Ammonia Refrigeration Technology high efficient and sustainable

Ammonia for air conditioning & industrial cooling

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GEA Refrigeration Technologies

Raised Topics

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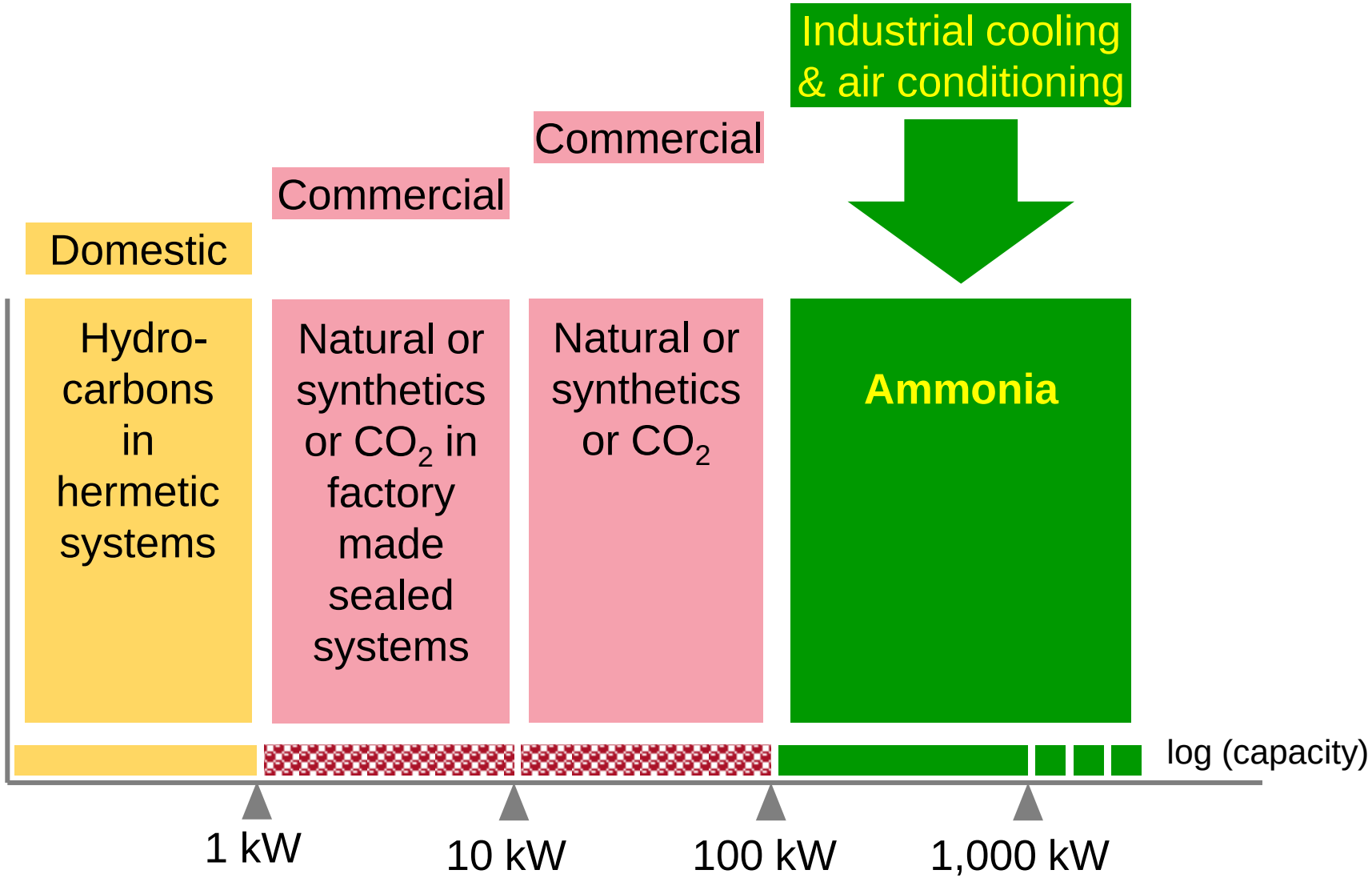
General

- Climate change is one of the major concerns of this generation.
- This is the root cause of the majority of changes we are seeing in the Refrigeration and air conditioning Industry.
- For Europe we can summarize this quite clearly by the EU 20-20-20 vision:
  1. 20% reduction in Green House Gas (GHG) Emissions
  2. 20% reduction in energy consumption
  3. 20% share of total energy generation from renewable sources
- GEA Refrigeration Technologies is actively supporting and promoting the use of natural refrigerants but we believe there is still a place (at least in short term) for low GWP synthetic refrigerants in commercial refrigeration and air conditioning applications.

Challenge: Awareness for sustainable refrigeration using ammonia

Substances for refrigeration depending on capacity



Characteristics of ammonia

1. Ammonia (R717) has the lowest GWP (0) of all refrigerants suitable for large refrigeration systems.
2. Ammonia refrigeration systems also usually achieve higher energy efficiency than HFC refrigeration systems.
3. Ammonia is toxic (maximum-workplace-concentration value (MAC) is 50).
4. Ammonia has a pungent odor and thus a high self warning effect.
5. Certain ammonia air mixtures are flammable. Mixture limits are between 15 and 30 per cent by volume in air. Ignition temperature and energy are extremely high
6. In connection with water the well-known liquid ammonia water (ammonium hydroxide) is created.
7. In connection with CO_2, ammonium carbonate or carbamate is formed.

Source: Michael Kauffeld

Ammonia & material requirements

1. Steel or cast grey iron are the most commonly used materials for ammonia refrigeration systems.

2. Copper- and zinc-free aluminum alloys can be used.

Iron material requirements are cost drivers and not acceptable for smaller refrigeration plants where pipe connections are capillary brazed.

Therefore ammonia is predominantly used for larger capacities.

Ammonia & Industrial refrigeration

Ammonia for industrial application

1. Ammonia is best natural refrigerant for industrial refrigeration (with CO_2 in cascade systems)
2. Ammonia is the refrigerant of choice in almost all process refrigeration plants & cold stores above 100 kW
3. Ammonia has been widely used in industries since more than 100 years, mainly the food industry and process cooling.

Precondition for ammonia application

- Adequate safety management is key for use of ammonia.

Ammonia & a.c. cooling Refrigeration

Since 20 years ammonia has been successfully used in chillers above150 kW.

Design and location of water chillers considers ammonia characteristics

- Plug and play design on chilled water and cooling water site
- Proven standard components are assembled
- Ammonia is encased inside the factory assembled and factory tested chiller
- Chiller is arranged inside a machine room or on top of a building

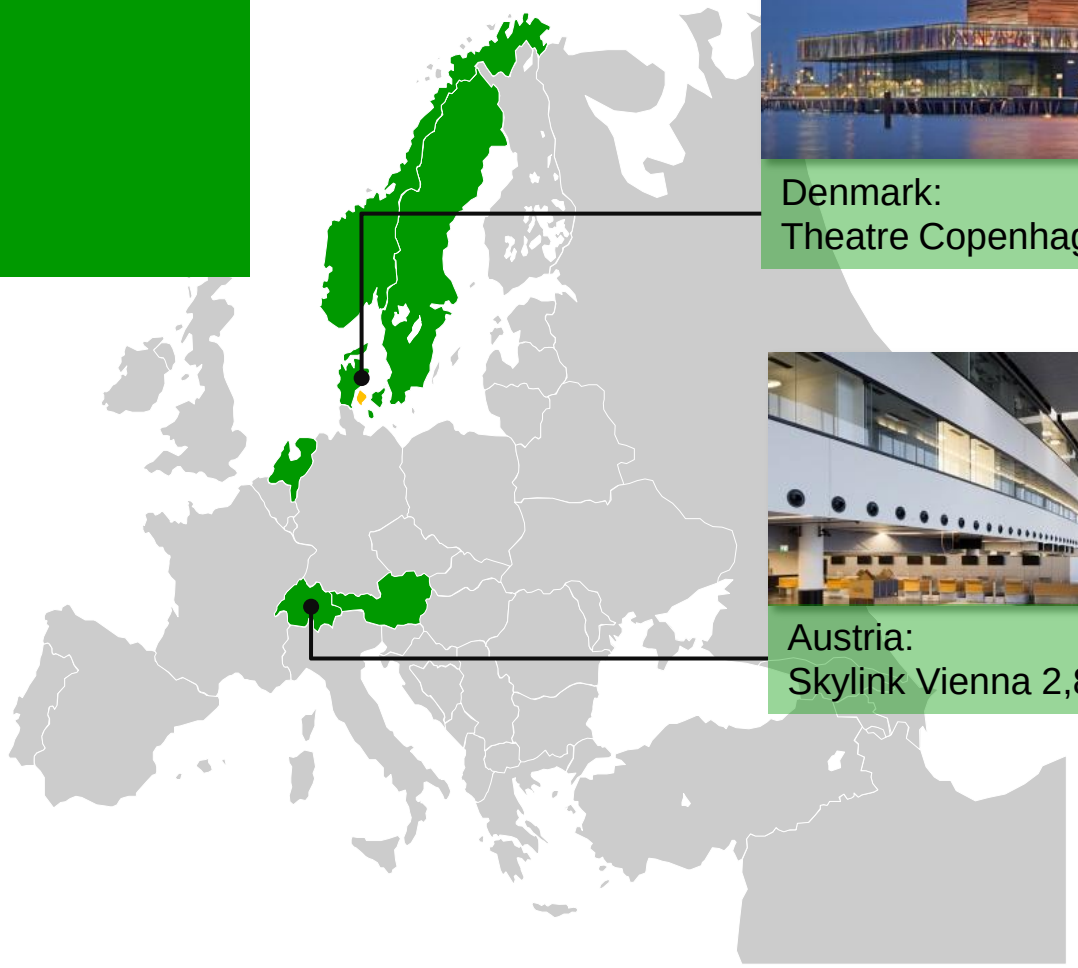
Overcoming barriers

- Education and training is required to understand ammonias hazardous nature.

Governmental drivers for ammonia AC cooling

European drivers for sustainable refrigeration:

- ✓ Norway
- ✓ Denmark
- ✓ Sweden
- ✓ Switzerland
- ✓ Austria

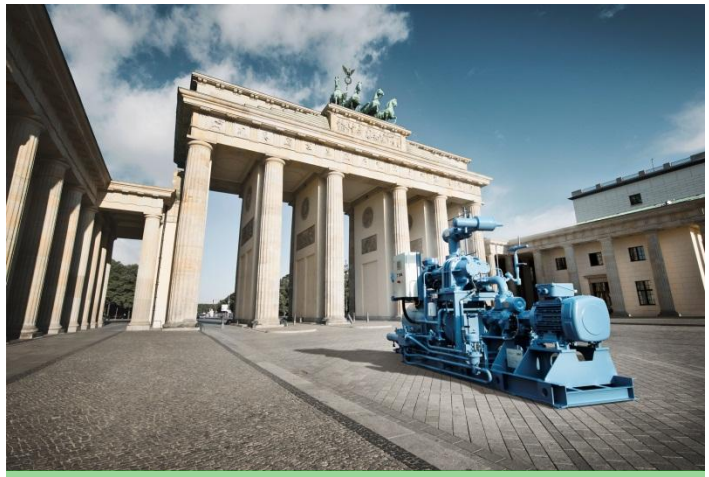


Examples

Denmark:
Theatre Copenhagen 2,200 kW

Austria:
Skylink Vienna 2,800 kW

Industry drivers for ammonia AC cooling



GEA Refrigeration Germany is one of the global active suppliers for sustainable refrigeration

Industry drivers for ammonia AC cooling

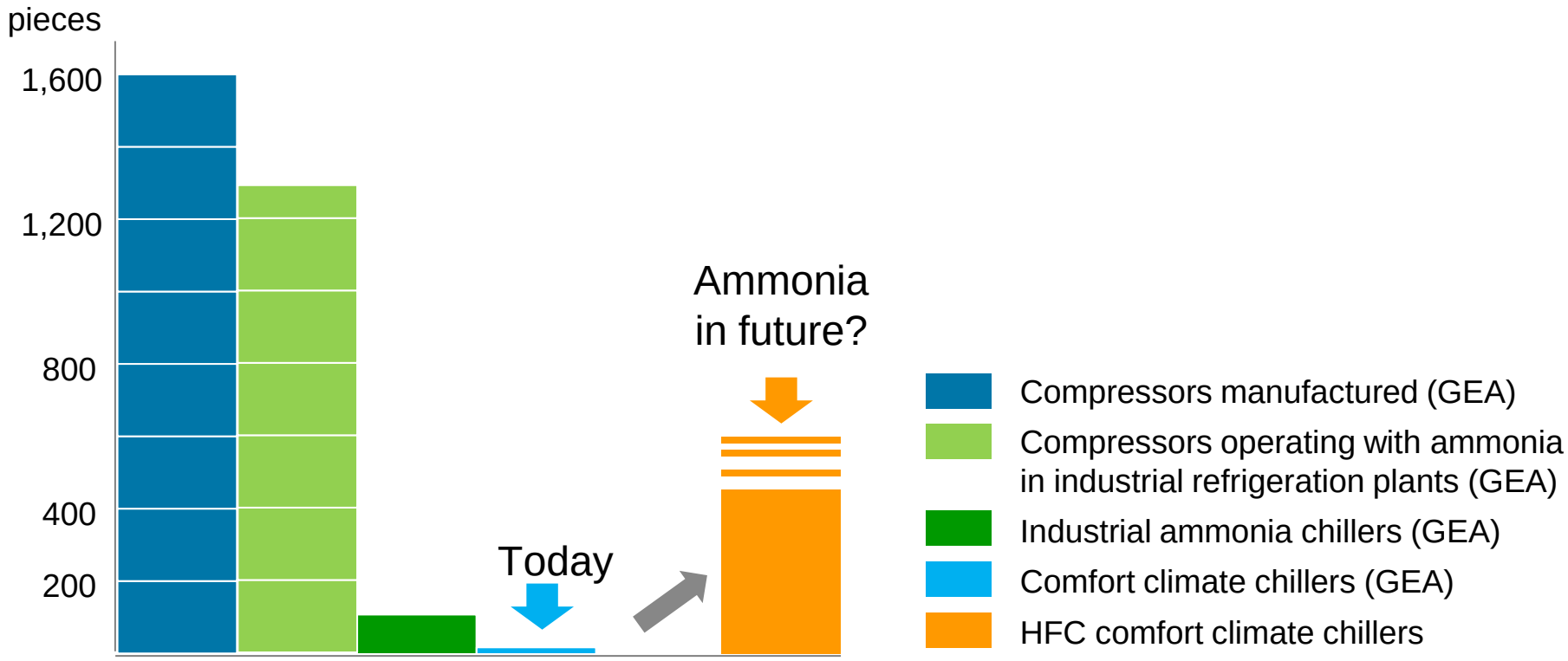
Product groups for ammonia technology

1. Open type screw compressors applicable
2. Single and two stage screw compressor packages
3. High efficient single and 2-stage piston compressors available
4. Ammonia chillers for low, medium and high temperature application
5. 28 bar components available for refrigeration
6. 52 bar components available for heat pumps and CO_2-cascade systems

16,000 screw compressors installed since 1994

12,800 of them (80%) operate with ammonia

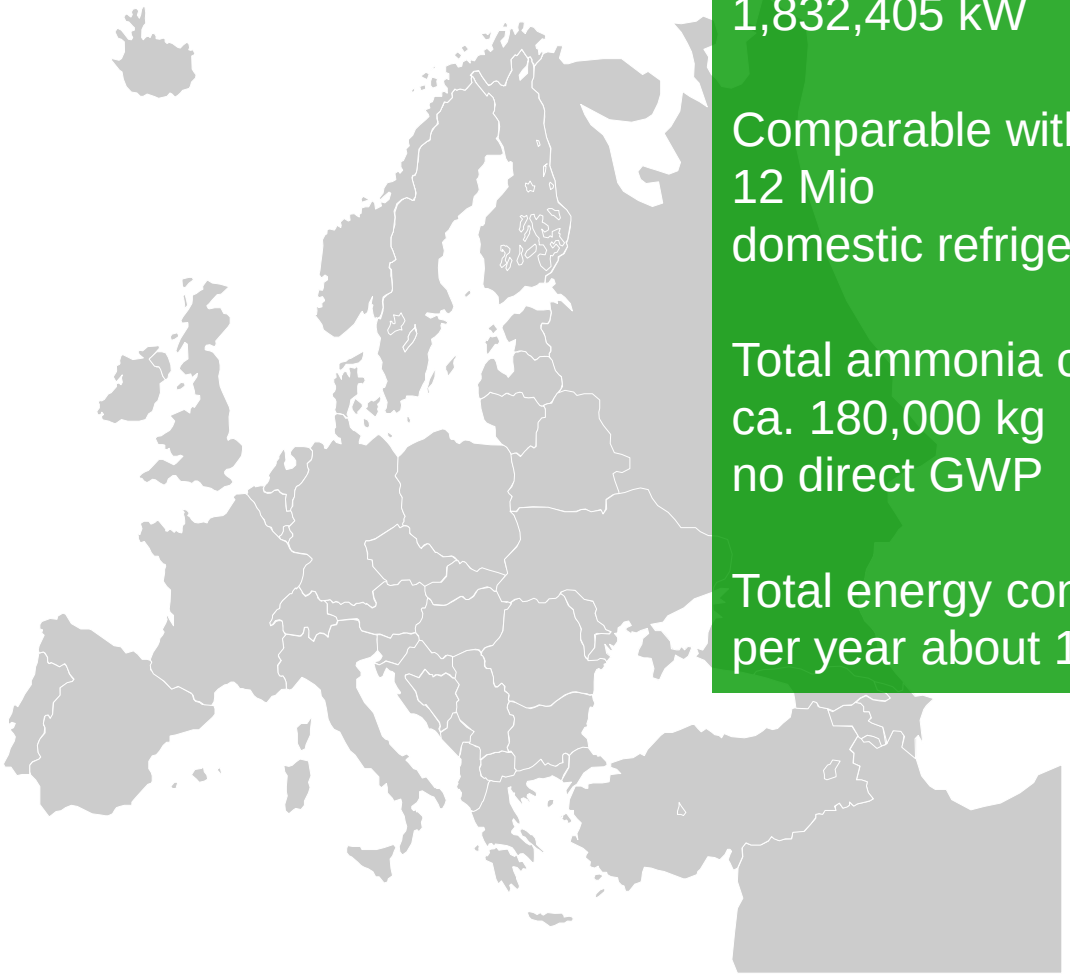
Industry drivers for ammonia AC cooling



An exceeding reduction potential of greenhouse gas emissions is in the nature of ammonia for comfort climate chillers >200 kW

Installed base of GEA ammonia chillers in Europe

More than 2,000 ammonia chillers installed in Europe since 1992



Total installed refrigeration capacity 1,832,405 kW

Comparable with about 12 Mio domestic refrigerators

Total ammonia charge ca. 180,000 kg no direct GWP

Total energy consumption per year about 1 billion kWh

Environ impact if HFC installed instead of ammonia

Possible environmental impact by 2,000 HFC chillers compared to ammonia ones installed since 1992

Assumptions for HFC installation :

- Charge: 0.1 kg/kW
- Leak rate: 5% per year
- Direct HFC-GWP: 2,200 kg CO_2
  (65% R134a, 35% mix of R404A, R507, R410a)
- 10% less efficiency compared to ammonia

Total HFC new charged: 180,000 kg
Charged direct GWP equivalent: 4,031,291,000 kg
Leaked direct GWP equivalent: 201,564,550 kg /year

+ 100 million kWh additional energy demand per year
+ 55,500,000 kg CO_2 output per year conversion factor: 0.55 kg CO_2/kWh)

During 20 years operation: + 5.1 billions kg CO_2 equivalent

Ammonia chillers in the center of Berlin, Germany

Department store 120 kW

Bank 2,400 kW

University 900 kW

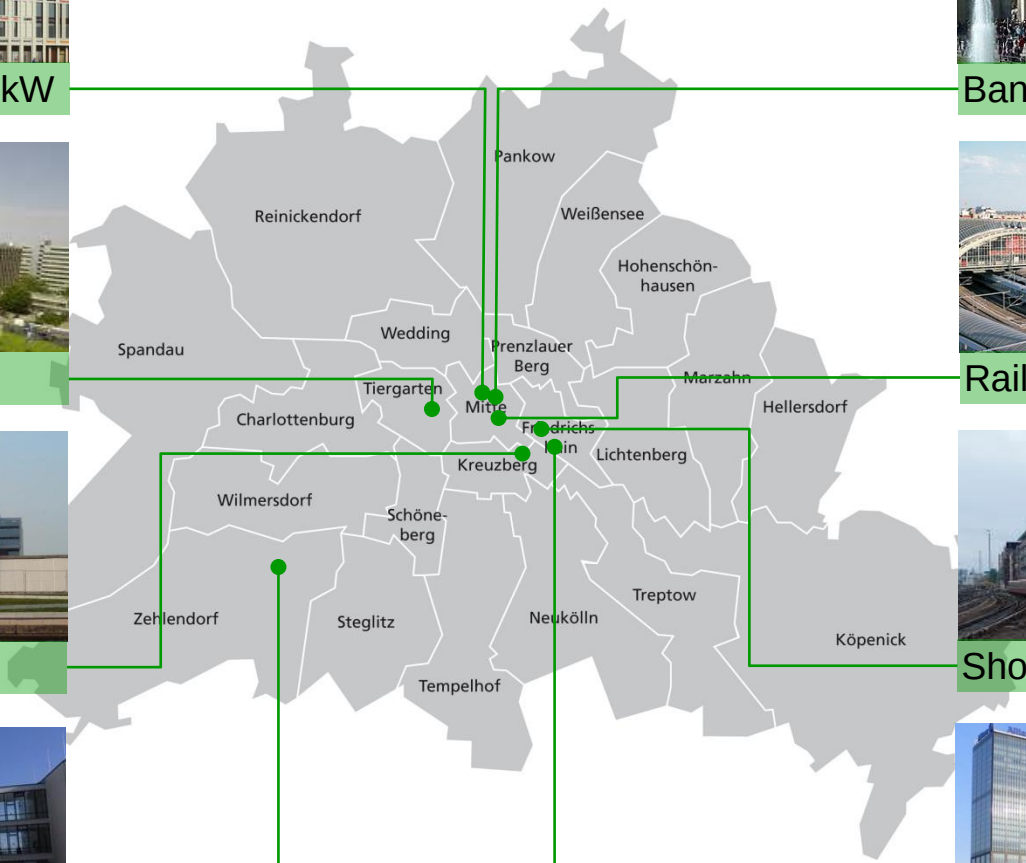
Railway station 1,250 kW

Event hall

Shopping mall 1,020 kW

Institute 1,050 kW

Office complex, 4220 kW



Current developments

Compact, low charge, high efficient for cooling or climate control

GEA Grasso BluAstrum Chiller

- Flooded evaporation
- Screw compressor with speed control
- Low refrigerant content (~90g/kW)
- Best ESEER value
- Integrated energy management to ensure peak efficiency under all operating conditions.

Awarded with the German Cooling Prize 2011 in the category ‘Climate friendly use of refrigeration systems in production of food and beverages’.

Current developments

- Natural refrigerant and working fluid solutions wherever practical.
- High focus on energy efficiency and energy management.
- Optimization of full life cycle of installations and promoting the total cost of ownership approach as opposed to lowest initial capital cost.
- Ensuring optimum efficiency through high quality after sales services.
- Efficient, simple, reliable refrigeration solutions for emerging markets.

Eurammon's outlook moving to sustainable refrigeration

Barriers on the extended use of ammonia

- The target of this WG is to make an overview of rules and barriers across Europe in use of ammonia.
- Output of this work should be a document, which will help our members to operate on whole European market and to be prepared for barriers, which have to be managed.
- Eurammon is asking for participation which will be joined with active cooperation.
- Participation of international companies is expected, which are active on whole European market and have already experience with this topic.

eurammon
refrigerants delivered by mother nature

Summary: Ammonia for AC cooling

- Equipment for industrial refrigeration sector in which ZERO-GWP alternatives is available (ammonia);
- Equipment for air conditioning cooling sector in which ZERO-GWP alternatives above 200 kW is available (ammonia);
- The important link between energy efficiency enhancements and greenhouse gas emissions reductions in refrigeration equipment is realized by ammonia
- The huge market share for AC cooling above 200 kW chilling capacity by HFC demands alternatives to HFC (ammonia) with respect to environmental aspects
- Maintenance and operation practices are important.

Thank you for your attention!

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