Danish Energy Agency

Energy efficiency improvements of cooling, vacuum and compressed air systems

Experience and best practice from Danish businesses

Cooling, vacuum and compressed air systems consume considerable amounts of energy

- and are used extensively by Danish businesses

Cooling, vacuum and compressed air systems are important supply facilities within nearly all sectors and, despite different technical components and uses, these systems share many characteristics. These systems often meet business requirements across areas and factory buildings etc., and their energy consumption often depends heavily on the pressure and temperature conditions under which they operate. It is therefore possible to compare energy saving efforts across the three types of technology.

Did you know that...

- Danish businesses completed more than 1,000 energy saving projects from 2010 to 2016 under the voluntary agreement scheme (energy and carbon taxes subsidies in return for energy efficiency improvements)?
- Energy efficiency improvements can improve the market position of a business?

Cooling, vacuum and compressed air systems account for 21 % of electricity consumption

In 2016, cooling, vacuum and compressed air systems in Danish businesses consumed 3,500 GWh (12 PJ) of electricity. This corresponds to 21 % of businesses' total electricity consumption and around 14 % of total energy costs.

There are several reasons why cooling, vacuum and compressed air systems require considerable amounts of energy. For example

- These systems often meet many different purposes across factories and therefore operate both day and night
- The systems have been designed for many and varied needs, temperatures and pressure requirements, and some of these factors have crucial significance for their efficiency
- The systems are often large-scale and therefore subject to significant pressure losses
- The systems usually do not have efficient heat recovery units
- Many of the systems have not been updated with the most recent and most energy efficient components and controls

Often, cooling, vacuum and compressed air systems are part of supply facilities that have been expanded incrementally. Such facilities might need extensive optimisation and adaptation to accommodate the business in its current situation.

Capitalise on the energy efficiency experience of other businesses

Through voluntary energy efficiency agreements with the Danish Energy Agency, Danish businesses have implemented numerous energy saving projects and have performed analyses of energy intensive processes and supply facilities, etc.

The Danish Energy Agency has compiled the most important experience from businesses into a number of feature articles targeted at businesses with energy efficiency (and therefore energy saving) potentials.

This feature article presents some of the results of energy saving efforts in other businesses and provides guidance for work with cooling, vacuum and compressed air systems.

Small changes, large savings
- and a future-proof supply structure

The considerable amounts of energy consumed by cooling, vacuum and compressed air systems mean that most businesses will have significant benefits from extensive optimisation and modernisation of their facilities and equipment.

A number of simple and small changes will often provide huge savings on energy bills. For example, repairing leaks, cleaning heat exchangers, and closing, or sectioning off, parts of the supply grid outside normal working hours.

Did you know that…

- A business can typically reduce the electricity consumed by its cooling, vacuum and compressed air systems by 19%, with a payback period of only four years?
- Danish manufacturing businesses usually save 5-15 % on system energy costs when they optimise their cooling, vacuum and compressed air systems?

More thorough analyses of supply requirements and system designs will often reveal even greater energy saving potentials. However, realising these potentials will also require more far-reaching changes. On the other hand, such analyses could also identify benefits from changing or adjusting important design parameters, and provide in-depth knowledge about the operation and performance of your facilities. In many cases, you will also be able to increase your production capacity without significant investment, as well as save money on maintenance.

Did you know that…

- Danish businesses are among the most energy efficient businesses in the world?
- •A strong green profile attracts more skilled employees and encourages them to stay longer?

Energy efficiency is a competition parameter

When you optimise and improve your energy consumption, you immediately reduce your costs. Moreover, you become part of the green transition and help Denmark reduce its carbon footprint and strengthen its position as one the most energy efficient countries in the world.

When you make optimal use of your energy resources, you also improve your competitiveness and prepare the ground for new business opportunities, increased exports and growth. This is good for Danish exports and it is good for your bottom line.

CASE • **RPC Superfos Randers**

The Danish packing factory, RPC Superfos in Randers, analysed its vacuum lifting equipment operations and found ways to cut energy consumption by 95 %.

Payback period after subsidies: 1.4 years

CASE • Vald. Birn A/S introduced a demand control system for its cooling system for three of its induction furnaces and cut energy consumption by 45 %

Vald. Birn A/S is one of the largest foundries in Northern Europe with an annual output of 45,000 tonnes of foundry goods. The company carried out an analysis of the energy saving potential in a cooling circuit supplying cooling water for the coils in three induction furnaces.

Because it is easy to determine when the furnaces are in operation, the cooling system can be aligned with demand. The solution was therefore twofold:

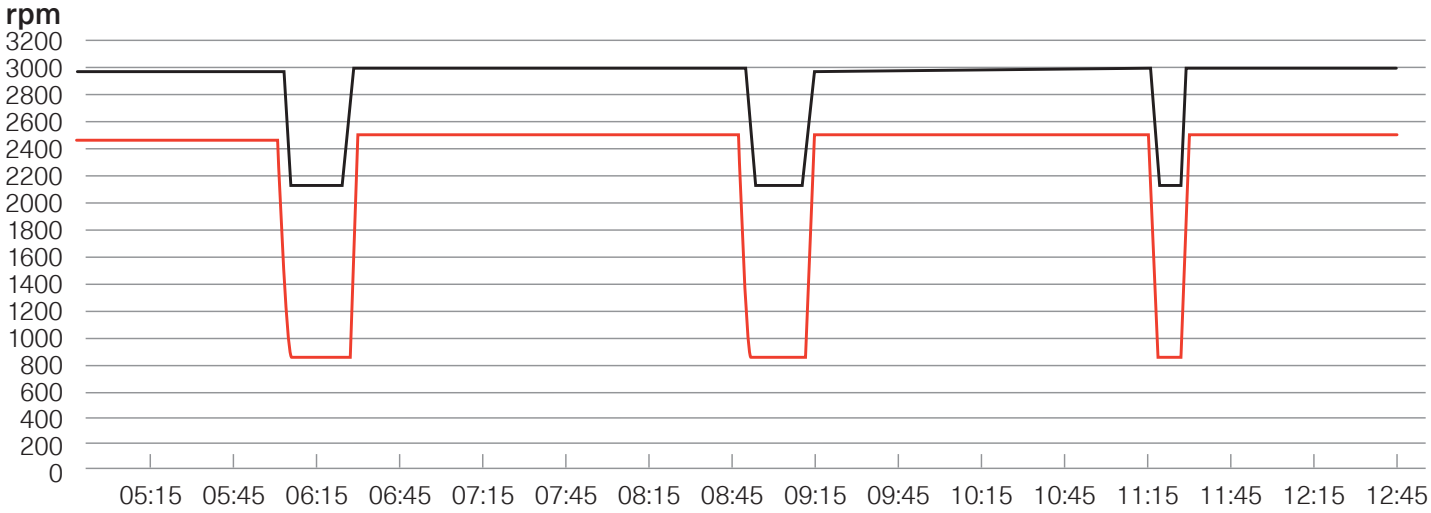
- To install frequency converters on cooling water pumps
- To program the controls between furnaces and pumps

The investment

The investment came to DKK 106,000 (EUR 14,000), resulting in a payback period (after subsidies) of 2.4 years.

The result

The introduction of a demand control system for the cooling circuit provided an annual energy saving of 78 MWh, corresponding to DKK 45,000 (EUR 6000) annually. The company cut its carbon emissions by around 15 tonnes annually.



The figure shows the effect when the pumps are turned down. The black curve shows the rotational speed and the red curve shows the power requirement. The figure clearly illustrates how even minor reductions in speed yield large power savings.

CASE • Heat recovery in cooling systems saves SuperBrugsen (supermarket) 60 % on its heating bill

The SuperBrugsen supermarket in Kerteminde on Funen has a shop area of 3,500 m^2 and the supermarket's cooling system used to generate considerable waste heat. The considerable amount of waste heat inspired the supermarket to collaborate with Danfoss to introduce heat recovery in the system.

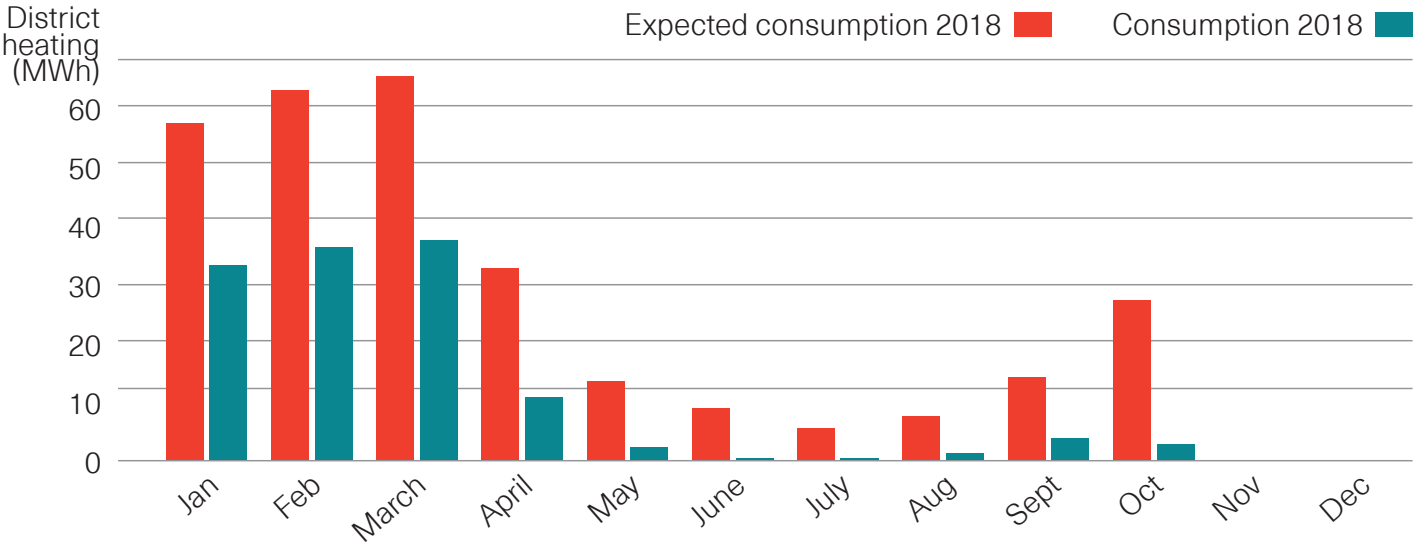
The idea was to exploit the waste heat before it enters the gas cooler in the shop's CO_2 cooling system. CO_2 cooling systems operate at high temperatures on the discharge side of the compressor and are therefore ideal for heat recovery. The supermarket also established an agreement with the local district heating company to sell the heat the supermarket cannot use itself to the district heating grid.

The investment

The investment came to DKK 180,000 (EUR 24,000). This is excluding the man-hours spent negotiating with the district heating company. After energy subsidies, the payback period is around 2 years.

The result

The test period from January to October 2018 resulted in a 165 MWh saving; a reduction of almost 60 %.



Expected and observed district heating consumption by the supermarket during the test period from January to October 2018.

How to save energy in your cooling, vacuum and compressed air systems

- experience and *best practice* from other businesses

Be systematic

Experience from other businesses shows that the best results are achieved if you systematically analyse your energy needs, the efficiency of your systems and the possibilities for operational optimisation. You can do this by considering three overall topics:

1. **Needs reduction:** Revise the design criteria of your system, so that critical processes and needs no longer have the same strict requirements for pressure and temperature, etc.

2. **System efficiency:** Reduce pressure losses, use more efficient compressors and systems, or exploit the waste heat from your systems.

3. **Optimisation of operations:** Adjust operations to the variations in your demand across the day, week or year. Or use better indicators to monitor the efficiency of your systems.

Remember...

Place demands on your supplier! The technical specifications can help you place the right demands on your supplier when converting or establishing your new system.

Adjust to demand

Your business will achieve much greater savings if you adjust the operation of your facilities to variations in demand for cooling, compressed air and vacuum.

You will therefore achieve the largest savings by assessing the intended uses of your facilities and by adjusting their design, configuration and mode of operation to your current business needs.

If you convert your facilities and increase their efficiency, and if you improve or introduce heat recovery, you will achieve even larger savings. However, this type of initiative is also more cost-intensive and usually requires external consultancy.

CASE • **Idé-Pro Skive A/S**

The manufacturing company Idé Pro in Skive, Jutland, optimised the energy consumption of its compressed-air system and reduced consumption by 120 MWh annually. Moreover, the company improved the operational security of its facility.

Payback period after subsidies: Less than 1.5 years

How to get started
– and achieve the best results

Use this approach to make sure you consider all relevant aspects of your systems and your needs. This will give you the best work process and the best results.

Remember...

... to apply for subsidies before you start!

You can apply for subsidies from an energy company, but you have to do so before launching your project - otherwise this possibility will no longer exist.

1. Identify the original design basis

- To which needs, temperature and pressure requirements were your facilities originally designed?
- Have your needs changed since then? Have your operating times changed for one or more areas?
- Have you converted and/or expanded your facilities since their establishment?

2. Analyse your current needs and existing operations

- How does demand for cooling and compressed air, etc. vary across the day, week, year?
- Can you reduce or change your cooling, vacuum and compressed air needs?
- Can you change your critical (design) supply requirements?
- Could you benefit from sectioning off or splitting up your supply facilities?

3. Assess your system efficiency

- Does your system use high efficiency compressors, pumps, etc?
- Can you reduce the pressure losses in your supply grids and in other components?
- Can you exploit your waste heat for space heating or other heating purposes?

4. Optimise your system operating parameters

- Can you adjust the frequency of your compressors and pumps to a varying demand?
- Can you operate your systems at lower temperature and pressure requirements, or can you close down the systems periodically?

5. Optimise your system maintenance procedures

- Do you have fixed routines for checking for leakages, insulation, etc.?
- Do you have fixed routines for checking the operating parameters of your systems?
- Do you check regularly whether exchangers and condensers, etc. are clean?

6. Define your key operating indicators

- Could you monitor critical process parameters and needs to achieve better control of your systems?
- Could you measure and monitor the output capacities and efficiency of your systems on a regular basis?

Learn more

You will find six remaining feature articles in this series:

- **Evaporation, drying and distillation**
- **Waste heat recovery and waste heat utilisation**
- **Ventilation and extraction systems**
- **Kilns and melting processes**
- **Energy management and employee involvement**
- **LEAN and productivity**

Furthermore the Danish Energy Agency have elaborated checklists (in Danish) for efficiency improvement initiatives, specification requirements for equipment, and analyses of efficiency potentials in the Danish Industry.

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