IIR Working Party on Life Cycle Climate Performance Evaluation

Yunho Hwang, Ph.D.
Chair of LCCP WP
Vice President of Commission B1
# Agenda

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<td>Refrigerant / sector advice matrix NVKL</td>
<td>Coen van der Sande</td>
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<td>Life cycle performance of refrigeration systems in the Dutch supermarket sector (TP-085)</td>
<td>Carlos Infante Ferreira</td>
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<td>Life cycle performance of refrigeration systems in the Dutch food and beverages sector (TP-086)</td>
<td>Hans Wijbenga</td>
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Environmental Impacts of Refrigerants

Some Metrics

**TEWI (Total Equivalent Warming Impact)**
- Indirect emission
- In operation (Includes servicing)
- Leakage
- Direct emission
- Not recovered

**LCCP (Life Cycle Climate Performance)** “Simple comparison for refrigerant”
- EM (FE + RIE)
- IE: Indirect emission
- DE: Direct Emission
- Emission during Refrigerant Manufacturing
- In operation (Includes servicing)
- Leakage
- Not recovered

**LCA (Life Cycle Assessment- LCCO₂)**
- Indirect emission for production
- Refrigerant Manufacturing
- Transporting
- Equipment Destruction

Source: LCCP OF SOME HVAC & R APPLICATIONS In Japan, Haruo Onishi, Ryuzaburo Yajima, Shotaro Ito, April, 2004 Earth Technologies Forum.
Some Metrics

**TEWI (Total Equivalent Warming Impact):**

\[
\text{TEWI} = \text{GWP (direct)} + \text{GWP (indirect)}
\]

Due to refrigerant leaks  
Due to A/C operation

**LCCP (Life Cycle Climate Performance):**

\[
\text{LCCP} = \text{TEWI} + \text{GWP (Indirect)} + \text{GWP (Direct)}
\]

- **Indirect** [energy consumption expressed as CO\textsubscript{2}-eq emissions from chemical production & transport, manufacturing components & product assembly and end-of-life]
- **Direct** [chemical refrigerant emissions including atmospheric reaction products, manufacturing leakage, and end-of-life]

*Source: Green-MAC-LCCP, Stella Papasavva and Stephen O. Andersen, 2008*
Properties of Carbon Based Refrigerants

(a) Methane series
- flammable
- toxic
- high boiling temperature
- long atmospheric lifetime

(b) Ethane series
- flammable
- toxic
- high boiling temperature
- long atmospheric lifetime
LCCP Contributions: MAC

**R134a Baseline**
- Atmospheric degradation: 0.02%
- Component manufacturing: 3.77%
- Total end of life: 0.14%
- Recover/recycle/recharge refrigerant: 0.13%
- A/C mass transportation: 14.92%
- Indirect emissions due to A/C vehicle operation: 60.30%

**R290 2LP**
- Atmospheric degradation: 0.00%
- Component manufacturing: 3.74%
- Total end of life: 0.20%
- Recover/recycle/recharge refrigerant: 0.24%
- A/C mass transportation: 23.07%
- Indirect emissions due to A/C vehicle operation: 72.68%

**R152a 2LP**
- Refrigerant emissions due to leakage: 2.78%
- Total end of life: 0.19%
- Recover/recycle/recharge refrigerant: 0.24%
- A/C mass transportation: 22.38%
- Indirect emissions due to A/C vehicle operation: 70.65%

**Refrigerant emissions due to leakage**
- R134a: 21.86%
- R290: 0.06%
- R152a: 0.06%

**Atmospheric degradation**
- R134a: 0.02%
- R290: 0.00%
- R152a: 0.00%
LCCP Comparison: MAC, US Cities

The chart compares LCCP CO2 Eq. emissions per lifetime/vehicle (kg) for different cities and refrigerants. The refrigerants compared are Baseline HFC-134a, 2LP HFC-152a, and 2LP HC-290.

- **Fargo** shows a reduction of -15.42% to -15.24%
- **Chicago** shows a reduction of -19.86% to -22.12%
- **Boston** shows a reduction of -15.00% to -19.21%
- **San Francisco** shows a reduction of -13.87% to -19.07%
- **San Diego** shows a reduction of -13.40% to -17.31%
- **Miami** shows a reduction of -12.18% to -12.96%

The cities are categorized as **Cold** or **Hot** based on their climate conditions.
Tools Available

- **GREEN MAC LCCP (2004)** – Excel based
  - GREEN-MAC-LCCP©
  - The Metric for MAC Environmental Superiority
- **AHRTI’s Residential HP LCCP (2011)** – Excel based
- **ORNAL’s Supermarket Refrigeration LCCP (2012)** – Web based
  - Life Cycle Climate Performance - Supermarket Systems V0.24
- **IPU’s Pack Calculation II, Refrigeration Plant TEWI (2012)**
Needs for New LCCP

• How to improve accuracy?
• How to quantify the importance of each contribution?
• How to harmonize the LCCP methodology?
• Do we need different versions?
  • Research version for accuracy
  • Public version for easy use
IIR’s LCCP Working Party (WP)

• In response to global warming concerns, the IIR has been advocating environmentally friendly, safe, energy-efficient and cost-effective design, operation and end-of-life management of refrigeration and air-conditioning systems.

• As part of these efforts, the IIR formed a working party to assess the merits of different methods for evaluating the environmental impact of refrigerants and to produce implementation protocols for these methods.
LCCP WP: Approach

• Collect information on direct and indirect emissions of working fluids for various applications from individual countries and from the current IIR’s WP on Mitigation of Direct Emissions of GHGs

• Initiate within IIR member states the formation of similar Working Party-Groups to cooperate with the IIR Working Party

• Establish the LCCP evaluation methodology applicable for refrigeration and air conditioning systems

• Evaluate how different assumptions selected by a user of these methodologies can affect the result of the assessment.
LCCP WP: Approach

• Evaluate how improvement options can affect the result of the assessment.
• Assemble such information and to disseminate it amongst WP members and all IIR member states.
• Write a booklet on the LCCP evaluation methodology developed and make it available to members of the WP and all IIR members, and to non-members via Fridoc.
• Support and promote international collaboration and initiatives to improve the LCCP of the refrigeration and air conditioning systems.
• Represent the IIR at events dealing with environmental impact evaluation.
LCCP WP: Timescale

- WP started: January 2012
- Entire WP efforts: 4 years
- First WP meeting: Delft, June 2012, during the 10th IIR-Gustav Lorentzen Conference
- Second WP meeting: Gaithersburg, October 2012, during the ASHRAE/NIST Refrigerant Conference
- WP shall hold one or two meetings per year.
- Minutes shall be taken at each meeting and posted on the IIR web page of the Working Party.

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<th>Working phase</th>
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<td>Year</td>
<td>2012</td>
<td>2013</td>
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<td>Meeting</td>
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LCCP WP: Roadmap

1. Collect information on direct and indirect emissions of working fluids
2. Establish the LCCP evaluation methodology

(Jointly)

3. Evaluate different assumptions on results
4. Assemble such information and disseminate it
5. Investigate pathways for improving LCCP
6. Write a booklet on the LCCP evaluation methodology
LCCP WP: Deliverables

• Consolidated listings and references for relevant information on direct and indirect refrigerant emissions
• One statement, position paper and/or Informatory Note
• Booklet on the LCCP evaluation methodology
• A workshop with the publication of the proceedings in CD-ROM form
• Periodically updated web page on the IIR site
LCCP WP: Website

- A new web site of the working party is prepared.
- Basic information of the working party can be obtained from this web site.


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Working Party on LCCP Evaluation

Welcome to the Working party Web page

Since the main part of the global warming contribution from refrigeration equipment (including air conditioning) is due to indirect emissions, the climate performance of refrigerating system during its life cycle is an area of concern. Moreover, its proper evaluation is a key factor in determining the true impacts of working fluids for specific application and geographic location, and will assist in determining next generation working fluids for refrigeration and air-conditioning systems.

The IIR has therefore decided to set up a working party (WP) to assess the merits of different methods for evaluating the Life Cycle Climate Performance (LCCP) for refrigerating systems environmental impact of refrigerants and to produce implementation protocols for these methods, for use by decision makers and refrigeration stakeholders. Yunho Hwang, Vice-President of IIR Commission B1, is the chairman of this new WP, which started from January 2012, after approbation of the Science and Technology Council of the IIR.
LCCP WP: Membership

• Membership of the Working Party should be multi-national and open to private members or representatives of corporate members of the IIR.
• The IIR is currently recruiting members from following areas for this WP:
  • Commission, private, and corporate members of the IIR
  • Experts whose knowledge of the subject will benefit the WP

You are invited!
Our Goals

Air Conditioning & Refrigeration

Drivers
- Increasing Population
- Energy Unbalance
- Climate Changes
- Environmental Regulations

Goals
- Provide Thermal & Food Safety
- Minimize Environmental Impacts

Lean and Green $f_{\text{min}}(LCCP)$

With Low GWP Refrigerants
With Minimum Charge
With Zero Leakage
With Improved Energy Efficiency
With Green Energy
Pathways for Efficiency Enhancement

Enhancement of Building Energy Efficiency

- Power Generation
  - Fuel Cells
    - Advanced Generators
    - Direct Conversion
    - Renewable Energy
    - Alternative Fuels
  - Electric Power Generation
    - Open Cycles
    - Closed Cycles
    - Thermomechanical Systems
    - Solar Cooling
  - Heating Output
    - Combined Outputs
    - Trigeneration (Cool, Heat, Power)
  - Cooling Output
    - Component Level
      - Sub-system Level
      - Integrated System Level

Enhancement of Cycle Efficiency
- Compressor
- Subcooling
- Recovery of Expansion Loss
- TE Subcooler/Expander Combined
- Multi-stage Cycle

Enhancement of Moist Control
- Mechanical Dehumidification
- Desiccant
- Crommer Cycle
- Integrated
- Condensate Utilization

Distribution & Control
- Architecture
- Switching
- Central/Local Control
- FDD
- Air-Side Distribution
- Energy Storage

Optimization Design Tools
Life comes from the earth and Life returns to the earth!  

Zhuangzi

Zhuangzi was an influential Chinese philosopher who lived around the 4th century BC.