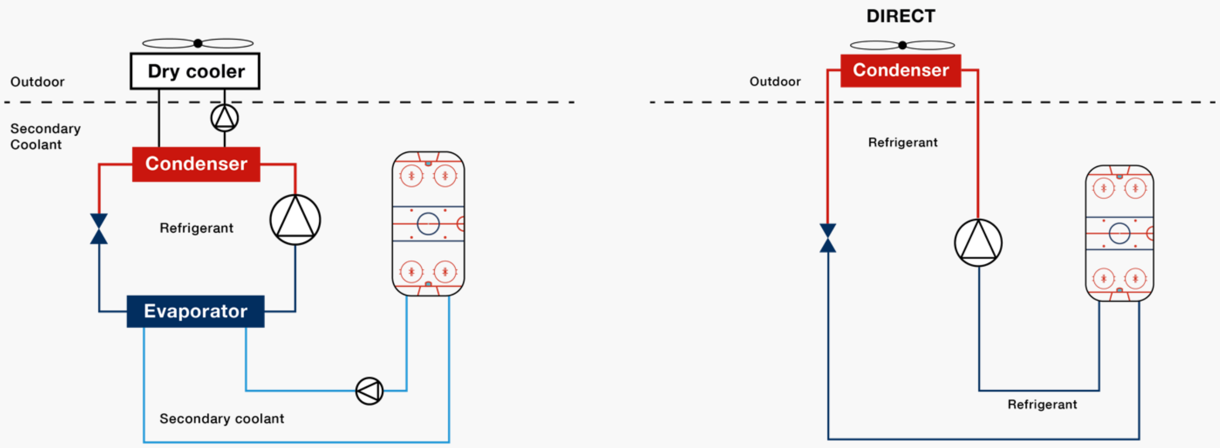


FIGURE 4.2: Two main refrigeration systems in ice rinks, simplified schematic.
To achieve sustainable and energy-efficient ice rink, it is necessary to recover the heat generated by the refrigeration system and use it for the heating purposes in the facility. The next three figures show three different system types common for new ice rink projects, that include heat recovery.

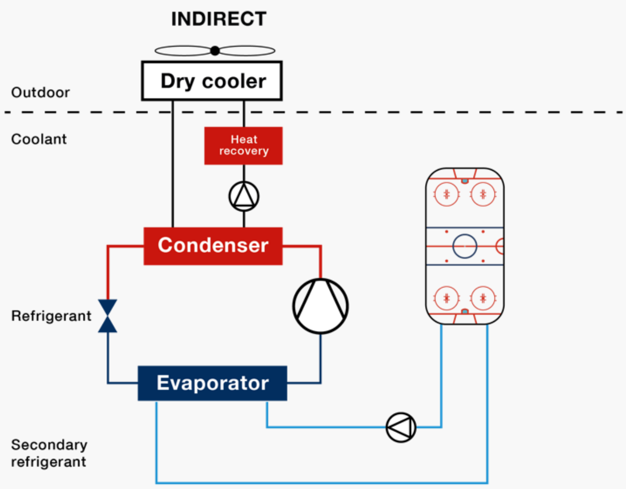


FIGURE 4.3: Indirect system, that has indirect piping loops for ice pad and condense heat removal.
Heat recovery functions can utilize heat from the condenser coolant pipes. Common system type in ammonia-, HFC and HFO-based refrigeration systems. (Schema taken from the IIHF sustainability guide & edited)

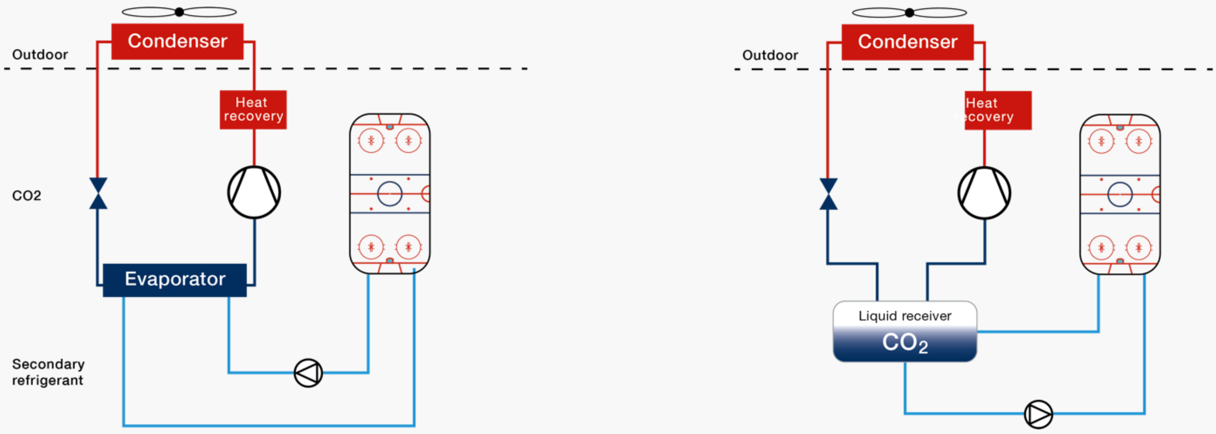


FIGURE 4.4: Two system types used especially for CO_2 refrigerant.
Indirect system with direct condenser on the left, and fully direct CO_2 system on the right. Indirect system type with direct condenser (left) is used in the older HFC systems as well. (Schemas taken from the IIHF sustainability guide)

INDIRECT SYSTEM, HFC/HFO/ AMMONIA REFRIGERANT (FIGURE 4.3)	CO_2 SYSTEM, INDIRECT ICE PAD (FIGURE 4.4 LEFT)	CO_2 SYSTEM, FULLY DIRECT (FIGURE 4.4 RIGHT)
+ Traditional, well-known system + Small refrigerant charge + Refrigerant leak into the ice rink space not possible	+ Low-GWP, non-toxic, non-flammable refrigerant + Smaller refrigerant charge than in the fully direct CO_2 + Possibility for high-temperature heat recovery	+ Low-GWP, non-toxic, non-flammable refrigerant + Efficient system, no additional pumps needed + Even ice temperature on the whole ice, good ice quality + Possibility for high-temperature heat recovery
− Lower efficiency, due to additional heat exchangers and pumping power − Low temperature level of the heat recovery − Use of chemicals that can be flammable or toxic (refrigerants & coolants)	− Lower efficiency, especially on high outdoor temperatures − Use of chemical coolants and additional pumping power − High pressures on the system	− Big CO_2 charge, big high-pressure vessels − Higher investment cost − Theoretical possibility of CO_2 leak into the ice rink space − Complicated system design

TABLE 4.2: Recommended maximum relative humidity in different ice rink temperatures.

Design and dimensioning aspects

The refrigeration plant is dimensioned according to the cooling load, and the required evaporation and condenser temperatures. For a standard single ice rink approximately 300 – 400 kW of refrigeration capacity is adequate.

The refrigeration capacity is normally sized according to the heat loads during the ice making process, but maximum heat load during normal usage periods must be also calculated and checked. The dimensioning cooling load during the freezing period is comprised of the following components:

- Cooling the ice pad construction down to the operating temperature within the 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 cooling load 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. This cooling load is heavily dependent on emissivity of the surfaces, especially the roof, and the temperatures of the surfaces.
- Convective heat load between the rink surface and the air. Cooling load 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 from the condensing water vapor transferring 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.
- Inner heat loads: lights, people, etc.
- Pump work of the coolant pump.
- Dehumidification loads, if the rink is equipped with a condensing-type dehumidification system that uses the same refrigeration plant as the ice rink pad itself.

4.3. Refrigerant

The refrigerant used in the compressor loop should be energy-efficient, safe, and environmentally and legally accepted. Refrigerants are divided into different subgroups:

- **HCFCs:** (hydrochlorofluorocarbons) are synthetic refrigerants, that have the undesirable feature of causing damage to the Earth's ozone layer, when released as a gas to the atmosphere. HCFCs are still used in some old systems but are being phased out in all parts of the world. The most widely used HCFC refrigerant is R-22.
- **HFCs:** (hydrofluorocarbons) are synthetic refrigerants that are widely used in conventional ice rinks. They have no effect on the ozone layer, but they are strong greenhouse gases. The greenhouse gas effect is described by the refrigerants GWP value, which tells how strong greenhouse gas the refrigerant is, if it is released to the atmosphere. High-GWP HFC refrigerants are being phased out in many parts of the world, but the phase-out timetables vary. However, GWP value does not describe the energy efficiency of the refrigeration system.
- **HFOs:** (hydrofluoricolefins) are newer synthetic refrigerants, that have no effect on the ozone layer and very low greenhouse gas potential / GWP value. However, several studies have reported other environmental and health concerns that HFOs introduce.
- **Natural refrigerants** are non-synthetic and can be found in nature. The most prominent of these are various hydrocarbons, carbon dioxide and ammonia. Natural refrigerants offer sustainable solutions in terms of ozone and greenhouse gas effect but cause some safety concerns about the design and use.

  Natural refrigerants are a highly recommended choice for the new ice rink refrigeration systems, because they offer the best long-term solution in terms of availability and maintenance. Especially in the EU area, all other refrigerant types are in the process of being phased out. Legislation and phase-out plans vary in different parts of the world, and therefore the country-specific situation must be considered.

  Safety factors (flammability, toxicity, etc.,) play a significant role in refrigerant selection, and should also be considered in the placement and design of the machine room.
  When choosing the refrigerant, the country-specific regulations must be considered. Please always contact the local safety and environmental authorities regarding this.
  The following TABLE, 4.2, offers an overview of the most common refrigerants and their properties.

Refrigerant	Group	Toxicity	Flammability	GWP (global warming potential)
R744 (carbon dioxide)	Natural	Non-toxic	Non-flammable	1
R717 (ammonia)	Natural	Toxic	Low	0
R290 (propane)	Natural	Non-toxic	High	3
R404 A	Synthetic HFO	Non-toxic	Non-flammable	3992
R410 A	Synthetic HFO	Non-toxic	Non-flammable	2088
R134a	Synthetic HFO	Non-toxic	Non-flammable	1430
R513A	Synthetic HFO	Non-toxic	Non-flammable	631
R1234yf	Synthetic HFO	Non-toxic	Low	4
R1234ze	Synthetic HFO	Non-toxic	Low	7

TABLE 4.3: Safety properties and GWP values of the commonly used refrigerants

4.4. Refrigeration Unit

A refrigeration unit is comprised of many components: compressor(s), evaporator, condenser, and expansion valve(s), piping, 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 a 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.

The refrigerant circuit normally includes at least 2 compressors in parallel, to guarantee flexible and economical use of the unit. A refrigeration unit can also include multiple refrigerant circuits.

From the energy point of view, it is essential that the compressor units should be as efficient as possible, not only in the design point but also under part-load conditions. The operational aspect is to equip the compressors with a good and efficient cooling capacity control, which can be achieved by using inverter driven compressors.

FIGURE 4.5: Three screw compressors in refrigeration unit

4.5. Ice Pad

The function of the ice pad piping and secondary coolant is to transfer heat from the ice rink to the evaporator in the refrigeration unit. This is achieved by circulating the cooling liquid in the pipes that are installed under the ice pad.

Piping is usually built from plastic, steel, or copper. Steel is used on the older ice rinks, as majority of the new ice rink projects include plastic piping. Copper is used for the high-pressure piping systems, such as fully direct CO_2 refrigeration system.

Piping is usually built from plastic, steel, or copper. The piping layout is usually arranged as indicated in the next picture, where the feed (supply) and return headers are placed on the short end side of the rink. Piping can also be built in such layout where the header is located on the long side of the rink, and the individual pipe loops are shorter.

As the flowing liquid in the pipes cools the ice slab, it absorbs thermal energy to itself. This means that the temperature of the liquid increases. As the liquid flows through the refrigeration unit, the thermal energy is absorbed into the refrigerant and the temperature of the cooling liquid decreases. The temperature difference between the supply and return temperatures of is known as the delta-t (Δt) of the indirect cooling system. This difference Δt is typically 2-4 degrees Celsius/Kelvin.

Delta t (Δt) must always be also taken into account when measuring the surface temperature of ice. If the measuring point is just above the supplying pipeline, the temperature of the ice is lower than just above the returning pipeline. It is not possible to give just one measurement number as the temperature of the ice. Therefore, the surface temperature of the ice varies within the rink, and the temperature rules are always only guidelines within which the highest temperature and the lowest temperature must be kept.

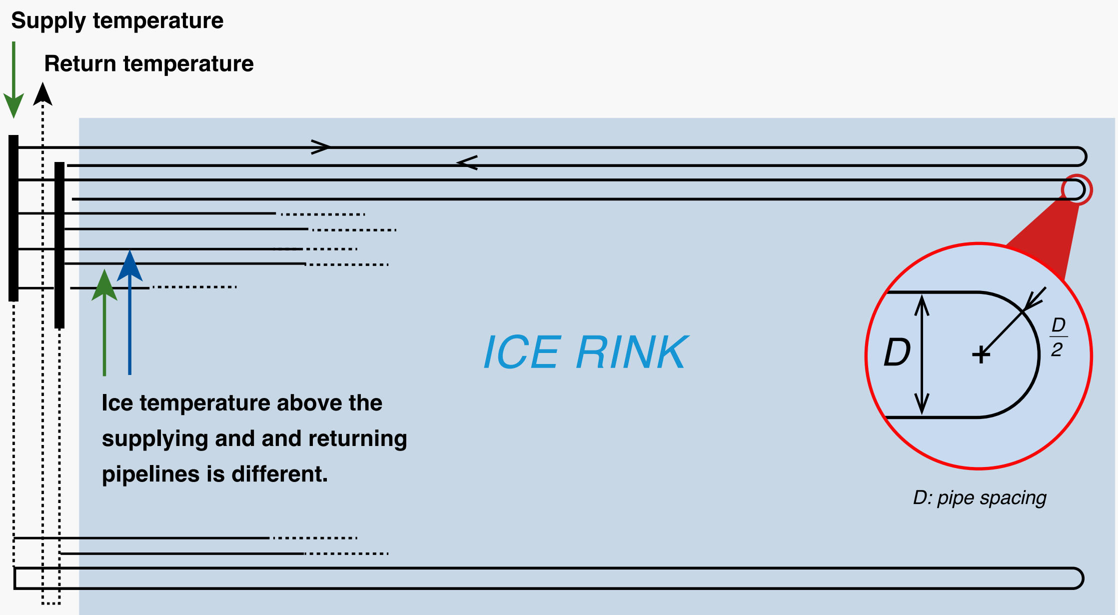


FIGURE 4.4. Piping layout with headers on the short end side.
(Source: IIHF guide to Sustainable Ice Arenas)

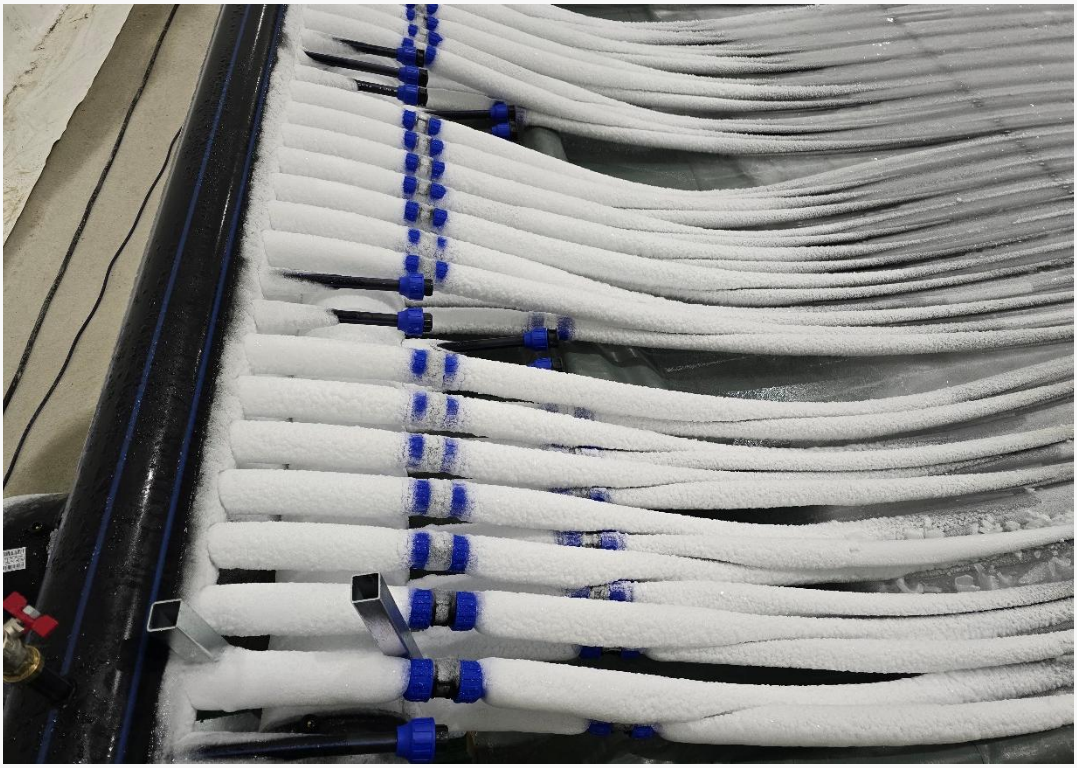


FIGURE 4.2. Plastic rink piping connections to the header and the collection mains.

The perfect ice pad coolant is environmentally friendly, non-toxic, has low pumping cost and high efficiency. It must also be non-corrosive, cheap and practical. A variety of coolants are in use,

TABLE 4.3. summarizes a few of them.

Secondary coolant	**Pros**	**Cons**
Glycols · Ethylene glycol	+ Easy to handle. + Low investment cost	− Toxic (ethylene glycol) − High pumping costs − Low efficiency
Salts (brine) · Calcium chloride	+ Non-toxic + Good efficiency	− Corrosive, special needs for the piping materials − Relatively high pumping costs
Formats · Potassium formats · Potassium acetates	+ Low pumping costs + Good efficiency	− Corrosive, special needs for the piping materials

		− Leaks easily, high requirements for the sealings
Aqua ammonia	+ Low pumping costs + Low investment cost + Good efficiency	− Toxic, difficult to handle − Corrosive, special needs for the piping materials
Carbon dioxide (direct system)	+ Non-toxic + Low pumping costs + Good efficiency	− High pressures, special piping needed − High investment cost − Special requirements for the off-season periods

TABLE 4.4: Summary about the main advantages and disadvantages of the commonly used secondary fluids

An important aspect in the energy chain is the heat resistance between the ice and the brine, which affects the energy consumption. The energy-thinking underlying the heat resistance is the bigger the resistance, the lower the brine and evaporation temperature of the compressor should be 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 four different parameters:

1. Heat resistance of the ice, mainly dependent on the ice thickness
2. The ice, the concrete slab or any other surfacing material constitutes heat resistance
3. 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 the floor material

In the construction of the ice pad, the ground frost insulation and in some cases ground heating is compulsory (condenser 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 an 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 arena for other sports (tennis, basketball) over the ice-free period. Moreover, a non-insulated pad increases energy consumption of the refrigeration.

NOTE: It is proved that a non-insulated pad tends to lose its flatness over the years

4.6. Ventilation And Air Conditioning

It is highly recommended to use mechanical ventilation in ice arenas to ensure healthy and safe indoor air conditions and maintain good ice quality. The air-handling unit(s) provide(s) fresh air to the ice rink and other spaces in the arena, and they can also be used for heating purposes and dehumidifying 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).

Ventilation is needed both in public spaces (dressing rooms, cafeteria, etc.) and in the hall. If you have ever visited a dressing room when the ventilation is off, you will realize the necessity of proper ventilation as the odor of the players' uniforms is unpleasant. Inadequate ventilation can also cause health problems in the arena.

To be energy efficient, air conditioning must be well controlled. This means that the ice rink envelope should be airtight 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 next basic demand: the ice arena must be heated. An unheated ice rink is freezing cold even in warm climates and humidity control of the air becomes difficult.

This leads us to the next purpose for the use of ventilation system in the arena: It is used for heating of the ice rink space. This is achieved by heating the supply air temperature above the desired indoor air temperature. An unheated ice rink is freezing cold even in warm climates and humidity control of the air becomes difficult.

The ice rink space is divided into two thermal zones: the ice rink and the public areas (stands etc.). The simplest and safest way is to equip the arena with two ventilation units, one for the rink space and one for the public spaces, but it can be costly. For a rink with only small stands, the same ventilation unit can be used, but supply air temperature must be independently controlled for both zones.

The energy-saving factor in ventilation can be found in the demand-controlled fresh-air intake, choosing energy-efficient fans, and equipping the ventilation unit with a heat-recovery part.

Maintaining closed doors in ice rinks is crucial due to the significant temperature difference between the indoor ice surface and the outside environment. When doors are left open, warm air from outside enters the rink, which can quickly raise the temperature and humidity inside, leading to poor ice quality. Even slight temperature fluctuations can cause the ice to soften, making it more difficult to maintain a smooth, high-quality surface for skating and hockey.

Closing the doors is a simple, cost-effective solution that helps preserve the ice's integrity by keeping the cold air in and the warm air out. This practice reduces the workload on refrigeration systems, lowers energy consumption, and extends the lifespan of the ice, ensuring optimal conditions for athletes and skaters alike

4.7. Dehumidification

The dehumidification 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 on the surfaces of the building structures, increased energy consumption and ice quality problems.
High humidity levels shorten the service lifetime of the construction components and materials, resulting in increased maintenance costs.

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.

The target value for the humidity of indoor air is often a compromise between energy usage, the quality of the ice, and indoor conditions for both people and materials. Recommendable water content in the indoor air of the ice rink is about 4 - 5 g/kg dry air, corresponding to approximately +11ºC and 55 % relative humidity and 2-3 °C dew point. Sometimes even drier indoor air would be needed due to the quality of the ice, but often for cost reasons values below the limit presented above are not used. Air humidity control is done either as dew point control or by adjusting the air state according to relative humidity and temperature.

Ice Rink temperature, °C	Maximum recommended relative air humidity, %	Maximum relative air humidity to avoid fog, %
5	70 %	90 %
10	65 %	80 %
15	50 %	70 %

TABLE 4.5: Recommended maximum relative humidities in different ice rink temperatures.

In the following tables maximum allowable ice rink air humidity rates are presented to avoid indoor air problems and depraving of constructions. In practice, the 80-90 % relative humidity would be so high that the conditions would become unpleasant, and it would not necessarily be possible to guarantee that moisture damage would not begin to occur, for example in blind spots in ventilation.

Air temperature and humanity criteria for rot and mould damages of wood structures.

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

TABLE 4.6: Table 4.5. Recommended maximum relative humidities to avoid damages in the structures.

Corrosion criteria for metals.

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

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.

Condensing dehumidification

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. This phenomenon is presented in the following FIGURE 4.6.

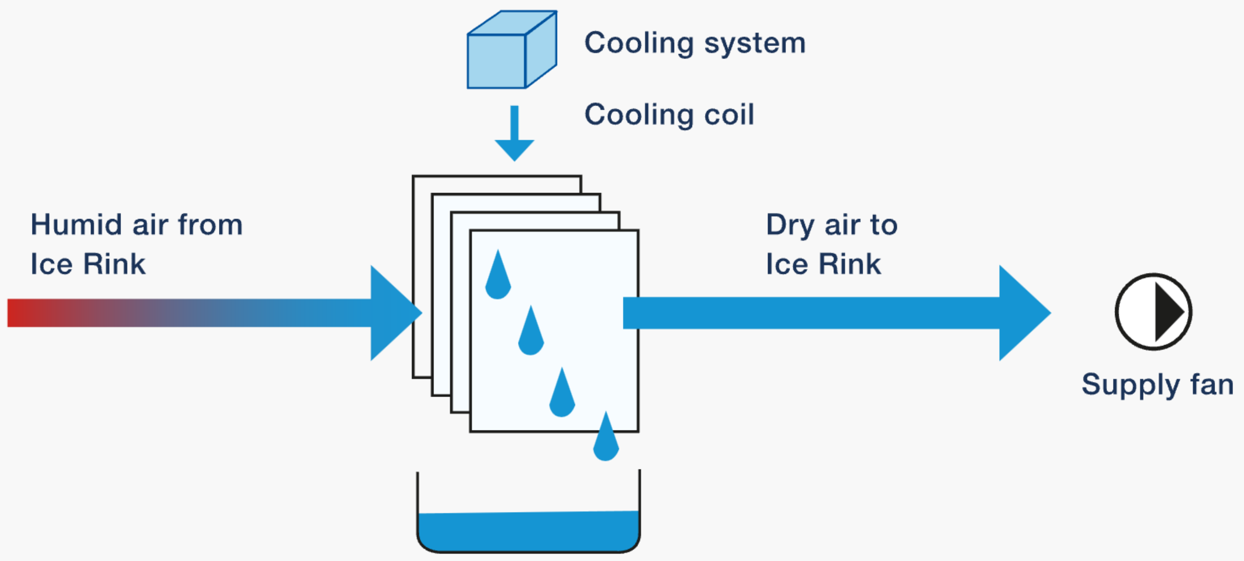


FIGURE 4.6: Condensing dehumidification process

Dehumidification cooling coil can be integrated in the ventilation unit and be cooled by same refrigeration system as the ice pad. The following schema shows the main functions of the ventilation unit that is equipped with condensing cooling coil.

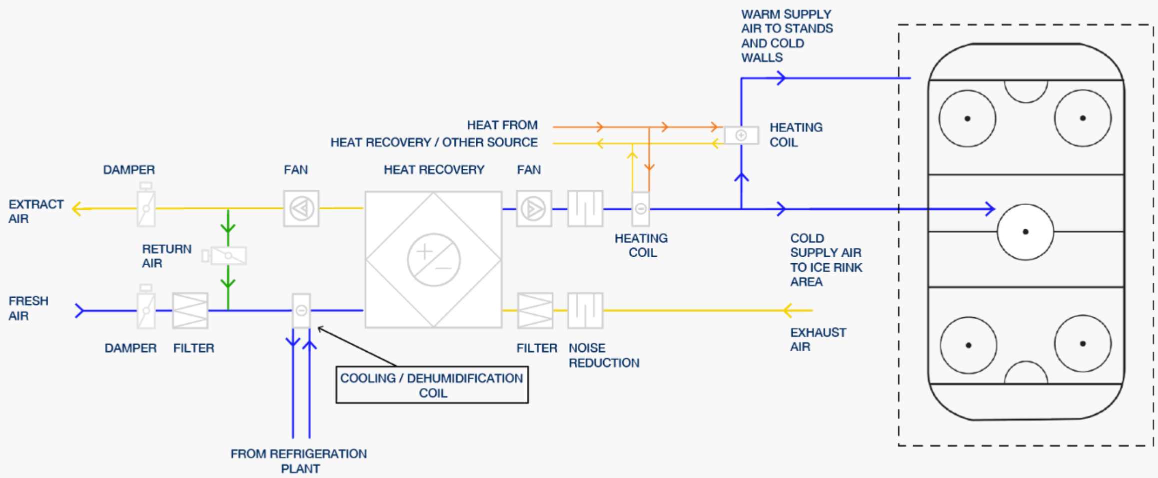


FIGURE 4.7: Schematic diagram of an ice rink air-conditioning system with dehumidification, heating, and heat recovery functions.

It is important to understand that achieving good low-humidity conditions for the rink space requires the dehumidifying cooling coil to operate at very low temperature levels. Temperature on the parts of the coil surface can often be below the freezing point of the water. This means that the condensation of the water will form frost and ice on the coil surface. This needs to be monitored by the automation system and taken care of by applying regular defrosting periods for the coil.

Absorption dehumidification

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

The desiccant dehumidification system, FIGURE 4.8, 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 solve 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 solve.

Absorption dehumidification requires a great amount of regeneration heat, at high temperature levels. This regeneration heat has been produced traditionally by electricity or gas, but the new generation adsorption driers also allow the use of heated water at lower temperature levels (+60-+70 °C). This enables the possibility to utilize recovered heat from the refrigeration system, which improves the energy efficiency of the absorption dehumidification system significantly.

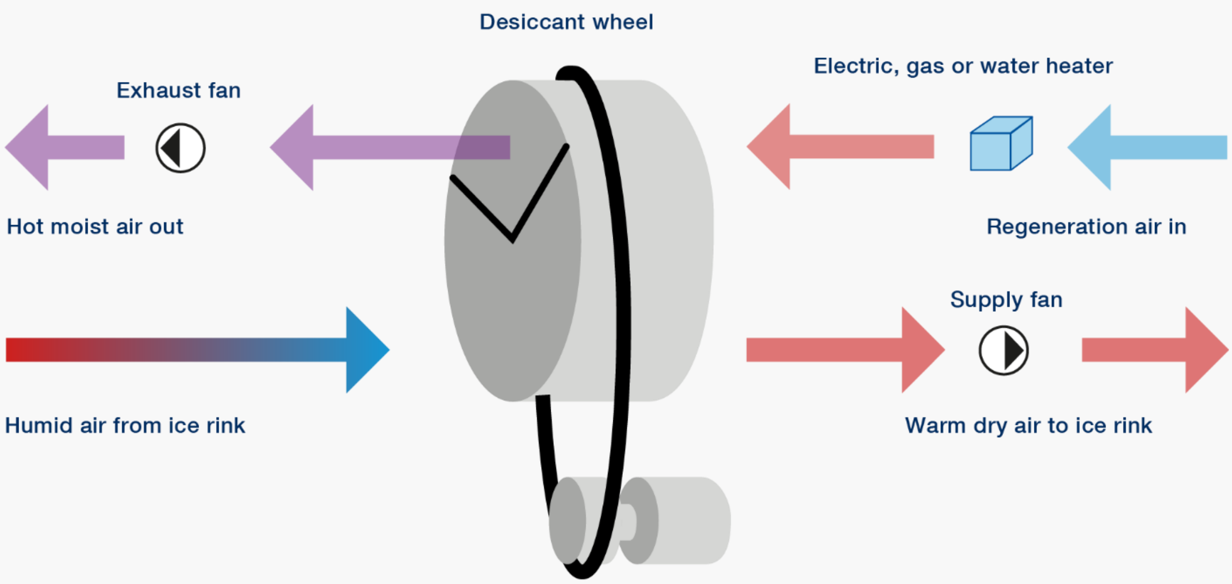


FIGURE 4.8: Desiccant dehumidification process

4.8. Heating

Ventilation also offers a means to heat the ice rink space. Heating the ice rink with air necessitates the use of recirculated air and that the 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.

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 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.

Arena spaces such as dressing rooms must also be heated. Dressing rooms can be heated by a low-temperature underfloor heating, which is very suitable for utilizing the heat recovery from the refrigeration system.

Heat recovery from the refrigeration plant

Waste-heat recovered from the compressor can supply almost all the heating demand of a small practice arena in most cases. When designing the heat recovery system, the relatively low temperature level should be considered.

Different refrigeration system types have somewhat different characteristics for heat recovery utilization:

Ammonia, HFC and HFO systems

In the traditional ammonia, HFC and HFO refrigeration systems the temperature level of the waste heat is normally around 30 – 35 °C and only 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.

The temperature level of the waste heat can also be increased with a separate heat pump. After that, the waste heat can be used for all heating purposes. The heat pump compressor uses electricity for this temperature increasing process, but usually it is beneficial for the maximal heat recovery.

CO_2 systems

Carbon dioxide as a refrigerant has a unique feature, that it allows high-temperature heat recovery from the refrigeration cycle itself, without a separate heat pump. This requires high pressures at the refrigerant cycle, which also increases the compressors electric consumption. However, this extra energy use might be acceptable if the recovered heat can then be more efficiently utilized, and reclaimed heat substitutes other expensive or non-sustainable energy sources.

4.9. Lighting & electrical system

In the implementation of the lighting of the ice arena, the following factors must be considered:

- illumination intensity
- uniformity of illumination
- orientation / glare minimization
- color of the light and color rendering
- TV requirements, usually minimum 800 lux
- energy efficiency
- maintainability and durability

National organizations have instructions specifically designed for determining ice rink lighting. IIHF also has guidelines for lighting in different international events. The table below includes some guidelines for general lighting levels at ice rinks.

LED lighting reduces energy costs by up to 70 – 80 % and eliminates maintenance fees while increasing your lighting quality and the use of different colors for different purposes. 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.

With simple and functional lighting control, significant energy savings can be achieved. The need for lighting control is determined by the operation and purposes of use of the hall and the lighting class. The lighting control must consider the multifunctionality of the halls, e.g. various sports.

Lighting Example

Building area/activity	**Lux**
Competitional hockey	500 - 1200
Recreational hockey	400
Recreational skating	300
Dressing rooms	300
Common areas	300

It must be possible to control the lighting of the hall to a minimum of three lighting levels (Match/Competition – Training – Maintenance). Control can be implemented by dropping or increasing the lighting level according to the intended use. Lighting control can also be associated with presence or motion detection. Lighting adjustment is recommended to be carried out by dimming. In this case, the overall uniformity of the illuminance is preserved.

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.

If the need for emergency power is small (emergency lighting and guide lights) power is usually supplied by battery back-up systems or a small generator.

4.10. 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 and very important part of the project.

Efficient automation for energy management of an arena 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 financial credibility and quality of your project.

4.11. 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 for warm water and to prohibit the risk of bacterial growth. Because of the Legionella risk, the hot water must be heated at least up to + 55 °C. 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 arena needs separate systems for the rink-melted water drainage and the melting pit of waste-ice slush. Surface water drains for melted water from ice defrosting are required outside and around the rink.

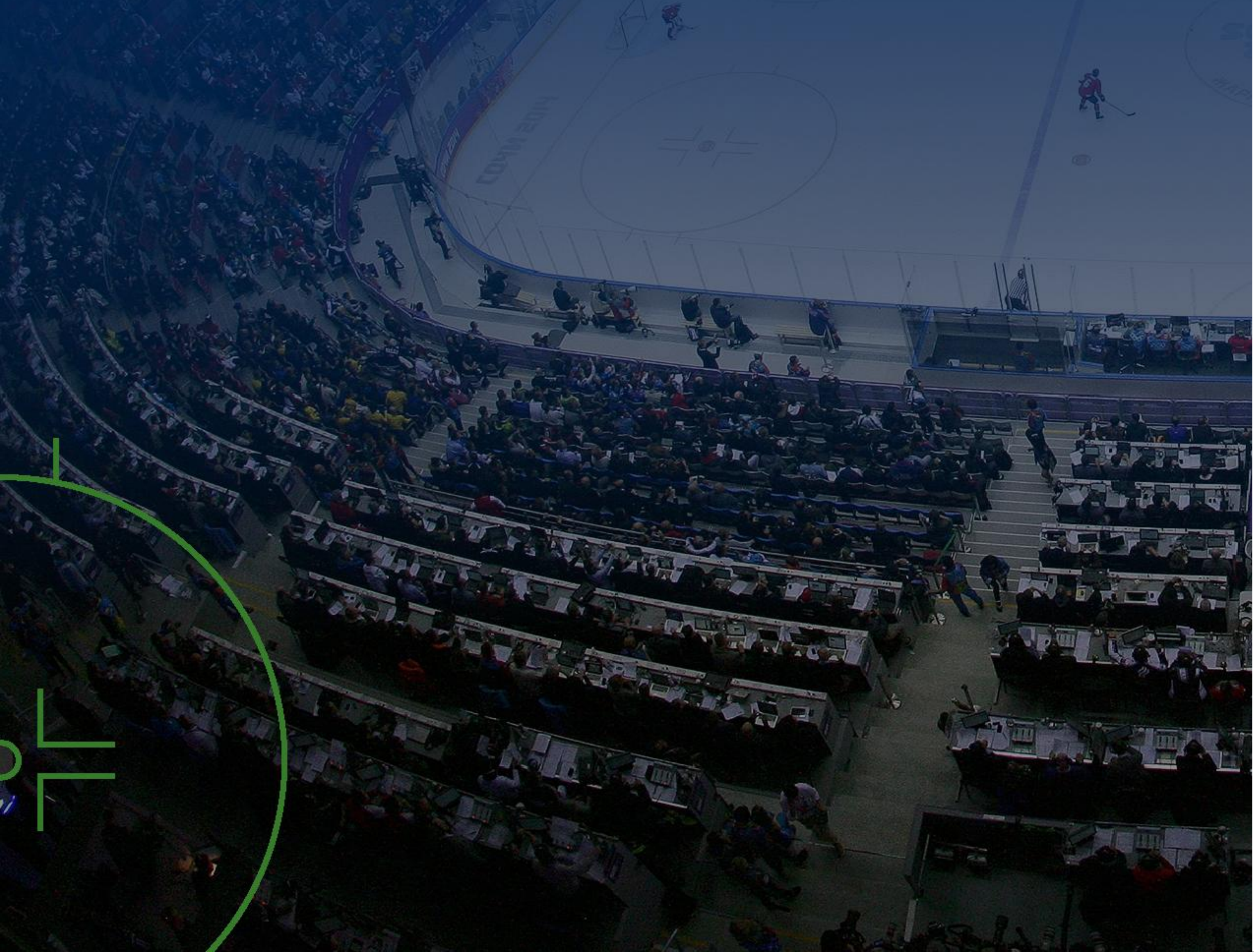
Waste ice slush can also be driven out of the building if there are proper areas where ice can melt.

Water usage for the ice resurfacing can be reduced greatly by installing a circulation system for the ice resurfacing water. The system takes in the ice slush from the resurfacer machine, melts it back into water, filters the impurities out of the water and heats it back up to temperatures suitable for ice resurfacing. There are different kinds of filters that can be used, and good water filtration is very important part of the circulation system. Recirculation of ice-surfacing water is also economical, if there is a good heat source for melting the ice. Usually this is achievable by using the recovered heat from the refrigeration system.

Local water quality has a significant impact on the ice quality of the rink. Need for a water treatment processing should be considered especially on the top-level competition arenas. Major things to be investigated are water hardness, ph., and conductivity. IIHF offers guidelines for the optimal quality of water in IQS chapter 6.

CHAPTER 5

SOCIAL AND SUSTAINABLE POLICIES



5 Social And Sustainable Policies

5.1. Introduction

Sustainability is a key consideration in all building projects, including ice arenas, where energy efficiency and environmental impact must be carefully balanced with user needs. The IIHF Guide to Sustainable Ice Rinks offers comprehensive guidelines and best practices for achieving this balance. While an ice arena may be highly sustainable in theory, if it fails to meet the needs of its users, it is not truly sustainable in practice. Therefore, every ice arena project must be designed to maximize sustainability and energy efficiency, while ensuring that it effectively serves athletes and the community.

Sustainability is a complex subject. It consists of many aspects, for example:

- economical sustainability in building period and the usage period
- social effects
- lifespan of the site
- building materials and their sustainability etc. CO_2 emissions
- site in terms of traffic and approachability
- use of the site, how long and in how warm of conditions it will be used?
- technical solutions, efficiency, and use of recycled energy
- used energy sources and their origins

Many of these aspects depend on local circumstances and vary as the knowledge increases. Because of the complexity of this concepts as whole, this chapter is concentrated on two aspects: energy efficiency and use of recycled energy. These are the main things to consider in the technical design of an ice arena. The less external energy a site uses, the more sustainable it is in this aspect.

Most of the CO_2 footprint of an ice arena during its lifecycle is caused by travel to and from the arena, energy (electricity and heat) and water use. It is impossible to give exact or general figures of the CO_2 footprint, because of the variety of energy production profiles and CO_2 footprint in each case.

More detailed information regarding Sustainability challenges and solutions are addressed in IIHF Guide to Sustainable Ice Rinks.

5.2. Energy Consumption

Energy consumption holds a key role when speaking of the lifecycle costs and above all the environmental load of the arena during its lifecycle. Energy in an ice arena is mainly used by the five major systems, which are all essential for achieving the wanted indoor conditions and running an ice arena in general. These five systems are refrigeration, heating, dehumidification, ventilation, and lighting, which are all described in the previous chapters 4.2-4.6. These systems also interact, and they must form a whole, comprehensive energy system. Some aspects in a sustainable, low energy consuming ice arena are:

Constructional characteristics:

- small heat and moisture transfer through the roof and walls
- small air leaks through cracks and openings in the building envelope
- small heat transfer below the ice slab

Use of ice rink, operational characteristics:

- ice quality (temperature, ice thickness)
- indoor conditions (temperatures, humidity)
- demand-controlled lighting

Refrigeration plant:

- effective equipment, good COP
- effective control and automation system
- heat recovery capabilities

Recycling of heat:

- low-temperature heat distribution
- where to use recycled heat, in site and/or nearby building

Air conditioning:

- demand-based fresh air control
- type of dehumidification process

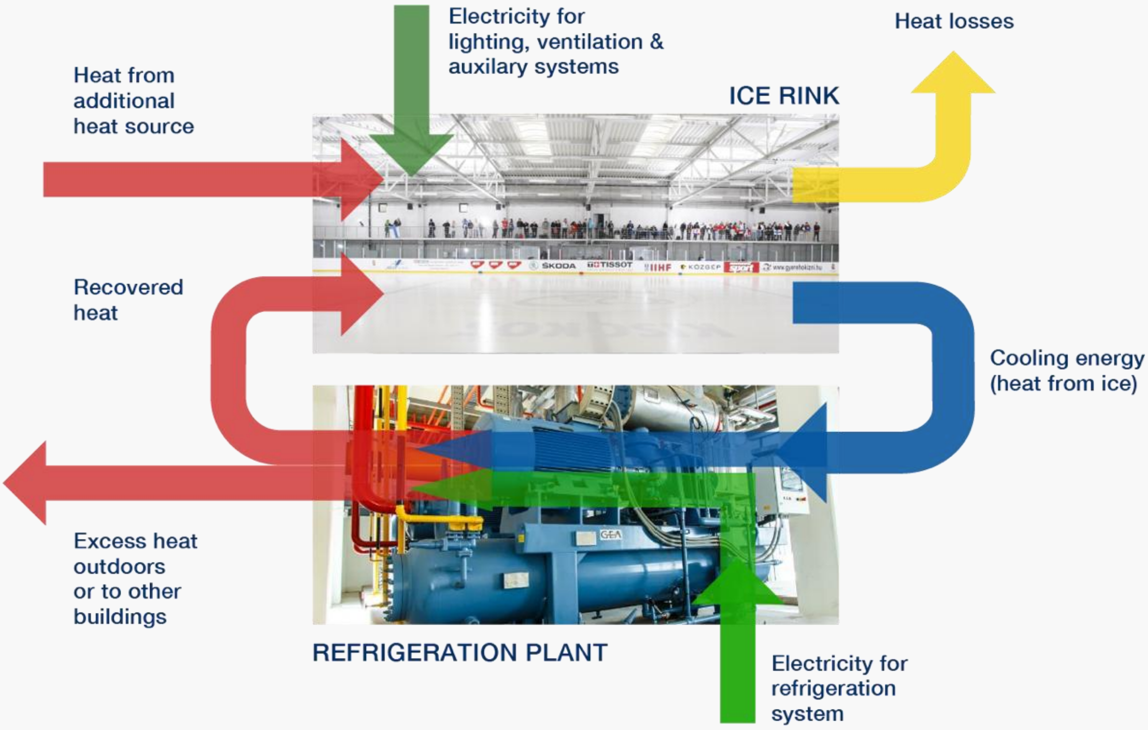


FIGURE 5.1: Energy flows of a small practice ice arena

FIGURE 5.1. Illustrates the energy flows of a typical practice ice arena. An arena is working as a thermal shortcut, that needs simultaneous heating and cooling. Refrigeration system collects low-temperature heat from the ice slab and refrigeration compressor uses electricity to rise this cooling/heating energy to higher temperature. The total amount of condense heat generated by refrigeration plant is a sum of produced cooling energy and electricity used by compressors. In other words, refrigeration system works as a heat pump.

Energy usage of the arena is broken down into different systems in the next figure, 5.2., both in a typical older arena with inefficient energy technologies and in a modern arena with maximal heat recovery capabilities. Ideally, the heating demand of the arena is fully covered by recovered heat from the refrigeration process, as energy breakdown on the right shows. In practice, extra heat is usually 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.).

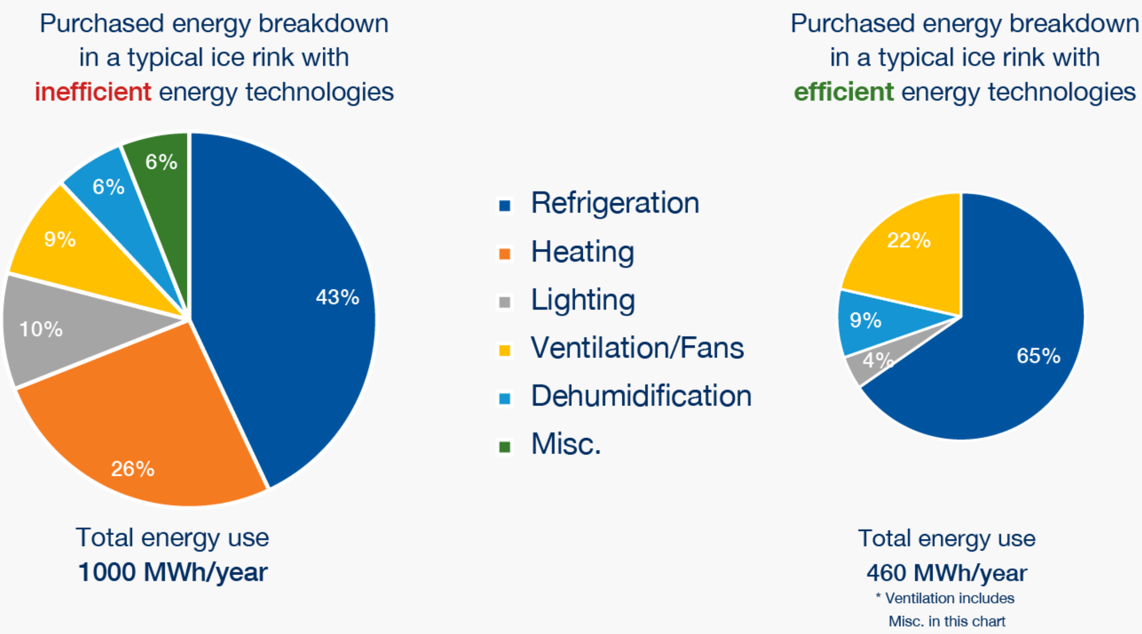


FIGURE 5.2: Energy usage breakdown in typical/conventional ice arena in Sweden, both with inefficient and efficient energy technologies. (Stoppled 2014, ASHRAE, 2017)

Various factors affecting energy consumption are studied in more detail in the following chapters.

5.3. Electric Energy Consumption, Refrigeration

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 include 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 emissivity.

The temperature level of the ice rink space 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, although below the freezing point, and the air temperature as low as possible in ice rink space. However, this cannot be done by compromising the desired conditions, since high ice temperature means also softer ice and low indoor temperature is very uncomfortable for the people.

The other operational parameters, besides the ice rink space air temperature, which affect the electricity consumption of the compressor, and the heating energy consumption are the ice temperature and ice thickness. Raising the ice temperature 1 °C 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 3,5 cm. The thickness and the even levels of the ice must be controlled weekly to maintain it optimally.

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 m3 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 increase the cooling load, because the condensed water on the ice surface must be frozen by refrigeration.

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.

5.4. Electric Energy Consumption

The electric energy consumption of the ice arena consists of ice refrigeration, rink lighting, air conditioning and heating systems (fans and pumps), public space lighting, different appliances, cleaning etc. Energy consumption of the lighting can be reduced greatly by applying LED lights and functional lighting control.

The refrigeration process consumes some half of the total electricity use of a small arena. In warm and humid conditions, the dehumidification of the rink space 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.

5.5. Heating Energy Consumption

Heating energy need in the ice rink space 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 considered, 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 on the climatic conditions, the heat flows through the exterior envelope 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 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 continuously produces large amounts of heat, as is shown in the previous FIGURE 5.1. This heat can be utilized directly for space heating and supply air heating, heating of hot water for ice resurfacing and showers, slush melting, heating of the auxiliary spaces, 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.

5.6. Dehumidification

The local weather conditions determine the dehumidification requirement, which in turn affects the energy use of the arena. This can be seen in figure 5.3, 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.

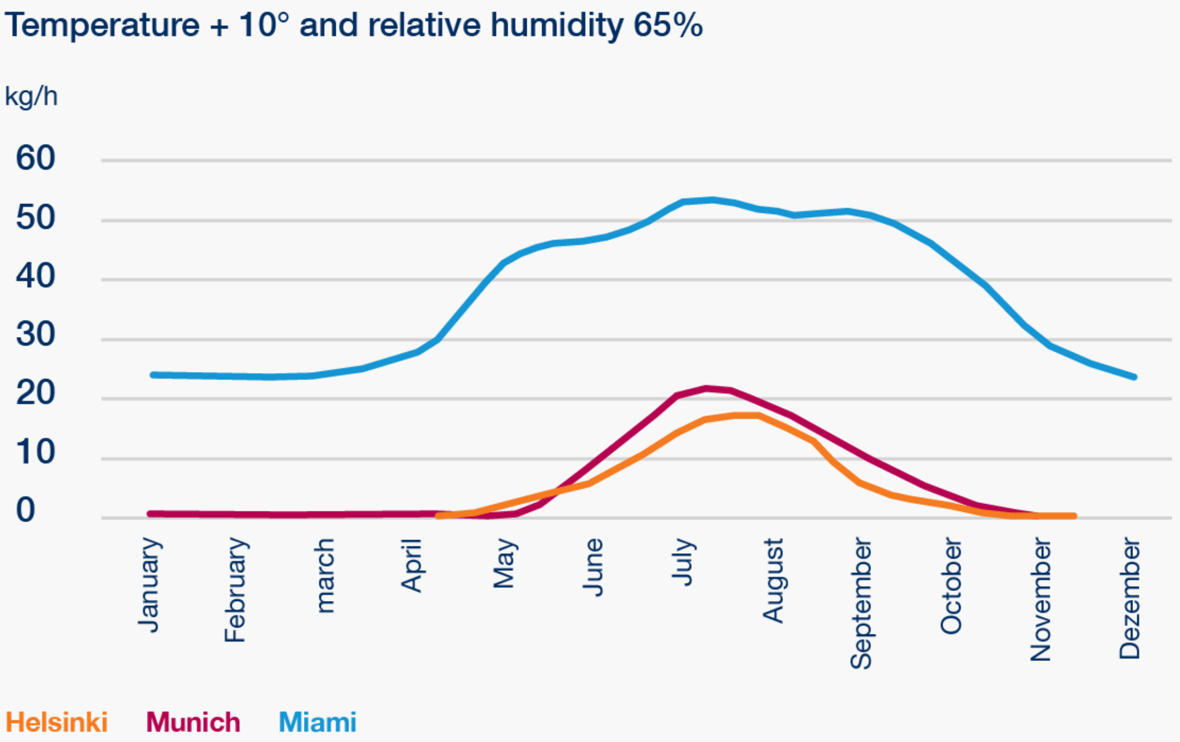


FIGURE 5.3: Moisture removal of the dehumidification system to maintain the required indoor air conditions, small practice arena. (Source: IIHF Ice Rink Guide 2002)

5.7. Water Consumption

Water consumption in an ice arena consists of the ice resurfacing water and the sanitary water. Shower and toilet use dominate sanitary water consumption.

Water usage for the ice resurfacing needs can be reduced greatly by installing a circulation system for the ice resurfacing water. The system takes in the ice slush from the resurfacer machine, melts it back into water, filters the impurities out of the water and heats it back up to temperatures suitable for ice resurfacing. There are different kinds of filters that can be used, and good water filtration is a very important part of the circulation system.

In some cases, treated water is used for cooling the condensers of the ice refrigeration plant. This can be the case especially during the summer operation, even in cold climates. However, direct use of treated water should be avoided as far as possible for this purpose because of high operation costs and high environmental effect.

Strong social policies and long-term sustainable strategies can help ice rinks and arenas open despite of criticism.

5.8. Environmental Considerations

1. Energy efficiency:

- Many modern arenas use advanced energy-efficient technologies, such as high-efficiency refrigeration systems, heat pumps, LED lighting, and heat recovery systems, building management systems, etc.
- Investing in renewable energy sources like solar panels and geothermal heating can greatly reduce the carbon footprint of these facilities

2. Sustainable practices:

- Water-saving measures, like recycling systems for ice resurfacing, help to reduce overall water usage
- Eco-friendly maintenance practices and materials minimize environmental impact

3. Community green spaces:

- Ice arenas can serve as year-round recreational facilities, reducing the need for other energy-intensive indoor sports facilities
- Supporting green initiatives such as tree planting and local biodiversity projects can offset environmental impacts

5.9. Social And Community Benefits

1. Youth Development:

- Ice arenas provide a safe, structured environment for youth to engage in physical activity, fostering discipline, teamwork, and leadership skills
- Programs targeting underprivileged and at-risk youth help reduce crime rates and improve educational outcomes
- Hockey and its related operations can motivate players who do not become paid professionals to stay engaged and pursue studies in areas such as refereeing, coaching, administrative roles in hockey clubs and arenas, social media management, health-related occupations, and more

2. Community health and well-being:

- Regular physical activity facilitated by Ice arenas contributes to overall public health, reducing healthcare costs associated with sedentary lifestyles
- Ice sports promote mental health through social interaction, stress relief, and community engagement

3. Inclusivity and accessibility:

- Ice arenas promote gender equality and support inclusive programs for people with disabilities, ensuring accessibility for all

5.10. Economic Impact

1. Local Economic Boost:

- Ice arenas generate local revenue through events, tournaments, and daily operations, supporting local businesses and creating jobs
- The presence of a arena can attract visitors from outside the area, contributing to the hospitality and retail sectors

2. Long-term Investment:

- Maintaining arenas ensures long-term community investment, fostering local pride and continuity of traditions
- Closing arenas can lead to economic decline in the area, with a loss of jobs and reduced property values

5.11. Educational And Cultural Significance

1. Educational Programs:

- Ice arenas often partner with schools to provide educational programs that incorporate physical education, nutrition, and academic support
- These programs can enhance students' academic performance and promote lifelong healthy habits. They also can motivate hockey players for future careers in areas related to hockey operations and ice arena management

2. Cultural Heritage:

- In many communities, hockey is a significant part of cultural heritage and identity. Ice arenas play a crucial role in preserving these traditions, fostering community spirit, and nurturing leadership legacies from world-class hockey players who grew up in these arenas
- The historical importance of the ice arena in the community can be highlighted, showing how it has been a gathering place for generations- players, referees and arena managers

We also want to address some misconceptions about ice arenas.

5.12. Environmental Misconceptions

- Clarify energy consumption: Provide data showing how modern arenas have reduced energy consumption through technological advancements. Use upgraded systems and their efficiency as proof of a responsible long-term strategy
- Highlight sustainable practices: Showcase examples and best practices of ice arenas that have successfully implemented green practices, reduced their environmental impact, and achieved cost savings

5.13. Policy And Advocacy

- Engage with local governments: Present these arguments to local councils and policymakers, emphasizing the balanced benefits versus perceived environmental costs
- Community mobilization: Encourage community members, parents, and coaches to voice their support through petitions, town hall meetings, and social media campaigns

By presenting a holistic and balanced view that incorporates environmental, social, economic, educational, and cultural perspectives, the case for keeping ice arenas open can be made compellingly and persuasively.

CHAPTER 6

ICE QUALITY STANDARTS

6 Ice Quality Standards

6.1. Definition Of Ice Quality Standard

- I.Q.S is an acronym for quality standards for ice management.
- I.Q.S. measures the overall ice quality of the ice rink, both in terms of structure, visuality and playability.
- I.Q.S. The test gives a clear and easy-to-understand picture of the field as a whole, not just a specific part of it.

6.2. Why Is It Important to Know Total Quality?

- When planning ice management and developing the overall quality of the ice, it is very important to know where we are now.
- In the future, test results can be used, for example, to determine the correct use of machinery and to determine the need for new equipment.
- If there is an upward or downward change in the ice maintenance and management budget, test results can show its effect.
- I.Q.S. is an excellent tool for ice management planning, as the results clearly indicate the points that need attention in the coming seasons. That is, doing the right things at the right time.

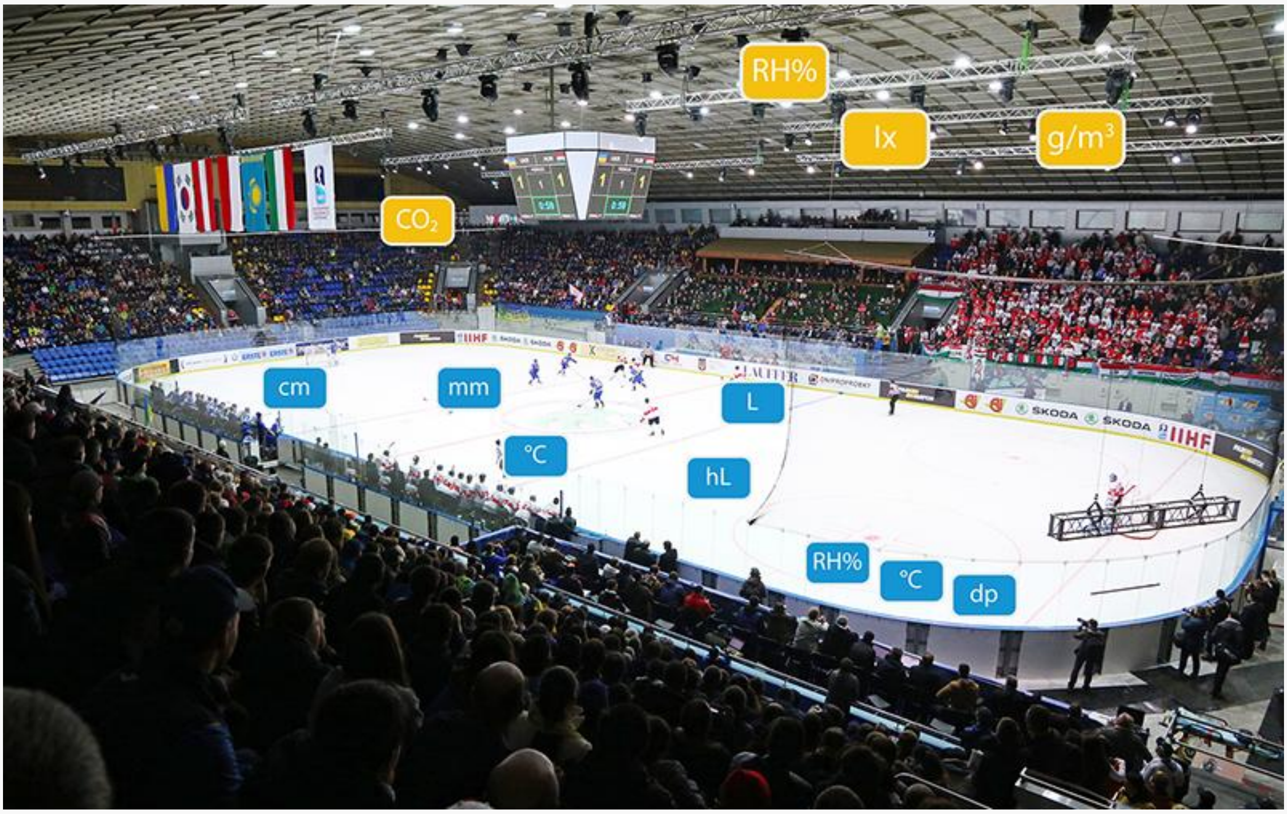
6.3. Units Of Measurement, acronyms

- **mm** in millimeters we measure the straightness of the ice and the height differences in the ice.
- **cm** in centimeters we measure the thickness of the ice at different points in the field.
- **L** a litre unit tells us how much water we have used to make ice and how much water we use in once ice treatment session.
- **hl** According to the dynamic Leeb principle, the hardness value is derived from the energy loss of the specified impactor after it has struck the specimen. The Leeb quotient (vi, vr) is taken as a measure of the energy loss due to deformation: the impactor recovers faster from harder test specimens than from softer test specimens.

- **lx** the illuminance (symbol E) is a quantity of photometry that describes the amount of light flowing over a given area. Illumination intensity is used to describe how good the lighting conditions are in a room. The SI unit for illuminance is lux (lx).

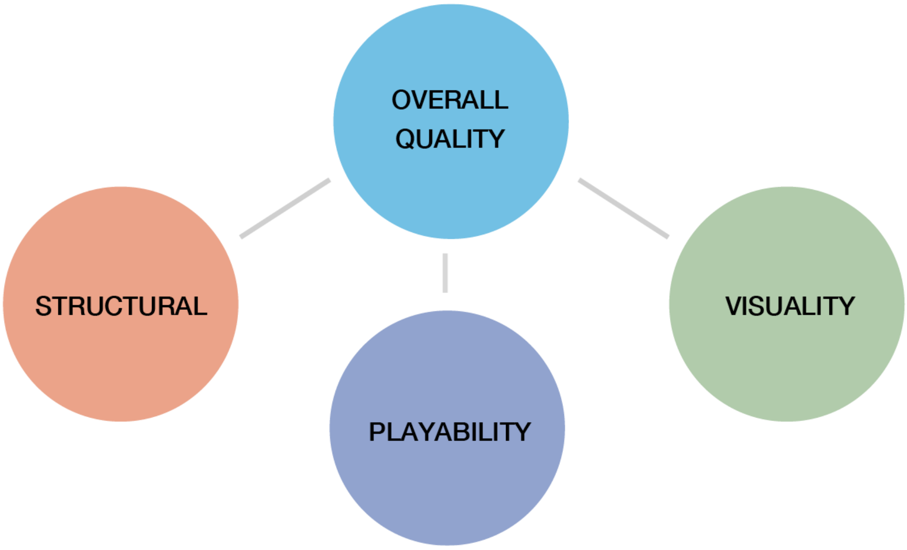
- A Certified Ice Master (**CIM**) is responsible for overseeing the maintenance and care of ice rinks, ensuring high-quality ice surfaces for various sports like hockey, curling, and figure skating. Their duties include creating and implementing an Ice Rink Care Plan, managing the different phases of ice-making and maintenance, and ensuring proper operation of technical equipment. Additionally, CIMs must uphold strong customer service principles, ensuring that the facility meets the needs of athletes and users while maintaining optimal conditions for all ice activities

What you cannot measure, you cannot control.



- **RH% Relative** Humidity is a measure of the water vapor content of air. More explicitly, it's the amount of the water vapor present in air expressed as a percentage (%RH) of the amount needed to achieve saturation at the same temperature.
- **ºC Celsius** is a unit of the temperature on the Celsius scale. We measure the temperature of the air, as well as the ice.
- **DP Dew point** is the temperature to which air must be cooled to became saturated with water vapor, assuming constant air pressure and water content. The dew point is affected by humidity. When there is more moisture in the air, the dew point is higher.
- **CO_2,** we measure the carbon dioxide values from the audience and the playing area and compare it to the air quality values.
- **g/m^3** inside there is air in the various cavities and pores, its properties in terms of humidity technology are the ability of the air to bind moisture differently at different temperatures. The warmer the air, the more it can bind moisture. Absolute moisture content of the air: in g/m^3 or g/kg (how many grams of water are in the air cube or kilogram of air).

6.4. I.Q.S. Quality Standards



6.5. Structural Quality and What It Consists Of

THE POINT TO BE MEASURED	EXCELLENT	GOOD	MINIMUM LEVEL
A) The refrigeration plant	5p/ *****	3p/ ***	1p/ *
Primary refrigerant	<10 GWP/ODP 0	<1000 GWP/ODP O	<1500 GWP/ODP O
COP value	We need	more data	(10 rink/country)
Secondary refrigerant	Other solution	Other solution	Ethylene glycol
Amount of secondary refrigerant in system	Unable to determine		
Service contract according to EN 378	24 service	Service contract	Min statutory
Competence of own operating staff	100% CIM / CIT	50% CIM / CIT	One person CIM/CIT
Number of control sensors	Flow and return solution and sensors in the slab	Flow and return solution	Only one measuring point
Sensors in the slab	> 6 pcs	> 6 pcs	1 pcs

TABLE 6.1: A-TOURNAMENTS (E.G. OLYMPIC WINTER GAMES, WORLD MEN, WORLD WOMEN, WORLD MEN U-20, WORLD MEN U-18)

THE POINT TO BE MEASURED	EXCELLENT	GOOD	MINIMUM LEVEL
B) Water	5p/ *****	3p/ ***	1p/ *
Temperature	60° C – 71° C	50° C – 59° C	> 40° C
Amount of drive water	400 ltr – 500 ltr	500 ltr – 550 ltr	< 600 ltr
Wash water system	Every time	Every time	Every time
Water TDS value	< 80 ppm	< 100 ppm	< 120 ppm
Water PH value	7,0 – 7,5	7,6 – 8,1	< 8,5
Conductivity of water	50 uS – 70 uS	71 us – 90 uS	< 100 uS
Grains of Hardness	0,8 – 1,0 mmol / ltr	1,1 – 1,3 mmol / ltr	< 1,6 mmol / ltr
Flooding	Every night of the tournament	Every second night of the tournament	Every third night of the tournament
Water laboratory tests *	Once of month	Twice a season	Once per season

TABLE 6.2: **A-TOURNAMENTS (E.G. OLYMPIC WINTER GAMES, WORLD MEN, WORLD WOMEN, WORLD MEN U-20, WORLD MEN U-18, WOMEN U18)**

* calcium, iron, manganese, chloride, opacity, color, amount of the organic matter
* Tab water, water sample from tank, thawed water sample from the ice surface

THE POINT TO BE MEASURED	EXCELLENT	GOOD	MINIMUM LEVEL
C) The ice	5p/ *****	3p/ ***	1p/ *
Average ice thickness / cm	3,0 cm – 3,5 cm	3,6 cm – 4,5 cm	< 5 cm
The thinnest point of ice / mm	25 mm – 30 mm	30 mm – 35 mm	35 mm – 40 mm
Ice straightness / mm	< 3 mm	< 6 mm	< 10 mm
Ice hardness / mm	80 – 100 HL	75 – 105 HL	70 – 110 HL
Average ice temperature / °C	- 4,5° C / -5,5° C	-5,6° C / -6° C	< -6,5° C
Ice temperature measurement points / pcs	6 pcs	4 pcs	2 pcs
Ice slippery / m (average)	measurements in progress	measurements in progress	measurements in progress

THE POINT TO BE MEASURED	EXCELLENT	GOOD	MINIMUM LEVEL
C) The ice	5p/ *****	3p/ ***	1p/ *
Air temperature 1 m / °C	10° C – 12 °C	9° C – 13° C	8° C – 14° C
Air humidity 1 m / RH%	40 % – 50 %	< 55 %	< 65 %
Absolute humidity of air / g/m3	4,5 – 5,0	4,0 – 5,5	3,5 – 6,0
dew point / °C (1m)	1,4° C - 2,1° C	1° C – 2,5° C	0,5° C – 3° C

TABLE 6.3: A-TOURNAMENTS (E.G. OLYMPIC WINTER GAMES, WORLD MEN, WORLD WOMEN, WORLD MEN U-20, WORLD MEN U-18, WOMEN U18)

6.6. Playability

THE POINT TO BE MEASURED	EXCELLENT	GOOD	MINIMUM LEVEL
D) Playability	5p/ *****	3p/ ***	1p/ *
Hockey sliding	Measurements in progress	Measurements in progress	Measurements in progress
Skate slide	Measurements in progress	Measurements in progress	Measurements in progress
The appearance of snow drifts	> 15 min	> 14 min	> 12 min
Ice straightness	< 3 mm	< 6 mm	< 10 mm
Ice treatment time* 1	20 min	18 min	15 min
Ice treatment time* 2	> 10 h / week	8 – 10 h / week	8 h / week

TABLE 6.4: DIV 1A-TOURNAMENTS (E.G. IIHF ICE HOCKEY WORLD CHAMPIONSHIP, DIVISION 1, GROUP A)

6.7. Visuality

THE POINT TO BE MEASURED	EXCELLENT	GOOD	MINIMUM LEVEL
E) Visuality	5p/ *****	3p/ ***	1p/ *
Staff education	Everyone has CIM* or CIT*	50 % has CIM or CIT	One of them has CIM to CIT
Layout	100% uniform look	> 90% uniform look	> 80% uniform look
Hockey nets	perfectly fit	perfectly fit	perfectly fit
Line marking	Bright	Clear	Clear
Adds	Bright	Clear	Clear
Ice color	100% uniform look	95% uniform look	90% uniform look
Dashboard	IIHF rules	IIHF rules	IIHF rules
Protecting shield	Bright	Clear	> 90% clear
Protecting shield	6 extra pcs	4 extra pcs	2 extra pcs

TABLE 6.5: A-TOURNAMENTS (E.G. OLYMPIC WINTER GAMES, WORLD MEN, WORLD WOMEN, WORLD MEN U-20, WORLD MEN U-18, WOMEN U18)

6.8. Measurement Tools

- The most important point in developing ice management is knowing where we are now and where we want to go
- Comparable data is obtained from different months, which removes the fact that we just remember what it was like
- Looking at the ice, you may think the ice is in order, but the truth may be different
- The result provides proven information on the effect of different treatments on your own ice
- If the budget and jobs are reduced / increased, the effect can be observed
- A proper report on the state of the ice will help the trained Master justify the acquisition of new technology or an increase in budget

6.9. What Are the Benefits of Ice Testing

- The score can be converted into a star rating scale (see hotel star rating)
- The result can be compared to other ice rinks and get a real time ranking
- Motivate your staff to improve quality and seek more information
- Serves the end user of ice in better quality conditions
- Value for money

After all, we all have the same goal, that is, the best possible ice to practice and play, save money and be energy efficient.

CHAPTER 7

FINANCIAL PARAMETERS

7 New Ice Arena Financing

Ice arenas are unique buildings that require expert input during construction to avoid major problems. Proper cost and operational structures must consider special features like indoor climate control, particularly temperature and humidity, to prevent issues such as corrosion and decay.

Ignoring these factors can lead to severe damage within a few years. For instance, high indoor humidity can corrode steel and decay wood structures. Meeting public demands for warmth and comfort increases the standards for indoor climate control, requiring temperatures around -4°C near the ice surface and +15°C in the seating areas.

Simplified solutions often result in high operational costs. Advanced and modern technology, however, can reduce energy consumption and operating costs by up to 50%, while improving the indoor climate. High energy costs necessitate energy-efficient designs, proper technical features, and skilled maintenance.

This guide provides technical and financial guidelines for constructing a modern, small ice arena and addresses the challenges faced by existing older arenas. It covers topics separately for arenas that are in the planning stage and for those that are already operational.

How to start financing ice hockey arenas and rinks

1. Cooperation with Local Governments and Municipalities:

- Initial Negotiations: Engage in discussions with local government officials and municipal representatives early in the conceptual planning process. Outline the benefits of having an ice hockey arena in the community, such as increased local sports participation, potential economic benefits, and enhanced community engagement. Please refer to chapter 5 with list of all benefits to have an Ice arena in a municipality.

- Operator Selection: Determine who will operate the ice arena. While municipalities can provide support and funding, they often lack the necessary experience to manage and operate sports facilities efficiently. Consider involving specialized sports management companies or highly experienced individuals with proven track records in operating similar facilities.

- Roles and Responsibilities: Clearly define the roles and responsibilities of all parties involved. Municipalities can handle infrastructure and funding, while private operators manage day-to-day operations, maintenance, and programming.

2. Public-Private Partnerships (PPP):

- Leverage PPPs: Explore public-private partnerships to share costs and risks. Private investors can bring in capital and expertise, while the public sector can provide land, tax incentives, or direct funding.
- Structured Agreements: Develop detailed agreements outlining each party's contributions, expectations, and profit-sharing arrangements. Ensure transparency and accountability to build trust and collaboration.
- Sustainable Financing Instruments: Especially in EU countries, sustainable solutions often have access to various financing instruments. Look into funding opportunities from EU programs and initiatives that support sustainable development and energy efficiency in sports facilities. Often those instruments require cross country cooperation.

3. Funding and Financing Options:

- Government Grants and Subsidies: Research and apply for grants and subsidies offered by local, state, or national governments aimed at promoting sports infrastructure and energy efficient and sustainable solutions in place.
- Bank Loans and Municipal Bonds: Secure financing through traditional bank loans or municipal bonds. Prepare a robust business plan (with both- financial and social benefits) demonstrating the project's viability and potential returns to attract lenders and financial contributors.
- Sponsorship and Naming Rights: Approach corporations for sponsorship deals or offer naming rights for the arena in exchange for long term financial support.
- Pre-sale agreements with clients and operators such as gym, equipment store, restaurant or cafeteria, conference facilities, etc.
- Pre-sale agreements for skyboxes or lounges.
- Community Fundraising: Engage the local community through fundraising campaigns, offering memberships, or selling commemorative bricks or plaques to generate additional funds.

4. Feasibility Studies and Market Research (please also see Chapter Nr 1)

- Conduct Feasibility Studies: Hire experts (both financial and engineers) to perform feasibility studies assessing the demand, potential revenue streams, new available technologies for ice machines and sustainable solutions and overall viability of the ice arena project. This will help in making informed decisions and attracting investors.

- Market Research: Understand the local market and community needs. Analyze demographics, competitive landscape, and potential user groups (youth leagues, recreational skaters, hockey teams) to tailor the arena's offerings accordingly.

5. Design and Planning:

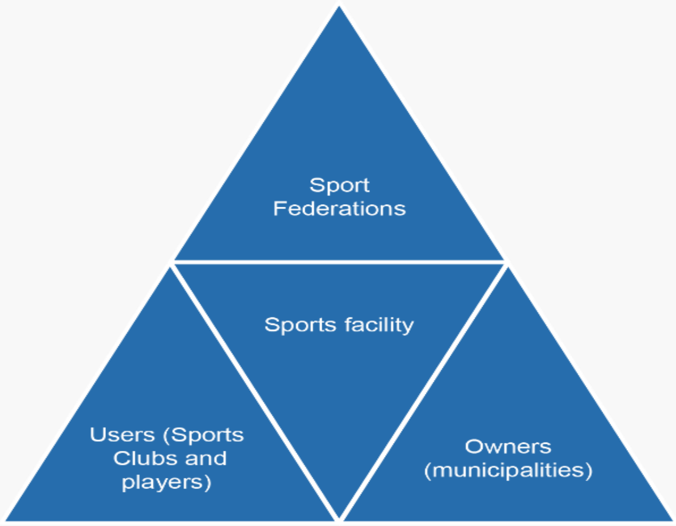
- Hire Experienced Architects and Engineers: Work with professionals experienced in designing sports facilities to ensure the arena meets all technical and safety standards.
- Sustainable and Efficient Design: Incorporate energy-efficient technologies and sustainable practices to reduce operating costs and environmental impact. **Please use IIHF Guide to Sustainable Ice Rinks.**
- Please download the **IIHF Guide to Sustainable Ice Arenas** from our download-page:
- Accessibility and Amenities: Ensure the facility is accessible to all, including individuals with disabilities. Plan for amenities such as seating areas, locker rooms, concession stands, and parking to enhance the user experience.

6. Community Engagement and Support:

- Build Community Support: Engage with the community through town hall meetings, surveys, and social media to gather input and build support for the project.
- Local Partnerships: Collaborate with local schools, sports clubs, and businesses to create programs and events that drive usage and support for the ice arena.

7. Operational Planning:

- Staffing and Training: Hire qualified staff and provide necessary training to ensure smooth operations. Ask IIHF Facilities Committee members and experts organize ice making and energy efficiency workshops, seminars. Focus on customer service, safety protocols, and maintenance procedures. Organize tours in Arenas with best practices procedures in place.
- Programming and Events: Develop a diverse range of programs and events to attract different user groups. Offer public skating sessions, hockey leagues (kids, juniors, adult and professional), figure skating classes, and special events to maximize utilization.



As shown in the diagram above, each participant or user of an ice rink or arena may have different objectives and priorities. Therefore, clear and professional communication between federations, associations, clubs, players, and rink owners is essential for the successful development and operation of these facilities. Ensuring that all parties are aligned and engaged is key to meeting both individual and collective goals.

In addition to municipality financing, there are multiple private investors looking for investment opportunities. And here are some incentives- why they could invest into ice sport arena:

Private investors may be willing to invest in ice rinks and arenas for several compelling reasons:

1. Profit Potential:

- Revenue streams: ice arenas offer multiple revenue streams, including ticket sales for events, memberships, public skating fees, concessions, and merchandise sales.
- Rental income: renting the arena for private events, tournaments, and leagues can provide steady income year-round.
- Sponsorship and advertising: naming rights, sponsorship deals, and advertising space within the arena can be highly lucrative.

2. Community impact and engagement:

- Community hub: ice arenas can become central community hubs, promoting health and wellness through sports and recreation. Investors can benefit from the positive public relations and community goodwill generated by supporting local initiatives.
- Youth and amateur sports: supporting youth and amateur sports programs can enhance community engagement and create loyal customer bases with several generations involved.

3. Economic and Social Benefits:

- Local economy boost: ice arenas can stimulate local economies by attracting visitors, creating jobs, and supporting nearby businesses like hotels, restaurants, and retail stores.
- Tourism: high-profile events, such as tournaments and concerts, can draw significant tourism, providing economic benefits to the area and increasing the visibility of the investor's brand.

4. Tax incentives and grants:

- Government incentives: various local, regional, and federal/national governments offer tax incentives, grants, and subsidies for developing sports facilities, which can reduce the overall investment cost and increase profitability.
- Sustainable initiatives: investors can take advantage of grants and incentives aimed at promoting energy efficiency and sustainability by incorporating green technologies into the arena.

5. Brand Building and Corporate Social Responsibility (CSR):

- Positive brand association: investing in community-focused projects like ice arenas can enhance a company's brand image and reputation, aligning it with positive values such as health, wellness, and community development.
- CSR Initiatives: supporting sports and recreational facilities can be part of a broader corporate social responsibility strategy, demonstrating a commitment to social and environmental well-being.

6. Long-term asset appreciation:

- Real estate value: ice rinks and arenas, particularly those in growing or desirable locations, can appreciate over time, providing long-term investment returns.
- Portfolio diversification: investing in sports facilities can diversify an investor's portfolio, spreading risk and potentially offering stable returns.

7. Innovative Business Models:

- Technology integration: modern ice arenas can integrate advanced technologies for energy efficiency, customer engagement, and operations management, making them attractive investments for tech-savvy investors.
- Flexible usage: multipurpose facilities that can host a variety of events (sports, concerts, community events) provide flexibility and increased utilization, maximizing revenue potential.

8. Competitive advantage:

- First-mover advantage: investing in an area with limited existing facilities can provide a competitive advantage, establishing the arena as the go-to venue for ice sports and events.
- Market demand: in regions with growing interest in ice sports, there can be strong demand for additional arenas, presenting a profitable investment opportunity.

By understanding and leveraging these motivations, project planners can effectively attract and secure private investment for ice arenas.

By following these steps and fostering strong partnerships with local governments, private investors, and the community, you can successfully finance, build, and operate a thriving ice hockey arena or rink.

7.1. Old Arenas, Challenges, Financing

In this guide we are addressing topics for ice arenas that are only in the planning stage and for existing arenas, older arenas are addressed separately.

Major challenges in existing ice arenas are:

- high energy consumption (old machines still in use)
- lack of knowledge in proper ice maintenance procedures
- inefficient systems- outdated HVAC, refrigeration, old ice resurfacers, indoor climate, water usage systems, lightning solutions, poor insulation, etc.
- Lack of indoor climate control

Quickest and best solutions are:

- upgrade refrigeration systems by installing modern and high-efficiency refrigeration units

- maximizing heat recovery from the machines used in ice arenas, particularly the refrigeration systems, can significantly enhance energy efficiency and sustainability
- install circulation pumps that move water through the heat recovery system and storage tanks quicker
- transition to environmentally friendly refrigerants like CO_2, which have lower global warming potential (GWP)
- install high-efficiency HVAC systems and dehumidification technology to better control indoor temperature and humidity and prevent structural damage
- upgrade insulation in walls, roofs, and floors to reduce heat loss
- use efficient and modern ice resurfacing machines that use less water and energy
- change traditional lighting with LED fixtures, which consume less energy and have a longer lifespan and use motion sensors and automated controls to reduce lighting energy use during off-peak hours.
- Install low-flow faucets, showers, and toilets to reduce water usage, install insulated tanks for storing heated water from heat recovery system
- train arena staff on best practices for energy efficiency and proper maintenance of ice and equipment
- conduct regular maintenance of HVAC, refrigeration, and lighting systems to ensure they operate at peak efficiency
- Install solar panels on the arena's roof to generate renewable energy and reduce dependence on the grid
- Consider geothermal heating and cooling systems for energy-efficient temperature regulation
- Pursue certifications like LEED (Leadership in Energy and Environmental Design) to demonstrate commitment to sustainability.
- Source materials and products that are environmentally friendly and sustainably produced.
- implement automated control systems to manage the heat recovery and optimized energy saving process. These systems can monitor temperature and pressure, adjusting the flow and distribution of heat as needed.

By addressing these challenges with targeted solutions, existing ice arenas can significantly improve their energy efficiency and sustainability, leading to cost savings and reduced environmental impact.

The topics mentioned above further highlight the importance of the IIHF Guide to Sustainable Ice Rinks, emphasizing its role as a crucial resource for developing energy-efficient and environmentally responsible.

As anyone can understand, the lack of financing for necessary upgrades and maintenance exacerbates these issues, resulting in inefficient systems that are prone to breakdowns and costly repairs. Additionally, outdated facilities struggle to meet modern environmental and comfort standards, further diminishing their appeal and usability. Without adequate funding, these ice arenas cannot implement the advanced technologies needed to improve energy efficiency, sustainability, and overall performance

Here are some few ideas where to look for additional financing:

1. Government Grants and Subsidies:

- Local and national financing programs, specifically for research aimed at improving energy efficiency, sustainability, and community sports facilities. Many governments offer funding for projects that align with environmental and community health goals.
- EU Funding: in European Union countries, explore EU programs such as Horizon 2020, the European Structural and Investment Funds (ESIF), and the LIFE program, which provide financial support for energy efficiency and sustainability projects.

2.Energy Efficiency Loans:

- Green Loans: Many financial institutions offer green loans specifically designed for energy efficiency projects. These loans often come with favorable terms to encourage sustainable development.
- Low-Interest Loans: Look for low-interest loan programs available from banks or government bodies that support energy efficiency improvements.

3. Public-Private Partnerships (PPP):

- collaborate with private investors: form partnerships with private companies that specialize in energy efficiency and sustainability. These companies can provide the capital and expertise needed to upgrade old ice arenas in exchange for a share of the energy savings or other benefits.
- shared investment models: develop investment models where costs and savings are shared between the public sector and private investors.

4. Utility rebates and incentives:

- Energy provider programs: many utility companies offer rebates and incentives for customers who implement energy-saving measures. Contact your local energy provider to learn about available programs.
- Demand response programs: participate in demand response programs where the arena agrees to reduce energy use during peak times in exchange for financial incentives.

5. Crowdfunding and Community Fundraising:

- Crowdfunding platforms: use crowdfunding platforms to raise funds from the community and other supporters. Highlight the environmental, community and other social benefits of the upgrades to attract contributions.
- Community events and campaigns: organize fundraising events, such as ice shows, tournaments, or charity skates, to engage the local community and raise funds.

6. Sponsorship and Naming Rights:

- Corporate Sponsorship: seek sponsorship from local businesses and corporations. Offer advertising opportunities and recognition in exchange for financial support. Think out of box! Many corporations are eager to participate as sponsors in modern and sustainable projects!
- Naming rights for modernized arena project: sell naming rights for the arena or specific areas within the arena to generate significant funding.

7. Energy Performance Contracting (EPC):

- EPC agreements: enter into energy performance contracts with energy service companies (ESCOs). These companies finance and implement energy-saving projects and are paid back through the energy savings achieved.
- Guaranteed savings: ensure that the EPC agreement includes guaranteed savings to protect the ice arena from financial risk.

8. Tax incentives and credits:

- Energy efficiency tax credits: take advantage of tax credits offered for energy-efficient upgrades. These can significantly offset the cost of improvements.
- Accelerated depreciation: use accelerated depreciation for energy-efficient equipment to reduce taxable income.

9. Foundation and nonprofit grants:

- Sports and environmental foundations: apply for grants from foundations and nonprofits that support sports development, community health, and environmental sustainability.
- Local nonprofits: identify and collaborate with local nonprofits that can assist in fundraising efforts or provide grants for community projects.

There are quite large number of available solutions how to finance the modernization and reconstruction of an old rink or arena. This undertaking will require additional hours and skills, and we recommend combining your efforts with other ice arenas and ask help in National Federations.

By leveraging these financing solutions, ice arena operators can address the challenges of upgrading old facilities, improve energy efficiency, reduce operational costs, and enhance sustainability. Combining multiple funding sources can provide a comprehensive approach to financing necessary upgrades.

7.2. Recommendations For Preparing Cost Calculations For Ice Rinks And Arenas

Preparing accurate cost calculations for the operation of ice rinks and arenas is crucial for financial planning and sustainability.

Here are our recommendations for the key steps and considerations to ensure comprehensive and accurate cost calculations:

1. Identify all expense categories and detail each of them

Operational Costs:

- Energy: Include costs for refrigeration, lighting, heating, and cooling. Monitor seasonal variations and peak usage times
- Ice resurfacing maintenance
- Water: Calculate costs for ice-making, cleaning, and general use
- Waste Management: Include costs for disposal of waste materials, recycling programs, and potential penalties for non-compliance with environmental regulations

Staffing Costs:

- Salaries and Wages: Include base salaries, overtime, and holiday pay
- Benefits: Health insurance, retirement contributions, and other employee benefits

- Training and Seminars: Costs for initial and ongoing training programs for staff, including regular seminars to keep staff updated on best practices, availability of new technology and safety regulations

Administrative Costs:

- Office Supplies: Stationery, office equipment, and software subscriptions
- Insurance: Property, liability, workers' compensation, and event-specific insurance
- Marketing: Advertising, promotions, website maintenance, and social media campaigns

Event-Related Costs:

- Setup: Temporary structures, decorations, and additional lighting
- Security: Additional personnel, security systems, and monitoring services

Equipment Costs:

- Purchase: Initial cost of new equipment
- Leasing: Ongoing costs for leased equipment
- Maintenance: Regular servicing, parts replacement, and emergency repairs
- Replacement: Planning for the depreciation and eventual replacement of equipment

Utility Costs:

- Electricity: Track usage for refrigeration, lighting, and other electrical systems
- Gas: Costs for heating systems, if applicable
- Water: Detailed accounting of water usage for ice maintenance and general arena needs

Arena Management:

- Inspections: Regular safety and compliance inspections
- Compliance: Costs for maintaining certifications and adhering to regulations
- Staff Training and Seminars: Regular training sessions and seminars to ensure staff are up to date with safety regulations and best practices

These costs should be categorized as monthly expenses (utilities, personnel, etc.) and annual expenses (property tax, insurance, etc.).

2. Use Technology and Software Tools

- Implement arena management software- such as Building management system- (BMS), also known as a Building Automation System (BAS). It is a sophisticated and very much needed control system designed to monitor and manage the various mechanical, electrical, and electromechanical services within a building. This system ensures efficient operation, enhances comfort, reduces energy consumption, and ensures the safety and security of the building's occupants and controls and keeps staffing costs low and helps to track and manage all expenses in real-time
- Utilize energy management systems to monitor and optimize energy usage
- Employ financial software for budgeting, forecasting, and financial reporting
- For smaller arenas we strongly recommend outsource bookkeeping and accounting services to specialized companies

3. Prepare a Detailed Budget

- Create a comprehensive budget that includes all identified cost categories
- If possible, allocate funds for unexpected expenses and emergencies
- Ensure the budget is flexible and can be adjusted as needed based on actual performance and changing circumstances

4. Benchmarking and Comparison

- Compare your arena's costs with industry benchmarks and similar facilities
- Identify best practices and areas for improvement based on these comparisons

5. Financial Reporting and Analysis

- Prepare regular financial reports to management and arena owners that detail all operational expenses
- Analyze these reports to track performance against the budget and make informed financial decisions

6. Stakeholder Communication

- Ensure transparent communication of cost calculations and financial performance to stakeholders (municipalities, federations, clubs), including investors, management, and staff
- Use this information to support funding requests, justify expenditures, and plan for future investments

By following these recommendations, ice arenas can prepare accurate and comprehensive cost calculations, ensuring effective financial management and operational sustainability.

7.3. On the Income Side We Are Recommend Focusing On the Following Categories

1. Admissions and Ticket Sales:

- Public skating sessions: fees collected from individuals attending public skating sessions
- Special events and shows: Revenue from ticket sales for events such as ice shows, concerts, and tournaments
- Season passes and memberships: Income from selling season passes or memberships for regular access (adult hockey leagues and recreational hockey memberships)

2. Rentals and Usage Fees:

- Ice Time Rentals: Fees charged to hockey teams, figure skating clubs, and other groups for renting ice time
- Arena Rentals: Income from renting the arena for private events, parties, and corporate functions

3. Programs and Classes (if Arena has qualified personnel available):

- Skating Lessons: Fees from offering skating lessons, figure skating classes, and hockey clinics
- Training Camps: Revenue from hosting sports training camps and workshops

4. Concessions and Merchandise:

- Food and beverage: Income from selling snacks, meals, and beverages at concession stands and/or rent from companies that can provide those services
- Merchandise sales: Revenue from selling branded merchandise, apparel, and equipment- this is relatively small income category, but important to boost the brand of Arena and recognition of it

5. Advertising and sponsorship:

- Sponsorship deals: Funds from corporate sponsorships and partnerships
- Advertising space: Income from selling advertising space within the arena (e.g., on the boards, scoreboard, or in the program). More and more Arenas are using various modern LED screen solutions to increase sales

6. Special programs and Initiatives:

- School programs: Revenue from special programs for schools and educational institutions in cooperation with local municipalities
- Community events: Income from hosting community events and activities

7. Parking fees:

- Parking charges: Fees collected from visitors using the arena's parking lot

8. Corporate Partnerships:

- Naming Rights: Revenue from selling the naming rights of the arena or specific sections of the arena.
- Corporate Events: Income from hosting corporate events and functions

9. Grants and Subsidies:

- Government Grants: Funds received from government bodies to support sports and community activities and energy saving and sustainability initiatives
- Subsidies: Financial support from local municipalities or sports organizations

10. Donations and Fundraising:

- Charitable Donations: Contributions from individuals (parents, local businesses, community leaders) and organizations supporting the arena.
- Fundraising Events: Revenue from special fundraising events and campaigns

We strongly recommend to diversifying these income categories to be able ensure a stable and sustainable financial model.

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IIHF Version 09/2024