CLIMATE CHALLENGE NETWORK

2022 Sustainable Communities Awards
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Roadmap to Net Zero Ice Rinks Pilot: Sharing best practices and lessons learned

June 2, 2023

TOROMONT CIMCO

ENBRIDGE

MAYORS' MEGAWATT CHALLENGE
leadership by example

Working together

Getting to net zero in ice rinks is a group effort. These are the technical experts, stakeholders and sponsors who made it possible.

- CIMCO Refrigeration (Official Sponsor)
- Accent Refrigeration
- Friar Architects
- Energy Network Services Inc. (ENS)
- AMP Solar
- Solar Wall
- Zamboni
- Ontario Geothermal Association
- Les Quinton, Parks & Recreation Manager, Town of Black Diamond
- Colleen O'Shea, President, Greener Arena Solutions Inc.
- RDH Building Science
- University of Toronto
- Enerlife Consulting
- Federation of Canadian Municipalities

Participating municipalities and rinks

City of Barrie - Sadlon Arena

City of Brampton - Terry Miller Recreation Centre

Town of Caledon - Caledon East Community Complex

Town of Halton Hills - Acton Arena + Mold Masters Sportsplex

Township of King - Trisan Centre

City of Markham - Mount Joy Community Centre + Crosby Arena

City of Toronto - Downsview Arena

What did we want to achieve?

- Set carbon reduction targets for ice rink facilities
- Determine a zero-over-time roadmap to achieving GHG reduction targets cost-effectively
- Build the case for low carbon measures
- Introduce integrated design process into measure development
- Compare ice rink performance metrics to evaluate ice rink building systems
- Support municipalities in planning equipment renewal

The pilot process

- Data collection and review
- Site visits
- Measure review
- Integrated Design workshops
- Capital Review workshops
- Final reports

Overall findings

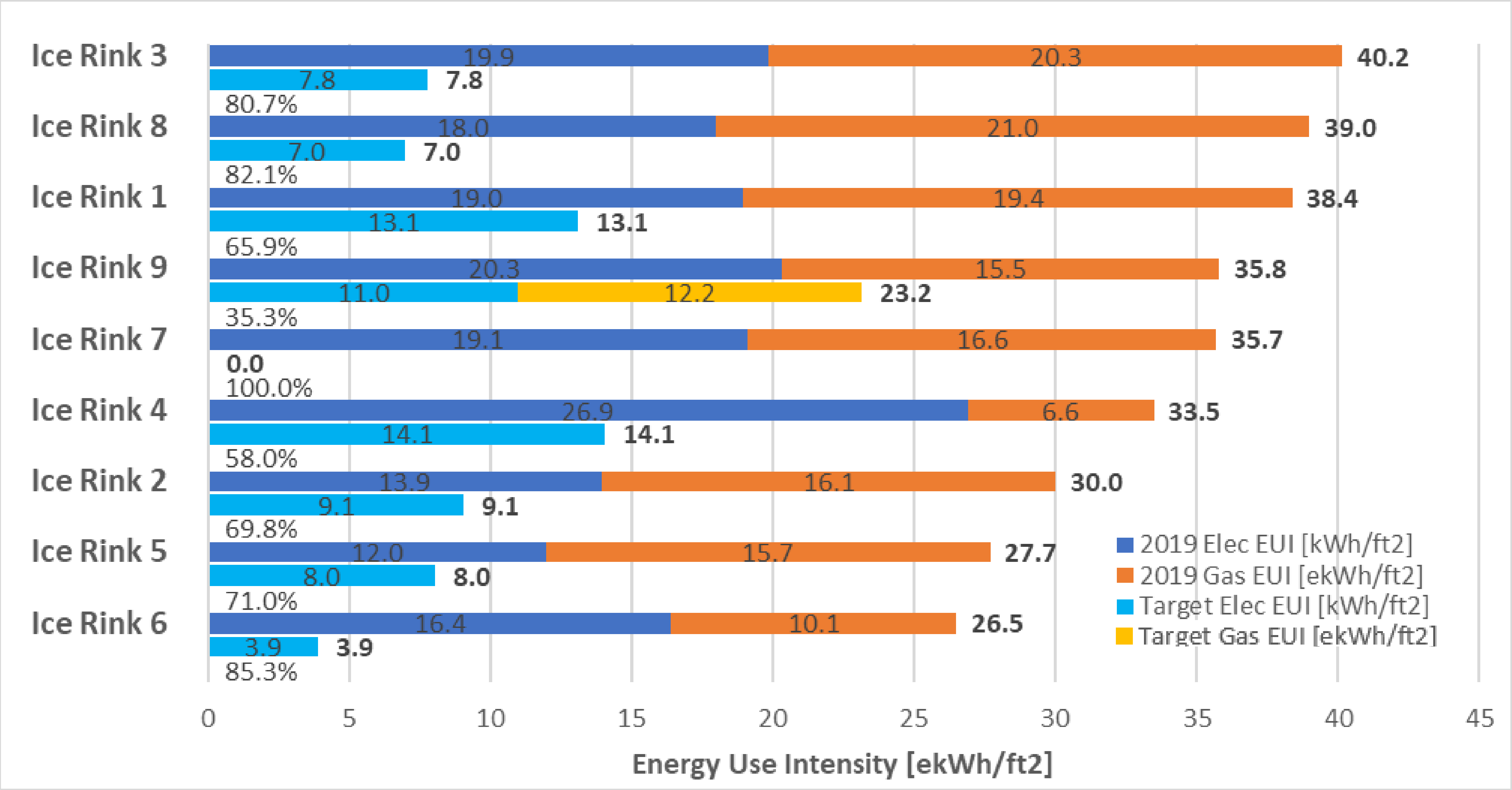
Net zero carbon emissions is achievable and financially feasible in municipal ice rinks.

It requires an all-encompassing evaluation and plan of measures, employing life cycle costing to account for operating and maintenance costs, and aligns the timing of measures with capital renewal or planned capital investments over time.

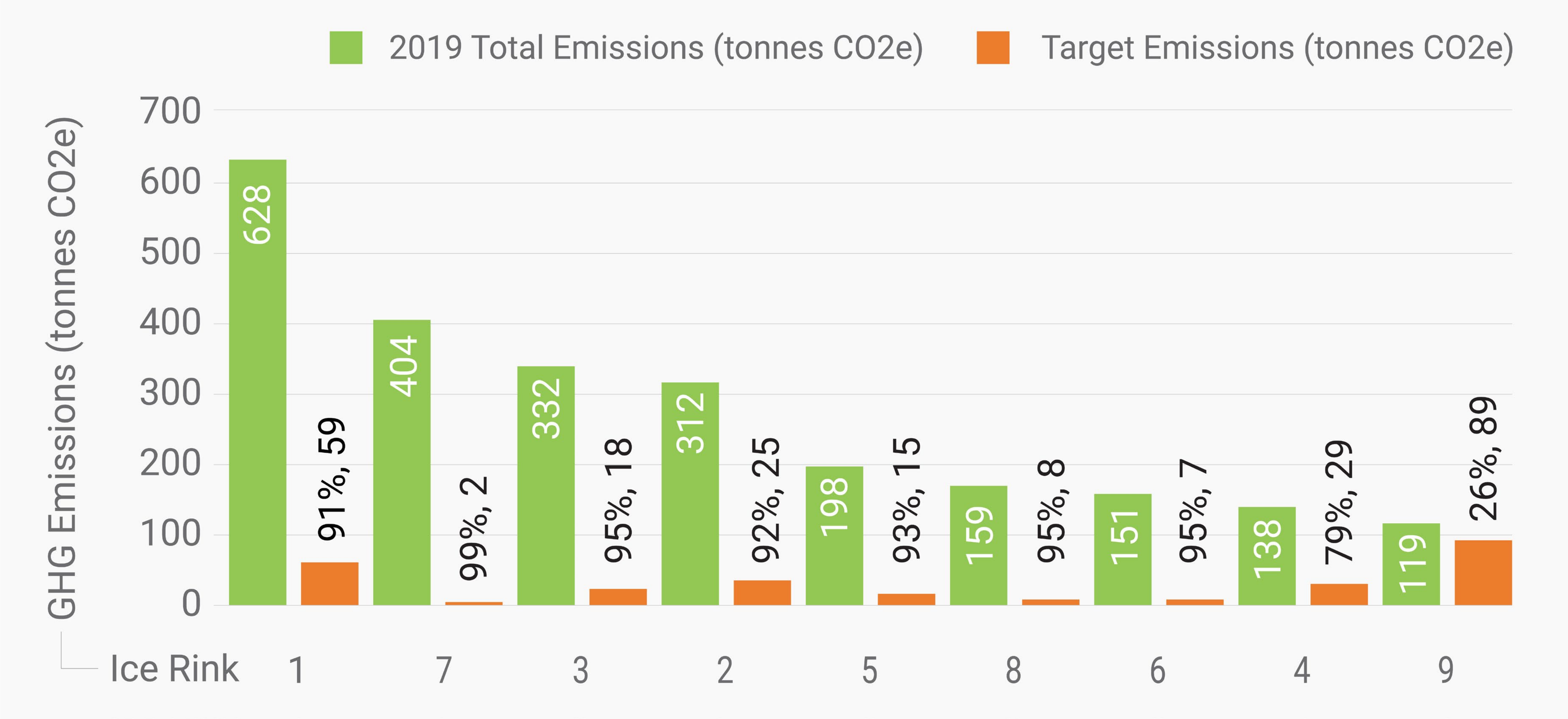
Participating Rink Details

Arena	Ice pad [ft2]	Rink less ice pad [ft2]	Building other [ft2]	Gross Floor Area [ft2]	# Ice pads	Months of ice in	# of refrigeration plants	Heat recovery	Desuperheater
Ice Rink 1	65,450	8,187	77,363	151,000	4	9	2	1 plant only	YES
Ice Rink 2	37,556	13,166	41,278	92,000	3	8	2	NO	YES
Ice Rink 3	28,595	9,637	54,236	92,468	2	1 pad - 12 months 1 pad - 9 months	1	NO	YES
Ice Rink 4	25,381	13,895	28,720	67,996	2	1 pad - 12 months 1 pad - 8 months	1	YES	YES
Ice Rink 5	17,484	6,849	36,164	60,497	1	8	1	NO	NO
Ice Rink 6	17,000	4,705	39,339	61,044	1	10.5	1	NO	Decommissioned
Ice Rink 7	17,000	28,713	64,287	110,000	1	9	1	NO	Decommissioned
Ice Rink 8	15,725	4,925	15,926	36,576	1	8	1	NO	Bypassed
Ice Rink 9	17,000	1,100	16,193	34,293	1	10	1	NO	YES

Current and Target Energy Intensities



Greenhouse Gas Emission Reduction Opportunities



Ice Rink System Metrics

Arena	Compressor [W/ft2]
Ice Rink 1	9.49
Ice Rink 4	9.31
Ice Rink 6	6.58
Ice Rink 3	5.80
Ice Rink 2	5.74
Ice Rink 8	5.72
Ice Rink 7	5.26
Ice Rink 9	5.12
Ice Rink 5	4.70

Arena	Brine pumps [W/ft2]
Ice Rink 8	2.35
Ice Rink 7	1.75
Ice Rink 4	1.63
Ice Rink 1	1.58
Ice Rink 2	1.54
Ice Rink 3	1.30
Ice Rink 9	1.22
Ice Rink 6	1.09
Ice Rink 5	0.95

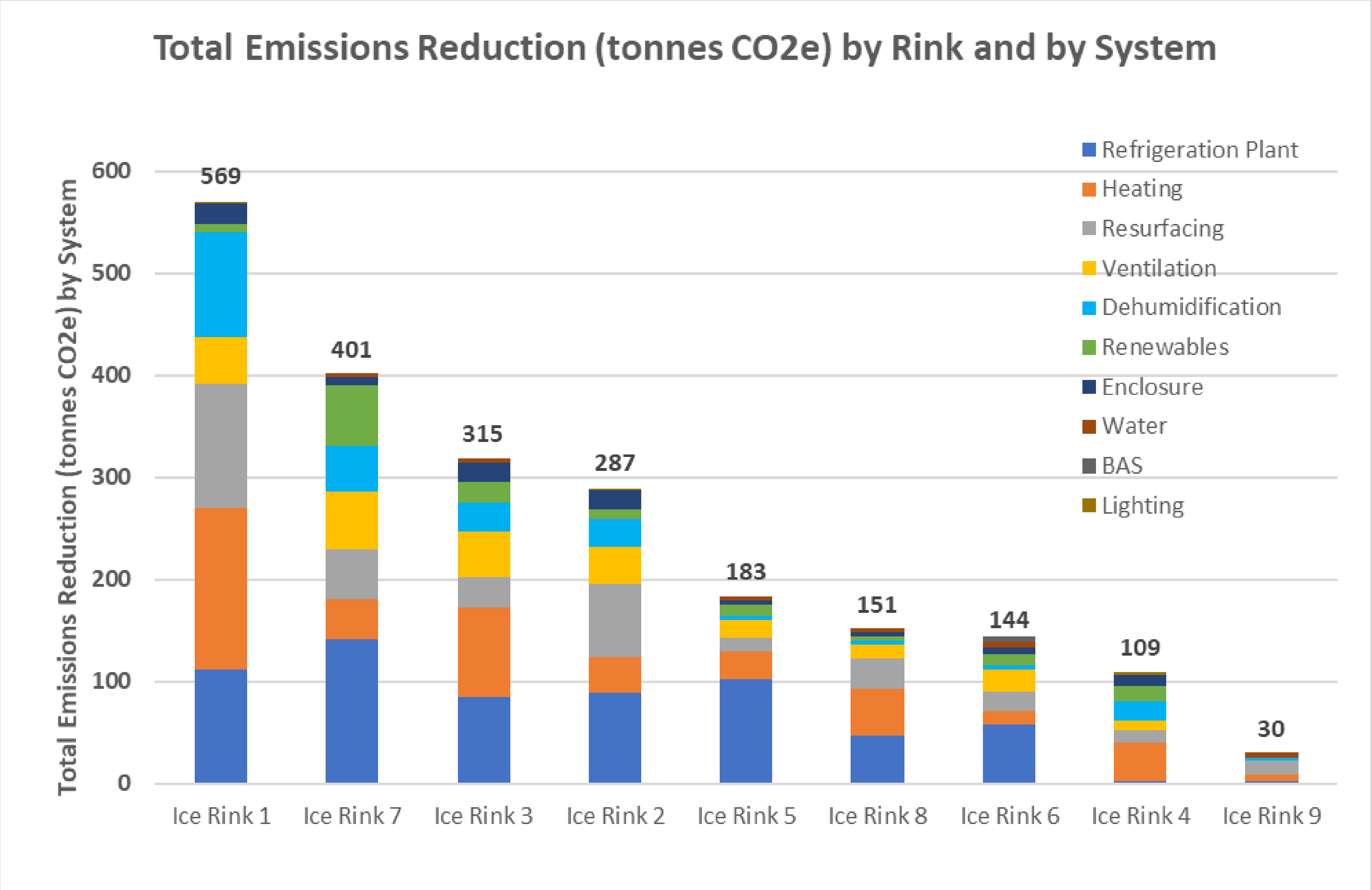
Ice Rink System Metrics

Arena	Dehumidifer [CFM/ft2]
Ice Rink 7	1.75
Ice Rink 4	0.51
Ice Rink 1	0.46
Ice Rink 3	0.44
Ice Rink 5	0.33
Ice Rink 2	0.28
Ice Rink 6	0.24
Ice Rink 8	0.22
Ice Rink 9	0.12

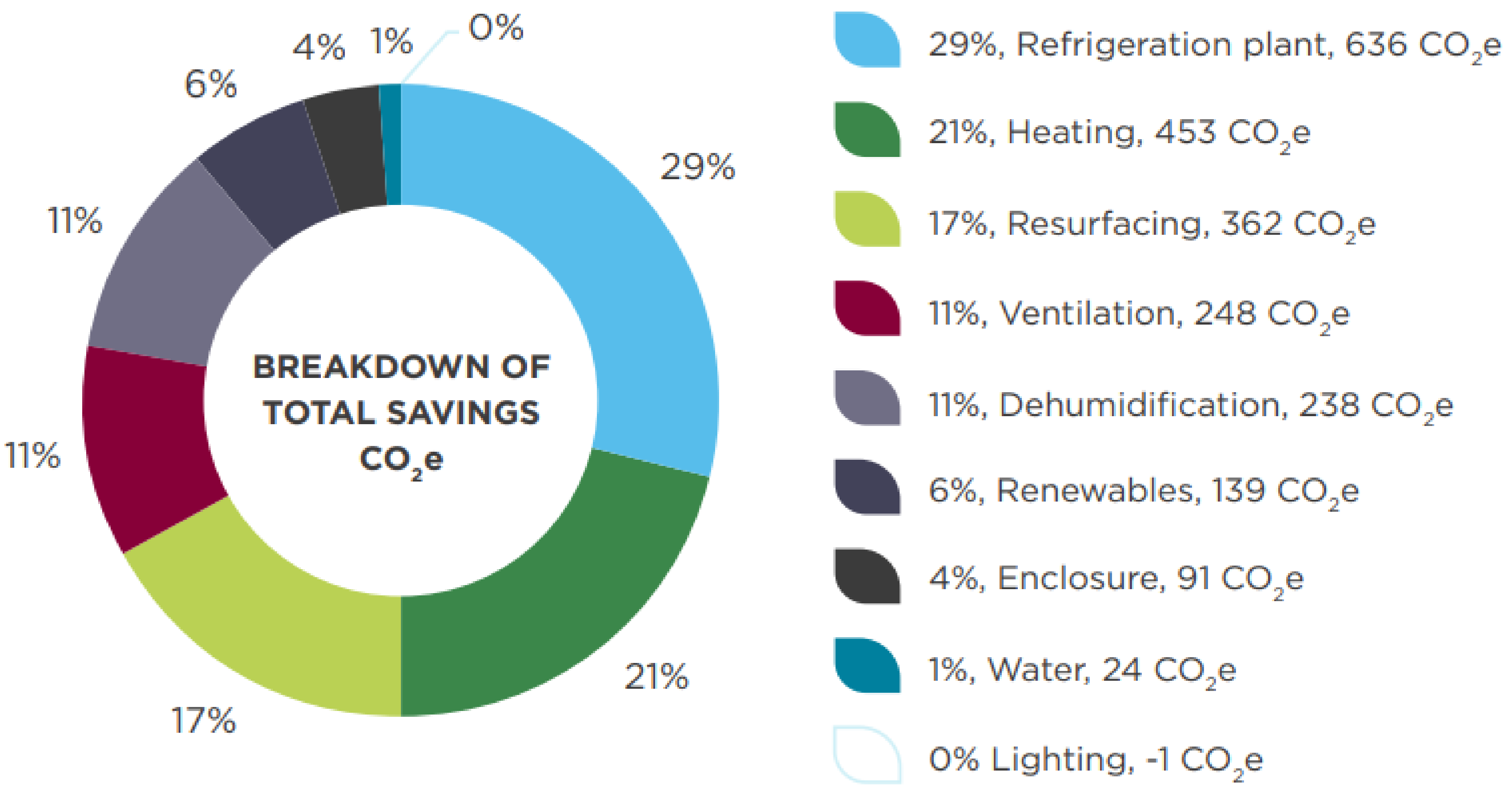
Arena	Dehumidifer fan [W/ft2]
Ice Rink 7	1.96
Ice Rink 4	1.03
Ice Rink 3	0.51
Ice Rink 5	0.49
Ice Rink 1	0.38
Ice Rink 2	0.23
Ice Rink 8	0.17
Ice Rink 6	0.15
Ice Rink 9	0.10

Arena	Lighting [W/ft2]
Ice Rink 3	1.27
Ice Rink 4	1.18
Ice Rink 1	1.06
Ice Rink 8	0.85
Ice Rink 7	0.54
Ice Rink 6	0.42
Ice Rink 2	0.33
Ice Rink 5	0.30
Ice Rink 9	0.23

Total Emissions Reduction by Rink and System



Emission Savings by System (total for all rinks)



Importance of Lifecycle Costing and Net Present Value (NPV)

Life cycle costing (LCC) is fundamental to the decision-making approach for low carbon measures

It is based on net present value (NPV). It lays out the total cost savings over 30-year period, compared to current operations, using 2019 as the baseline. It follows FCM's GHG reduction pathway study approach.

LCC considers the **total cost of ownership** including the initial upfront cost, operating costs such as utility, maintenance and carbon taxes as well as inflation and other considerations.

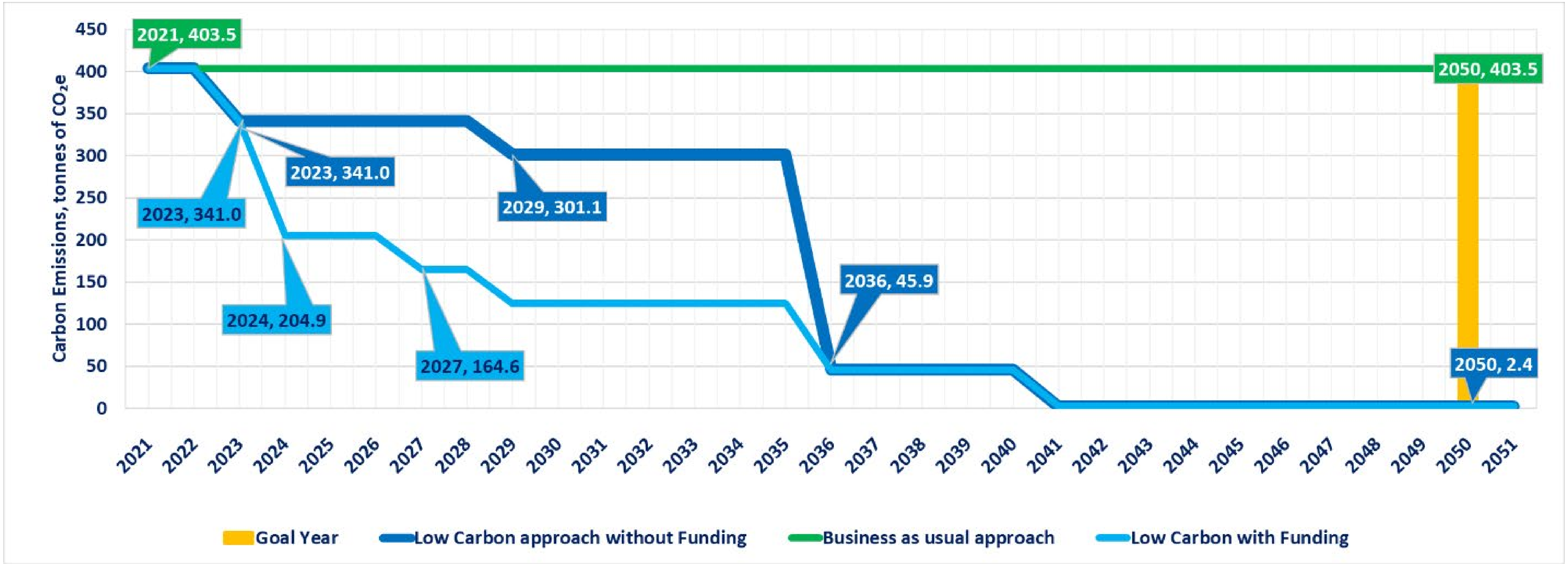
Why over a 30 year period?

- Takes us to close to 2050 – point by which carbon emissions need to be at zero to avoid 1.5 degree warming

Aggregate of financial findings

System	Business As Usual		Low Carbon approach without funding		Low Carbon approach with funding		Low Carbon Emissions savings (Tonnes CO2e)
	Initial Outlay of Costs ($)	NPV ($)	Initial Outlay of Costs ($)	NPV ($)	Initial Outlay of Costs ($)	NPV ($)	
Refrigeration Plant	$5,298,000	-$5,084,023	$11,185,875	$4,626,367	$4,555,575	$14,793,199	636.3
Heating	$2,516,854	-$2,244,546	$2,226,205	-$214,450	$805,241	$1,154,239	453.2
Resurfacing	$945,000	-$1,284,733	$1,720,000	$11,575,659	$1,272,000	$9,373,519	362.0
Ventilation	$1,616,376	-$2,315,698	$2,703,048	$999,902	$1,067,810	$2,775,088	247.8
Dehumidification	$1,733,200	-$2,673,514	$2,754,793	$3,880,101	$667,759	$5,442,670	237.7
Renewables	$0	$0	$8,102,376	$13,696,313	$4,080,137	$17,564,057	138.9
Enclosure	$0	$0	$3,242,148	-$228,394	$786,670	$2,239,359	90.8
Water	$0	$0	$7,000	$941,918	$1,400	$947,115	24.2
Lighting	$5,592	$242,811	$279,221	$1,286,403	$55,844	$1,525,427	-1.0
Grand Total	**$12,115,022**	**-$13,359,703**	**$32,220,667**	**$36,563,819**	**$13,292,435**	**$55,814,674**	**2189.8**

Carbon reduction over time



High Impact Measures Overview

Measure	Average Emission Savings (Tonnes CO_2e)	Average Emissions reduction (%)
Adding heat recovery to the refrigeration plant	88.9	34%
Replacing the gas boiler plant with an electric equivalent	45.8	17%
Replacement of ice resurfacing machine with electric equivalent	29.5	9%
Installation of Building Automation System	29.4	10%
Installing a cold-water resurfacing system	21.7	13%
Installation of solar photovoltaic cells	17.4	7%

Operational (low cost/no cost) measures

- Implement early (energy savings, early wins)
  - Optimize ice temperature based on activity level and occupancy

Period (24 hrs)	Brine Temperature	Rink Function
00:00 - 06:00	25°F	Night setback
06:00 - 08:00	25°F	Ice maintenance
08:00 - 16:00	22°F	Low load
16:00 - 18:00	20°F	Figure skating
18:00 - 24:00	18°F	Hockey

  - Maintain ice thickness – ideal thickness as per ORFA is between 1” to 1.25”
  - Adjust humidity setpoints during the day with low occupancy at 60% and during unoccupied night to 65%
  - Schedule building systems to operate only when needed
  - Control lighting levels based on activity
  - Reduce water per flood to 150 USGal

- **Operator training is critical and was identified by most municipalities as an area where additional support would be needed**

Building Automation System (BAS) Integration

- BAS is an essential ingredient to operate a facility optimally and find energy and emission savings
- Based on the site visits, we have observed the following:
    - Different types of controllers used to operate the refrigeration plant
    - Most are generally monitored by a BAS (typically Delta Controls)
    - Remote access is challenging
    - None are integrated with the rest of the building HVAC
    - Some don’t have any BAS for the rest of the facility
- Strategies need to be optimized (scheduling, occupied and unoccupied smart energy efficient operating strategies)
- Must set up trend logs and archive – Only refrigeration system had them set up

Trends and Building Automation System (BAS)

- Eight of nine rinks in the pilot did not have BAS systems that covered the whole building
- Most had the capability of capturing trends in their refrigeration systems
- Accessing trends was difficult and most buildings were not reviewing them on a regular basis
- Reviewing the trend logs allowed the project team to identify immediate operational savings opportunities that helped improve the financial forecast
- Planning to implement a whole building BAS early in the low carbon plan will help better control building systems, develop and consistently apply best operational practices, and provide a view into how the building is operating

Refrigeration Plant – Key Measures

- Adding heat recovery is fundamental to achieving significant carbon reduction
  - Essential to make sure heat recovered can be used to offset heating in facility
  - Use of high temperature heat recovery chillers or heat pump to elevate temperatures to be used in existing building infrastructure.
- Need for ice storage to address misalignment of ice plant operation with building heating requirements (i.e. resetting ice temperature at night)
- Use of VFDs on brine pumps and compressors where feasible
- Optimization of sequences such as staging of compressors, resetting of temperature and humidity setpoints and integrating with other building systems

Heating – Key Measures

- Optimization of boiler plant operating sequences including the setup trend logs and having an archiving solution
  - Requires a BAS on the boiler plant to accomplish this
  - Smart operating strategies such as unoccupied temperature set back, efficient staging of boilers etc...
- Replace spectator gas fired infra-red heaters with electrical equivalent
- Boiler plant replacement with electric equivalent
  - Must ensure heat recovery is installed already to avoid huge increase in utility costs
  - Check to see if electrical service needs to be upgraded as this can be costly

Resurfacing – Key Measures

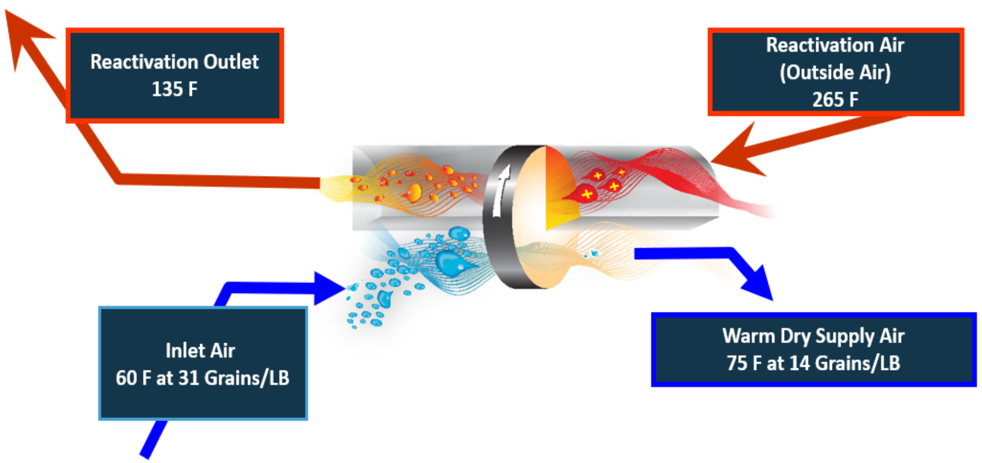
- Reduce ice resurfacing water temperature by using cold water ice resurfacing product
- Optimize ice thickness where possible
- Replace ice resurfacing machine with electrical equivalent at end of life

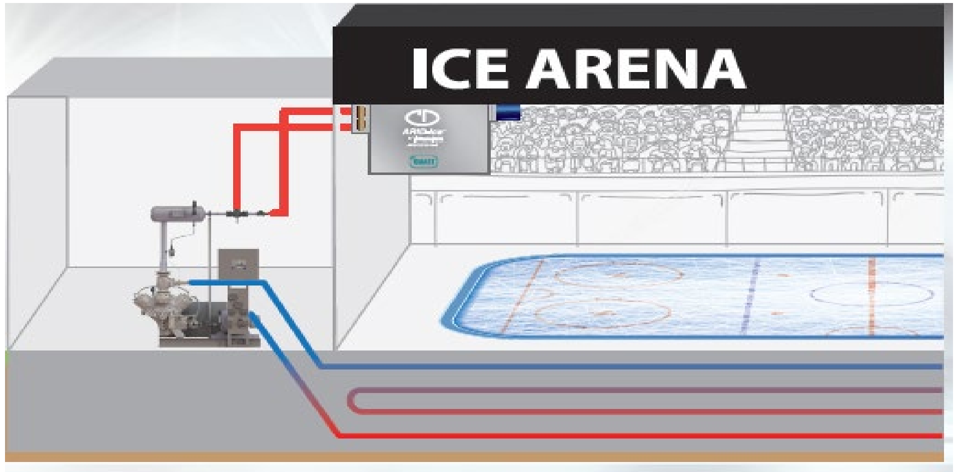
Ventilation – Key Measures

- BAS control and optimization of AHU/RTU operating sequence
  - Unoccupied temperature setpoint reset
  - Tighten operating schedules
  - Economizer operation using enthalpy
- Replace existing AHU/RTU with equipment that has hydronic coils fed from heat recovered from refrigeration plant

Dehumidification – Key Measures

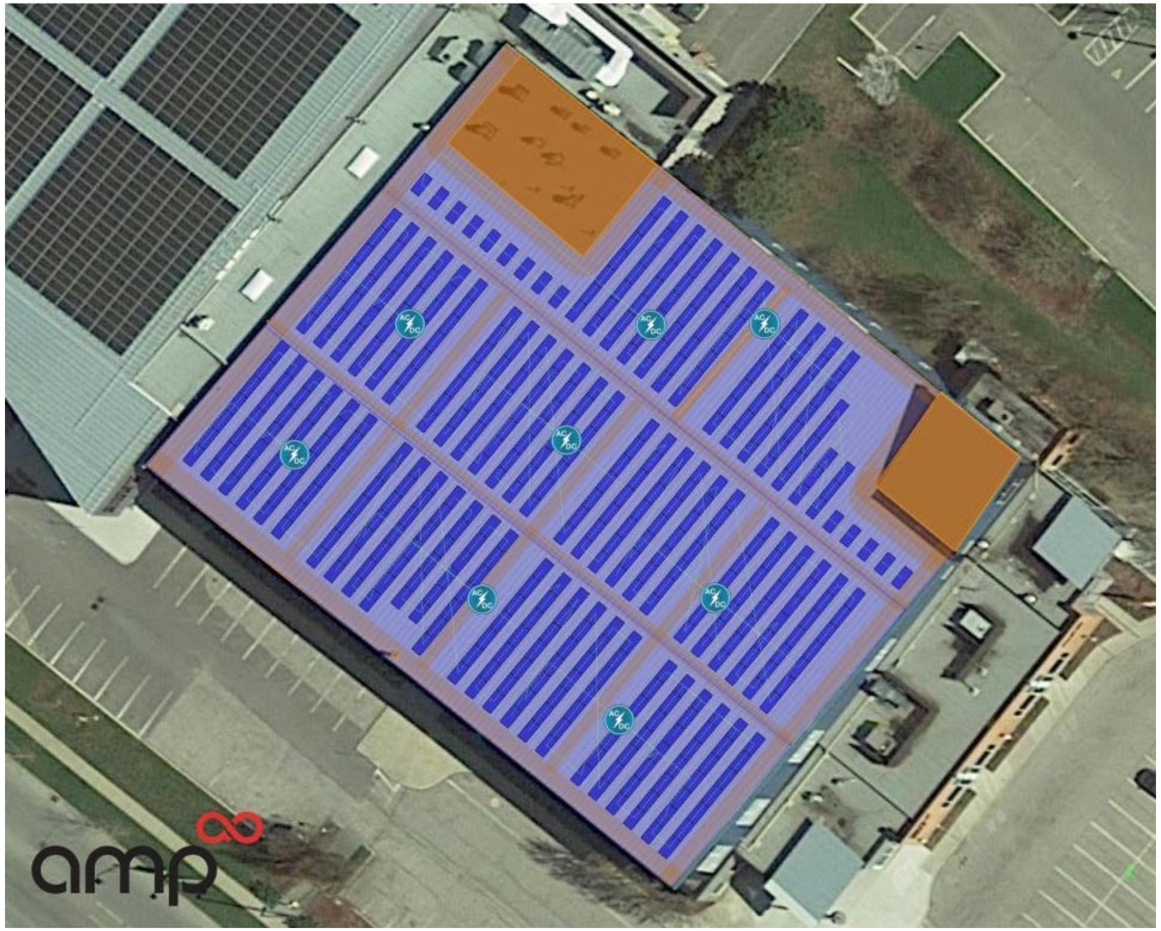
- Optimize relative humidity setpoint including resetting the setpoint up to 65% using dew point control during unoccupied periods
  - Shutting system off during unoccupied periods with automatic restart if RH rises above safe dewpoint
  - Lower occupied setpoints all while ensuring fogging does not develop and ice quality is not compromised
- Leverage outside air to help dehumidify using enthalpy control
- Consider retrofitting existing dehumidifiers (if gas fired desiccant) with hydronic heating element, fed by the heat recovery from refrigeration plant
- Evaluate separating ventilation for spectators from dehumidifier and replace dehumidifier at end of life with electric powered desiccant wheel using heat recovery as source of generation from refrigeration plant





Renewables – Key Measures

- Solar PV is the most suitable and financially attractive renewable for ice rinks
- Geothermal in ice rink only facilities was not found to be economically attractive given the amount of heat readily available from heat recovery in the refrigeration plant
- Solar wall and solar thermal were evaluated and deemed not to be financially attractive



Envelope – Key Measures

- Low-e ceiling is recommended in ice rinks but need to address potential obstructions and sprinklers. Professional rinks may be problematic.
- Other than low-e ceiling, typically these measures are not the most financially attractive. These measures are generally more driven by occupant comfort than by emissions reduction.
- Wall envelope insulation improvement is generally very costly to do but should be examined if existing is very poor.
- Window replacement with better thermal performance options should be examined at end of life.

Water – Key Measures

- Reduce water per flood from 225USGal to 150USGal or less
- Water efficient fixtures, low flow toilets/urinals
- Heat recovery reduces use of cooling tower and in turn reduces water usage

Lighting and Lighting Controls – Key Measures

- Convert from fluorescent to LED lamps/fixtures (use metrics to guide design)
- Implement lighting controls to vary light levels based on activity type
- Use of occupancy sensors to control lighting in space with intermittent use such as changerooms and washrooms
- Understand secondary effects of lighting energy reduction (less load on ice rink but heating penalty in heated spaces)

Lessons Learned

- Get organized – gather building data and documentation early
- Get everyone involved - Integrated Design Process
- Understanding of life cycle costing
- Operational (low cost/no cost) measures first
- Integrate refrigeration plant with other building systems
- Building Automation System (BAS)/controls
- Heat recovery is essential

Net Zero Carbon Readiness – Getting Organized

- Building performance data
  - Monthly (2 years)
  - Interval, if available (2 years)
  - Submetering or datalogging high energy using equipment and systems
- Energy management software – tracking performance
- Critical drawings - mechanical, refrigeration, electrical (lighting), architectural, schematics or Process and Instrumentation Diagram (P&ID) (if available)
- BAS trend logs
- Previous energy audits and a summary of recent measures completed
- Current operating conditions and occupancy schedules
- Building condition assessments
- Asset management plan/capital plan

Want to learn more?

Guidebook produced with Federation of Canadian Municipalities

Available on Green Municipal Fund website

FCM now offering CBR advisory service support

What’s happened after the pilot

- Cohort project for net zero indoor swimming pool facilities
- Recommissioning activities
- Recommissioning cohort project launching in the fall
- Heat recovery installations

Thank you!

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