Validation of energy efficiency and emissions

Example: Supermarkets in SA

Irene Papst
HEAT
Köngistein, Germany
Content

- The Conversion Project
- Methodology
- Data Collection
- Results
- Conclusion
The Conversion Project

- Funded the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety through the International Climate Initiative (IKI)
- Implemented by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
- Technical consultant: HEAT GmbH
- Local Partner: Pick’n’Pay South Africa
Implementation

- Two sites: Cape Town and Johannesburg
- Replacement of two supermarket refrigeration systems:
  - CFC based refrigeration systems (installation date early 1980) with a NH$_3$/CO$_2$-cascade refrigeration system
  - Implementation Dec 2009 to April 2010
- Monitoring period April 2010 to March 2013

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Methodology for emissions monitoring

Indirect emissions from electricity consumption
(Direct emissions from (avoided) refrigerant leakage)

Determination of emissions savings:
- What to compare?
- What is the Business as Usual scenario?
- How to collect the necessary data?
What to compare?

Project stores: Stores built in the 1980 with revamped refrigeration system

Aim of emissions monitoring: Demonstrate competitiveness to other „state of the art“ stores.
What to compare? - Project stores

- Two supermarkets of different size
- 1 in Gauteng, 1 in Cape Town (different climate)
- Previous refrigeration systems were more than 20 years old
- Buildings did not undergo complete renovation, therefore occasional severe shortcomings in cold room insulation
What to compare to? - BAU

What is the business as usual scenario?

- Continue to operate old refrigeration systems?
- Tear down the whole store and build a new one?
- Revamp the refrigeration system with an R22/R404A system (the PnP standard solution in 2009)?

Reference refrigeration systems are divided into two groups:

- brand new stores: the whole supermarket is new and hence insulation of cold rooms is state-of-art
  \(\rightarrow\) lower energy demand
- Refurbished stores: new refrigeration system (max. 3 years old), but insulation of cold rooms was not renewed and may be insufficient
  \(\rightarrow\) higher energy demand (room for improvement)
Reference stores

7 Stores

Location

Building age

Gauteng (5 stores)

New (3 stores)

Revamped (2 stores)

Cape Town (2 stores)

New (2 stores)

Revamped (no reference)
Raw Data

Monthly Energy Consumption

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How to compare?

- Supermarket refrigeration systems are made-to-measure systems, situated in different climates, with differing opening hours, ...
- Need for a simple benchmark
- Based on „Quick-Check“ for supermarkets, developed by the VDMA* („Einheitsblatt“ 24247, Part 4)
- Benchmark value is

  \[
  \text{Energy Consumption [kWh]} \over \text{Cooled Display Area [m2]}
  \]

- Allows to compare supermarkets of different sizes

* Verband Deutscher Maschinen- und Anlagenbau, Mechanical Engineering Industry Association

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Cooled Display Area (CDA)

- The cooled display area is the opening of the cooling cabinets and can be easily measured
Why normalized to CDA?

- What a supermarket operator requires are cooled shelves to display fresh goods for sale.
- The input into the refrigeration system is normalized to the CDA that is provided by the refrigeration system.
Data collection

- Cooled Display Area is determined only once on site
- Most supermarket refrigeration systems of PnP are connected to an online monitoring system, which also records the energy consumption.
- We received read-only access to a selected number of refrigeration systems for monitoring purposes.
- Refrigerant charge and leakage rate collected via service contractors.
Results: Energy Consumption

Cape Town

Energy consumption, kWh/m² cooled display area

Gauteng

Energy consumption, kWh/m² cooled display area
Evaluation

- Energy efficiency of refrigeration system compared to equal baseline stores
  - Result as percentage improvement
- Energy efficiency of refrigeration system compared to brand new baseline stores
  - Result as percentage improvement
- Emission reduction compared to average baseline store (Energy + Refrigerant)
  - Result as t COeq saved
Project Stores vs revamped Stores*

*normalized to project stores

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Project Stores vs all monitored stores*

*normalized to project stores

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## Results

<table>
<thead>
<tr>
<th></th>
<th>Cape Town</th>
<th>Johannesburg</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Annual Energy Saving Average (revamped/new)</strong></td>
<td>13%(-/-13%)</td>
<td>21% (28%/13%)</td>
</tr>
<tr>
<td><strong>Saved kWh/year</strong></td>
<td>94630</td>
<td>201787</td>
</tr>
<tr>
<td><strong>Saved t CO2/year</strong></td>
<td>88</td>
<td>188</td>
</tr>
<tr>
<td><strong>HCFC 22 t CO2eq/year</strong></td>
<td>106</td>
<td>154</td>
</tr>
<tr>
<td><strong>HFC 404A t CO2eq/year</strong></td>
<td>130</td>
<td>189</td>
</tr>
<tr>
<td><strong>Sum t CO2eq/year</strong></td>
<td>324</td>
<td>530</td>
</tr>
</tbody>
</table>
Conclusion

- Limited use to conduct a before/after comparison
- Best compare to other well designed systems
- The larger the reference base, the better
- Select a benchmark that is suitable to compare across design differences
- Account for climatic variations of installation sites
Thank you for your attention!

Irene.Papst@heat-international.de