COMPARATIVE LIFE-CYCLE COST ANALYSIS OF REFRIGERATION SYSTEMS IN ICE RINKS

Cajus Grönqvist, Jörgen Rogstam

EKA – Energi & Kylanalys (Sweden)

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Introduction

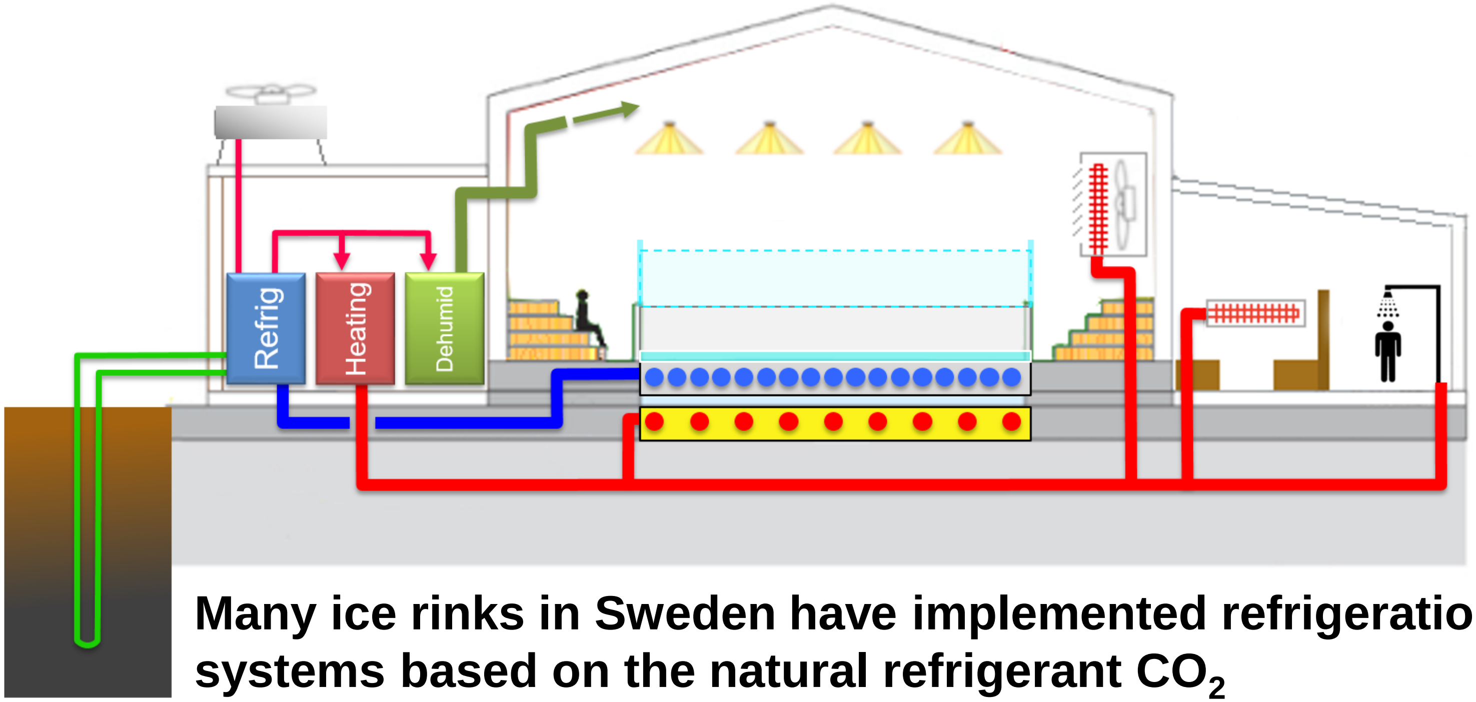
Many ice rinks must undergo renovation

Popular refrigerants in EU ice rinks no longer fulfill the Global Warming Potential (GWP)-requirements set by the F-gas Regulation

- E.g. R-22 and R-404A

Subsequent renovations will require sound financial decision-making in order to improve overall performance

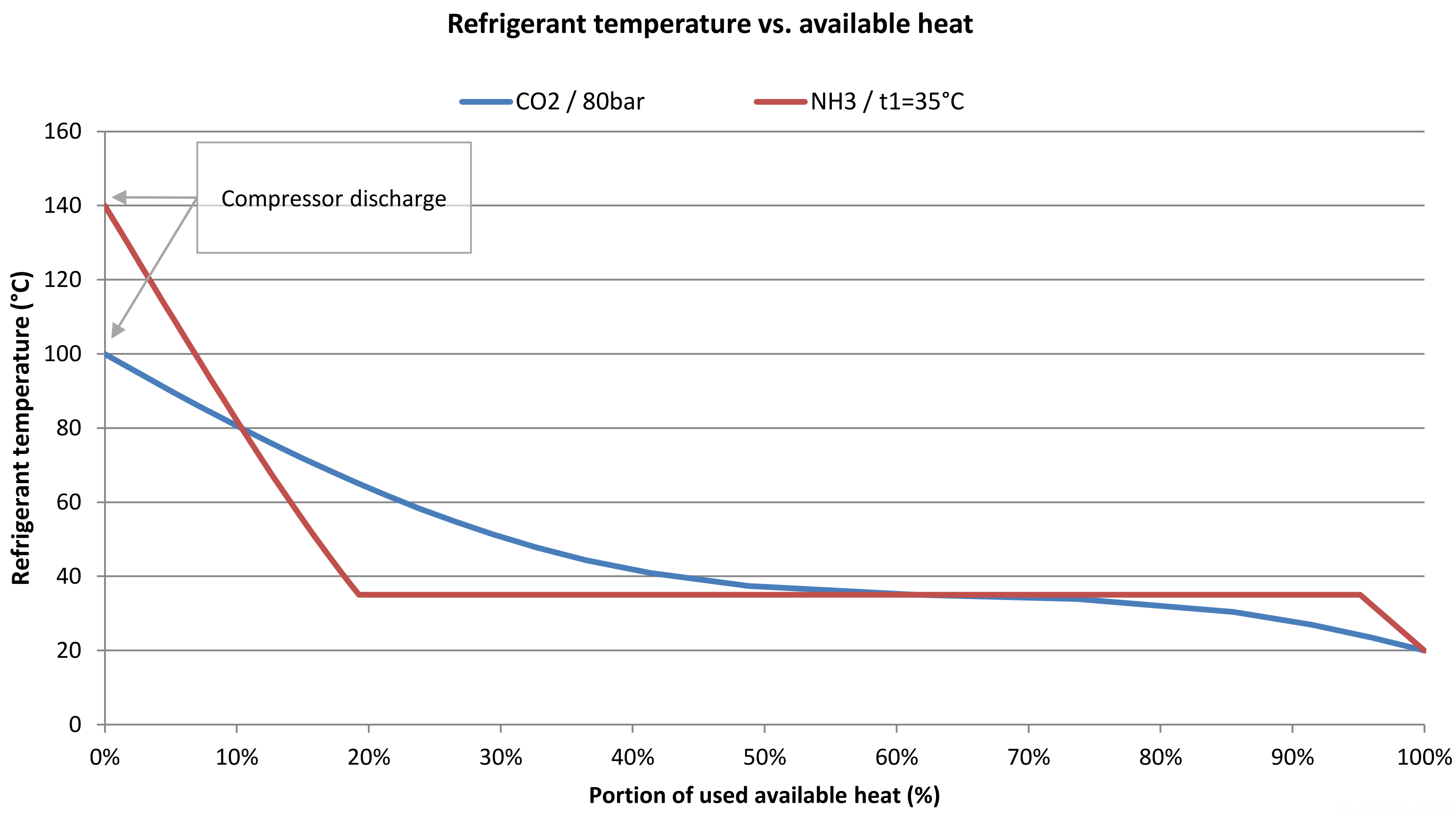
CO2-based systems becoming popular



Many ice rinks in Sweden have implemented refrigeration systems based on the natural refrigerant CO_2

- Energy consumption went down, in some cases by half
- Due to CO_2 properties, some ice rinks became self-sufficient on recovered heat
  - *Heat export possible*

Heat recovery potential of CO_2



Problem, objective & scope

Missing:

- A practical and reliable way to incorporate life-cycle cost (LCC) analysis when comparing refrigeration systems in ice rinks

Solution:

- Develop an LCC analysis model that is effective and capable of producing reliable results when comparing refrigeration systems in ice rinks
  - Focus on financial performance
  - Heat recovery performance is included

LCC analysis model

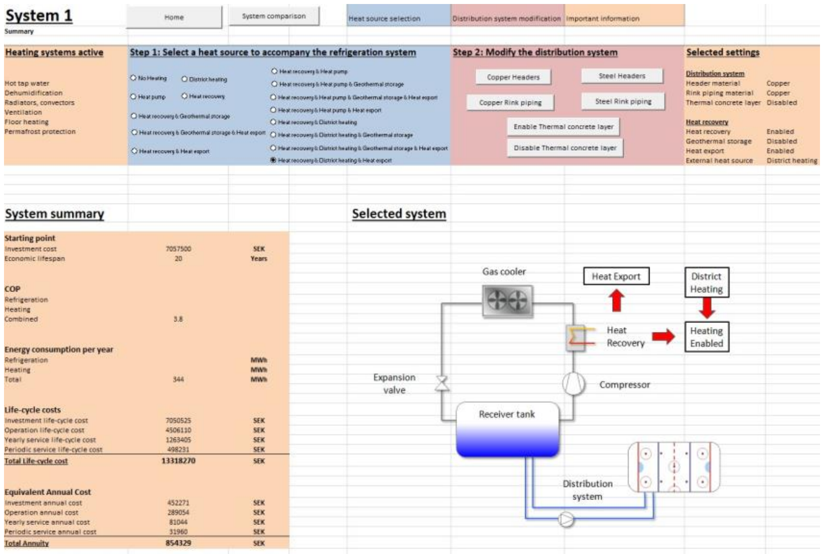
Model structure & input data

Developed in Excel

- Programmed macro commands
- Automatic calculations and LCC analysis

Input data gathered from various sources

- Energy use model (Bolteau et al.)
  - Including released heat
- Cost breakdown
  - Investment
  - Yearly and periodic service cost



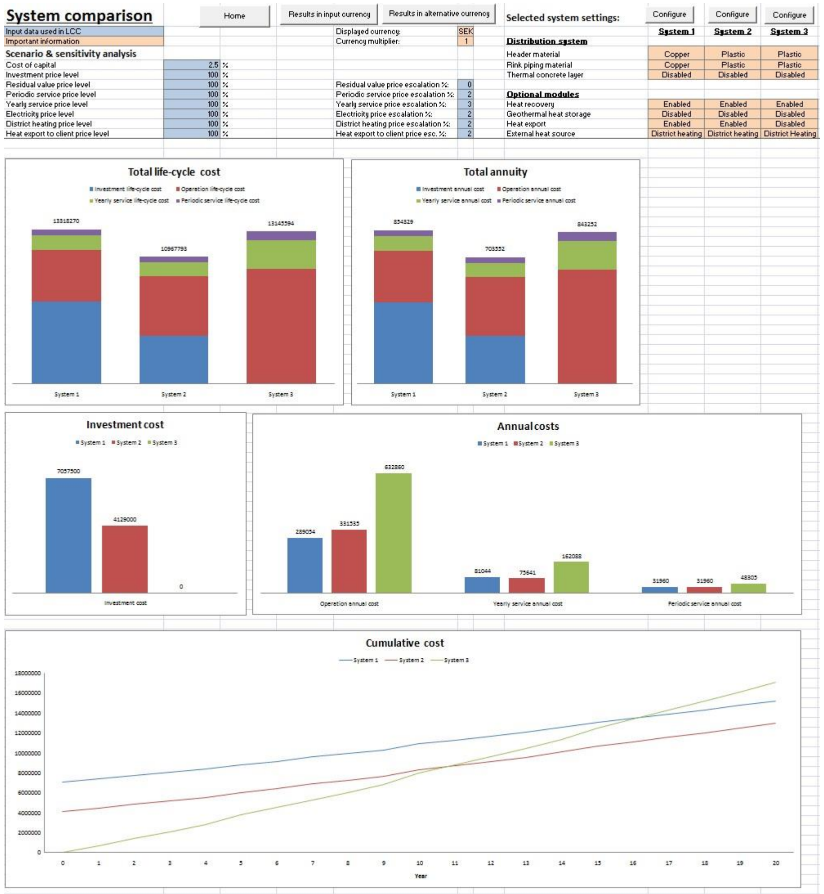
System comparison

System solutions are compared simultaneously

- Investment cost
- Annual cost
- Total life-cycle cost
- Equivalent annual cost
- Cumulative cost

Live sensitivity and scenario analysis

- Evaluates quality of input data
- Tests robustness of analysis results



Case examples
&
Results

Three case examples

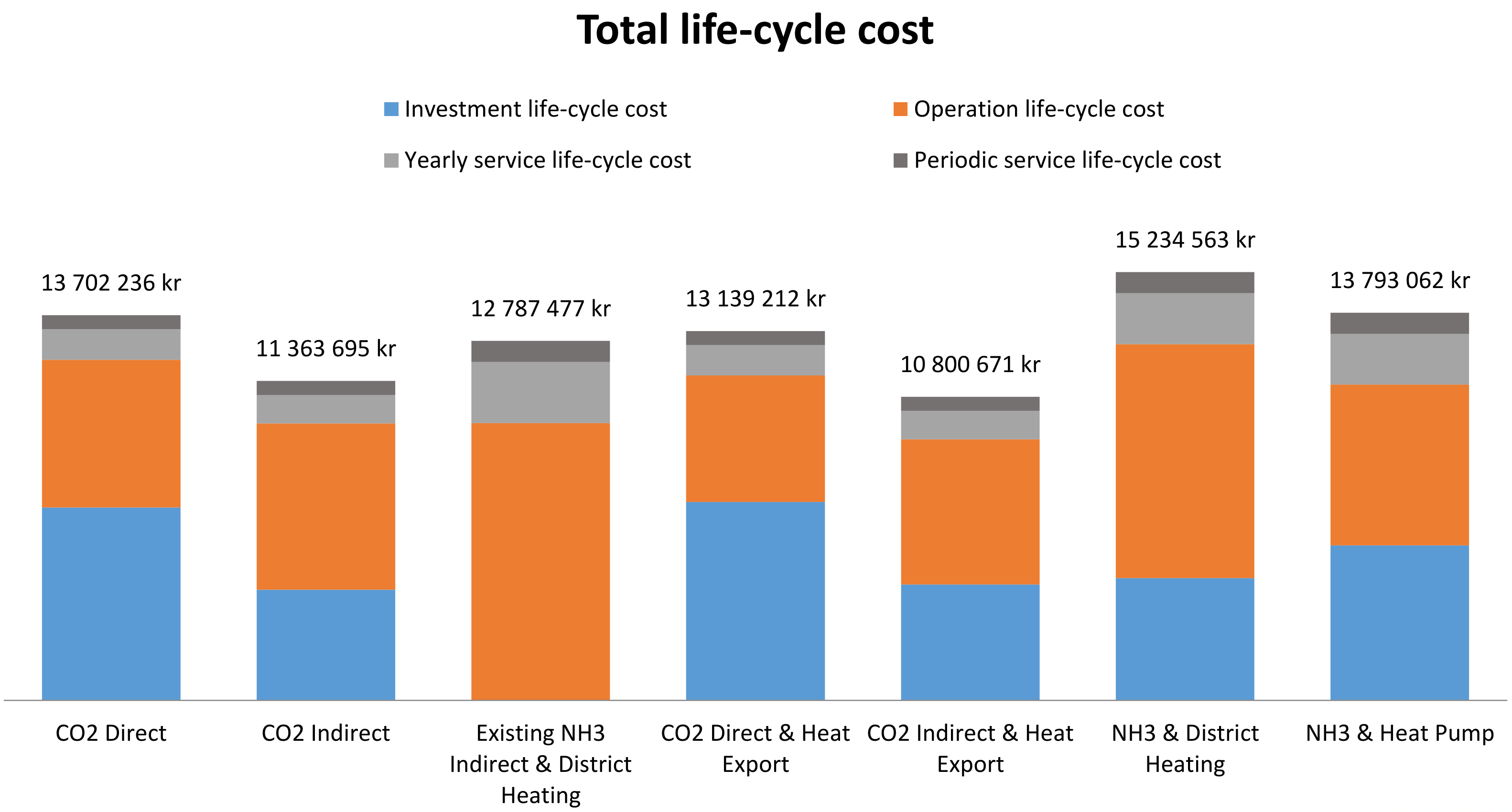
Ice rinks located in Sweden

- Existing systems were reviewed
- Refrigeration and heating demands were estimated

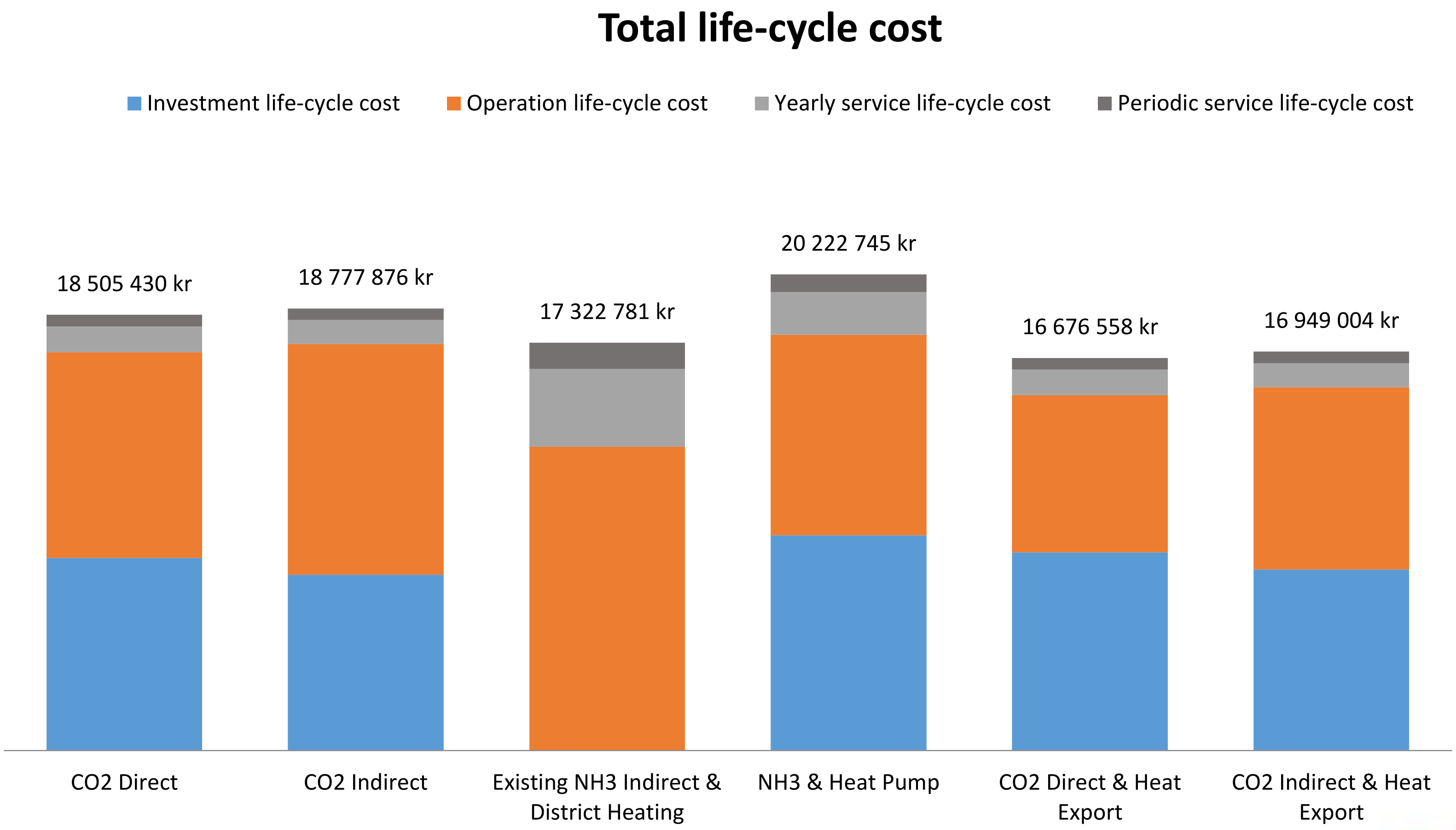
New alternatives were proposed

- Systems based on CO_2 and NH_3
  - With additional options, e.g. heat export
- LCC calculations were done in model for all refrigeration systems
- Comparison with existing system

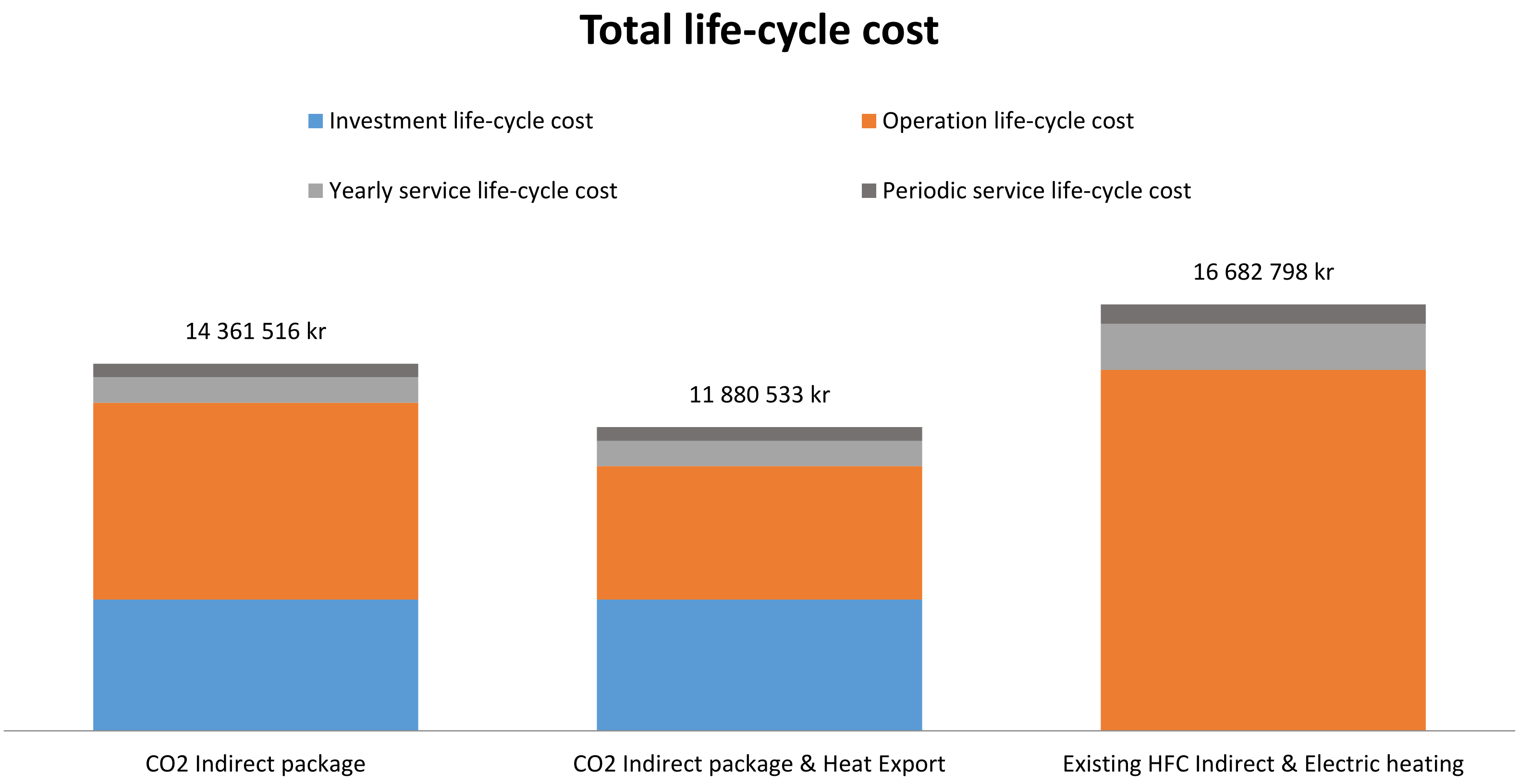
LCC results: Case X



LCC results: Case Y



LCC results: Case Z



Conclusions

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Sensitivity and scenario analysis plays a crucial role when evaluating the quality of input data

The reliability of the results can be assessed in the model

- The model is applicable and effective in comparative LCC analysis of refrigeration systems in ice rinks

Refrigeration systems based on CO_2 with optimized heat recovery seem to have a competitive advantage in ice rinks

- In investment
- In service
- In overall energy cost

Thank you!

Cajus Grönqvist
Jörgen Rogstam

EKA

Cajus.Gronqvist@ekanalys.se
Jorgen.Rogstam@ekanalys.se
www.ekanalys.se