End of life treatment for RAC appliances and destruction of associated gases

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Overview

• End-of-life treatment of RAC appliances
• Handling/Management of associated refrigerants
• Best practice: incentives for responsible handling
• Examples: specific considerations for handling flammable refrigerants
Environmental impacts per average piece diverted from disposal

<table>
<thead>
<tr>
<th>Env. impact: End of Life</th>
<th>Refrigerants combined with Blowing agents</th>
<th>CFC-11</th>
<th>HCFC 141-B</th>
<th>Pentane</th>
</tr>
</thead>
<tbody>
<tr>
<td>CFC- 12</td>
<td>Ultra high</td>
<td>Very high</td>
<td></td>
<td>Medium</td>
</tr>
<tr>
<td>HFC-134a</td>
<td>Very high</td>
<td>High</td>
<td>Medium</td>
<td>Ultra low</td>
</tr>
<tr>
<td>Isobutane (HC- 600a)</td>
<td>Medium high</td>
<td>Medium</td>
<td>Ultra low</td>
<td></td>
</tr>
</tbody>
</table>

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Contained emission potential: indicative example for global stock of split AC units

- Estimated stock worldwide: 2 billion split ACs in 2010
- Typical refrigerant charge: 1.25 kg
- GWP: 1,800 (R410A: 1,923 / R22: 1,760)\(^1\)
- Potential direct emissions at end of life: ~ 4 Gt CO\(_2\)eq assuming ACs contain 90% of initial charge at decommissioning

\(^1\) GWP values (100 years) according to IPCC 5\(^{th}\) assessment report, 2014
Approaches for end-of-life treatment of RAC appliances
From collection to destruction – Management of decommissioned appliances has high associated costs

**Collection**
- Take back
- Collection centres
- Informal waste pickers

**Recovery & consolidation**
- Stage 1
- Stage 2
- Dismantling

**Testing**
- Laboratory

**Destruction & recycling**
- Refrigerant
- Blowing agent
- Metals, plastics

**Transport**

Stage 1: Extraction of refrigerant
Stage 2: Hermetical shredding
Who is responsible and who pays for the disposal?

- Owner/Consumer
- Retailer
- Technician
- Importer
- Municipality
- Producer of equipment
- Waste collector
- Producer of gas
- Recycling companies

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Different forms of responsibility

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual</td>
<td>Each producer/importer is responsible for their own waste</td>
</tr>
<tr>
<td>Collective</td>
<td>Producers/importers organise in Producer Responsibility Organizations (PROs), which carry out collection, recycling and treatment</td>
</tr>
<tr>
<td>Financial</td>
<td>Fees paid to municipalities, which carry out collection. Recycling is outsourced.</td>
</tr>
<tr>
<td>Organisational</td>
<td>Producers/importers and PROs finance and organise waste management operations. Direct contact with recyclers.</td>
</tr>
</tbody>
</table>
Collection – Collective systems

Advantages

- More efficient collection – concentrated knowledge, equipment, personnel
- Most feasible of being implemented
- Cost-effective

How are they organised

- Often Not-For-Profit Organisations or government agencies
  - coordinate take-back companies, recyclers, producers/importers and consumers;
  - manage financing

What are their tasks

- Take on producers’ legal obligations
- Coordinate the collection and the recycling of appliances
- Provision of information to all stakeholders
- Reporting to all actors involved
- Monitoring of results
## Costs, Income and Payment options

<table>
<thead>
<tr>
<th>Costs</th>
<th>Income</th>
<th>Payment options</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Collection &amp; transport</td>
<td>• Sales of secondary raw material</td>
<td>• Advanced disposal fee</td>
</tr>
<tr>
<td>• Recycling &amp; disposal</td>
<td></td>
<td>• Producer pays</td>
</tr>
<tr>
<td>• Management and operation</td>
<td></td>
<td>• Tax</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Levy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Utilities (new for old)</td>
</tr>
</tbody>
</table>
Common models

**Increasing producer responsibility**

- **Product stewardships**: Voluntary programs, putting the responsibility on all stakeholders to pay for the lifecycle costs. Often the financial burden lies with the consumer and at the end of a product's life.

- **Shared responsibilities**: Responsibilities are shared between producer and public waste management, i.e. the state.

- **Extended producer responsibility (EPR)**: Manufacturer of the product is made accountable for the entire life-cycle of the product – especially for the take-back, recycling and final disposal.
Shared Producer Responsibility

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Source: Gabriele Markmann-Werner, Ministry of Environment and Climate Protection of Lower Saxonia, Germany; modified by E-waste management in Germany, UNU-ISP/GIZ
Extended producer responsibility (EPR)

- **Aim**
  - Environmentally sound product design
  - Relieve financial burden of municipalities
- **Applicable to:**
  - Appliance sector, e.g.: Residential and commercial ACs, Domestic refrigerators, Stand-alone commercial units
  - Refrigerants
- **Advantages:**
  - Can be self-financing
  - Comprehensive and sustainable way for long-term management of e-waste
  - Mechanism to transfer market to more environmentally friendly products
- **Challenges:**
  - Complex development with involvement of many stakeholders from different backgrounds
  - Infrastructure and supporting measures need to be in place or to be established
Extended producer responsibility (EPR) – a mixture of measures

Product take-back requirements
- Producer or retailer has to collect product at EoL.
- Recycling and collection target.
- Incentive for consumers to take back equipment
- Producer pays fee for collection and treatment

Economic and market-based instruments
- Deposit-refund schemes
- Advanced disposal fees
- Material taxes, subsidies for producer

Regulations and performance standards
- Minimum technical requirements
- Minimum recycling rate

Accompanying information-based instruments
- Public awareness raising
- Reporting requirements for producers
The role of the informal sector

- Prevalent situation:
  - Majority of EoL appliances are sold to street collectors
  - Waste picking can be only possible income for poorest section of the population
  - Informal sector can always operate cheaper
  - Exclusion from scheme will lead to parallel structures
- Transition to formal waste management by increasing job security and income
  - Participation of informal sector in recycling activities and take-back schemes
  - Create alternative employment opportunities and social frameworks
  - Provide funding for collection
  - Training and certification

- Example Ghana: Health insurance is paid by formal waste management company if a certain minimum waste is sold/handed over per month by informal waste collector
Norway – Refrigerator/WEEE take-back

Consumer
- Hand in old equipment at municipal collection points or distributor

Distributor
- Take back requirement
- Storage, sorting and forwarding requirement
- Information provider

Municipality
- Receive e-waste
- Sorting, storage and forwarding requirement
- Information provider

Producer/Importer
- Membership in take-back company
- Finance collection, sorting, reuse, recycling, disposal, treatment
- Provides information
- Register

Take-Back Company
- Collect free of charge from distributors and municipalities and other collection points
- Treatment of e-waste according to standards
- Registered and certified

Money
RAC appliance

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Approaches for proper handling of refrigerants
Terminology

- **Recovery**: Removing refrigerant in any condition from a system and storage in an external container
- **Recycling**: Reduction of contamination in used refrigerants with the aim of the subsequent reutilisation of the refrigerant
- **Reclamation**: Processing recovered refrigerants to new product specifications (in Germany DIN standard 8960) and verifying by analysis of the refrigerant that new product specifications have been met
Destruction technology alone is not sufficient for successful refrigerant waste management
Policy framework: required regulations

1. Refrigerant venting ban
2. Mandatory technician certification (leakage control and recovery at decommissioning)
3. Monitoring scheme of recovered refrigerant
4. WEEE\(^1\) regulation with take-back obligations for refrigerant containing equipment
5. Awareness and enforcement

\(^1\) WEEE: Waste Electrical and Electronic Equipment
Possible financing mechanisms

- EPR\(^1\) scheme for the appliance sector (possibly part of WEEE policy framework)

- End-user of large systems are obliged to pay for the recovery and management of refrigerant

- Import tax on refrigerants

- Advanced disposal fee

\(^1\) EPR: Extended Producer Responsibility
Collection: what is needed?

• Collection infrastructure for recovered refrigerant including sufficient number of collection points
• Collection infrastructure for appliances
• Study on available/future waste streams
• Monitoring of substances flow
• Capacity building and awareness raising for technicians and end-users
• Inclusion of informal sector
• Incentives for refrigerant recovery and collection
Creating suitable incentives

Direct incentives

• Discount for recycled/reclaimed refrigerant, when recovered refrigerant is delivered
• Discount for recovery equipment of technicians
• Tax-rebate system (e.g. Denmark with HFC)
• Incentives for informal sector

Indirect incentives

• Tax abatement when destruction technology is imported
• Tax abatement when natural refrigerants are imported
• etc.
Best practice: SF₆ collection and reclaim

- Collection infrastructure for recovered refrigerant
- SF₆ is costly to produce
- Reclamation is a business case
- Often SF₆ is not contaminated
- Returned SF₆ is tested if it can be reclaimed
- SF₆ is only destroyed when too contaminated for reclaim

SF₆ (Sulfur Hexafluorid) is an anorganic chemical compound used as insulation gas in medium and high voltage technology.
Best practice: Refund system in Denmark

• Tax on HFCs depending on their GWP value
  ➢ Incentive for use of low GWP refrigerants

• Handling fee collected at point of sale
  ▪ Fee partly refundable if HFC is returned, depending on quality of returned refrigerant
  ▪ More refund for refrigerant that can be reclaimed, less refund for refrigerant that can only be destroyed
  ➢ Incentive for responsible handling
GIZ products

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Cylinder charging with hydrocarbons (HCs)

- Liquid HCs have less than half the density of fluorinated refrigerants. Therefore, HCs take up more than twice the volume within a cylinder.

- Fill recovery cylinder with max. 80% of its volume!
Cylinder storage: outdoors

- Outside - follow local regulations for LPG, if none exist adhere to the following:
  - Store in a locked cage
  - At ground level
  - Away from air intakes to building
  - Remote from ignition sources
  - No smoking
Cylinder storage: indoors

- Inside - follow local regulations for LPG, if none exist adhere to the following:
  - 🎉 Max 5 cylinders, 70 kg
  - 🎉 Limit access
  - 🎉 Ground level, accessible
  - 🎉 Away from ignition sources
  - 🎉 Install gas detector
  - 😞 No smoking
Cylinder transport

- Outside - follow local regulations for LPG, if none exist you should at least:
  - ☺ Carry a dry (blue flash) power fire extinguisher
  - ☺ Stow cylinders upright, capped, secure
  - ☺ Ventilate and label vehicle
  - 😞 No smoking

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Thank you for your kind attention!

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Bayerisches Landesamt für Umwelt (LfU)

On behalf of
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
of the Federal Republic of Germany