Chapter 1

Our mission

We optimize the performance of our customers' processes.

Time and time again.

Pure Performance

Alfa Laval focuses closely on offering its customers solutions that pay off.

This is clearly reflected in our mission:

To optimize the performance of our customers'processes. Time and time again.

This is a never-ending commitment. Every improvement we achieve creates a new platform for the next step on the improvement ladder.

Our aim is to stay in pole position at all times.

High-tech performance

The Alfa Laval brand stands for technical expertise, reliable products, efficient service and the finest possible process-engineering skills.

Our reputation is based on our unique knowledge and experience in three key technologies:

- Separation
- Heat transfer
- Fluid handling

These are technologies that play major roles in most sectors of industry.

Our company

A global brand
Our equipment, systems and service are hard at work in more than 100 countries.
In 2011 Alfa Laval had 37 major production units and 99 service centres all over the world. The proximity to the market is vital to the company's success, for it is only by working closely with our customers that we can respond to their needs.

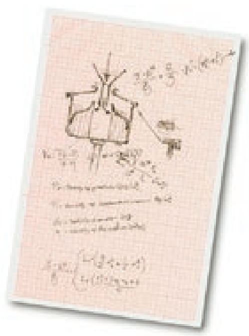
129 years young
The origin of the company dates back to 1883, when Gustaf de Laval founded Alfa Laval to exploit his pioneering invention of the centrifugal separator.
Gustav de Laval was a great technical genius who registered 92 patents in his lifetime. His innovative spirit has always been the guiding star for Alfa Laval and remains so to this day.

3.2 billion euros in sales
During 2011, Alfa Laval posted sales of 3.2 billion euros.
Europe is the biggest geographical market in terms of sales volume – roughly twice the size of both Asia and the American continent.

14,700 employees
Alfa Laval has nearly 14,700 highly qualified employees worldwide. Their basic mission is to assist industries of almost every kind to refine and improve their products and to optimise the performance of their processes. Thereby we help create better living conditions and a cleaner, safer environment for all mankind.

Ten customer segments
To create a clear focus on different types of customer, Alfa Laval's business is divided into ten segments.
Each segment is dedicated to working closely with specific customer groups. This gives us insight into their special needs and the power to develop the best possible solutions to fulfil them.

Technical leadership
Alfa Laval holds world-leading market positions in its fields of technical expertise.
Its success is based on an average investment of 2.5% of annual turnover in Research & Development.
The work of our almost 300 dedicated R&D specialists results in 35-40 new product releases every year.



Our key areas

Separation
Alfa Laval has led the development of separation technology since the company was formed in 1883. Today Alfa Laval is the world's largest supplier of separation technologies.

Heat transfer
Alfa Laval is the world leader in plate and spiral heat exchangers.
It also offers the market's most extensive range of refrigeration equipment.

Fluid handling
Alfa Laval produces flow equipment for industries requiring high standards of hygiene and reliable, continuous process flows.

Heat transfer

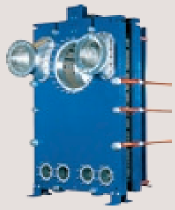


Plate heat exchangers
Alfa Laval has the most comprehensive range in the market for industrial, sanitary and heating applications.

Air heat exchangers, evaporators and condensers
Designed for refrigeration.

Shell-and-tube heat exchangers
An extensive range of heat exchangers dedicated to pharmaceutical, food and refrigeration applications.

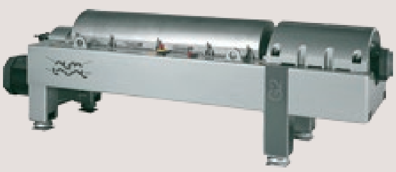
Spiral heat exchangers
Tailored for viscous and particulate products that can cause severe fouling or corrosion.

Finned tube heat exchangers
Alfa Laval's range covers most types of refrigerants and most cooling applications.

Separation

High-speed separators
Primarily used for separating fluids and sludges containing up to 30% of solid particles.

Membrane filtration
Alfa Laval's wide range of filters covers reverse osmosis, nanofiltration, ultra-filtration and microfiltration.



Decanter centrifuges
For separating solids from liquids: a key function in countless industrial, food and treatment processes.

Fluid handling

Valves
Sanitary mixproof valves.
Intelligent control equipment. For example:
Butterfly valves.
Seat valves.
Aseptic diaphragm valves.

Pumps
We cover every need for gentle, precision pumping of all kinds of fluids of all viscosities in sanitary applications.

Tank equipment
We offer the widest range of sanitary applications for the marine/offshore business – supplying everything except the tank itself.

Installation material
Our promise: You can always find the right installation material, in the right quantity, for the right application.

Focus on customer segments

Vegetable oils industry
Our equipment and systems produce tons of extra virgin olive oil every day.

Marine industry
More than half of the world's ships are equipped with Alfa Laval products and solutions.

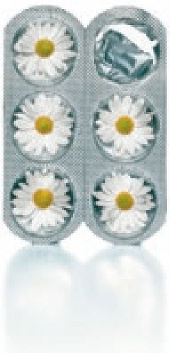
Beverage industry
We manage the vital balance between flavour, food safety and manufacturing efficiency. Our equipment handles millions of litres of wine and beer every year.

Wastewater
Alfa Laval has unique knowledge in the increasingly critical areas of effluent treatment and recycling.

Energy
Alfa Laval is involved throughout the long process from the extraction of raw materials to the production and use of energy.

The process industries
Alfa Laval's equipment and solutions are critical for performing and optimizing many industrial processes.

Starch industry
More than half of the 60 million tons of starch produced in the world every year comes from our products and processes.



Pharmaceutical and biotech industry
We offer a wide range of products to satisfy the industry's exceptional demands for precision, safety and cleanliness.

Comfort/HVAC and refrigeration
Alfa Laval is a leader in climate control, providing an optimized balance of heating and cooling.

Food industry
Our equipment helps the food industry to turn quality raw materials into equally high-quality products.

Chapter 2

Heating and cooling solutions from Alfa Laval

The Alfa Laval Business Unit Comfort/ HVAC applies heat-transfer technology to heating and cooling systems, helping you to be more efficient in obtaining the ideal temperature in any area.

Customers in more than 60 countries have made Alfa Laval the world market leader in heat exchangers and thermal solutions. Over 60 years of dedicated research and development in the field of heat-exchanger solutions, together with field experience from some 500,000 heating installations around the world, are your assurance that we have the solutions you are looking for.

There are many different ways to achieve comfortable, economic climate control. That's why a thorough understanding of each individual situation, the available resources and the real needs is the first step towards success.

Global experience always near you

In a world of constant change, it can be comforting to know that some essentials will remain the same. One such essential is the local presence of Alfa Laval through our local sales companies and network of authorized distributors, who can meet all your needs and help you optimize your systems' performance.

Many of our customers are engaged in building a modern infrastructure based on proven, effective and sophisticated technology.

This calls for customized design to meet specifications that address local conditions and specific needs.

Others are expanding current plants or designing next generation systems. This means analyzing the application benefits that new technology has to offer, locating opportunities for even faster return on investment, ensuring lower than ever total cost of ownership, and reducing environmental impact. Globalization is an obligation – the obligation to adapt global experience to meet local needs.

Alfa Laval is fully equipped to meet any project requirements from day one with fast answers and timely suggestions for improvements. These are the success factors that lead to a rewarding, long-term customer supplier relationship.

Time is money: that's why it's easy to do business with us
Speed and simplicity are essential for us, because a company's leadership derives not just from the quality of its products, but also from its organization and the services it offers. This is why we provide our customers with all the tools they need to do business with us easily and efficiently. Contact our local representative to learn more about the latest available tools.

We know because we have been there
Alfa Laval customers always benefit from our first-hand experience in hundreds of projects in different countries and climates all over the world. You can access our experience through our global team of Alfa Laval experts and partners. Your Alfa Laval agent is just a phone call away, while contact details for all countries are continually updated on our website at www.alfalaval.com

Fast, timely delivery
Experienced planning means superior logistics. At Alfa Laval, we believe that deliveries should not merely be in time. They should be just in time in order to save money and storage space for our customers. This is one of our major strengths together with supplying and supporting the resources needed at each different stage of a project.

From a single product to the complexity of a power plant
Close collaboration with the customer and every one of his partners and advisors is essential. We contribute actively and constructively from the very first enquiry in order to assure you the best possible solution – whether you need a single product or a full-scale project.

Advanced design
Alfa Laval's extensive product development work has led to technologically advanced plates for heat exchangers that make it possible to adopt our "close approach" to energy efficiency. The optimized plate corrugation pattern not only increases heat transfer, but also reduces the risk of fouling thanks to highly turbulent flow. Plates are available in different materials and configurations to suit the customer's needs.

Alfa Laval's innovative heating and cooling systems are certified according to ISO 9001 and we have the possibility to control every component. As the interaction between all components is thoroughly tested, you can be sure to receive a reliable and cost-efficient system, ensuring lowest cost of ownership.

Leveraging local energy sources
The availability of local energy is an important cost parameter in designing a system. By using heat exchangers from Alfa Laval, you can choose one or several of a wide variety of energy sources in order to maximize economic benefits and minimize environmental impact.

Global expertise for local projects
District-heating system projects typically span a period of several year. These projects are complex processes that are often split up into several stages. Each of these starts with a pilot project, and is minutely documented as a basis for improvements and refining specifications for coming stages.

This meticulous process is even more critical when external financing and approvals need to be obtained.
At first it may seem daunting, but it is part of our global experience and everyday work.

Full documentation
We provide documentation and specifications for local authorities, consultants and contractors. We can customize throughout the project – down to the smallest details of three-dimensional drawings.

Innovative solutions
Alfa Laval pursues an active research and development policy at laboratories around the world. All Alfa Laval development projects are based on an analysis of the benefits of applying new technologies and the opportunities for even faster return on investment, reducing both the total operating cost and environmental impact.

We're closer than you think
Alfa Laval is represented in most countries by local sales companies, and a network of regional authorized distributors are responsible for serving our customers at all times. All of our authorized distributors and sales companies are able to perform dimensioning of heat exchangers based on application, heat load and available space, and to provide installation guidelines together with full pricing details.

We understand and meet your needs
There are many different ways to achieve comfortable, economic climate control. A thorough understanding of each individual situation, the available resources and the real needs is always the first step towards success.

Power and performance
Alfa Laval has a full range of products catering for every need, however large or small. We offer versatile, compact and easy-to-install products that ensure high efficiency and low maintenance costs. Alfa Laval is your assurance of reliable operation, unsurpassed operating life span, fast return on investment and low cost of ownership.

Chapter 3

Applications

In this chapter, we will illustrate a number of common applications of heat exchangers and heat-exchanger systems in HVAC installations.

The diagrams and other information provided are intended only to clarify the operating principle. Actual systems must thus be completed with the components and accessories envisaged by current regulations.

For a more tailor-made design, contact your local Alfa Laval representative, who will be happy to provide you with professional assistance in selecting the best heat exchanger or heat-exchanger system for the job (see contact details at www.alfalaval.com).

At www.alfalaval.com/HVAC you can check out our reference library and read about installations we have completed within all applications in different places all over the world.

District heating/Community heating

Space heating

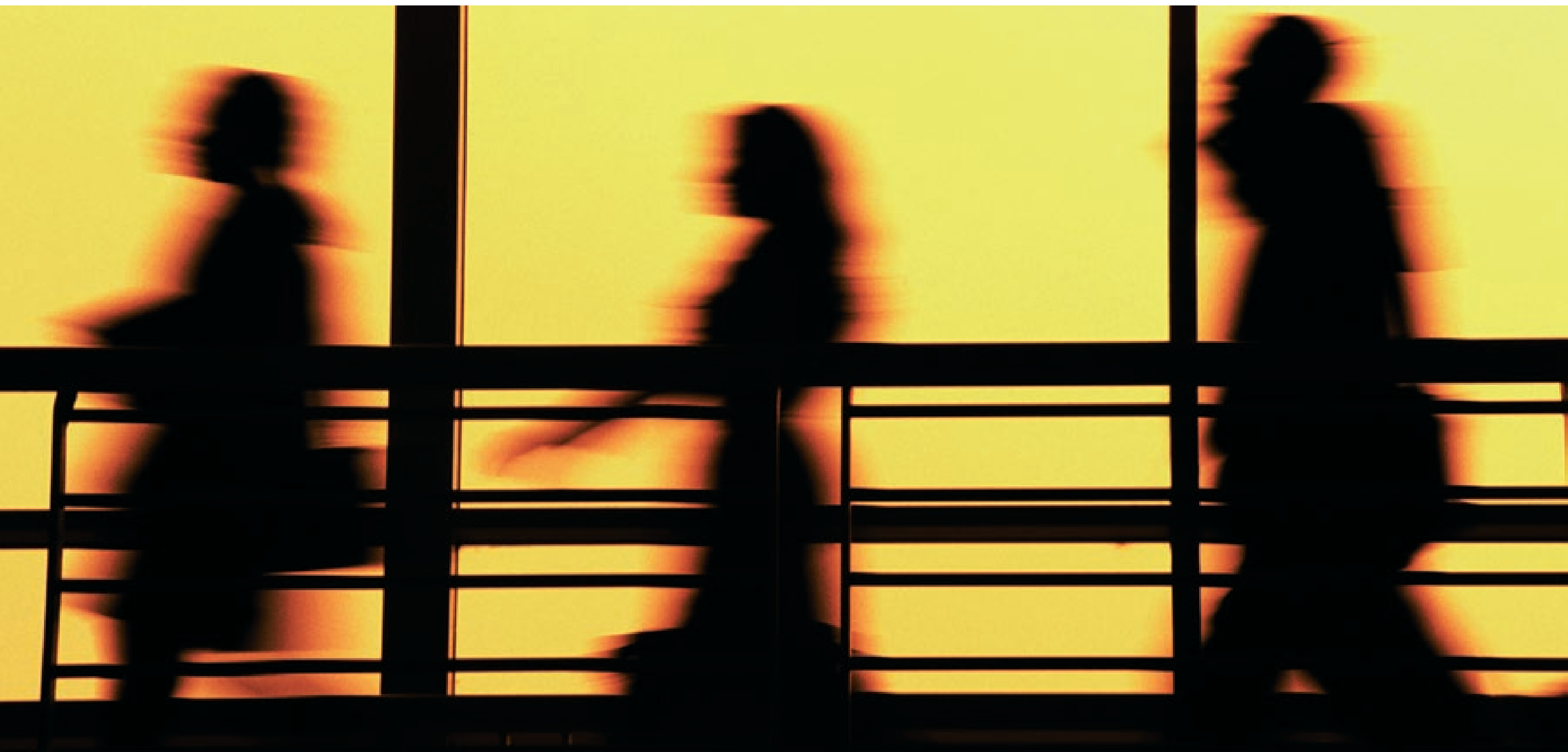
Heating, in most cases, is a matter of providing a comfortable indoor environment, whether at home, at work or in a public facility. Heating can also involve tapwater heating, swimming pools, greenhouses etc.

Space heating
The use of hot water for space heating is very common. The methods used to transfer energy from the water to a comfortable indoor environment vary. Using radiators is one common method.

An alternative to radiators is under-floor heating, where heat circuits are placed under the floor. The floor-heating circuit can be connected to the radiator circuit.

An air heater, blowing hot air into a room, is more commonly used in public buildings. Very often a combination is used, with for example radiators and floor heating, or radiators and air heaters via a separate mixing loop.

The objective of space heating is usually to achieve a comfortable indoor temperature. The heat can be transferred using radiators, floor heating or air heaters.



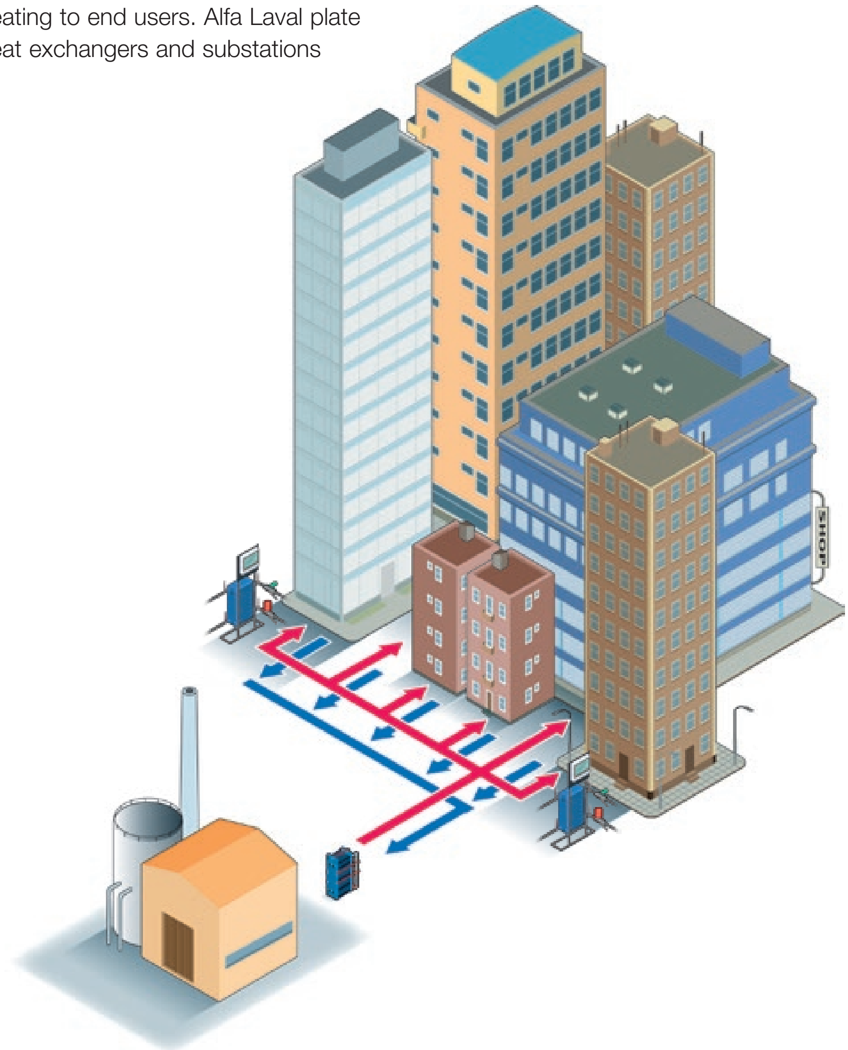
What is district and community heating?

District heating and community heating are environmentally friendly and energy-efficient methods of delivering hot tapwater and radiator heating. Heat generated in a central boiler plant is transferred to several buildings through pipes. A very wide range of energy sources, including combustion of oil, natural gas, biofuel or renewable energy, can provide the heat. A successful energy company will have 6-8 heating sources that they can combine and utilize according to their priorities – fuel cost, emissions, etc. The possibilities of using waste heat from industry, surplus heat from waste incineration, industrial processes and sewage, purpose-built heating plants or co-generation plants in district heating make it a flexible and energy-efficient choice. You can optimise costs as prices change, and maximize environmental protection.

For the consumer, district or community heating means a trouble-free way of receiving energy. The heating sources of a district or community heating system are more convenient and more efficient than small individual space-heating systems. Combustion techniques and exhaust cleaning will decrease the negative impact on the environment.

Plate heat exchangers and heat-exchanger systems, substations, play a major role in enabling efficient heat transfer between the two systems in order to deliver heated tap water and heating to end users. Alfa Laval plate heat exchangers and substations deliver the preferred solution in district- or community-heating systems throughout the world today.

Alfa Laval currently offers different types of plate heat exchangers and substations in district- and community-heating applications.

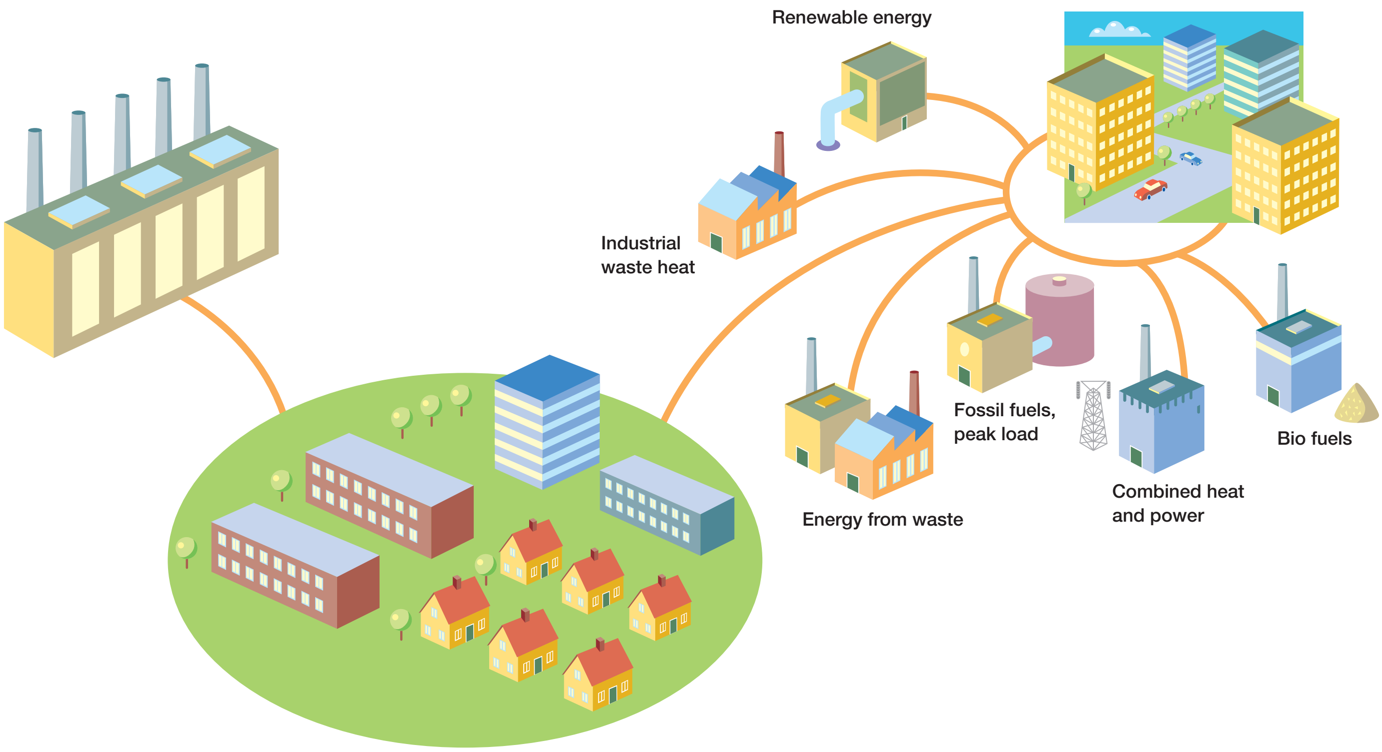


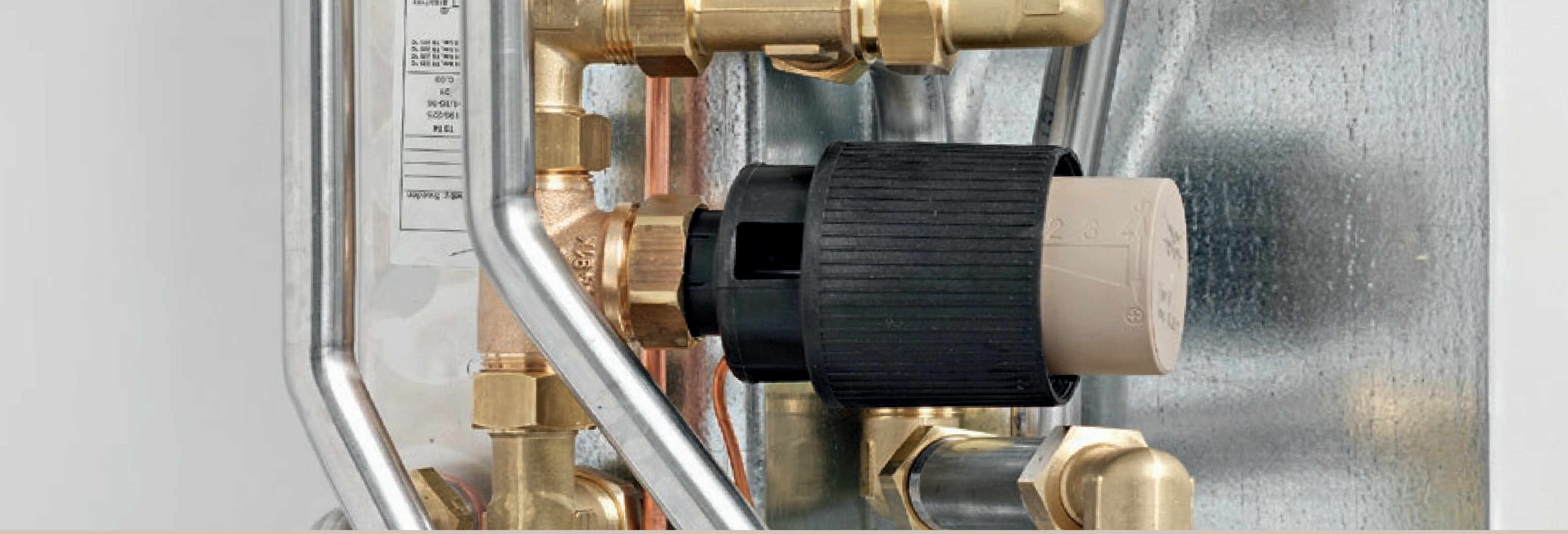
Community heating

Community heating is based on the same technology as a "standard" district-heating network but on a smaller scale. Even in networks consisting of a relatively small number of houses or apartments, the technology developed for district heating offers some obvious benefits. One central boiler will replace several of small boilers. Fuel from different local sources – e.g. industrial waste energy, garbage or solar – can be used.

In many cases, small-scale community heating networks can be integrated into more comprehensive district-heating networks, thus creating economies of scale while some of the initial investments in equipment are already taken.

Substations are the brain of the community-heating concept. The challenge is to achieve the ideal temperature while simultaneously reducing energy consumption and paying attention to environmental issues. During the last few years, compact and very efficient units have been developed specifically for small-scale applications. As metering can be set individually, residents are offered an incentive to save energy, while sensors adjust the indoor temperature in relation to temperature fluctuations outdoors.



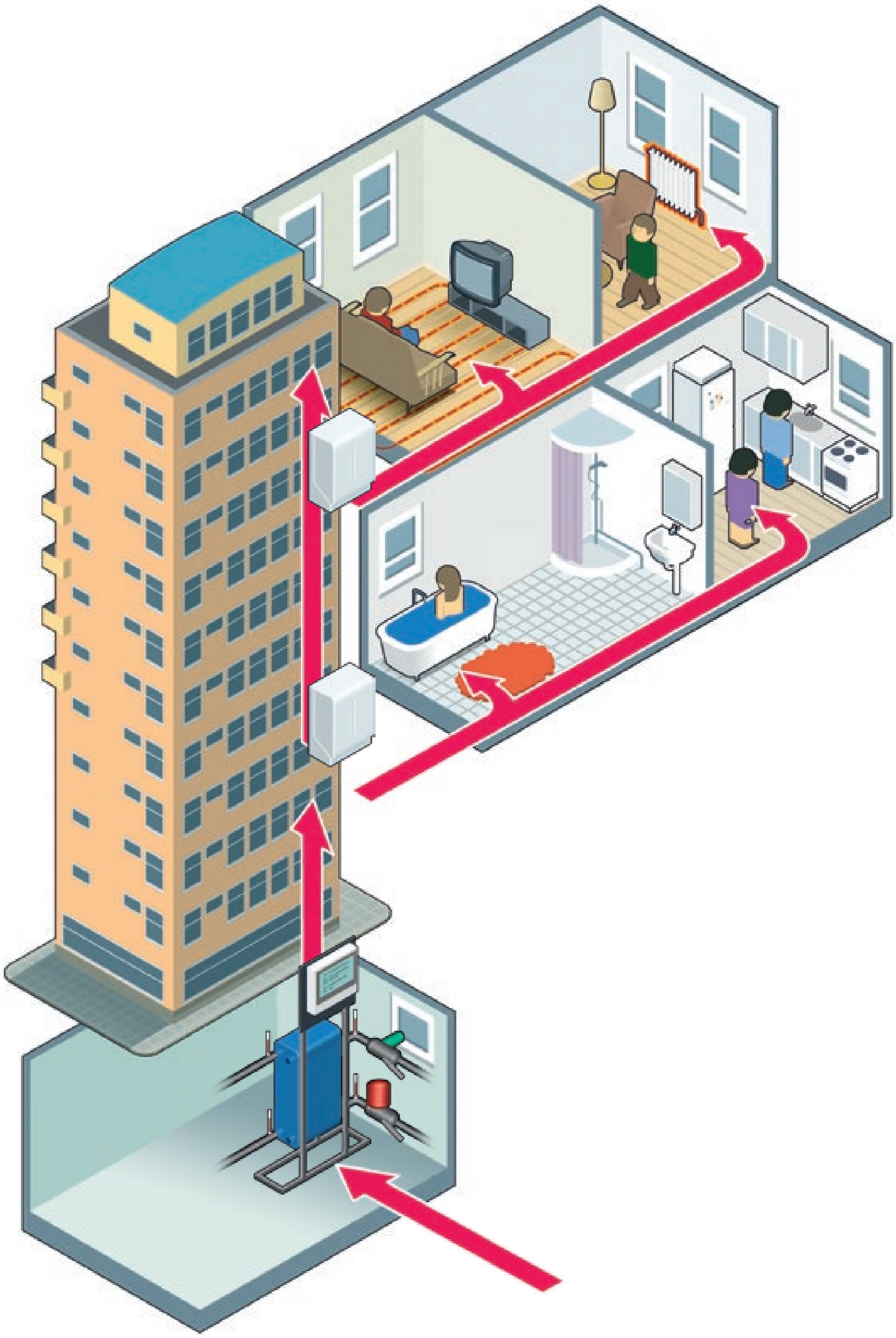


Energy savings in district/community heating

Today, the district- and community heating application is moving from "production-driven" towards "demand-driven". In a production-driven system the production plant regulates the volumes of heat delivered to residents. The residents have no technical means of regulating the heat reaching their apartments, as the system temperature can only be set at the heat source.

In a demand-driven system, each building is furnished with an individual substation equipped with a weather sensor. The sensor and control equipment adjust the supply temperature automatically, taking into account the specific heating needs of the building. Therefore, the substation will capture only the heat needed from the network. A refined regulation of the ambient temperature also means that the temperature gap between the supply and return temperatures can be expanded. As a result, pipe dimensions can be kept relatively small, thus cutting investment costs and pumping costs.

One substation in every building (even every apartment) has proven to provide the best result, enabling individual control and superior economy.



District and community heating must be viewed as a total system, and as all systems, it requires a holistic approach – optimising and working with the total system and not only focusing on parts. For district and community heating it is crucial to have products and components in the system that work together as well as separately in an optimal way.

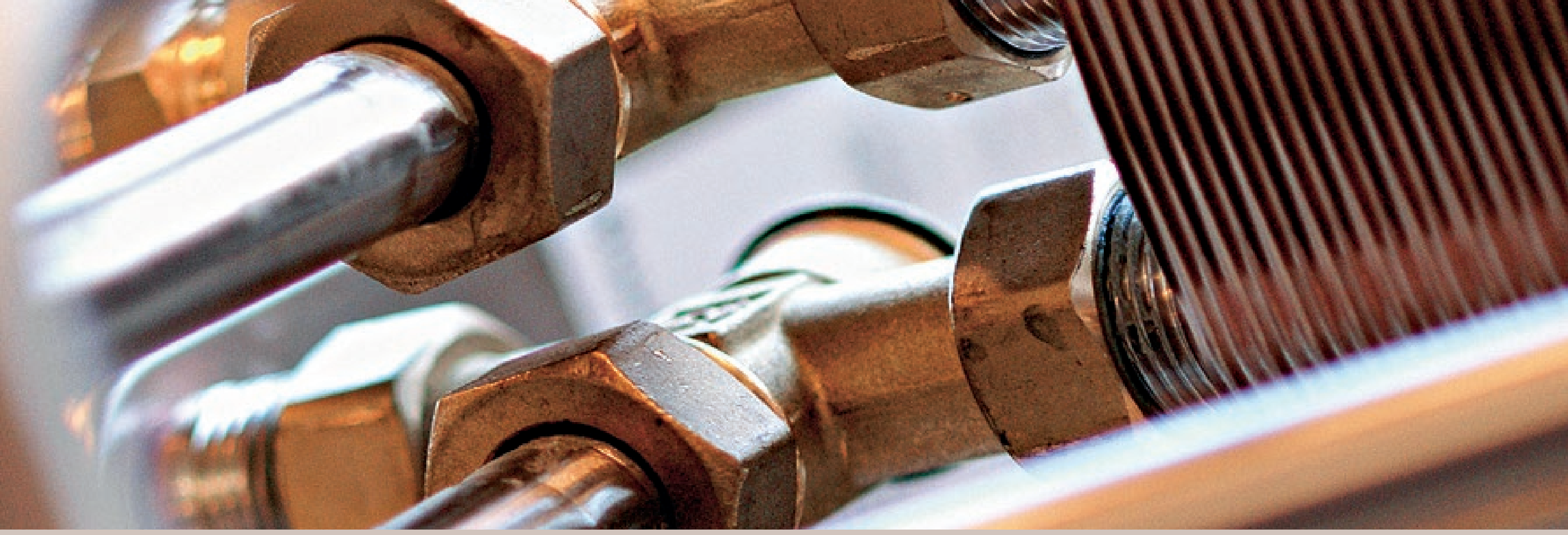
Strategy

- Two pipe systems
- Eliminating leaking pipes and waste of water
- A substation in every building
- All buildings need its own metering
- Individual measuring of use of energy for every apartment
- Connecting small district- and community-heating networks to the main city networks
- Analysis of optional energy supply
- Individual building efficiency

Keeping waste heat from going to waste

In many companies and industries there are untapped sources of waste heat or surplus heat. Such heat can be found in many forms, whether it is steam going out into the air or hot water going out into the ocean. By utilizing the waste heat in district heating, the same fuel achieves twice the work, thereby doubling fuel efficiency.

Huge heat losses appear in power plants, oil refineries and industrial processes. Much of this heat could be retrieved and distributed by district heating systems to heat urban buildings. District-heating systems provide the necessary heat load for high-efficiency combined heat and power plants while at the same time, allowing the use of renewable energy.



Connection principles

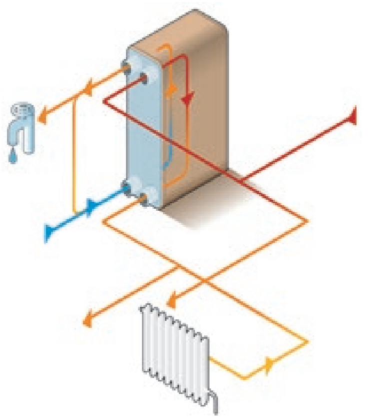
There are many different ways to connect district heating/community heating to buildings. The most common principles are:

1. Direct connection
2. Indirect parallel connection
3. Indirect two-step connection

The direct-connection system includes a heat exchanger for the domestic tap water circuit but there is no heat exchanger between the heating network and the customer heating circuit. The same heating water is inside the secondary network (radiators, underfloor heating etc.).

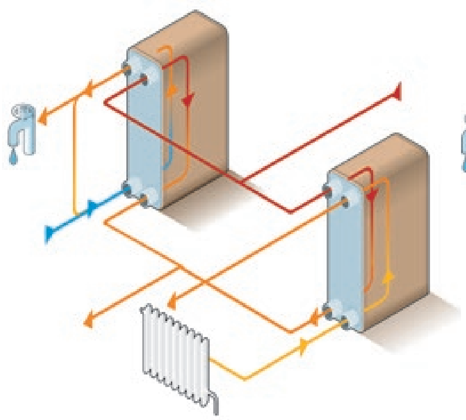
The indirect parallel-connection system includes a heat exchanger for the domestic hot water circuit and a heat exchanger separating the district- or community-heating network from the customer heating circuit.

The indirect two-step connection includes a two-step heat exchanger for the domestic hot water circuit and a heat exchanger separating the district- or community-heating network from the customer heating circuit. The heating flow from space heating flows through the pre-heater of the domestic tap water exchanger and improves the total cooling of the district- or community heating system.



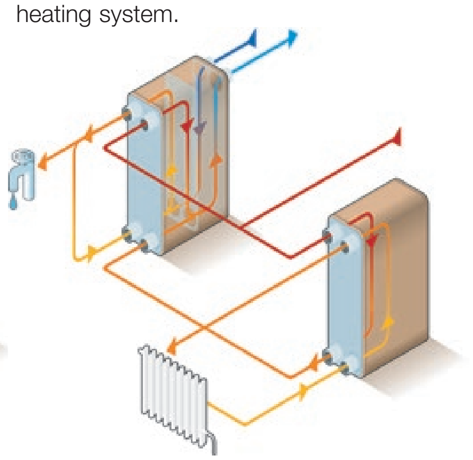
Direct connection

A direct connection system needs a differential pressure controller in order to decrease pressure on the secondary side and is recommended for low-pressure systems.



Indirect parallel system

In the indirect parallel connection system, a differential pressure controller can be used in some cases.



Indirect two-step system

The indirect two-step connection means maximum utilization of heat and a low return temperature during tap water consumption.

Environmental aspects

Combined Heat & Power (CHP) is a key technology for district and community heating. It will almost double fuel efficiency and at the same time reduce the need for additional heating sources. This reduces the impact on the climate and environment and increases the energy efficiency.

Wherever district or community heating is established, the surrounding environment benefits. One large plant has better combustion and cleaner emissions than many smaller plants. District and community heating enables the utilization of waste heat from industries and garbage from both households and industries; energy that would otherwise be lost.

Large or small-scale district and community heating open up for using local fuels and switching between different heat sources, thus making renewable energy sources an attractive alternative.

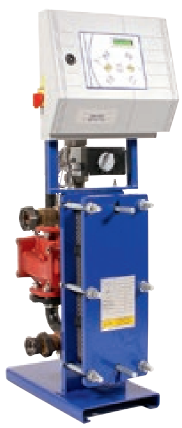
Tap water heating

Hot tap water is a convenience and comfort that most people take for granted in modern society. For cleaning, washing and personal hygiene, we're used to turning a tap and getting as much hot water as we need – quickly and reliably. And we do use lots of it!

Close to 40% of all energy consumed by households in Europe goes to heating tap water. Hot tap water can be produced in a variety of ways, depending on the type of energy employed (electricity, gas, solar or other fuels) and the users needs. Essentially, tap water heating systems can be either instantaneous, without a storage tank, or semi-instantaneous, using a tank storage.

Which method is best for any particular application is determined by weighing the advantages and disadvantages of each solution. The main factors involved are:

- available capacity (kW) on site
- temperatures needed on the primary and secondary sides
- available energy on site
- available place in the boiler room
- local preferences and/or habits



Instantaneous

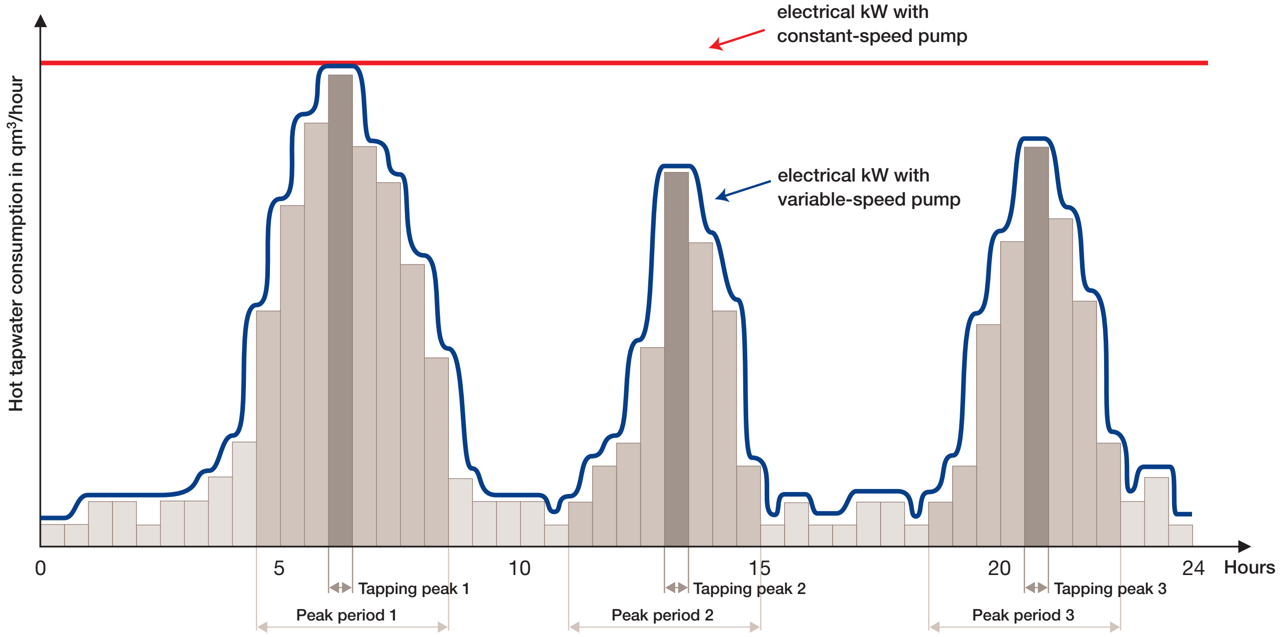
&

Semi-instantaneous

Some of the key requirements that are considered in selecting a system are as follows:

Indicator	Benefits
Cost efficiency	Low up-front investment, operating and maintenance cost
Energy efficiency	Low energy consumption
Space efficiency	Using minimal floor and room space
Installation efficiency	Simple and quick to install, test and start up
Service efficiency	Easy to clean and maintain; long maintenance intervals with short service shut-downs
Comfort	No waiting for hot water; and appropriate temperature levels, no risk of scalding at the tap
Dependability	Hot water available at the right moment
Health	No build-up bacteria cultures
Sufficiency	Enough hot water even during peak-consumption hours

Tap water demand



Modern buildings are designed to consume less and less energy. If building losses can thus be brought down to very low levels, the same cannot be said of domestic hot water production: it is not possible to reduce the heat needed to produce hot water significantly, as it depends on quantity and distribution characteristics.

In order to keep energy consumption low, it is thus essential to optimise the hot water production system, where tap-water systems from Alfa Laval play a fundamental role.

A tap-water system is much more than a heat exchanger; it combines the Alfa Laval know-how of heat exchangers with a perfect knowledge of quality material and professional skills in order to offer a complete ready-to-use hot-water system to the customer.

Alfa Laval offers:

- Instantaneous systems
- Semi-instantaneous systems
- Anti-legionella systems
- Multi functional electronic controlbox
- Choice of gasketed, brazed and fusion-bonded heat exchangers
- Choice of 2-port, 3-port and 4-port valves on the primary side

These systems are the best solution for anywhere where hot water is needed in large volumes in a short time:

- For any collective application:

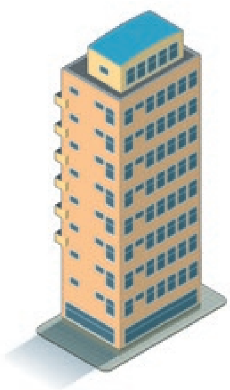
- Apartment blocks
- Hotels
- Hospitals
- Sports facilities
- Retirement homes
- Schools & universities
- Prisons

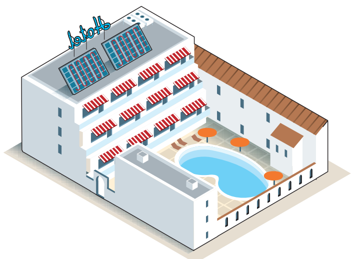
- For any heating source:

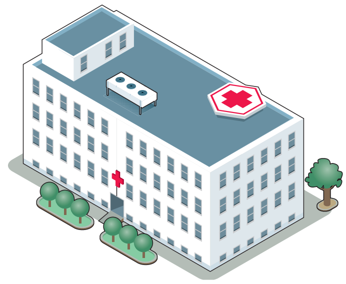
- Local boiler
- District heating
- Community heating
- Renewable energies

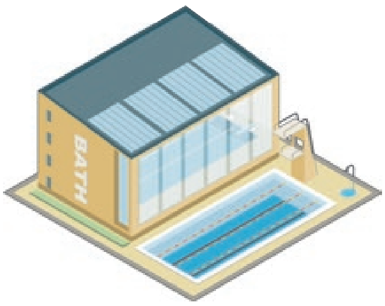
- For any functionality:

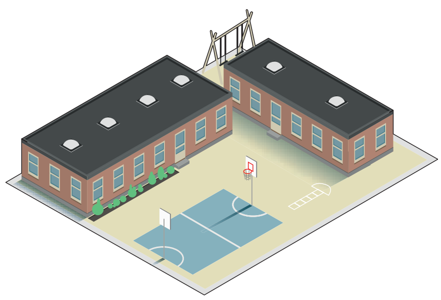
- Simple product range
- Standard product range
- Smart product range

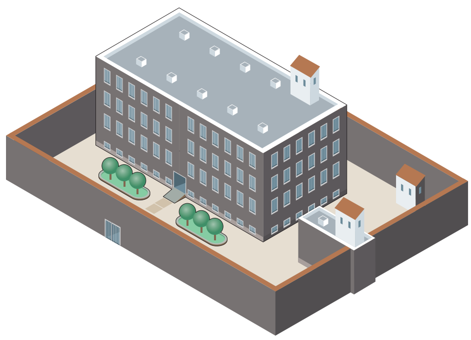












Instantaneous hot water production

An instantaneous tap water system heats the water at the moment it is needed by the user.
The working principle is very simple: connected to the hot water distribution pipe works, the heat exchanger provides controllable domestic hot water directly to the consumption taps in large volumes and at very fast pace.
The primary side can be fed by different heating sources such as:

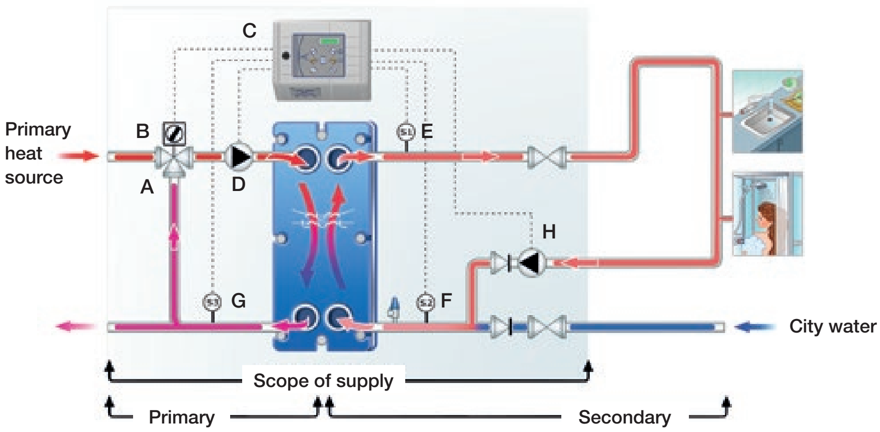
- A local boiler
- A district-heating system
- A community-heating system
- A system using renewable energy: solar, heat pumps etc.

The system operates with a 2-, 3- or 4-port *control valve* on the primary side (A). The valve is connected to an *actuator (B)* and the *control box (C).*

The *temperature sensor S1(E)*, located at the secondary outlet, checks the temperature and adjusts the control valve accordingly, via the control box, in order to supply domestic hot water at the right temperature.

The *primary pump (D)* maintains a constant flow rate whereas the temperature entering the heat exchanger is continuously adapted to the demand detected at sensor S1(E).

Working principle instantaneous, 3-port valve



Advantages of an instantaneous tap water system:

- It is simple, reliable and easy to install (plug & play)
- It provides domestic hot water in large quantities, up to 1220kW, in a very short time
- It comfortably keeps up with peak consumption without having a tank on site; cost and space saving
- With no stagnant water, there is no less risk of legionella
- Limited lime scaling thanks to the mixing valve on the primary side and turbulent flow through the plate heat exchanger
- Extremely compact
- One instantaneous tap water system has the muscle to replace several storage tanks

This eliminates thermal shock in the plate heat exchanger and reduces the build-up of lime scale on the tap-water side.

Sensor S2 (F) indicates if circulating water has reached 70°C minimum for thermal treatment.
Sensor S3 (G) indicates a decrease of the heat-exchanger efficiency due to scaling.

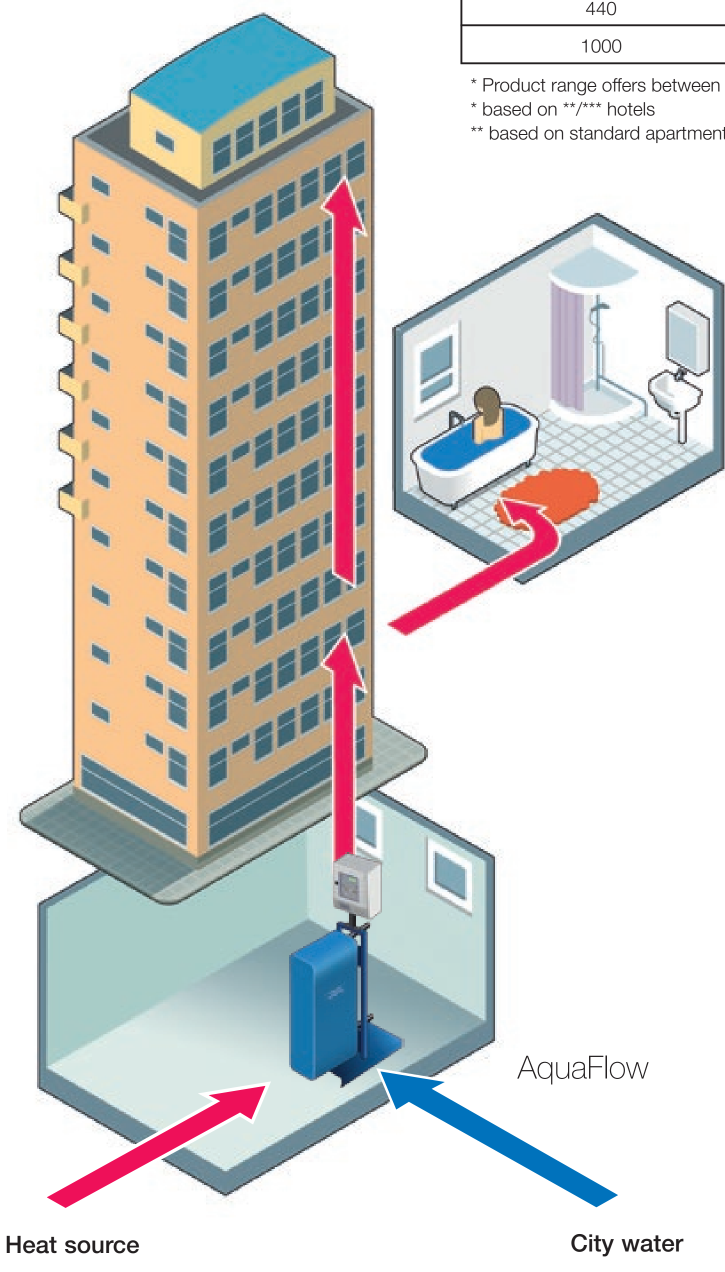
The *circulation pump (H)* maintains a minimum flow rate through the entire network.

An instantaneous tap water system must be sized to cope with peak consumption which means that both the plate heat exchanger and the boiler capacity (or heating network) must be larger than for a semi-instantaneous system (see next section).

Application examples for one single instantaneous tap water system:

Nominal capacity of the system (kW)*	number of hotel rooms**	number of apartments***
70	8	5
150	25	20
440	100	130
1000	320	500

* Product range offers between 50 and 1220kW
* based on **/*** hotels
** based on standard apartments of 3/4 rooms



Semi-instantaneous hot water production

In a semi-instantaneous tap-water system, the heated domestic hot water is stored in a buffer tank on the secondary side. The stored hot water is only used for peak periods when the domestic hot water demand is higher than the energy supply.
Contrary to instantaneous systems these systems can operate with a smaller boiler (or heating network).

The primary side can be fed by different heating sources:
- A local boiler
- A district-heating system
- A community-heating system
- A system using renewable energy: solar, heat pumps etc.

The system operates with a 2-, 3- or 4-port *control valve* on the primary side (A). The valve is connected to an *actuator (B)* and the *control box (C).*

The *temperature sensor S1(E),* located at the secondary outlet, checks the temperature and adjusts the control valve accordingly, via the control box, in order to supply domestic hot water at the right temperature.

The *primary pump (D)* maintains a constant flow rate whereas the temperature entering the heat exchanger is continuously adapted to the demand detected at sensor S1. This eliminates thermal shock in the plate heat exchanger and reduces the build-up of limescale on the tap-water side.

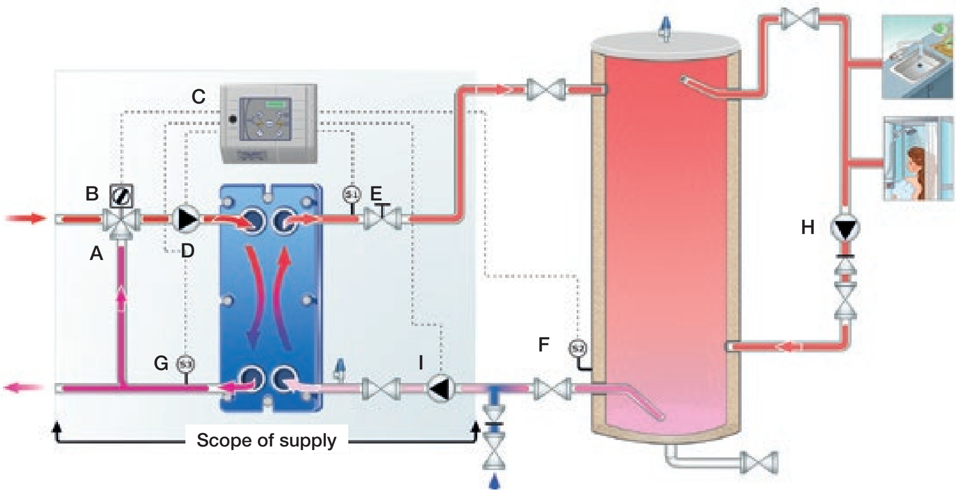
Sensor S2 (F) indicates if circulating water has reached 70°C minimum for thermal treatment.
Sensor S3 (G) indicates a decrease of the plate heat-exchanger efficiency due to scaling.

The *circulation pump (H)* maintains a minimum flow rate through the entire network.

The *charging pump (I)* on the secondary side is used to store hot water in the storage tank.
When there is no or limited tapping of domestic hot water, the storage vessel is gradually heated up to the set point temperature. When tapping occurs, hot water is being drawn from the top of the storage tank.

The only feature difference between an instantaneous and a semi-instantaneous tap water system is the charging pump (I) on the secondary side.

Working principle semi-instantaneous, 3-port valve



Advantages of a semi-instantaneous tap-water system:

- It is simple, reliable and easy to install (plug & play)
- Even where hot water demand is not constant, it comfortably keeps up with sudden peak consumption thanks to the buffer tank
- No need for a large boiler capacity on site
- No need for a very large heat exchanger
- Any combination of power output (50-1220kW) and tank size (150 to 4000L) is possible, thus providing large quantities of hot water
- To avoid legionella proliferation the semi-instantaneous systems are equipped with a thermal treatment function which raises the temperature to 70°C in order to kill the bacteria
- Limited lime scaling thanks to the mixing valve on the primary side and turbulent flow through the plate heat exchanger

Applications

Application examples for one single semi-instantaneous tap water system combined with one 300L storage tank:

Nominal capacity of the system (kW)*	number of hotel rooms**	number of apartments***
70	25	20
150	50	45
440	130	200
1000	350	620

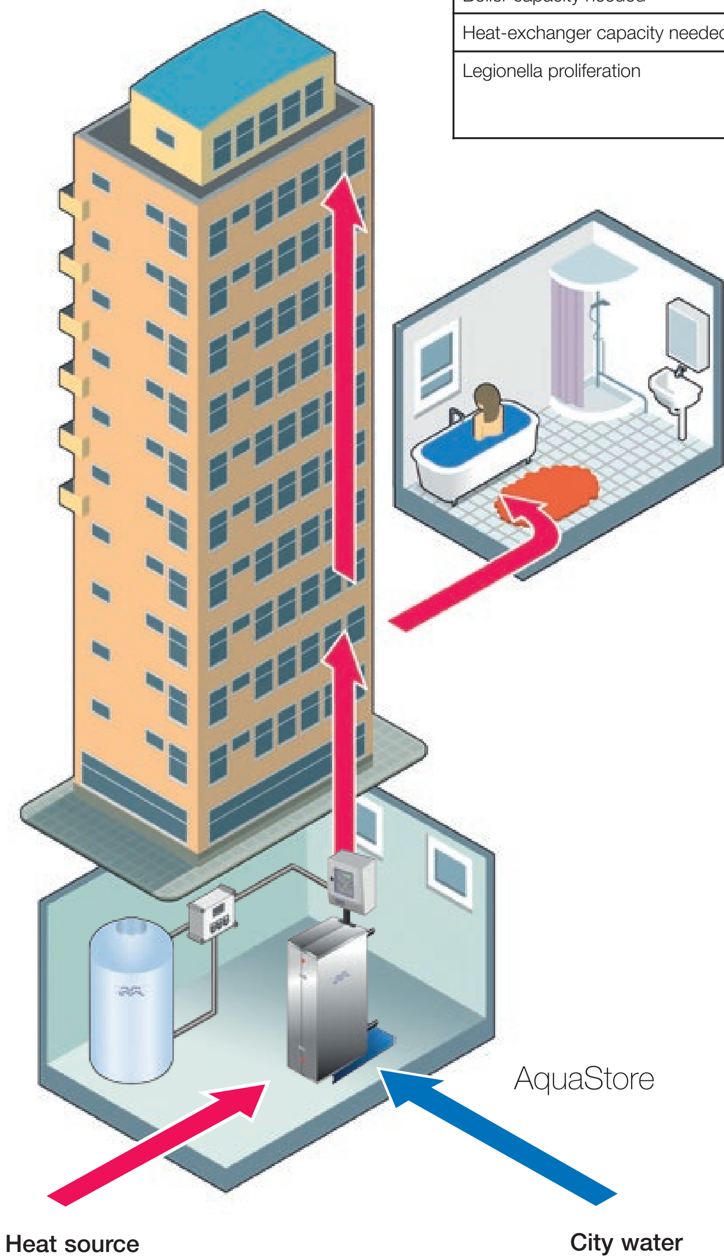
* Product range offers between 50 and 1220kW
** based on **/*** hotels
*** based on standard apartments of 3/4 rooms

Application examples for one single semi-instantaneous tap water system combined with one 2000L storage tank:

Nominal capacity of the system (kW)*	number of hotel rooms**	number of apartments***
150	100	120
440	320	430
1000	580	950

Comparison Instantaneous versus Semi-instantaneous

	Instantaneous	Semi-instantaneous
Features	No charging pump	One or two charging pumps
Tank needed	No	Yes
Boiler capacity needed	High	Mid to Low
Heat-exchanger capacity needed	High	Mid to Low
Legionella proliferation	No stagnant water, reduced risk, possibility for thermal treatment function	Stagnant water in tank but possibility for thermal treatment function

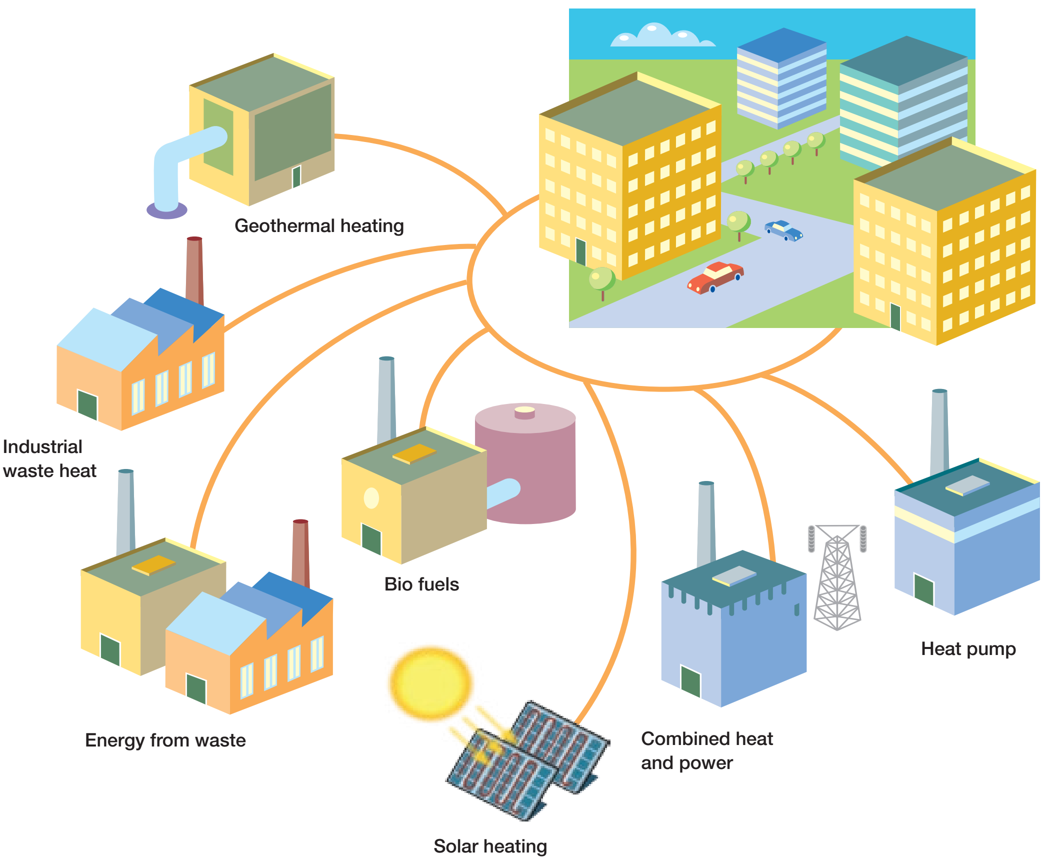


Renewable energies

The fact that reserves of fossil fuels (e.g. coal, petroleum and natural gas) are depleted much faster than they develop, and that CO_2 emissions need to be reduced, poses a giant challenge within multiple fields of technological evolution. Renewable energies represent a "technology of the future", and Alfa Laval has developed solutions for heating systems based on alternative energies as heating sources.

A major characteristic of a modern district- and community-heating system is flexibility – also when it comes to fuels. Switching from one fuel to another can be done without adjustment or change of equipment in the houses or apartments of the subscribers. The preparedness for future changes of energy source is built into the system.

A district- or community-heating network can be integrated with local recycling energy sources, such as industrial waste, garbage and biomass. There is also a possibility to use geothermal or solar energy as an energy source.



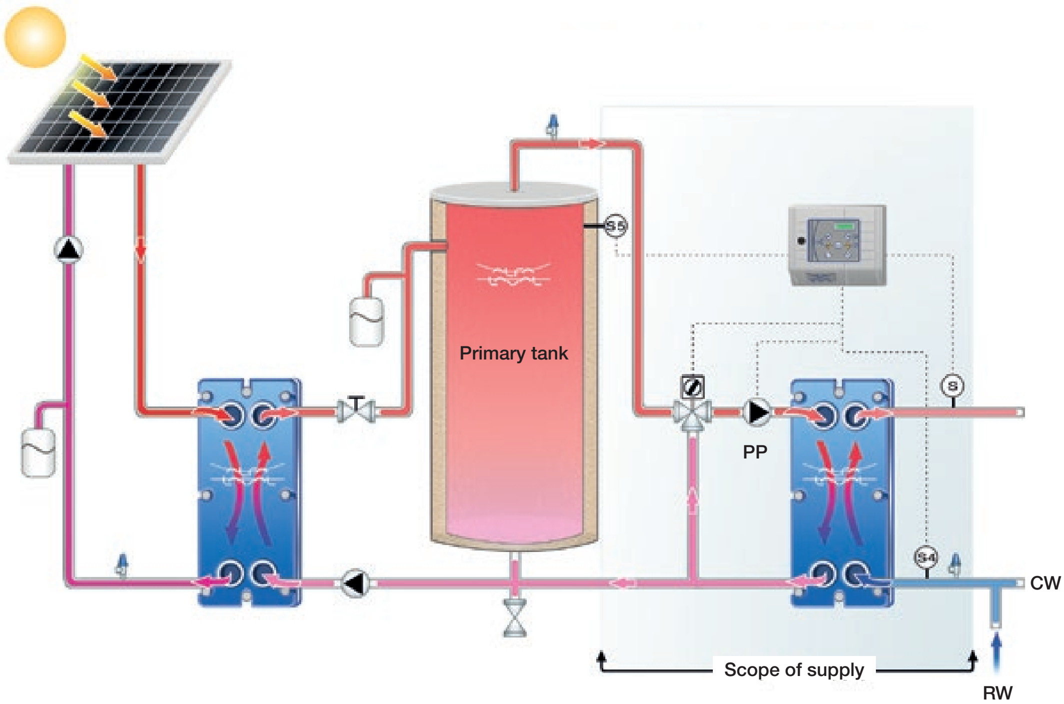
Solar heating

Transferring heat from solar collector panels is an ideal way of using the sun's energy. The sun's heat is absorbed on a flat surface, and then transferred to a fluid. The hot fluid can be used for heating domestic tap water and for radiator heating.

Solar heating is a renewable energy that works well as an alternative or supplement to other energy sources in a district-heating plant. During peak loads, or during seasons when the number of sunshine hours are not sufficient, other energy sources can be used as a complement.

It is advisable to separate the primary and secondary circuits with a plate heat exchanger and a heat exchanger system. For heating of domestic tap water, a storage tank can be used to cover the peak load demand. Alfa Laval offers suitable products for solar heating of both domestic tap water and radiators.

Working principle SolarFlow



Working principle
On the primary side, SolarFlow is connected to a primary tank that is heated by renewable energy.

A temperature sensor (S4) located at the secondary inlet checks the temperature of the water entering into SolarFlow.

The water can come from the water main (CW) or from the circulation loop (RC). This temperature is compared to the temperature checked by a sensor (S5) located on top of the primary tank.

Renewable energy vs. fossil
If water heated by renewable energy is available in the primary tank (S5>S4), then SolarFlow regulation is engaged.

A temperature sensor (S), located at the secondary side outlet, checks the temperature and adjusts the control valve (VA) accordingly in order to always maintain domestic hot water as close as possible to the set-point temperature.

If water heated by renewable energy is not available in the primary tank (S5<S4), SolarFlow goes to stand-by mode. The valve is closed, the pump (PP) is switched off and the energy consumption of SolarFlow equals zero. In that case, the tap water will have to be heated using different source of energy.

Economy mode
To generate further energy savings, SolarFlow can switch to an economy mode that will limit the electricity consumption of the pump when the network temperature is stable.

SolarFlow offers electronic control equipment that provides several user-definable functions to customize the system and ensure precise temperature control in order to reduce the build-up of limescale.

Geothermal heating

Geothermic is the science that studies the earth's heat. The earth´s heat content (enthalpy) is 10^{31} Joule and the energy the earth sends out in the atmosphere is double that what we consume. Today we only use a small fraction (0,07%) of the available geothermal energy available. A great untapped resource is at our disposal.

By using heat from geothermal water we have a cheap and environmentally friendly method for heat generation.

The ground is an inexhaustible source of heat and the seasonal variations in the soil temperature is reduced as depth increases.

At depths of 15 to 18 meters, the ground's temperature will remain absolutely constant year round at 9-12 °C. As we go deeper, the temperature will not only remain constant, but will increase by an average of 3 °C every 100 meters.

Geothermal heat is used in two major areas of application:

– Direct use of geothermal energy, involving geological anomalies or volcanic activity that provide a source of steam (which can be used to produce electricity) or hot water for heating buildings and tap water
– Low enthalpy geothermal energy, where the subsoil or ground water is used as a thermal reservoir in combination with heat pumps.

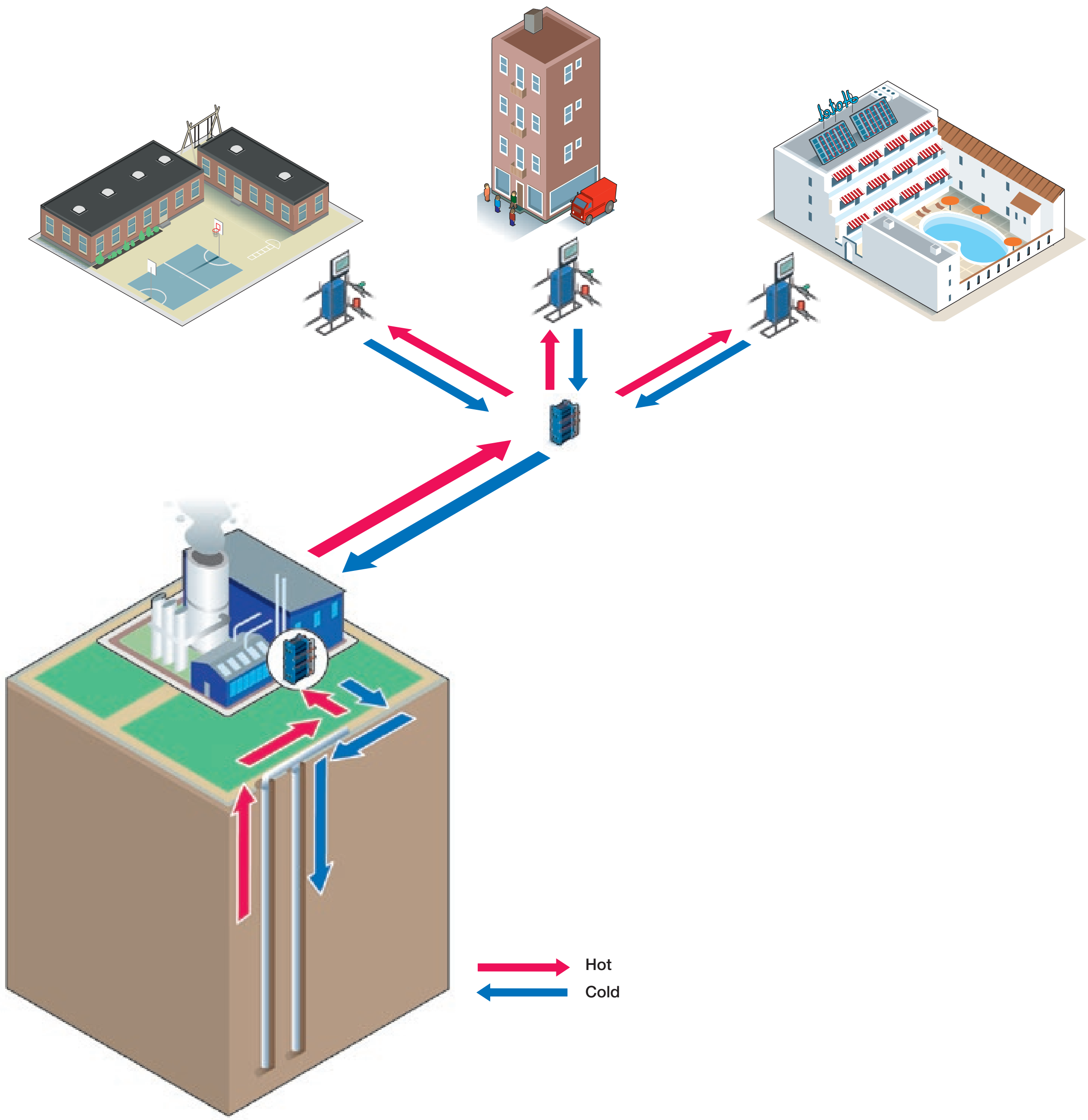
Especially in the low enthalpy geothermal energy, growth has been spurred by the availability of increasingly efficient heat pumps. With current technologies, using heat pumps is very safe and requires no additional energy from other sources (e.g. natural gas boilers) to cover consumption peaks or situations where performance is reduced.

Since the geothermal water often contains chemicals and solid particles aggressive to the plate it is important to select suitable plate materials for the main heat exchanger. Titanium or SMO are often used because of high content of calcium. Gasketed plate heat exchangers are often the preferred solution due to good serviceability, maximum heat transfer, high capacities and possibilities to increase or decrease the capacity.

The supply of geothermal heat is the same as district and community heating; it is only the heat source that differs.

Typical end users of geothermal heat are single and multi-family houses often using a heat exchanger system.

Other common applications using geothermal heat are fish farms, green houses, thermal spas and industrial applications.



Other heating applications

Steam heating

Steam has been used as a carrier of heat since the Industrial Revolution and continues to be a modern, flexible and versatile tool wherever heating is needed. It is produced by the evaporation of water; a relatively inexpensive and plentiful commodity that is environmentally friendly. Its temperature can be adjusted very accurately by the control of its pressure and it carries a large amount of energy in a small mass.

Steam is commonly used in HVAC applications as the primary heat source, heating water in the secondary circuit:

- Heat generation: Boiler plants, Combined heat and power plants
- Heat usage: Tap water heating, space heating and maintaining temperature in tanks/pools.

Some industries use a lot of steam in their processes. Surplus steam may be used for space heating and tap water heating locally, or sold for use in district- and community-heating systems.

Alfa Laval can offer different types of equipment for steam duties:

Gasketed plate heat exchangers
It is usually the temperature performance of the gaskets that sets the limits of its use. Their elastic mechanical design makes them resistant to pressure pulsation and thermal fatigue. Alfa Laval has developed a range of steam plate heat exchangers, the TS-M Series, for heating water with industrial steam

All-welded plate heat exchangers
In the all-welded heat exchanger, the gaskets have been replaced by laser-welds. This raises the performance limits considerably and makes it a very good choice for large capacities, high pressures and high temperatures.

Tubular heat exchanger
The tubular heat exchanger, Cetecoil, is well suited in steam systems due to flexibility in connections and low pressure drops on the shell side, as well as high temperature performance.

Swimming-pool heating

Using plate heat exchangers to heat swimming pools has become common practice because of its unquestioned thermodynamic advantages and low cost compared to conventional shell-and-tube heat exchangers.

At heat transfer level, the problem is maintaining temperatures steady. Accordingly, it is important that the heat exchanger be dimensioned as suggested in our selection tables.

It's important to remember that additions of chlorine should take place after the water has passed the heat exchanger to avoid a high concentration of chlorine flowing through the exchanger from coming into contact with the plates and causing cracking.

Alfa Laval offers a compact system for reheating and maintaining the temperature of water in swimming pools of any dimension – the AquaPool.

The AquaPool can be connected to any primary heat source, such as a local boiler, a solar installation, a heat pump etc.

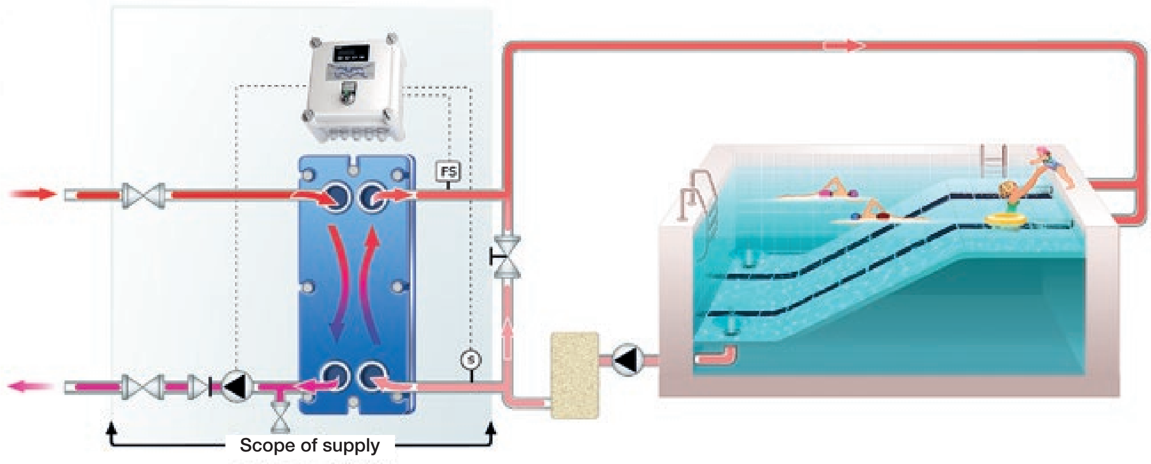
The AquaPool system consists of a gasketed plate heat exchanger, with plates in either stainless steel or titanium, an electronic control panel, a primary pump and various valves.

The AquaPool is extremely simple to use, robust, compact and highly reliable.

3 key parameters for the right AquaPool selection:

1. Volume of the swimming pool
2. Temperature rises necessary
3. Time required to heat up the pool

Working principle AquaPool



AquaPool selection tables

Model	90°C					80°C					70°C					55 °C				
	kW	Primary		Swim. pool		kW	Primary		Swim. pool		kW	Primary		Swim. pool		kW	Primary		Swim. pool	
		m^3/h	kPa	m^3/h	kPa		m^3/h	kPa	m^3/h	kPa		m^3/h	kPa	m^3/h	kPa		m^3/h	kPa	m^3/h	kPa
AquaPool-7	30	0,5	44	1,3	41	30	0,9	24	1,3	41	30	1,2	6	1,3	41	17	1,2	6	0,7	18
AquaPool-11	52	0,9	41	2,2	43	51	1,4	25	2,2	41	50	1,8	5	2,2	41	30	1,8	5	1,3	19
AquaPool-17	82	1,3	36	3,5	43	79	1,9	19	3,4	40	76	2,5	6	3,3	38	46	2,5	6	2	18
AquaPool-23	111	1,7	30	4,8	43	104	2,3	18	4,5	38	96	2,9	6	4,1	33	58	2,9	6	2,5	16
AquaPool-29	140	2,2	26	6,0	43	125	2,7	18	5,4	34	111	3,2	6	4,8	28	69	3,2	6	3	14
AquaPool-35	166	2,6	22	7,1	42	144	3,0	15	6,2	32	123	3,5	5	5,3	27	78	3,5	5	3,4	12
AquaPool-41	194	3,1	16	8,3	42	164	3,4	11	7,1	30	134	3,6	6	5,8	21	84	3,6	6	3,6	11
AquaPool-49	222	3,5	11	9,5	41	184	3,6	11	7,9	28	146	3,8	5	6,3	19	96	3,8	5	4,1	9
AquaPool-55	246	3,8	5	10,6	41	199	3,8	5	8,6	27	151	3,8	5	6,5	16					

Note: Secondary conditions: 27/47°C (if primary at 70°C, 80°C or 90°C)
20/40°C (if primary at 55°C)

Waste heat recovery

For many energy companies and municipalities there are untapped opportunities for using waste heat or surplus heat. Such heat can be found in many forms, whether it is steam going out into the air or hot water going out into the ocean.

A lot of heat is lost in power plants, oil refineries and industrial processes. Many of these losses could be retrieved and distributed by district-heating systems to heat buildings. The same fuel achieves twice the work, thereby doubling fuel efficiency.

District-heating systems provide the necessary heat load for high-efficiency combined heat and power plants, while at the same time enabling the use of renewable energy. It demonstrates fantastic opportunities for other communities from a financial as well as an environmental point of view.

A residential building in Belgium, heated by surplus energy from a waste incineration facility.

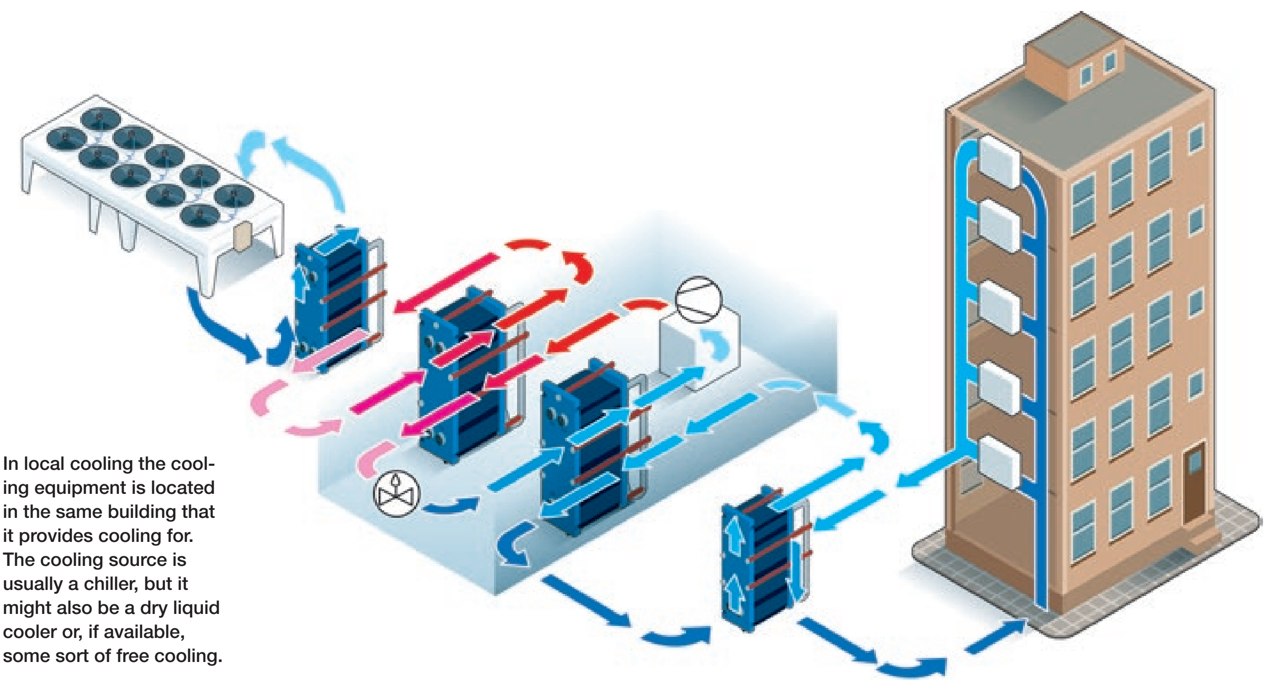
Local and district cooling

Local cooling

Local cooling is the most common cooling system globally. The local cooling system provides cooling for a single building, for example a hotel, conference center, sports center, hospital, or an office block. The chiller plant and the storage facility are located inside each building, the cooling source usually being a chiller. Depending on availability some sort of free cooling might be used, alone or in combination with the chiller. The cold from the source water is transferred to the building's internal cooling system through a plate heat exchanger.

OLA (Optimization Liquid Air), Alfa Laval's new special software, will let you calculate an optimized combination of two heat exchangers, for example a dry liquid cooler and a plate heat exchanger. This optimized package will make your system work at just the right capacity. A fine-tuned system will run smoother and minimize maintenance. It will also enable you to choose the most economical cooling source solution for each season, for example free cooling in the wintertime.

Another application is installing plate heat exchangers at different stories in tall buildings to solve the cooling system's pressure problems. These heat exchangers act as pressure interceptors, transferring the cold between the separate zones, and also protecting the air handling units and other equipment from excessive pressure.



In local cooling the cooling equipment is located in the same building that it provides cooling for. The cooling source is usually a chiller, but it might also be a dry liquid cooler or, if available, some sort of free cooling.

District cooling

The concept of district cooling is becoming more and more widespread all over the world. The idea, as for district heating, is to use one central source instead of local systems for each building. This will create both economic and environmental benefits.

The district-cooling system offers operating flexibility, since each building can use as much or as little cooling as needed, without worrying about chiller size or capacity. The installation will be very comfortable and convenient for the customer, with the possibility of using the same supplier for electricity, heating and cooling. The installation of a district cooling system is greatly facilitated if combined with an existing district-heating system, or one built at the same time, since the costs can be shared between the two systems.

One of the benefits for the customer is the saving of space at the location as there is no chiller. The investment cost will also be less than when having to invest in a chiller. There will be no need to re-place chiller, cooling towers or pumps due to wear or CFC/HCFC phase-out, as the CFC/HCFC handling problem will be taken care of. With centrally produced comfort cooling there will be no noise or vibrations. Maintenance and running costs will be lower, and a better level of equipment redundancy and round-the-clock expert management, which individual buildings cannot match, will be achieved.

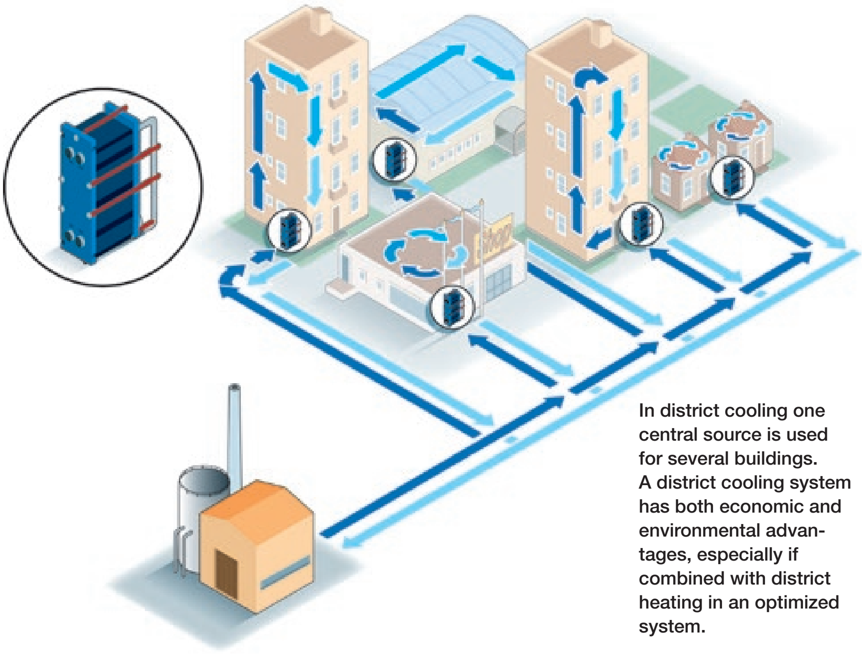
Direct and indirect cooling systems

In cooling systems the distribution can be either direct or indirect. If direct, the cooling water goes directly into the internal piping system of a building. In an indirect system, a heat exchanger separates the internal from the external system. Today this is the most common system, and the indirect system provides several benefits.

Leakage will be easier to detect, and if it does occur, will create minimum damage. There is no risk of one system contaminating another. In a district cooling system the responsibility line will be clearer, and the regulation and sales are easier to monitor with clear borders. With separate circuits the customers may experience fewer fluctuations and disturbances, should the central system expand or need maintenance.

In an indirect system the heat exchanger will also decrease the static pressure, thus working as a pressure interceptor. Noise from valves can be eliminated when the pressure in the pipes is decreased. In the indirect system solution the dimensions of the consumer's in-home system will be smaller, and thus cheaper.

Installing Alfa Laval plate heat exchangers in an indirect cooling system ensures minimal energy loss throughout the system. Alfa Laval's "close approach" enables temperature exchange approaches of no more than 0.5°C/<0.9°F.



In district cooling one central source is used for several buildings. A district cooling system has both economic and environmental advantages, especially if combined with district heating in an optimized system.

Pressure interceptor

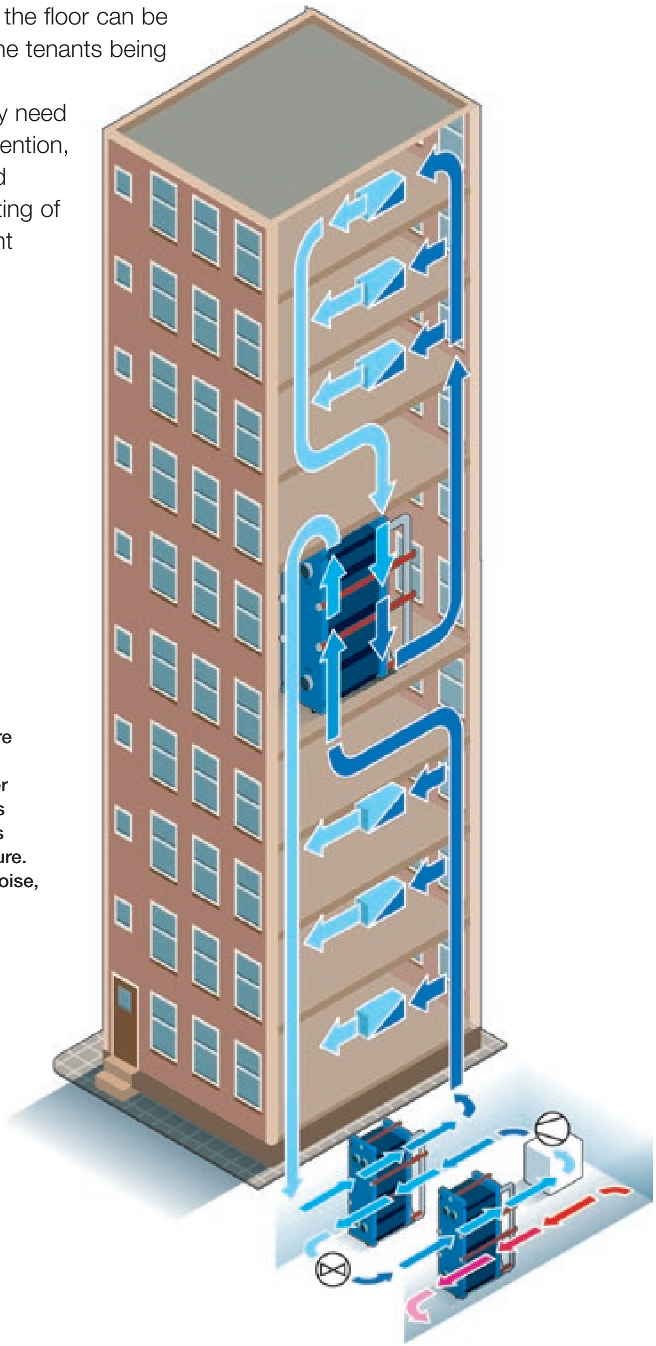
In skyscrapers, the static head creates a pressure that may exceed what the chiller condenser or room air conditioners can handle. A plate heat exchanger will then split the circuit in order to keep the pressure at an acceptable level. It is possible to put plate heat exchangers on different levels throughout the building, thus limiting the pressure and the corresponding requirements on, for example, pumps, piping and valves.

Depending on the size of a skyscraper there might be many plate heat exchangers acting as pressure interceptors. It is very important that cold is not wasted in the cooling system. Alfa Laval's "close approach" when it comes to energy efficiency means that the heat exchangers will transfer practically all cold to the top of the building with minimum loss.

Advantages of plate heat exchangers as pressure interceptors

The entire chilled water system will be designed for low pressure, for example 10 bar (150 psig). This means cost savings in the chiller as well as in the selection of air handling units and other system equipment. Instead of having many chillers in a building, plate heat exchangers can be placed on several floors as pressure interceptors. This has a positive effect on building design:

- They are very compact and only require normal room height, i.e <3 m/10 ft, and only a third of the floor space of a chiller with identical capacity. This makes them easy to install, even in buildings with limited space.
- They do not cause any vibrations or noise. This will save money for the owner as the rest of the floor can be rented out without the tenants being disturbed.
- They do not normally need any maintenance attention, apart from a planned maintenance consisting of a gasket replacement approximately every 10-12 years.



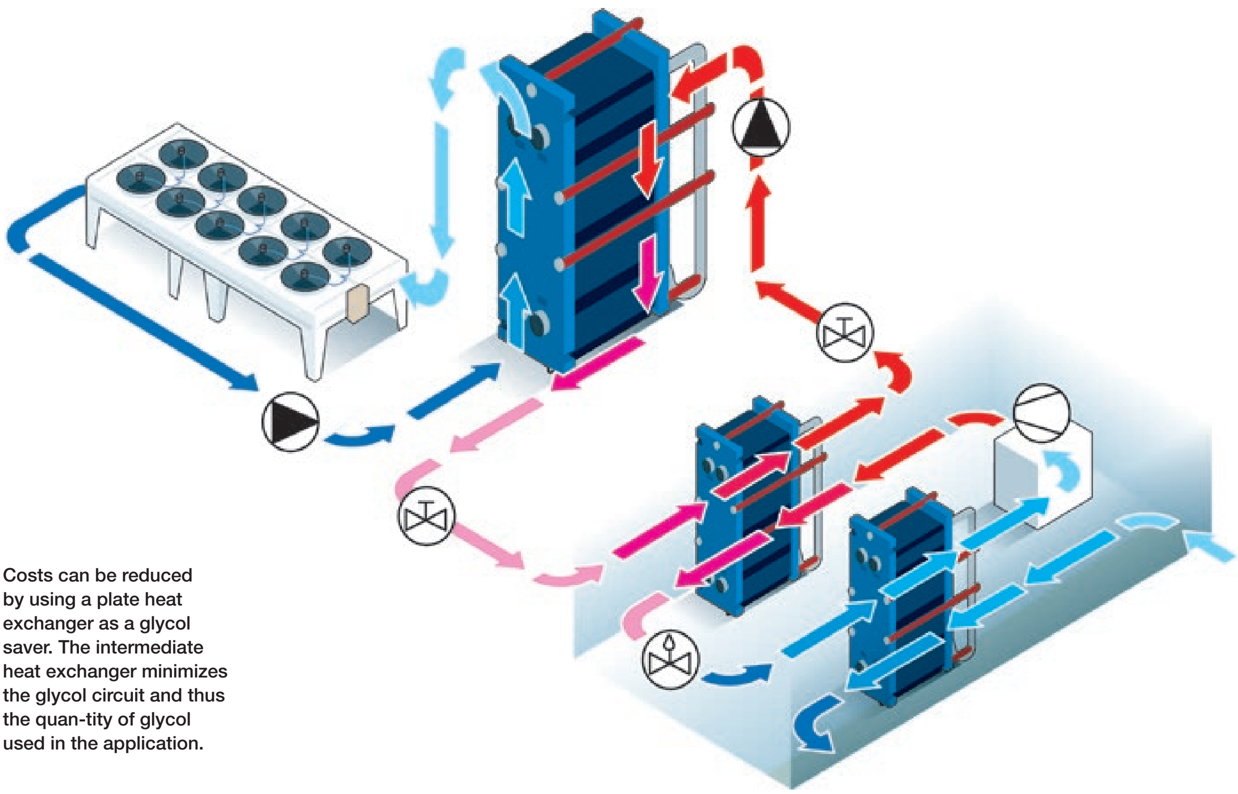
PHEs used as pressure interceptors in tall buildings protect other equipment like chillers and air condition units from excessive pressure. It is a compact, low-noise, no-worries solution.

Glycol saving

Glycol is used in systems with outside piping when there is a risk of the ambient temperature dropping below 0°C/32°F. Another cooling application for plate heat exchangers is to use them as glycol savers.

The sketch above shows an example where a dry liquid cooler is used instead of a cooling tower.
In order to avoid the risk of bacteria in the cooling tower water, this is increasingly required by law in many countries.

In cases where the dry liquid cooled condenser is situated far away from the chiller and glycol is used, the amount of glycol that has to be added to the system is high and so is the cost. An intermediate plate heat exchanger will minimize the glycol circuit, thus acting as a glycol saver and cutting expenses.



Costs can be reduced by using a plate heat exchanger as a glycol saver. The intermediate heat exchanger minimizes the glycol circuit and thus the quan-tity of glycol used in the application.

Cooling sources

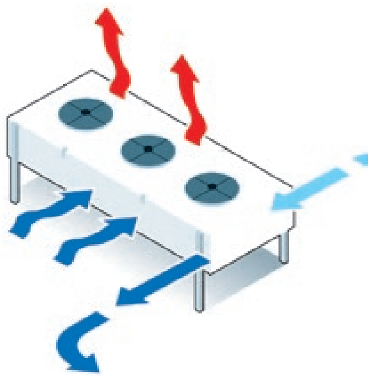
Cooling tower

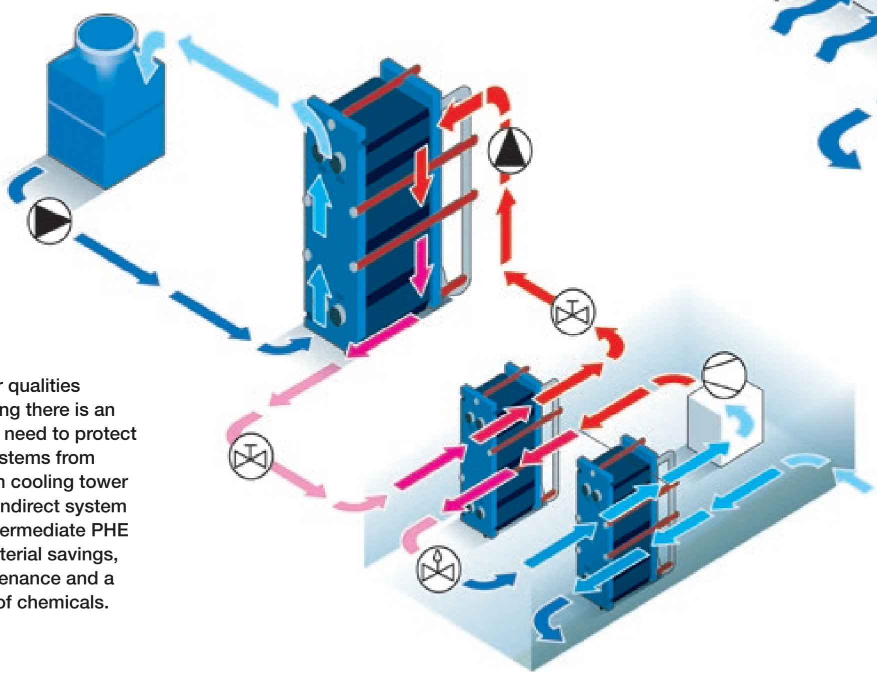
Today water qualities are deteriorating because of different kinds of pollution. This increases the risk of chiller shut-downs due to operation problems of the condenser. The condenser is subject to attacks from either chlorides that will cause corrosion or impurities or biological activities in the water that will cause fouling. As the expectations of trouble-free cooling operations have increased, it has become more and more interesting to look at alternative solutions where these problems can be avoided.

One solution is an indirect system using a heat exchanger in combination with an open cooling tower. The advantages of this are:

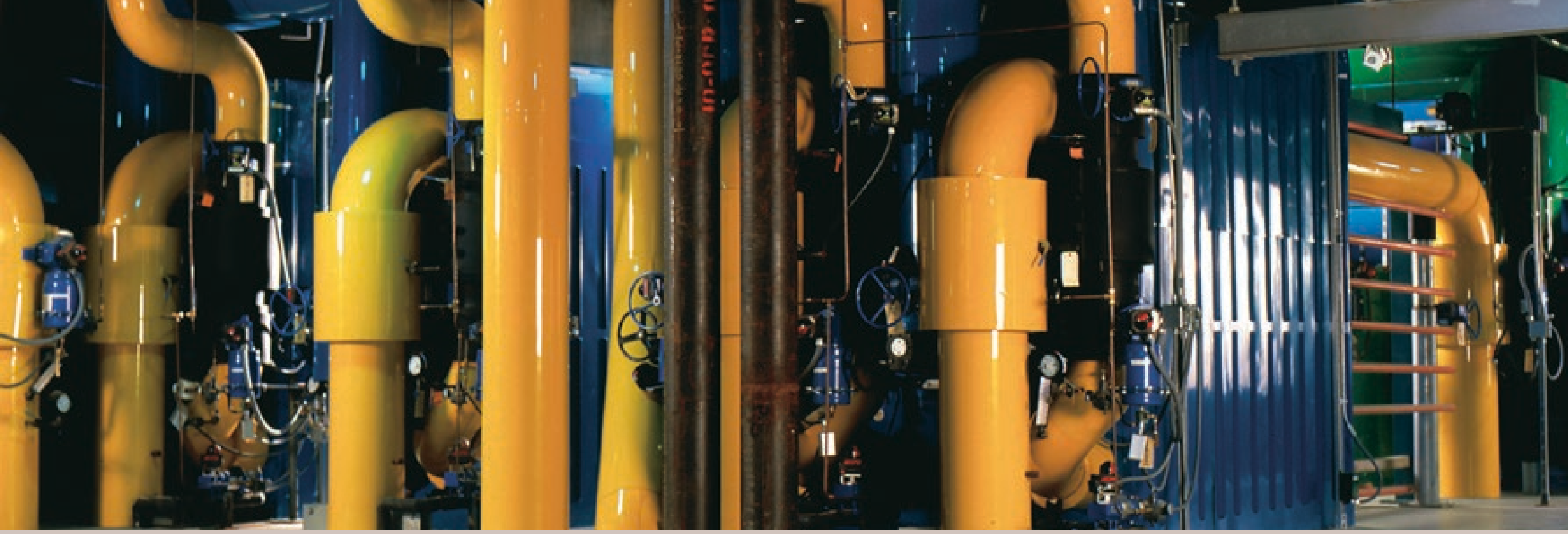
- Low system cost: Cost calculations show that the payback period of the heat exchanger is very short.
- Material savings in the condenser: Less expensive materials can be used.
- With an intermediate heat exchanger, chillers as well as cooling towers can be run at an optimal temperature.
- An intermediate heat exchanger means that the use of water treatment chemicals, for example chromates used for the cooling tower water, can be minimized.
- Less maintenance of the condenser.

For smaller or medium-sized cooling applications a dry liquid cooler is an energy-saving option that might be a source of free cooling when the temperature drops. Alfa Laval offers a wide range of high-quality dry liquid coolers.





With water qualities deteriorating there is an increasing need to protect cooling systems from pollution in cooling tower water. An indirect system with an intermediate PHE means material savings, less maintenance and a minimum of chemicals.



Free cooling

Free cooling combines an environment-friendly alternative for producing cold with economical benefits. Cooling applications relying on free cooling have been installed with good results in many countries around the world.

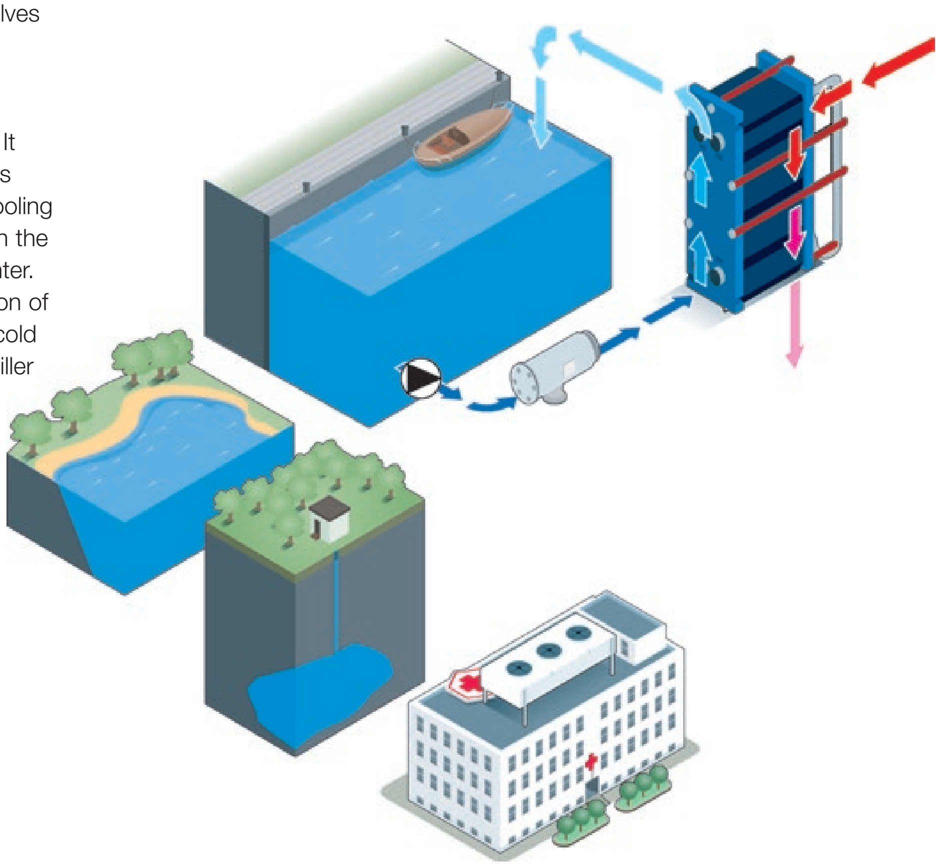
When utilizing free cooling as a cooling source in an application, the use of ecologically harmful refrigerants can be reduced. Free cooling is also a way to cut down on electricity costs – in some cases the reduction might exceed 75 percent, resulting in great savings. Reduction in electricity consumption also has positive environmental effects, as electricity production often involves air pollution.

Free cooling is used mainly for air conditioning and process cooling. It can cover the cooling requirements during the period when the free cooling source has lower temperature than the cold water, for example during winter. In spring and autumn a combination of free cooling and chiller-produced cold is used. In the summertime the chiller supplies the total cooling requirement. Suitable free cooling sources are water from for example rivers, lakes, (deep) oceans or ground water, ice and snow storage, or air.

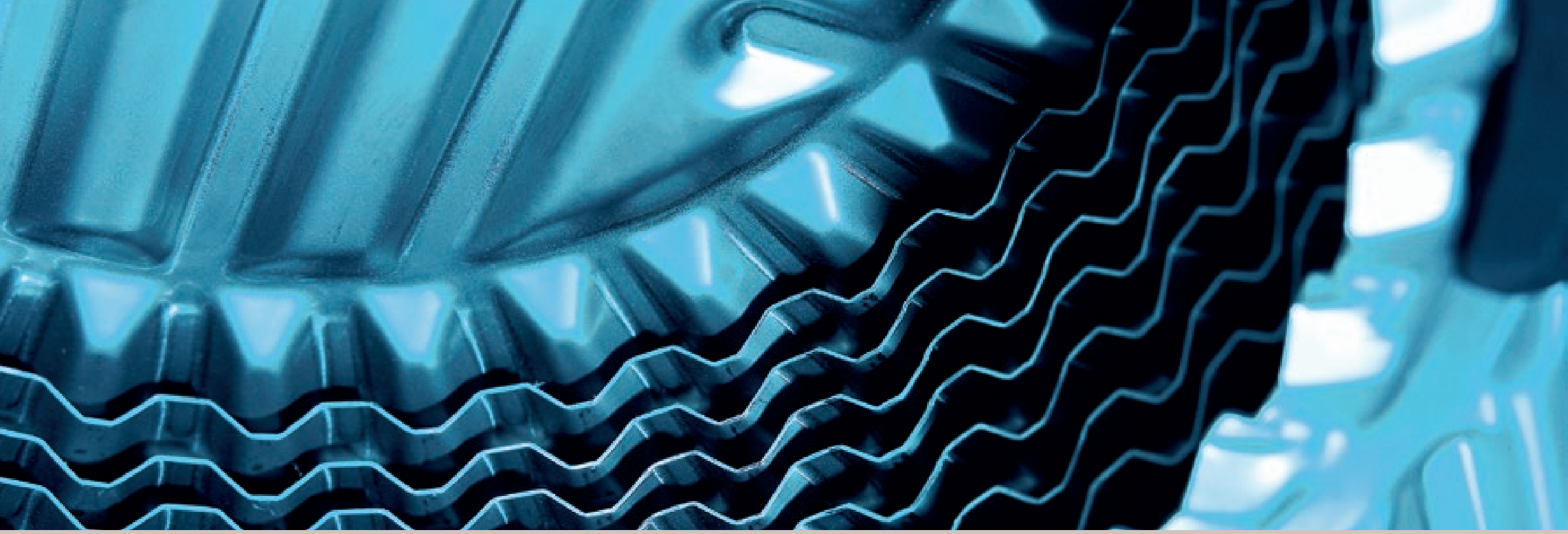
Products for free cooling

Alfa Laval's continuous research and development strategy means we are able to supply products for any cooling application, regardless of cooling media and cooling source. This makes it possible to utilize aggressive cooling media such as sea-water, brackish water, or water from rivers and wells.

By installing a plate heat exchanger, the chilled water loop can be totally isolated from sensitive equipment like air conditioners, thereby eliminating corrosion, scaling and constant maintenance. In seawater and fresh-water applications, installation of a filter for protecting the heat exchanger is recommended.
A cooling system using free cooling in combination with a plate heat exchanger will also require less space, creating an extremely compact solution.
But Alfa Laval is more than outstanding products and optimized systems. Based on our vast experience we are always able to provide quality solutions.



Free cooling has many economical and environmental advantages. Alfa Laval's knowledge about for example corrosive media has resulted in products that can handle aggressive cooling media like seawater and brackish water.

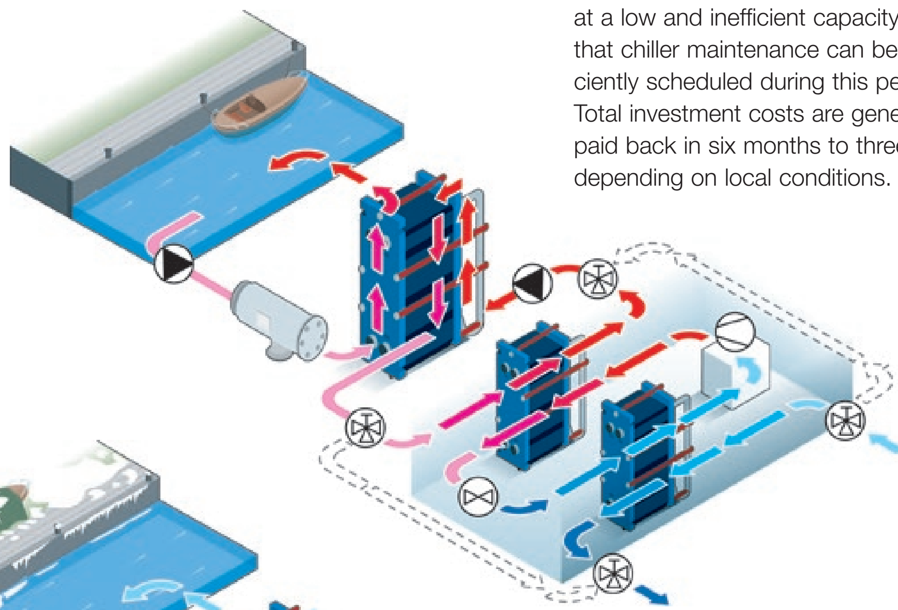


Chiller bypass

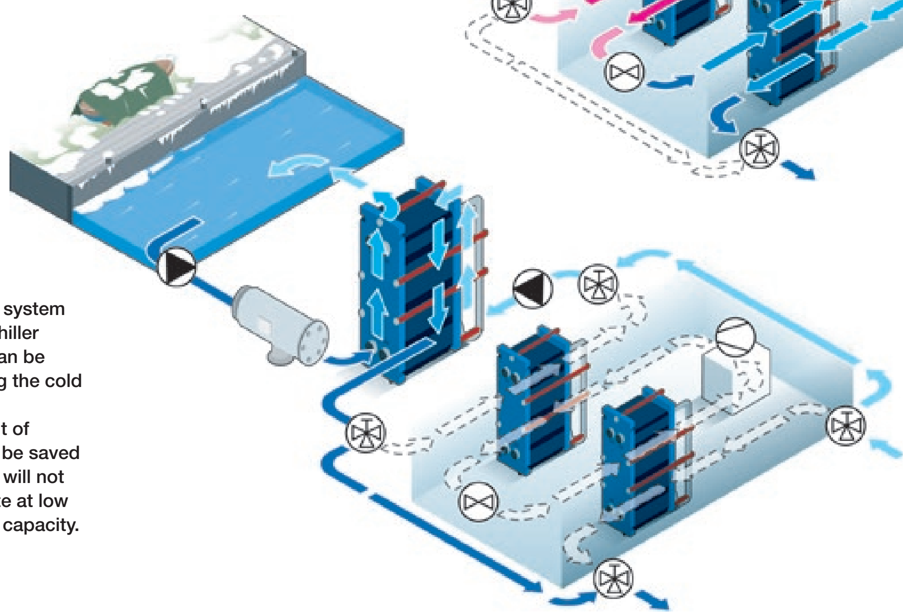
Traditionally the chiller in an air conditioning system runs continuously during the entire cooling season, even when full capacity is not required. Previously, the only alternative to constant chiller operation has been a chiller bypass system using a strainer. This strainer removes impurities, but at the same time it requires costly maintenance, chlorination and other chemical treatment.

By installing a plate heat exchanger – and sometimes a filter to protect it – in the chiller bypass system, corrosion, scaling and constant maintenance can be virtually eliminated. Another advantage is that this system can use any type of cooling, such as a cooling tower or free cooling with river or well water, even seawater or brackish water, without ruining sensitive equipment like air conditioners.

As soon as the bulb drops below the required condenser temperature (min. 1°C/1.8°F), the heat exchanger makes it possible to reduce the chiller temperature. This means that a large amount of electricity can be saved during the cold season. It also means that the chiller will not have to operate at a low and inefficient capacity, and that chiller maintenance can be efficiently scheduled during this period. Total investment costs are generally paid back in six months to three years, depending on local conditions.



Chiller bypass system (summer). The chilled water is isolated from the other cooling equipment. This minimizes costly maintenance and the system can use aggressive cooling media.



**Chiller bypass system (winter). The chiller temperature can be reduced during the cold season.
A large amount of electricity can be saved and the chiller will not have to operate at low and inefficient capacity.**

Ice accumulator/storage

An ice accumulator/storage is a tank where ice can be accumulated during one period, stored and then thawed and used during another. There are two main reasons for using an ice accumulator/storage:

- Where the cooling requirements vary during the day a smaller chiller can be used. As a result the initial cost of cooling equipment can be reduced considerably.
- Cooling energy can be purchased during the night or off-peak hours. In many countries this means that it can be obtained at a lower price.

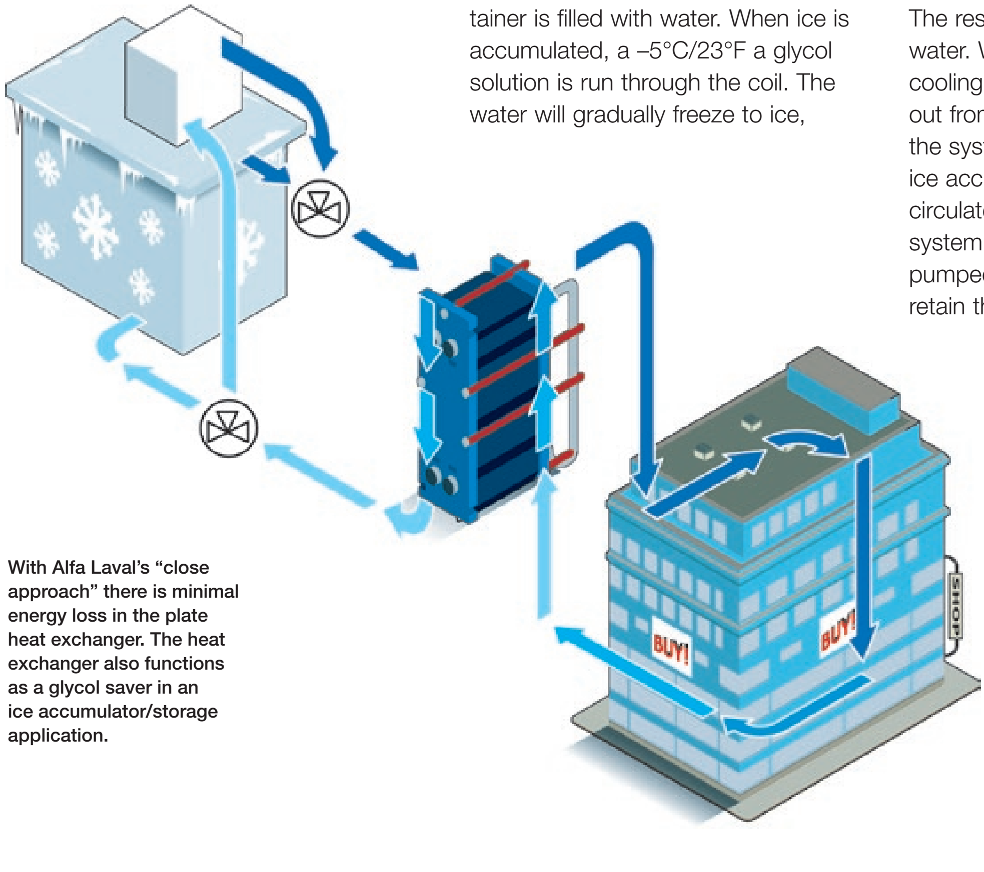
Since it has been shown that payback periods for ice accumulators will be as low as two years, it is an increasingly worthwhile investment. There are two main applications for ice accumulators: air conditioning and industry. Especially in industry, the cooling demand is often variable, for example in a dairy where the milk will be brought in in the morning.

Types of ice accumulators

There are two main types of ice accumulator systems:

- Systems with internal melting consist of a polyethylene tank containing coils of the same material. The container is filled with water. When ice is accumulated, a –5°C/23°F a glycol solution is run through the coil. The water will gradually freeze to ice, first around the coils and then further and further out in the tank. When the extra cooling capacity is required, the glycol solution in the coils will be led through the system and returned to the tank at a higher temperature. The ice accumulated in the tank will then melt, and the glycol solution will be recooled until all the ice is consumed.

- In systems with external melting the tank is made of steel or concrete. Here too are coils with glycol or a CFC/HCFC coolant, and ice is accumulated to a thickness of 35 mm/1.4 inches around each coil. The rest of the tank will be filled with water. When there is a need for cooling energy, ice water is pumped out from the bottom of the tank to the system. When it returns to the ice accumulator it will be forced to circulate around the ice. In this system, the ice water that is pumped into the system will always retain the same temperature.



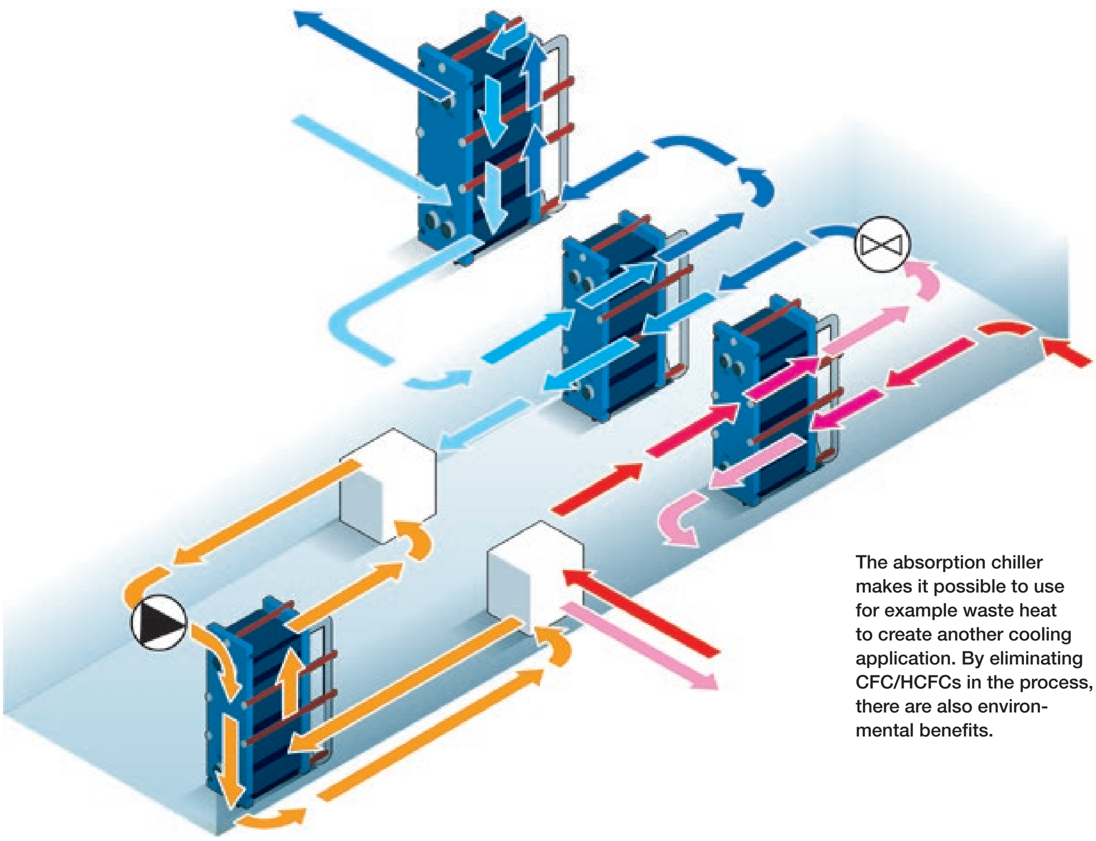
With Alfa Laval's "close approach" there is minimal energy loss in the plate heat exchanger. The heat exchanger also functions as a glycol saver in an ice accumulator/storage application.

Other cooling applications

Absorption chiller

If district heat or waste heat is available, for example from waste disposal, there is another possibility for comfort cooling with an absorption chiller. This is an example of the kind of system optimization that Alfa Laval excels in. We have the knowledge and just the right equipment for providing solutions with both economical and environmental benefits.

In this application the CFC/HCFCs influencing the ozone are replaced with for example water and lithium bromide, both environment-friendly. In the evaporator the refrigerant (water) takes up heat/energy from the connected system, thus cooling the air conditioning circuit in a heat exchanger. The refrigerant enters the absorber as low-pressure vapor, where the liquid solvent (lithium bromide) absorbs it. The pump increases the pressure and the mixture continues to the interchanger where it is preheated in for example a plate heat exchanger. Using the district heat, the refrigerant is boiled off from the solvent in the regenerator. The high-pressure vapor is sent to the condenser, where heat is emitted during the refrigerant's condensation.



The absorption chiller makes it possible to use for example waste heat to create another cooling application. By eliminating CFC/HCFCs in the process, there are also environmental benefits.

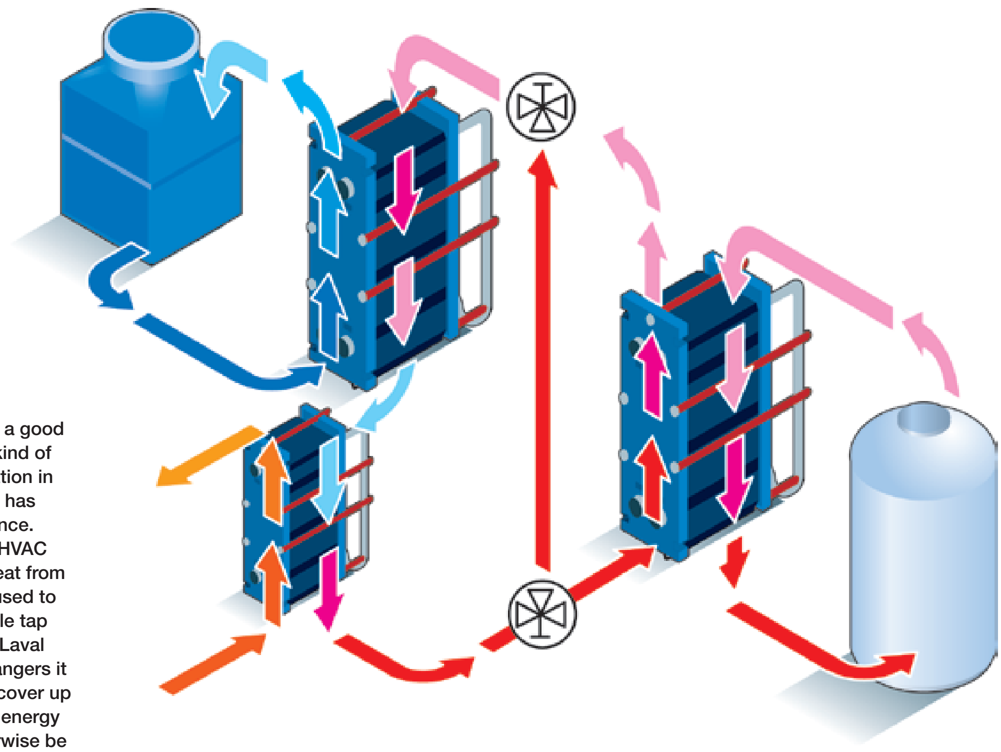
Heat recovery

In an optimized HVAC system, cooling and heating are integrated and waste heat and cold will be re-utilized in the system. Heat recovery is one often-neglected area where plate heat exchangers can be profitably used.

There are large potential savings as soon as there is a demand for hot tap water or other types of heating at the same time as the cooling system is running. Some types of buildings where this may be the case are hospitals and hotels, or different production facilities, for example in the chemical, pharmaceutical and beverage industries.

Alfa Laval has many years' experience from both cooling and heating applications and from customizing this kind of optimized system.

The heat-recovery plate heat exchanger will be installed between the condenser and the cooling tower, recouping part of the energy that would otherwise be let out in the air. While recovering heat for pre-heating tap water, for example, the cooling need decreases on the condenser side. Thus the savings will not only be the energy recovered in the heating system, but also the energy not wasted in the cooling system. Due to the extreme efficiency of the plate heat exchanger it is possible to recover up to 95 percent of the energy that would otherwise be wasted. This is often more than enough to offset the capital and operating costs of the plate heat exchanger. In this case the heat exchanger should be of the double-wall type, with double walls between the condenser circuit and the tap water, to give extra protection against contamination.



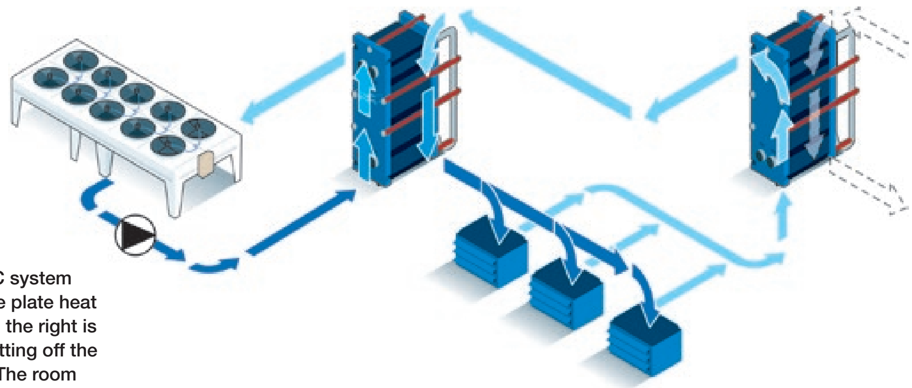
Heat recovery is a good example of the kind of system optimization in which Alfa Laval has years of experience. In an optimized HVAC system waste heat from cooling can be used to warm for example tap water. With Alfa Laval plate heat exchangers it is possible to recover up to 95 percent of energy that would otherwise be wasted.

Reversible air conditioning system

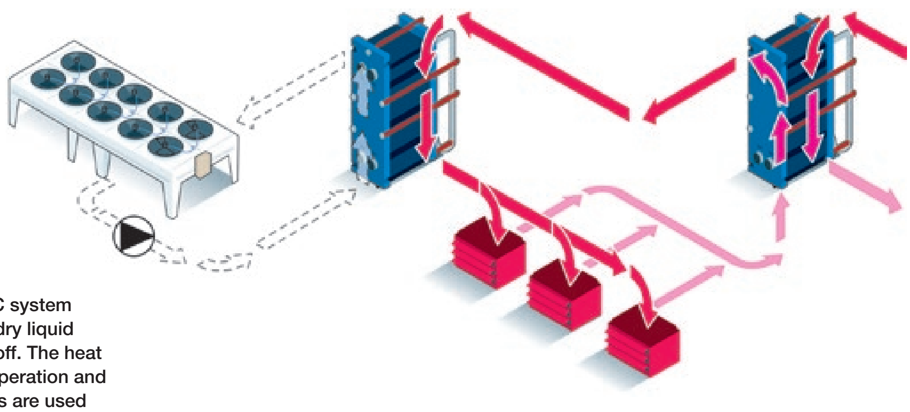
Another system where heating and cooling is integrated is the reversible air conditioning system. In this particular type of condenser cooling system there are separate small cooling units in each room of, for example, an office building. These chillers can be used as either chillers or heat pumps, depending on the season and the climate. They are all connected to a main pipe that carries water through the system. This pipe is connected both to the cooling source and to the heat source of the building.

During summer, the heat source is cut off and the water will flow directly through the plate heat exchanger on the heat-source side. The water of the main pipe will cool the condensers of the room units and transport the excess energy to the cooling source via the heat exchanger on the cooling-source side.

During winter, the cooling source is cut off and the water will flow through the plate heat exchanger on the cooling-source side with no change of temperature. Instead the heat source will now be in operation, and the water will be heated when passing the plate heat exchanger on the heat-source side. The room units will now be reversed, so that the hot water will go into the evaporators and transfer the heat to the rooms. The room units are now heat pumps.



Reversible AC system (summer). The plate heat exchanger on the right is bypassed, cutting off the heat source. The room units are used as chillers.



Reversible AC system (winter). The dry liquid cooler is cut off. The heat source is in operation and the room units are used as heat pumps.

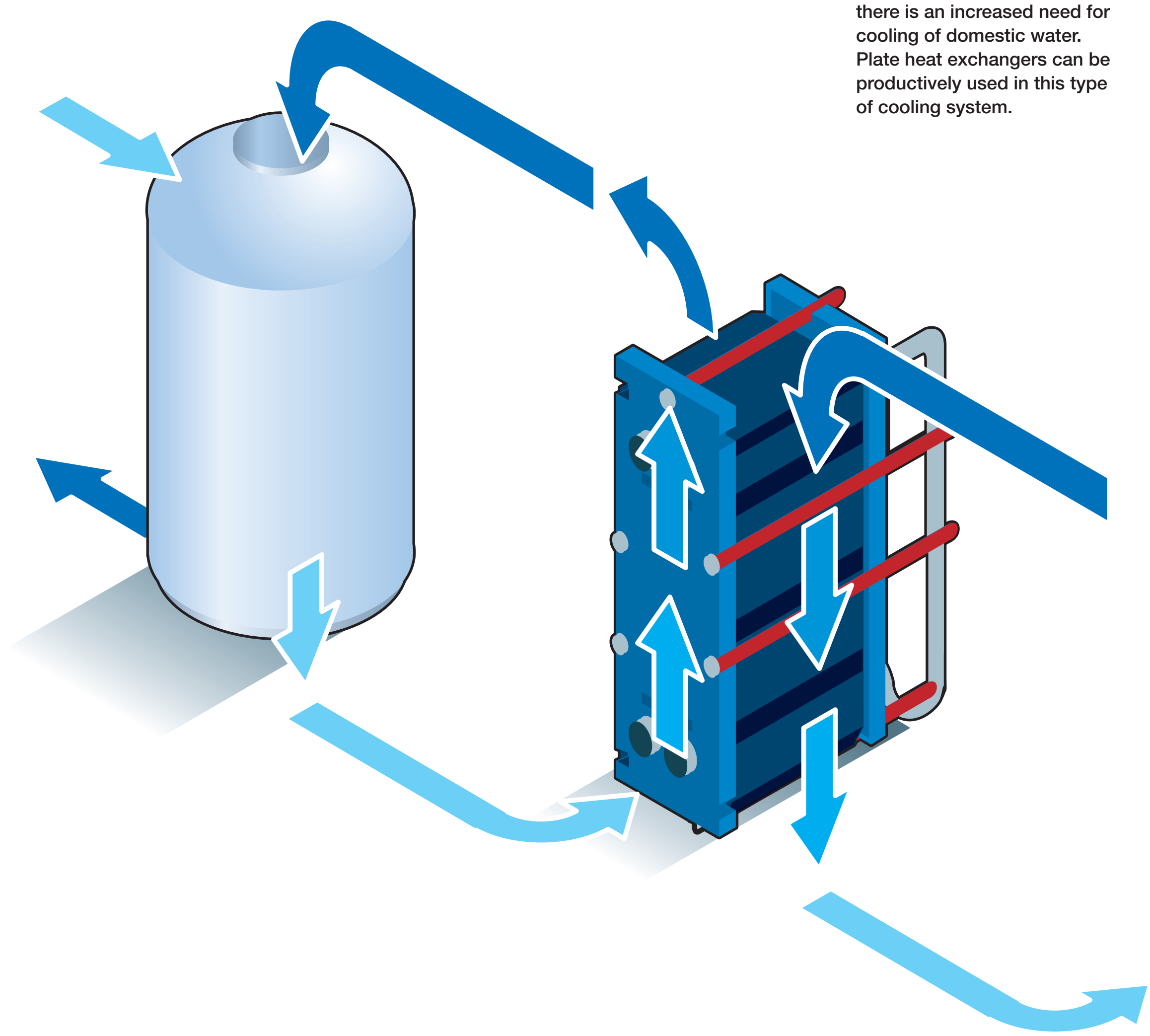
Tap water cooling

In hot geographical regions, where the atmospheric temperatures are in the range of 40–45°C/104–113°F, cooling plays a vital role in an individual's daily life. With such an atmospheric temperature one can easily imagine the water supply temperature to be in the range of 35°C/95°F.

This gives rise to the need for domestic water cooling.

This is achieved by having domestic water flowing through one side of the heat exchanger. The other medium flowing through the heat exchanger is chilled water.

In regions with extremely hot atmospheric temperatures there is an increased need for cooling of domestic water. Plate heat exchangers can be productively used in this type of cooling system.

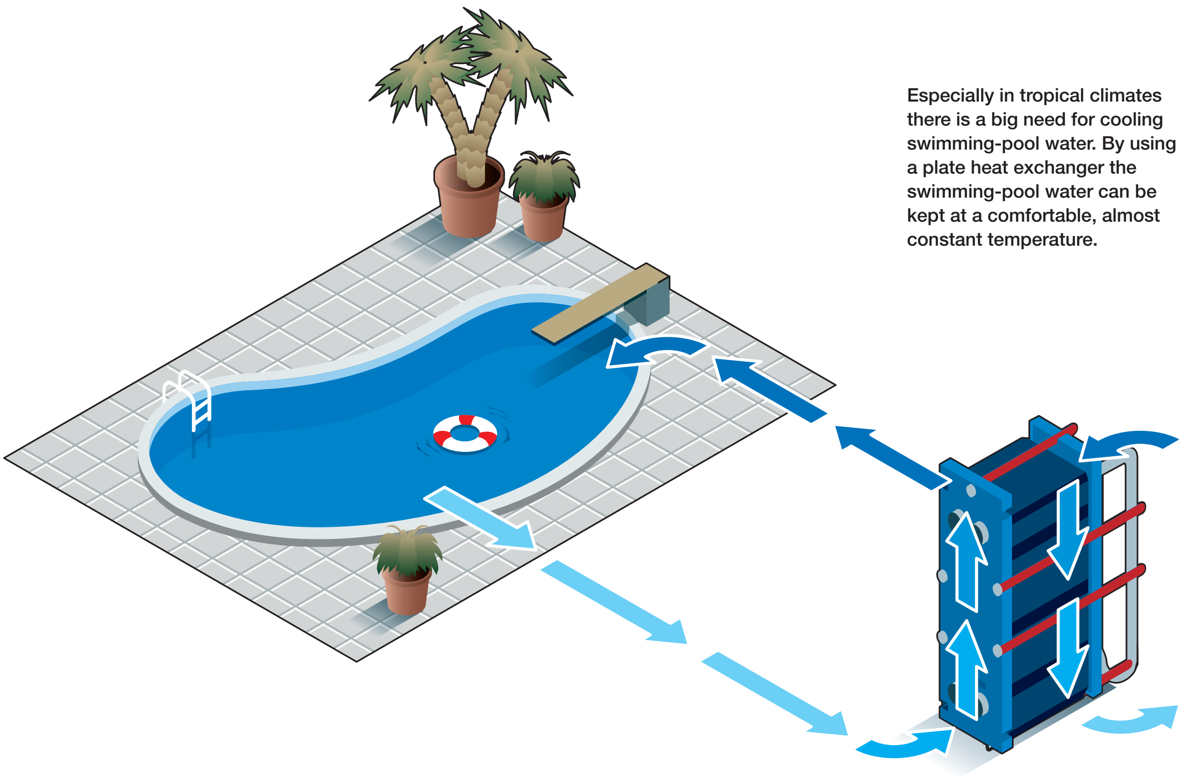


Swimming pool cooling

Plate heat exchangers can be used to maintain a nearly constant temperature in swimming pools all year round.

In hot geographical regions where the atmospheric temperatures are in the range of 40–45°C/104–113°F, there is a need to cool the incoming water temperature (~40°C/104°F) to more suitable pool temperatures (~26°C/79°F).

The swimming pool water is one of the media that flows through the heat exchanger. Chilled water is used as the other medium.



Especially in tropical climates there is a big need for cooling swimming-pool water. By using a plate heat exchanger the swimming-pool water can be kept at a comfortable, almost constant temperature.

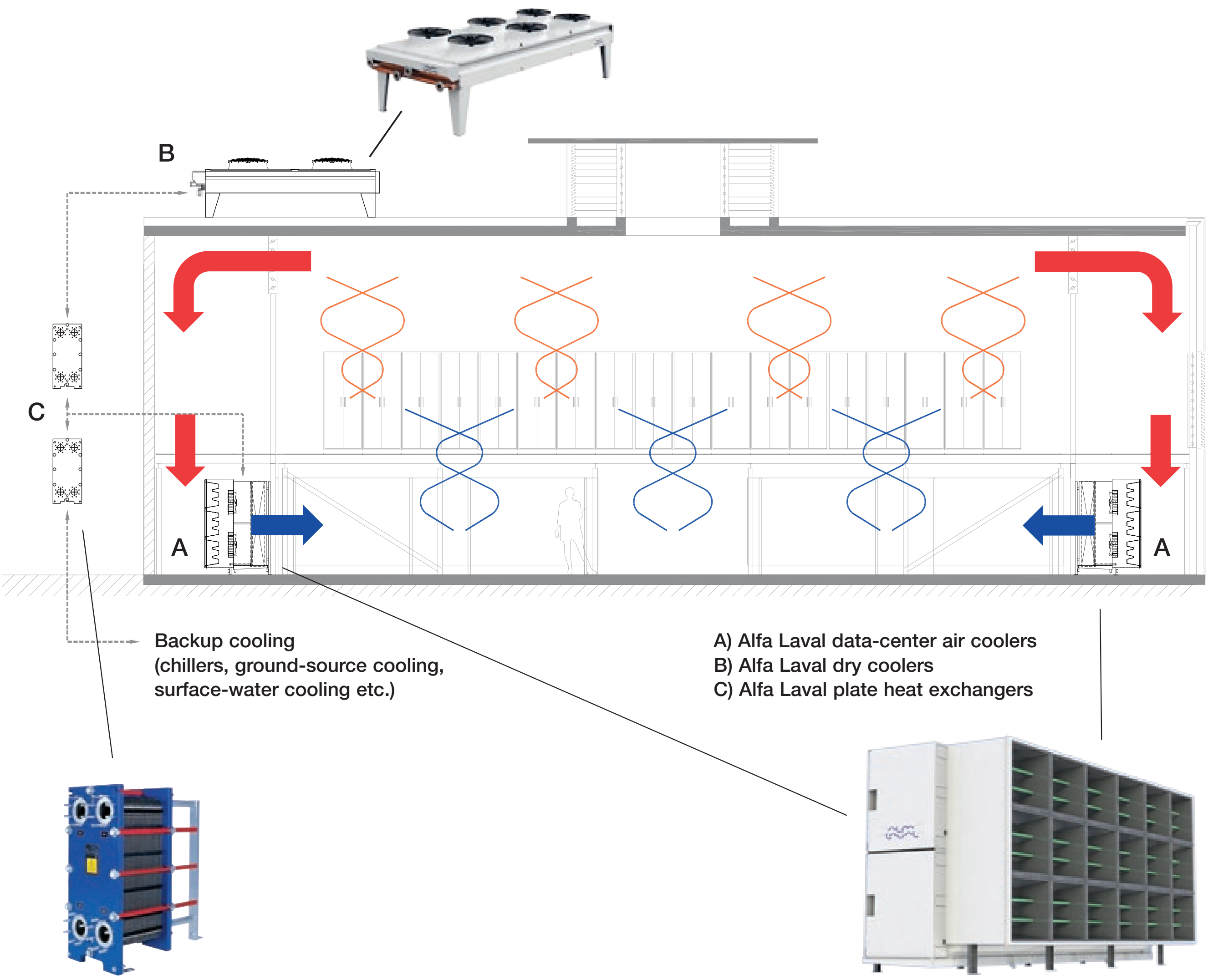
Data-center cooling

The data-center industry is a big industry in full expansion. Their needed cooling capacities grow fast, especially driven by the latest trend in cloud computing.

Typically, data-center owners and operators are looking for reliable, cost-efficient equipment with long lifetime, energy savings, elimination of hot spots in their servers and minimum maintenance.

The Low Speed Ventilation concept for data centers is a completely integrated building ventilation/recirculation system. It dissipates heat from the servers by means of low-speed controlled-air recirculation. As a result, hot spots are avoided at the lowest energy consumption possible (-30%).

Example of data-center design



Additional benefits of the Low Speed Ventilation Datacenter™ concept are:

- Lower investment compared with traditional Computer Room Air Conditioning units (CRAC): CAPEX -15%
- Very low maintenance cost (OPEX)
- Maintenance happens outside the whitespace, avoiding unauthorized people entering this sensitive area
- Suitable for both cold and hot containment
- Optimal temperature and humidity conditions at any server position
- Possibility to re-use dissipated heat
- No dust accumulation

Alfa Laval products used in the Low Speed Ventilation Datacenter™ concept

- **Alfa Laval THOR LSV Air Cooler**

THOR LSV air coolers are heavy duty industrial air coolers specifically designed for cooling servers in data centers that have been built according to "Low Speed Ventilation". LSV air coolers operate with low fan speed, low air velocities and minimal pressure differences along the route of the air flow. This is achieved by the building itself being part of the system. For this reason all THOR-LSV air coolers have been designed with a nominal of 12 Pa air-sided pressure drop and a sensible heat factor of 1.0. In case direct fresh air is used in the computer room the THOR LSV air cooler contains an F7 or F9 filter, with a pressure drop of just 25 Pa.

- **Alfa Laval plate heat exchangers**

Plate heat exchangers are used for general heating and cooling duties.

- **Alfa Laval dry coolers**

Alfa Laval dry coolers are mainly used for free cooling duties.

Alfa Laval THOR LSV Air Cooler

Alfa Laval plate heat exchangers

Alfa Laval dry coolers

Chapter 4

The theory behind heat transfer

The following pages will help you gain a better understanding of how heat exchangers work.

The basic principles of heat transfer will be clearly and simply illustrated.

The natural laws of physics always allow the driving energy in a system to flow until equilibrium is reached. Heat leaves the warmer body or the hottest fluid, as long as there is a temperature difference, and will be transferred to the cold medium.

A heat exchanger follows this principle in its endeavour to reach equalization. With a plate type heat exchanger, the heat penetrates the surface, which separates the hot medium from the cold one very easily. It is therefore possible to heat or cool fluids or gases which have minimal energy levels.

The difference in temperature is the heat exchanger's "driving energy".

Heat transfer theory

The theory of heat transfer from one media to another, or from one fluid to another, is determined by several basic rules.

- Heat will always be transferred from a hot medium to a cold medium.

- There must always be a temperature difference between the media.

- The heat lost by the hot medium is equal to the amount of heat gained by the cold medium, except for losses to the surroundings.

Heat exchangers
A heat exchanger is a piece of equipment that continually transfers heat from one medium to another.

There are two main types of heat exchangers.

- Direct heat exchanger, where both media are in direct contact with each other. It is taken for granted that the media are not mixed together.

An example of this type of heat exchanger is a cooling tower, where water is cooled through direct contact with air.

- Indirect heat exchanger, where the two media are separated by a wall through which heat is transferred.

Heat transfer theory
Heat can be transferred by three methods.

- **Radiation** – Energy is transferred by electromagnetic radiation. One example is the heating of the earth by the sun.

- **Conduction** – Energy is transferred between solids or stationary fluids by the movement of atoms or molecules.

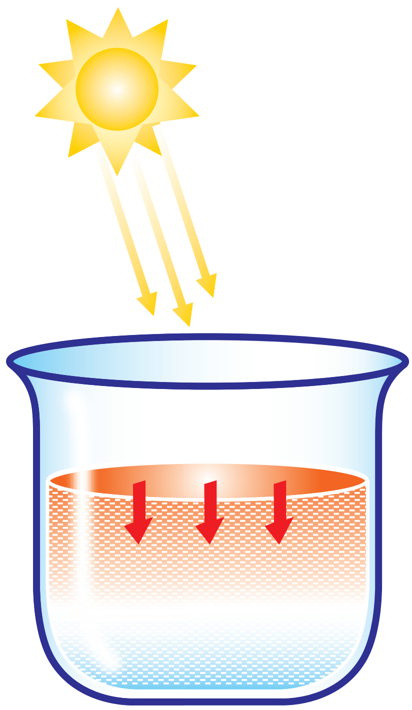
- **Convection** – Energy is transferred by mixing part of a medium with another part.

a) Natural convection, where the movement of the media depends entirely upon density difference, and temperature differences are evened out.

b) Forced convection, where the movement of the media depends entirely or partly upon the results of an outside influence. One example of this is a pump causing movement in a fluid.

Heat exchanger types
In this context only indirect heat exchangers are discussed, i.e. those where the media are not mixed, but where the heat is transferred through heat-transfer surfaces.

Temperature losses through radiation can be disregarded when considering heat exchangers in this context. Indirect heat exchangers are available in several main types (plate, shell-and-tube, spiral etc.) In most cases the



Radiation

plate type is the most efficient heat exchanger. Generally it offers the best solution to thermal problems, giving the widest pressure and temperature limits within the constraint of current equipment. The most notable advantages of a plate heat exchanger are:

- Takes up much less space than a traditional shell-and-tube heat exchanger.

- Thin material for the heat transfer surface – this gives optimum heat transfer, since the heat only has to penetrate thin material.

- High turbulence in the medium – this gives a higher convection, which results in efficient heat transfer between the media. The consequence of this higher heat transfer coefficient per unit area is not only a smaller surface area requirement but also a more efficient operation.

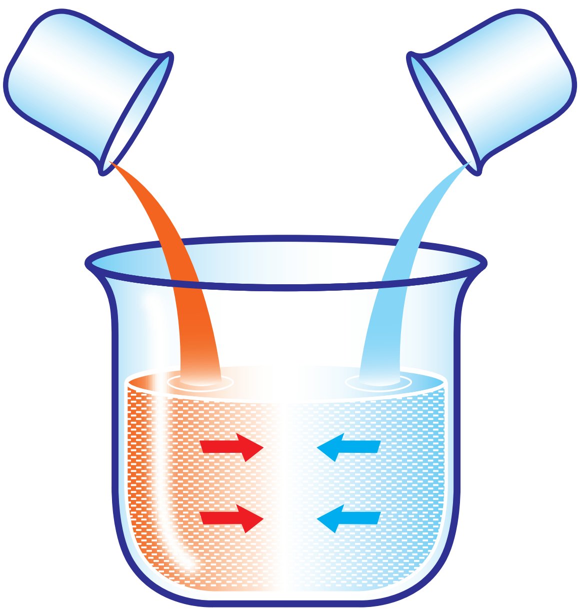
The high turbulence also gives a self-cleaning effect. Therefore, when compared to the traditional shell-and-tube heat exchanger, the fouling of the heat transfer surfaces is considerably reduced. This means that the plate heat exchanger can remain in service far longer between cleaning intervals.

- Flexibility – the plate heat exchanger consists of a framework containing several heat transfer plates. It can easily be extended to increase capacity. Furthermore, it is easy to open for the purpose of cleaning. (This only applies to gasketed heat exchangers, and not to brazed or fusion-bonded units.)

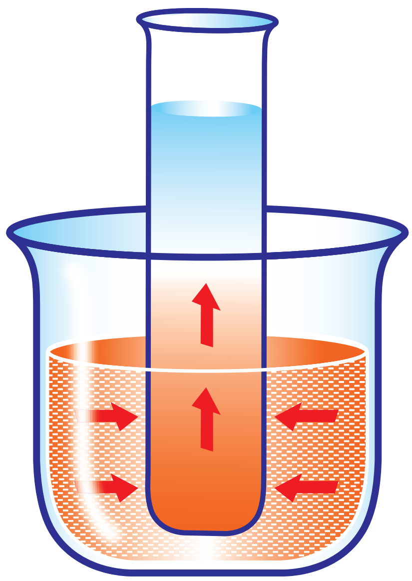
- Variable thermal length – most of the plate heat exchangers manufactured by Alfa Laval are available with two different pressing patterns. When the plate has a narrow pattern, the pressure drop is higher and the heat exchanger is more effective. This type of heat exchanger has a long thermal channel.

When the plate has a wide pattern, the pressure drop is smaller and the heat transfer coefficient is accordingly somewhat smaller. This type of heat exchanger has a short thermal channel.

When two plates of different pressing patterns are placed next to each other, the result is a compromise between long and short channels as well as between pressure drop and effectiveness.

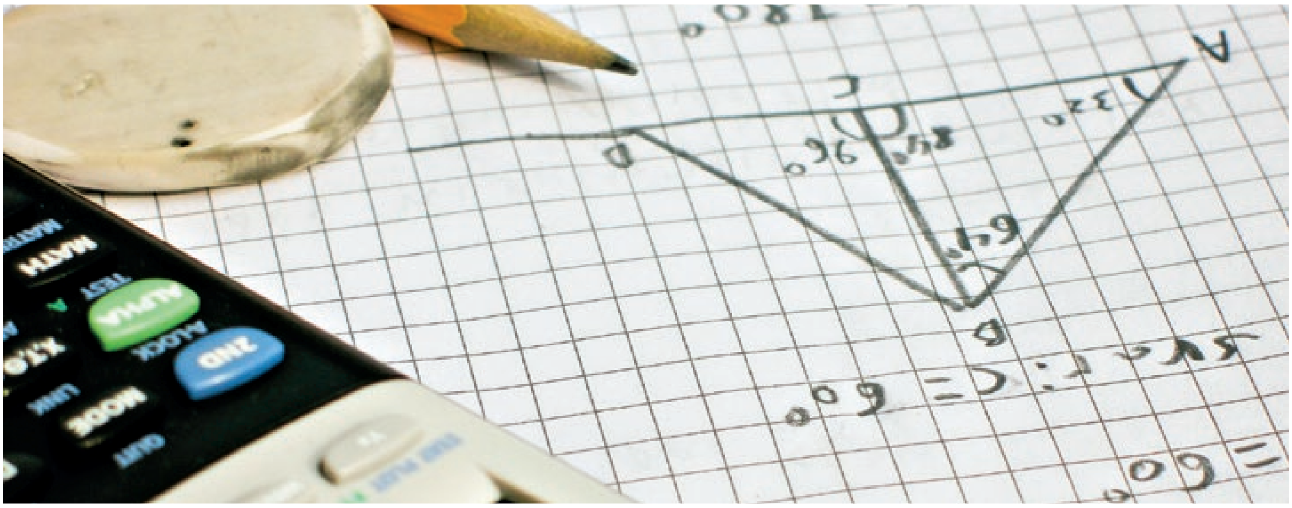


Convection



Conduction

Calculation method



To solve a thermal problem, we must know several parameters. Further data can then be determined. The six most important parameters are the following:

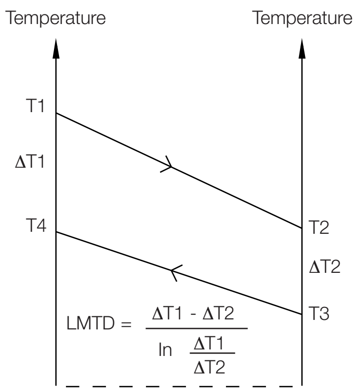
- The amount of heat to be transferred (heat load).
- The inlet and outlet temperatures on the primary and secondary sides.
- The maximum allowable pressure drop on the primary and secondary sides.
- The maximum operating temperature.
- The maximum operating pressure.
- The flow rate on the primary and secondary sides.

If the flow rate, specific heat and temperature difference on one side are known, the heat load can be calculated. See also page 4:6.

Temperature program
This means the inlet and outlet temperatures of both media in the heat exchanger.

T1 = Inlet temperature – hot side
T2 = Outlet temperature – hot side
T3 = Inlet temperature – cold side
T4 = Outlet temperature – cold side

The temperature program is shown in the diagram below.



Heat load
Disregarding heat losses to the atmosphere, which are negligible, the heat lost (heat load) by one side of a plate heat exchanger is equal to the heat gained by the other. The heat load (P) is expressed in kW or kcal/h.

Logarithmic mean temperature difference
Logarithmic mean temperature difference (LMTD) is the effective driving force in the heat exchanger. See diagram to the left.

Thermal length
Thermal length (Θ) is the relationship between temperature difference δt on one side and LMTD.

$$\Theta = \frac{\delta t}{LMTD}$$

Thermal length describes how difficult a duty is from a thermal perspective.

Density
Density (ρ) is the mass per unit volume and is expressed in kg/m^3 or kg/dm^3.

$$P = m \times c_p \times \delta t$$

Where;

P = Heat load (kW)

m = Mass flow (kg/s)

c_p = Specific heat (KJ/kg °C)

δt = Difference between inlet and outlet temperatures on one side (°C)

Cooling

For some duties, cooling applications for example, the temperature program is very tight with close approaches on the different temperatures. This gives what we refer to as high theta duties and requires high theta units. High theta duties are duties that have $\Theta > 1$ and are characterized by:

- Long plate, longer time for the fluid to be cooled
- Low pressing depth that gives less fluid per plate to be cooled

Plate heat exchangers are superior compared to shell-and-tube heat exchangers when it comes to theta values. Shell-and-tube heat exchangers can go up to a maximum value of theta ~1 while plate heat exchangers reach theta values of 10 and more. For a shell-and-tube to climb over theta value of 1 or more, several units need to be installed in a series.

Flow rate

This can be expressed in two different terms, either by weight or by volume. The units of flow by weight are in kg/s or kg/h, the units of flow by volume in m^3/h or l/min. To convert units of volume into units of weight, it is necessary to multiply the volume flow by the density.

The maximum flow rate usually determines which type of heat exchanger is the appropriate one for a specific purpose. Alfa Laval plate heat exchangers can be used for flow rates from 0.05 kg/s to 1,400 kg/s. In terms of volume, this equates 0.18 m^3/h to 5,000 m^3/h in a water application. If the flow rate is in excess of this, please consult your local Alfa Laval representative.

Pressure drop

Pressure drop (Δp) is in direct relationship to the size of the plate heat exchanger. If it is possible to increase the allowable pressure drop, and incidentally accept higher pumping costs, then the heat exchanger will be smaller and less expensive. As a guide, allowable pressure drops between 20 and 100 kPa are accepted as normal for water/water duties.

Specific heat

Specific heat (c_p) is the amount of energy required to raise 1 kg of a substance by one degree centigrade. The specific heat of water at 20°C is 4.182 kJ/kg °C or 1.0 kcal/kg °C.

Viscosity

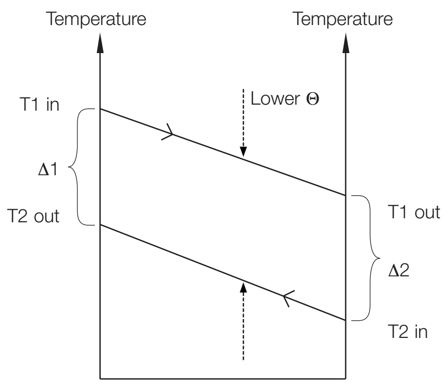
Viscosity is a measure of the ease of flow of a liquid. The lower the viscosity, the more easily it flows.

Viscosity is expressed in centiPoise (cP) or centiStoke (cSt).

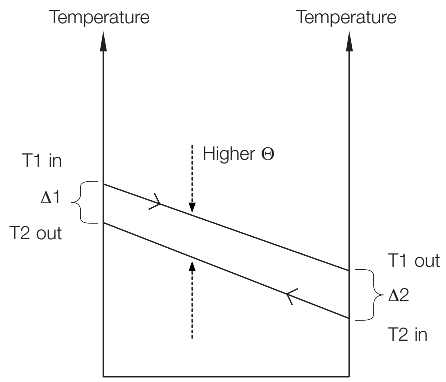
Overall heat transfer coefficient

Overall heat transfer coefficient (k) is a measure of the resistance to heat flow, made up of the resistances caused by the plate material, amount of fouling, nature of the fluids and type of exchanger used.

Overall heat transfer coefficient is expressed as W/m^2 °C or kcal/h, m^2 °C.



The diagram shows that large temperature differences result in low theta.



The diagram shows that small temperature differences result in high theta.

Calculation method

The heat load of a heat exchanger can be derived from the following two formulas:

1. Heat load, Theta and LMTD calculation

$$P = m \cdot c_p \cdot \delta t \;\left(m = \frac{P}{c_p \cdot \delta t}\;;\; \delta t = \frac{P}{m \cdot c_p}\right)$$

$$P = k \cdot A \cdot LMTD$$

Where:

P = heat load (kW)
m = mass flow rate (kg/s)
c_p = specific heat (kJ/kg °C)
δt = temperature difference between inlet and outlet on one side (°C)
k = heat transfer coefficient (W/m^2 °C)
A = heat transfer area (m^2)
LMTD = log mean temperature difference

$$\Theta = \text{Theta-value} = \frac{\delta t}{LMTD} = \frac{k \cdot A}{m \cdot c_p}$$

T1 = Temperature inlet – hot side
T2 = Temperature outlet – hot side
T3 = Temperature inlet – cold side
T4 = Temperature outlet – cold side

LMTD can be calculated by using the following formula, where $\Delta T1$ = T1–T4 and $\Delta T2$ = T2–T3

$$LMTD = \frac{\Delta T1 - \Delta T2}{\ln \frac{\Delta T1}{\Delta T2}}$$

2. Heat transfer coefficient and design margin

The total overall heat transfer coefficient k is defined as:

Where: $$\frac{1}{k} = \frac{1}{\alpha_1} + \frac{1}{\alpha_2} + \frac{\delta}{\lambda} + R_f = \frac{1}{k_c} + R_f$$

The design margin (M) is calculated as: $$M = \frac{k_c - k}{k}$$

α_1 = The heat transfer coefficient between the warm medium and the heat transfer surface (W/m^2 °C)
α_2 = The heat transfer coefficient between the heat transfer surface and the cold medium (W/m^2 °C)
δ = The thickness of the heat transfer surface (m)
R_f = The fouling factor (m^2 °C/W)
λ = The thermal conductivity of the material separating the medias (W/m °C)
k_c = Clean heat transfer coefficient (R_f=0) (W/m^2 °C)
k = Design heat transfer coefficient (W/m^2 °C)
M = Design Margin (%)

Combination of these two formulas gives: $M = k_c \cdot R_f$

i.e the higher k_c value, the lower R_f-value to achieve the same design margin.

$$\mathrm{LMTD} = \frac{\Delta T1 - \Delta T2}{\ln \frac{\Delta T1}{\Delta T2}}$$

$$\frac{1}{k} = \frac{1}{\alpha_1} + \frac{1}{\alpha_2} + \frac{\delta}{\lambda} + R_f = \frac{1}{k_c} + R_f$$

Every parameter in the equation above can influence the choice of heat exchanger. The choice of materials does not normally influence the efficiency, only the strength and corrosion properties of the unit.

In a plate heat exchanger, we have the advantages of small temperature differences and plate thicknesses of between 0.3 and 0.6 mm. The alpha values are products of the very high turbulence, and the fouling factor is usually very small. This gives a k-value which under favourable circumstances can be in the order of 8,000 W/m^2 °C.

With traditional shell-and-tube heat exchangers, the k-value will be below 2,500 W/m^2 °C.

Important factors to minimize the heat exchanger cost:

1. Pressure drop
The larger allowed pressure drop, the smaller the heat exchanger.

2. LMTD
The larger the temperature difference between the media, the smaller the heat exchanger.

Manufacturing materials
High-quality AISI 316 stainless steel plates are used in most Alfa Laval heat exchangers for water/water applications. When the chloride content does not require AISI 316, the less expensive stainless steel material AISI 304 may sometimes be used. Several other plate materials are also available for various applications. For Alfa Laval brazed and fusion bonded plate heat exchangers AISI 316 is always used. For salt and brackish water only titanium should be used.

Pressure and temperature limitations
The maximum allowed temperature and pressure influence the cost of the heat exchanger. As a general rule, the lower the maximum temperature and maximum pressure are, the lower the cost of the heat exchanger will be.

Fouling and fouling factors
Fouling allowance can be expressed either as a design margin (M), i.e. an additional percentage of heat transfer area, or as a fouling factor (R_f) expressed in the units m^2 °C/W or m^{2}h °C/kcal. R_f should be much lower for a plate heat exchanger than for a shell-and-tube exchanger. There are two main reasons for this.

Higher k-values means lower fouling factors
The design of plate heat exchangers gives much higher turbulence, and thereby thermal effeciency, than a shell-and-tube exchanger. A typical k-value (water/water) for a plate heat exchanger is 6,000-7,500 W/m^2 °C while a typical shell-and-tube exchanger only gives 2,000-2,500 W/m^2 °C. A typical R_f-value used for shell-and-tube exchangers is 1 x 10^{-4} m^2 °C/W. With k-values 2,000-2,500 W/m^2 °C this give a Margin of 20-25%. ($M = k_c \times R_f$). To achieve M = 20-25% in the plate heat exchanger with 6,000-7,500 W/m^2 °C the R_f-value should only be 0.33 x 10^{-4} m^2 °C/W.

Difference in how margin is added
In a shell-and-tube heat exchanger margin is often added by increasing the tube length, keeping the same flow through each tube. In a plate heat exchanger however, margin is added by adding parallell channels, i.e. lowering the flow per channel. This results in lower turbulence/efficiency, increasing the risk for fouling. A too high fouling factor can result in increased fouling!

For a plate heat exchanger in a water/water duty a Margin of 0-15% depending on water quality is normally enough.

Chapter 5

Product range

Alfa Laval has a full range of heat exchangers, heat exchanger systems and accessories catering to every need, however large or small.

Alfa Laval is your assurance of quality in terms of compactness, ease of installation, low maintenance costs, high energy efficiency, confidence and flexibility.

In other words, reliable operation, unsurpassed operating life span and fast return on investment.

Alfa Laval product range

Gasketed Plate Heat Exchangers

Read all about it in chapter 6

Brazed Plate Heat Exchangers

Read all about it in chapter 7

Fusion-bonded plate heat exchangers, AlfaNova

Read all about it in chapter 8

Air Heat Exchangers

Read all about it in chapter 9

Heating and Cooling systems

Read all about it in chapter 10

Tap Water Systems

Read all about it in chapter 11

Tubular Heat Exchangers

Read all about it in chapter 12

All Welded Heat Exchangers

Read all about it in chapter 13

Filters

Read all about it in chapter 14