Technology and Economic Assessment Panel (TEAP)

Decision XXXV/11 Task Force Report on Life cycle Refrigerant Management (LRM)

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Decision XXXV/11 and outline of the report

1. To request the TEAP to prepare a report to the parties, to be presented at the OEWG46 on :

Chapter 1 = Introduction and Chapter 9 = Conclusions

(a) Available technologies for the leakage prevention, recovery, recycling, reclamation and destruction of refrigerants, and their accessibility in parties operating under paragraph 1 of Article 5 of the Montreal Protocol, including regionally specific approaches;	**Chapters 2,3,4**
(b) The obstacles and challenges associated with the effective leakage prevention, recovery, recycling, reclamation and destruction of refrigerants;	**Chapter 6**
(c) The costs and climate and ozone benefits associated with the leakage prevention, recovery, recycling, reclamation and disposal of refrigerants, taking into account the experience under the Multilateral Fund for the Implementation of the Montreal Protocol;	**Chapters 7,8**
(d) Policies, incentive schemes, such as producer's responsibility schemes, good practices and lessons learned related to ensuring the effective leakage prevention, recovery, recycling, reclamation and disposal of refrigerants.	**Chapter 5**

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9 A5 and 13 nA5

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What is Life cycle Refrigerant Management (LRM) ?

- A comprehensive approach **to manage refrigerants in Refrigeration, Air conditioning and Heat pumps (RACHP)** from the design of the equipment, the installation, use and waste phase, through to the reuse or destruction of the refrigerant.
- Life cycle refrigerant management (LRM) aims to minimise direct emissions of refrigerants in RACHP and increase refrigerant supply through:

  - ➢ Prevention of refrigerant leakage
  - ➢ Recovery of refrigerant during servicing and at end-of-life
  - ➢ Reuse (either through recycling or reclamation)
  - ➢ Destruction

Leak Prevention (1)

- Measures to avoid refrigerant loss during the RACHP life cycle
  - ➢ Results in climate, ozone and other environmental, health and safety benefits
  - ➢ Provides energy savings by maintaining RACHP performance.
- Leak prevention requires a variety of preventive actions during design, manufacturing, transport, storage, installation, use and end-of-life treatment
- International standards and other guidelines provide recommendations
  - ➢ Examples :
    - Selection of suitable materials (components, joints, packaging,..)
    - Training
    - Tightness inspections to verify that the refrigerant is not leaking

Leak Prevention (2)

- Tightness inspection requires the use of leak detection methods
  - Direct methods (sensors, soapsuds, UV dyes, acoustic cameras..)
  - Indirect methods (analysis of performance parameters)
- Achieved through:

  (a) comprehensive training,

  (b) accessibility to leakage detection equipment,

  (c) policies that promote regular RACHP inspection and repair.
- Leak detection technologies are available but not always accessible in A5 parties
- Examples of policies are provided in Chapter 5

Refrigerant Recovery (1)

Refers to the recovery of refrigerants from RACHP and from refrigerant cylinders, during servicing or prior to disposal

Off-the-shelf and custom-made recovery technologies are available but not always accessible in A5 parties

Definition Montreal Protocol :
Recovery is "*the collection and storage of controlled substances from machinery, equipment, containment vessels etc., during servicing or prior to disposal*"

Refrigerant Recovery (2)

- Refrigerant recovery is essential before recycling, reclamation, or destruction can take place, but remains low in many A5 and nA5 parties
- Effective refrigerant recovery requires a change in behaviour to stop venting to atmosphere through:
  - Comprehensive and continued technician training
  - Access to refrigerant recovery machines
  - Establishing of a logistic “reverse supply chain”, with sufficient access to refrigerant recovery cylinders and tanks
  - Sufficient technician time for complete recovery
  - Financial mechanisms to support responsible recovery

Refrigerant Reuse (1)

- Recovered refrigerant can be **reused** by either:
  - **Recycling**
  - **Reclamation**

- To determine whether a recovered refrigerant can be reused and where, it may be necessary to conduct a chemical analysis to know its composition
- In some cases the reuse may occur immediately without prior treatment

Refrigerant Reuse (2)

- Reused refrigerant does not count towards MP consumption targets and can contribute to compliance
- Both recycling and reclamation support the circular economy by reducing the need to produce new refrigerants
- Incentives for recovery and reuse are highly sensitive to the size and accessibility of the bank of refrigerant in RACHP systems, regulatory environment, availability of alternative technologies and to virgin refrigerant prices:
  - If a phase out or phase down regime creates a shortage of refrigerant and leads to price increases, then refrigerant recovery and reuse may increase
  - However, if supply of newly produced refrigerant remains plentiful, then reused refrigerant may be non-competitive, and other policy and economic measures may be required to incentivise LRM

Refrigerant Recycling

- Refrigerant recycling involves a basic cleaning process such as filtering and drying
- It often occurs “on site”
- Most suitable for single component refrigerants

Refrigerant Reclamation

- The re-processing and upgrading of a refrigerants in order to restore the substance to a specified standard
- Through mechanisms such as filtering, drying, distillation and chemical treatment
- It often involves "off-site" processing at a central facility
- The reclamation of blends presents particular challenges as in some cases composition changes can occur
- Reclaimed refrigerants may need to be mixed with new refrigerants or reclaimed single component refrigerants to meet the required specification

Refrigerant Destruction

- Some recovered refrigerants (e.g., highly contaminated or no market need) need to be **destroyed**
- The Montreal Protocol has established a list of approved destruction methodologies for the purpose of production data reporting
- There is adequate global capacity for destruction, but it is unevenly distributed between nA5 and A5 parties and between A5 parties
- It can be anticipated that destruction technology may improve in cost, scalability, mobility and efficiency

Cement Kiln

Costs of LRM

- LRM requires substantial investment for the acquisition and operation of leak detection, Recovery, Recycling, Reclamation and Destruction equipment in A5 and nA5 parties
- Costs depend on the type of refrigerant, the scale of the operation, regional regulations, the technology used, and the fate of the recovered refrigerant (reused or destroyed)
- Recovery and recycling is relatively simple and dispersed. To be effective, a large amount of recovery and recycling equipment is needed
- Equipment for destruction and reclamation (sophisticated separation/testing technologies) is capital intensive and centralized
- Costs include capital, variable costs (e.g., labour), and opportunity costs (e.g., revenue from leak controls and refrigerant recovery compared to installing new equipment). Variable costs are determined by the volumes of refrigerant being recovered and re-used

Costs of LRM – Leak detection, Recovery, Recycling

Cylinders < US$100 for the smallest cylinder
Recovery equipment : US$ 300-1000 (basic);
~ US$ 30,000 (high capacity)

Hand-held leak detectors
~ US$ 400

Recovery and recycling machine: US$ 1200 onward depending on capacity

Costs of LRM - Reclamation

Refrigerant identifiers:
US$ 1,000-5,000

Gas Chromatography :
US$ 45,000

Reclamation unit :
US$ 5,000 onward depending on capacity

Costs of LRM - Destruction

Retrofitting existing hazardous waste facilities
e.g rotary kilns, cement kilns (US$50,000 – 100,000)

New dedicated facility:
small rotary kiln ~US$3 million;
commercial plasma arc facility ~US$.4.2 million

LRM Policy Framework

- Mandatory and voluntary LRM policies and programmes are currently implemented in many parties, and
- Many lessons have been learnt from the varying success of LRM policies and programmes:
  - LRM policy enforcement is challenging due to the large volume of end-users, distributors, and independent contractors that are involved
  - Effective LRM requires stakeholder support, particularly when developing reverse supply chain infrastructure and technician training.
  - Voluntary action, compliance offset generation, incentivization and corporate citizenship programmes are important
  - The safe handling/transportation of refrigerants must be also considered

LRM infrastructure and accessibility in A5 Parties

- A5 parties and especially LVCs lack or have inadequate LRM infrastructure
  - Leak detection equipment
  - Recovery and recycling equipment and associated tools
  - Access to reclamation and destruction units and facilities
  - Analysis laboratories
  - Expertise and logistics to effectively manage reused refrigerants
- While some larger industrialised A5 parties may have more developed infrastructure, they often require upgrades or replacements for their existing tools and equipment to improve LRM.
- Significant benefits could arise from A5 parties working together in regional groups to set up capital intensive integrated reclamation and destruction infrastructure

LRM Capacity Building

Technician training programmes

- Are critical in changing behaviour from venting refrigerants during servicing and at EOL, to responsible LRM
- Consideration of safety during handling and transport will be increasingly important in training programmes

Local infrastructure

- Leak detectors
- cylinders
- Testing and analysis equipment
- Recovery equipment
- Recycling equipment
- Centralised Reclamation facilities
- Destruction facilities

Ozone and Climate Benefits

- Implementing effective LRM practices during the use and end-of-life of RACHP equipment is projected to achieve:

	Refrigerant transition measures implemented before June 2018	LRM measures implemented before June 2018	LRM measures in all parties
Pre-Kigali baseline	√	√	
Pre-Kigali with Additional LRM	√	√	√

Estimated additional avoided emissions
Cumulative
from 2025 to 2050

Up to 5 ODP kt

Up to 39 Gt CO_2e

Conclusions (1)

- Technologies are available for the leakage prevention, recovery, recycling, reclamation and destruction of refrigerants but not accessible in all A5 parties

- There are policy, economic, and accessibility obstacles and challenges associated with effective LRM

Conclusions (2)

- If a phase out / phase down regime creates a shortage of refrigerant and leads to price increases, then refrigerant recovery may increase. However, if supply of newly produced refrigerant remains plentiful, other policy and economic measures may be required

- Mandatory and voluntary LRM policies and programmes are currently implemented in many parties with varying levels of effectiveness

- Establishing a data collection system by parties could inform their decision-making for optimal LRM strategies

- The cost effectiveness of LRM could not be assessed

LRM Opportunity

- LRM practices can be a key component of refrigerant emissions reductions
- LRM can achieve emissions reductions beyond those from strictly Kigali compliance
- LRM may be the key tool for some parties to achieve Kigali compliance
- TEAP continues to follow these issues and its potential emission reduction opportunities

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THANK YOU !