NO. 1 /2019

HOT|COOL

INTERNATIONAL MAGAZINE ON DISTRICT HEATING AND COOLING

FOCUS

DISTRICT HEATING
FINANCE AND ECONOMY

TCO
- SECURE THE BEST POSSIBLE LONG-TERM INVESTMENT

INTERNAL RATE OF RETURN
AND HOW IT AFFECTS DEVELOPMENT OF DH PROJECTS

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Front page: Heat exchanger where surplus heat from the CP Kelco process is transferred to the district heating system (see article page 4).

HOT|COOL

HOT|COOL is published four times a year by:

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DK-2000 Frederiksberg
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Total circulation:
8,000 copies in
60 countries

ISSN 0904 9681

Layout:
DBDH /
AGENCY.071

Pre-press and printing:
Kailow Graphic A/S

The Column

By Knud Bonde, Senior Vice President,
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THE BENEFITS
OF DISTRICT HEATING

The benefits of district heating (DH) are certainly many, and the beauty is that there are also benefits to many of the different "stakeholders". Just to mention a few: the users or customers of the "product", the society – locally and nationally, the energy preservation and the environment.

Let us take a closer look at these different stakeholders…
The customer of DH is of course the most important stakeholder in this, since if they do not choose DH, DH has no market justification. The basic benefits for the customer are that they will always have an adequate supply of heat and hot water, without having any worries about operational issues, etc. Once installations are set up, the supply will simply always be available and unrestricted. Compared to other sources of heat/hot water, this means no worries, no service calls, no risk of break downs and so on. The overall economy is at a competitive level while the investment is on a similar or lower level compared to other ways of achieving heat comfort and hot water. At the same time, the current payment of usage is on a competitively low level and based on the concept "you pay as you go / for what you use".

Over the years, DH has brought benefits to the local community, having removed a lot of chimneys, which were connected to individual heating sources, thus contributing substantially to cleaner air in the surrounding areas. DH is often set up locally in conjunction with e.g. water or electricity supply, thus enabling the use of the most modern(convenient) technology. An example of this would be in the collection of consumption data from the different usages of energy and water, enabling the utilities to provide efficient and seamless services to the customers.

Generally, both locally and on a national basis, DH acts as an absorber or user of energy that would in other cases be wasted, for instance, cooling water from power production or from a variety of other productions where cooling is needed, such as production of cement or of oil. Over the latest years, DH is also absorbing excess production of electricity and converting this into hot water. With the increasing adoption of electricity production from wind and solar, 'wrong timing' of excess production of electricity is happening more and more frequently. This is where DH is helpful in creating a better balance in the total energy picture by absorbing excess produced electricity. There are numerous other examples of where energy, otherwise wasted or sold at very low prices, is converted into heat comfort and hot showers. The exploration of this issue will surely continue.

In other cases, DH is often produced by different types of biomass, like wood chips and non-recyclable waste type of materials, which are often not useable in other contexts.

To summarise, in many cities these sources will cover the entire need for DH, with the positive consequence that the usage of primary energy sources, such as oil, coal and gas for heating purposes, are constantly reduced or eliminated. Everybody can imagine the positive significance of this when it comes to using our basic energy sources on Earth and when it comes to benefitting CO2 and other environmental balances as well as reducing pollutions.

Furthermore, the use of local DH sources will for many countries, be beneficial to their international balance of payments, which any government would gladly welcome.

All in all, DH proves that it has a lot of advantages for the environment, the energy balance, the economy and last, but not least, with the built-in "no-trouble-concept" it fits very well with the modern human being, who wants to spend their time on other things in life than caring about operating a technical system for bringing up heat comfort and hot water.

Finally, we might add that most of the advantages of DH can be adopted by producing and distributing cooling/air-condition, in fact these similar concepts already exist on a big scale in areas such as e.g. Dubai.

FOCUS
FINANCE & ECONOMY

By Lars Gullev,
Managing Director, VEKS

FINANCIAL GAIN THROUGH HEAT AGREEMENT

BETWEEN DISTRICT HEATING COMPANY AND SURPLUS HEAT SUPPLIER

Well thought out heat agreement between a producer of surplus heat and a district heating company ensured both parties an economic gain at the project's realization.

This article describes the background and content of a heat agreement between the company CP Kelco and the district heating company VEKS - both located near Copenhagen, Denmark.

BACKGROUND

CP Kelco is a US-owned company that produces pectin, a natural starch. The company is located in Lille Skensved approx. 40 kilometres from Copenhagen. Pectin can be found in apples and in the shells of citrus fruits - and it is exactly the peels of citrus fruits that are used by CP Kelco at the factory in Denmark. The factory in Denmark is the largest of its kind in the world, and 98 % of the production is exported. We often encounter pectin (E-440) when we eat processed foods such as marmalade, desserts, ice-cream, ketchup, or dairy products such as yogurt and smoothies.

The process used to extract the pectin from the citrus peels involves large amounts of energy, and at the factory in Lille Skensved, the excess heat from the process has so far been emitted to the surroundings via large cooling towers.

VEKS operates a large district heating transmission network in the western part of Copenhagen and the local district heating distribution network in the town of Køge, situated right next to the CP Kelco factory. It was therefore natural to look more closely at whether the large amounts of unused surplus heat from the production of pectin could be utilized in the local district heating network in Køge.

CP Kelco and VEKS already know each other well. Already in 2008 the parties had been working together with Solrød municipality in order to examine the possibilities for Solrød municipality to establish a biogas plant, where part of the organic "waste" for the plant was to be composed of citrus peels from CP Kelco. In addition, seaweed from beach cleaning, slurry from cattle and pigs, and residual products from a pharmaceutical company were to be supplied to the biogas plant. The biogas from the plant was to be purchased by VEKS, which would utilize it in a gas engine for the production of green electricity, and the surplus heat from the engine was to be used for heating of district heating systems.

Existing cooling towers, which will, in the future, only be used as back-up if the district heating system cannot receive the surplus heat from the process at CP Kelco

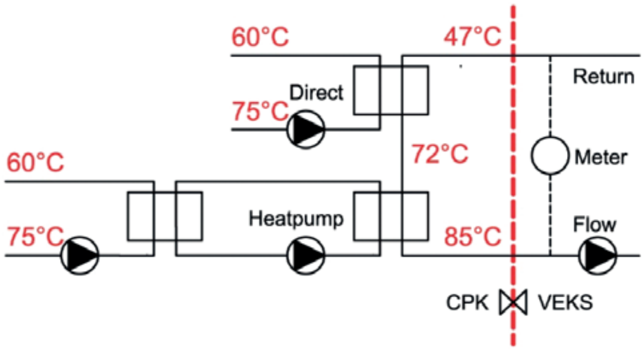
The biogas plant was officially inaugurated in November 2015, and VEKS bought the first biogas from the plant at the end of 2016, when the biogas was sufficiently clean to be used in a gas engine.

The experience from the collaboration between CP Kelco and VEKS regarding the biogas plant was so positive that the parties without reservation again in 2015 took up the collaboration with the goal of utilizing the surplus heat from CP Kelco to district heating targets, while at the same time both CP Kelco and VEKS should be able to see a financial gain from the possible realization of the surplus heat project.

After about two years of negotiations, the heat agreement was signed in December 2016, and the planning of the technical installations began. One year later, in December 2017, the surplus heat project was formally put into operation. Schedule as well as budgets had been met.

HOW IS THE SURPLUS HEAT UTILIZED?

The production of pectin generates large amounts of surplus heat, which until now has been directed to cooling towers. The idea of the project was to utilize the surplus heat in the local district heating network as follows:



The surplus heat from the process, which has a temperature of 75°C, is led to a heat exchanger. Here, the surplus heat meets return water in the district heating network at a temperature of 47°C, which is heated to 72°C through the heat exchanger. For a large part of the year, this temperature is sufficient as flow temperature in the district heating network.

If there is a need for a higher district heating flow temperature than 72°C, the temperature can be "boosted" via a heat pump, which is also provided with surplus heat from the process, at a temperature of 75°C. Thereby, the supply temperature in the district heating water can be increased from 72°C to 85°C, should the need arise.

Since the transfer of surplus heat to the district heating network for a large part of the year only takes place through the heat exchanger, the COP for the overall system is calculated to be 18.5. The first year's operating experience has shown that the COP for the system is even higher than 18.5.

But how, then, is the heat agreement - based on this plant concept - designed?

MAIN FRAMEWORK FOR THE AGREEMENT

The two parties - CP Kelco and VEKS - are very different. CP Kelco is a 100 % commercial company, which must, necessarily, focus on the fact that free capital must be yielded interest in the best way possible. This means, as a starting point, a large focus on investments with a short payback period. In contrast, VEKS - as operator of infrastructure in the form of a district heating system - has a longer time horizon for its investments. In other words: VEKS works with more patient capital.

The challenge, therefore, was to set up a contract model that catered for both considerations. A realization of the surplus heat project could be attractive for both parties with the right agreement.

What benefits did CP Kelco gain from an agreement with VEKS?

- Constant and financially attractive sales of surplus heat produced in connection with the company's primary activity - to produce pectin.
- An alternative to cooling the surplus heat in cooling towers and thereby minimizing future investments in noise reduction of existing cooling towers.

What benefits did VEKS gain from an agreement with CP Kelco?

- Future-proof and constant delivery of surplus heat at a competitive price, which in the first years would be on a par with the heat price from VEKS' alternative heat suppliers.
- In the long term, the heat price from CP Kelco would be lower than VEKS' alternative heat purchase price from other suppliers.

What are the benefits for both CP Kelco and VEKS with the agreement?

- The heat agreement would contribute to both companies' environmental and climate-related objectives - a green CO2 footprint.

Heat pump where the flow temperature in the district heating system can be boosted from 72°C to 85°C if necessary.

CONSTITUENT PARTS OF THE AGREEMENT - RESPONSIBILITY FOR INVESTMENTS AND DESIGN

CP Kelco is responsible for the investments and the design of the technical installations for utilizing the surplus heat right up to the "connection point" with VEKS - that is, for example, heat exchangers and heat pumps. The design concept must be presented to and approved of by VEKS.

VEKS is responsible for the investments and the design of the technical installations from the "connection point" with CP Kelco and to the existing district heating network - that is, for example, district heating pumps, meters, and about 150 meters of district heating pipes in the ground.

Each party prepared a budget for their own investments, freezing each party's share of the investments that would subsequently be included in "Budget Net Investments". This "Budget Net Investment" is subsequently used as a distribution number between the parties for determining the heat price, when both parties' investments have been repaid.

After completion of the construction work, each party had to prepare a building account including documentation for costs incurred. The building accounts were to be presented to and approved of by the counterparty.

The realized investments should subsequently be included in each party's "Actual Net Investments", which forms the basis for the length of the repayment periods for the parties' respective investments.

CONSTITUENT PARTS OF THE AGREEMENT - DELIVERY PERIOD

The basis for pricing of the surplus heat depends on which period of the year the supply of surplus heat occurs. A distinction is made between two periods:

- "Off-Peak Consumption Periods" are those months of the year when the heat deliveries from CP Kelco alone could be replaced by heat deliveries from the KKV CHP plant - typically 4-5 months.

- "Peak Consumption Periods" are those months of the year where the heat deliveries from CP Kelco would have been replaced by heat supplies from AVV1 CHP plant and AVV2 CHP Plants - typically 7-8 months.

CONSTITUENT PARTS OF THE AGREEMENT - SUBSTITUTION PRICE

The substitution price is defined as the price VEKS should have paid for heat deliveries from either KKV CHP, AVV1 CHP or AVV2 CHP Plant, if no surplus heat was supplied from CP Kelco:

- In the "Off-Peak Consumption Periods", this means that the substitution price corresponds to the price for heat supplies from the KKV CHP Plant.

- In the "Peak Consumption Periods", this means that the substitution price corresponds to the price for heat supplies from AVV1 CHP plant and AVV2 CHP plant.

CONSTITUENT PARTS OF THE AGREEMENT - PRICING OF SURPLUS HEAT

The agreed price for the surplus heat is in the interval between VEKS' substitution price for heat deliveries from alternative heat suppliers and the operating costs for the surplus heat from CP Kelco, including surplus heat taxes.

In period 1, it is ensured that CP Kelco's investments will be repaid. During this period, the surplus heat is settled at VEKS' substitution price, which means that for the depreciation of CP Kelco's investments, there will be the difference between VEKS' payments for the heat supply and the direct operating costs for heat exchanger and heat pump etc. This period is expected to last 3-4 years.

In period 2, it is ensured that VEKS' investments are repaid. During this period, the surplus heat is settled with VEKS, corresponding to the direct operating costs for heat exchanger and heat pump, etc., so that for the depreciation of VEKS' investments, there will be VEKS' substitution price and the difference between VEKS' payments for the heat supply. This period is expected to last about 3 years.

In period 3, which starts when both parties' investments have been repaid, the profit is divided between the parties when the surplus heat project has been realized. The profit is determined as the difference between VEKS' substitution price for heat supplied by alternative heat suppliers and the current operating costs for the supply of surplus heat. As previously mentioned, the profit between CP Kelco and VEKS is divided according to their "Budget Net Investments".

SUMMARY

The surplus heat project has now been in operation for a year and the experience from this has met expectations. Heat production has been slightly lower than expected, which has also characterized the operating costs - thus, it means a better operating result than budgeted.

The learning from the project here and now is that for such a project to succeed between such different parties like CP Kelco and VEKS, the secret is:

- A good chemistry between the parties involved at all positions of the collaboration.
- Open calculations in which each party has the full insight into the counterparty's financial calculations.
- Respect for each other's interests.
- Trust.

If the above framework conditions are present, a good, but also necessary, foundation has been created for a good project and, thus, for a good business for both parties.

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FOCUS
FINANCE & ECONOMY

By Lars Gullev, Managing Director, VEKS &
Morten Jordt Duedahl, Business Development Director, DBDH

IRR INTERNAL RATE OF RETURN AND HOW IT AFFECTS DEVELOPMENT OF DH PROJECTS

IRR is the theme discussed everywhere when looking at how to establish district heating (DH) systems – these words are still to be understood in detail and are at the same time a very important part of understanding how to roll out city-wide networks. All organisations hoping to enjoy the benefits of DH must understand what the IRR means and how a low or a high level of IRR affects the roll-out of DH. Not least, how high IRR will limit city-wide expansions of DH.

INTERNAL RATE OF RETURN - IRR
Internal rate of return (IRR) is a metric used in capital budgeting to estimate the profitability of potential investments. Internal rate of return is a discount rate that makes the net present value (NPV) of all cash flows from a particular project, equal to zero. IRR calculations rely on the same formula as NPV does.

Cities discuss how to buy back their DH companies from private companies, how they can get private funding involved and how to become more competitive and efficient all over the world. This discussion often leads back to one of private ownership or council led ownership and then again to the IRR.

In this article the authors do not discuss local framework conditions that allow or do not allow specific business models nor how local traditions influence the choice of ownership of public goods. The authors have simply noted that ownership of DH companies is (one of) the most important discussions these days – at least in Europe. The discussion of how control, cost, expansions etc. differs depending on the ownership, is becoming more and more important and often ends up being the crucial factor for a project to go forward.

THE TWO BASIC MODELS FOR OWNERSHIP

In this article we discuss two basic models of ownership: A strictly commercial and a strictly municipal/cooperative with the only difference being the expectation to IRR. Many scholars have identified several models in between the two, but for simplicity, this article claims that in essence, there are only the two. In the end, the actual ownership of pipes and production facilities is the key.

For both models, we assume that they are active market players accessing the competitive and commercial market for the best offers for pipes, welding, digging, planning, finance, operation, maintenance etc. In this sense they are both equally cost and quality conscientious. We have found no general evidence of the opposite.

LEVEL OF IRR IN THE TWO MODELS FOR OWNERSHIP

The assumption of this article is to compare similar systems – pears to pears, apples to apples! The projects are in both cases well managed, well planned, well built, well financed – in short, a "well-made" project. DH systems with their small flaws, some uncertainties, normal but good management etc. – nothing fancy or extraordinary, just a good ordinary system.

In many places with a municipal or co-operative ownership, the IRR threshold for a DH project can be around 4%, based on the cost of capital plus a security element, leaving room for small changes in the economy of the system. This is not a set standard, as the DH company may accept a lower IRR, if the project is straightforward and something that has been done many times before. Or, it may be a bit higher, if the DH company finds that there are extra uncertainties or risk factors that should be included. The 4% threshold is used often in Denmark to evaluate projects and could be used in many other countries where the main interest is to provide comfort and city development.

For a strictly commercial operation, the level of IRR will vary from project to project. Numbers as high as 18% have been mentioned – but a more realistic level may be around 14%. It must be stressed that these numbers are speculations only, as the actual level is a commercial secret, and therefore most often unknown. On the other hand, numbers around 14% are not unrealistic. It seems to be accepted in some DH communities, that 14% is acceptable and sometimes even discussed as a fact.

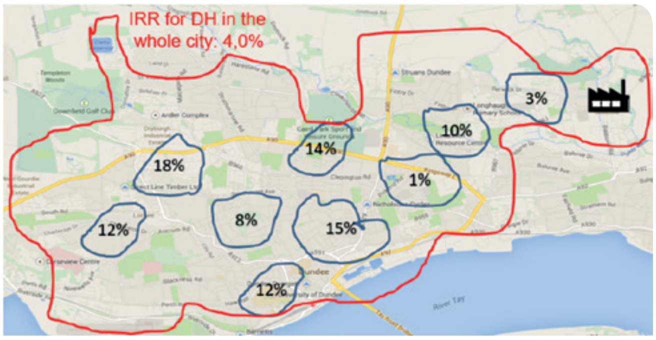
When looking at it from a different perspective, 14% does not seem way off. The commercial companies can invest in other projects (in any industry or country – chicken farming in Uganda, wind turbines in Vietnam or solar projects in Australia – just to mention a few) that will provide an IRR at the same level to their owners. And they should! The commercial companies are here to give their owners the highest possible return on investments with the lowest possible risk, including the perceived risk of long pay back times. If that leads to developing DH or something else, it is entirely up to the owners of the company.

THE LOWER THE IRR - THE MORE DH

It is as simple as that…. The lower expectations to the IRR, the more or larger DH projects a company can invest in, within their economic framework. The picture below illustrates this fact.

People familiar to the east of Scotland will recognise the map of Dundee. The examples given are not in any way based on the actual situation in Dundee – any city map could have been used. Dundee has merely been used, as discussion with knowledgeable people from Dundee created the initial idea for this article some years back.

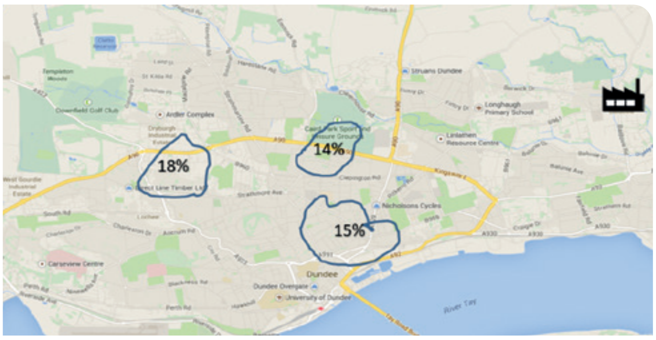
The drawing illustrates that a DH system in a city (at least in the beginning) consists of several individual projects – the blue line areas. For each of them the IRR can be calculated ranging from very high to very low. At the same time, an IRR calculation has been made to establish how large a DH system the city could create within the IRR threshold at 4% - the red line.



Picture 1. A simplified example of several projects which are to be developed over time with different levels of calculated IRR. For simplicity, only a limited number of projects have been illustrated. The remaining parts of the city will also have DH in the future. These areas would have an even smaller IRR and would therefore be the last to be developed

If a project can only muster up 10% IRR, a commercial company would not accept it unless support is given that would bring the calculated IRR up to their threshold. A municipal DH company, with a threshold of 4% IRR, would see this as a very relevant and investable project and would go ahead immediately.

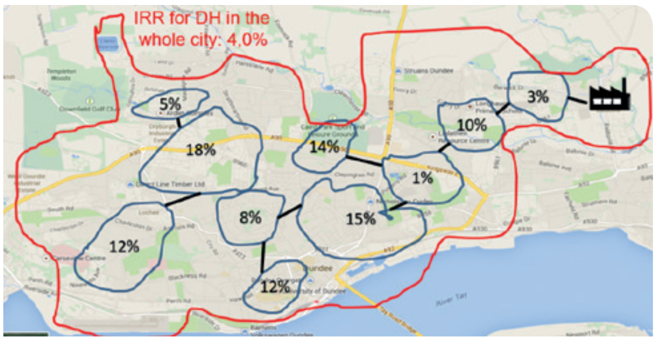
In the case of a strictly commercial ESCO approach, only three projects would be built in this city, see figure 2 – the ones with an IRR of 14% or above. A few more could be added if the local authority or another benefactor would support the developments with subsidies or cash allowances. Sooner or later, the ongoing support from any benefactor will run out and then no more projects will be developed. The complexity of having up to three individual and competing companies operating in the same area and the effects on possibilities for expansions and alterations to the systems is not discussed here.



Picture 2. An example of projects that can be developed with high IRR expectation (14% or more). More may be developed but would then rely on subsidies or grants from e.g. the local authority. The large low carbon heat sources to the left will not be included in the project and thereby lost.

A municipal led DH company with a 4% threshold will over many years develop DH throughout the entire area - see picture 3. Of course, starting with the most economic viable projects and then working their way through the different expansions and new projects. Please note that a municipal led company planning to build out into the entire area will consider building a project with a very low IRR in order to improve the economy of the entire system. In this example, it could be creating the 3% project (to the right in the picture) with the main purpose to gain access to low-cost surplus heat (as illustrated with the small black production site) and connecting several individual projects to that heat source through the project with only 1% IRR.

Other factors than strictly economical could similarly influence the order of which projects are rolled out. For example, areas with severe fuel poverty, areas in need of renovation and other local and political reasons may lead to decision makers prioritising specific projects before projects with a higher IRR – again illustrated as the 1% area.



Picture 3. Development of projects based on a council approach - on the way to rolling out DH in the whole city. In this picture the expansion of projects has been included. IRR has been assumed constant due to access to the large low carbon heat source, lower cost as the DH company has been established, experience has been gained etc.

DEPRECIATION TIME MAY ALSO DIFFER

The depreciation period (or pay-back period) used in different business models may also differ – that again makes the comparison of IRR difficult as projects should be similar in order to make a correct comparison of IRR.

For a classic end user owner / municipal owned DH company, the depreciation time in theory would be the technical life time minus a few years. For a pipe network, this may be 30 years or up to 50 years, for a biomass plant maybe 20 years, etc.

For a commercial operator it may be shorter. How much shorter is not known! Many commercial companies do simply not allow investment that has a very long payback time, as it is considered higher risk.

In this article this perspective is not discussed further but it is, however, worth considering when looking into an investment. A simple (but not entirely correct) analogy would be to consider how one would prefer to pay back a property investment – e.g. you own home. All things equal, one would prefer the longest possible payback time (up to the technical lifetime) as that would keep annual costs down.

EFFECT OF DIFFERENT EXPECTATIONS TO IRR

Imagine a project that is commercially viable for a commercial ESCO, i.e. the IRR is calculated to 14%. This project would be an easy sell and would be rolled out soon. The below will discuss the effects if a municipal ESCO with a threshold at 4% was asked to do the same project. In other words, what could the difference in IRR be "used" for. Remember that the price offered to the end user on the 14% project must be acceptable – otherwise it would not have been built.

Some of the effects are relevant in different stages of the roll out of DH in a city. Price reductions are always welcome, expansion also. But the complex process of establishing a DH company with all the lawyers, accountants etc. is a one-off situation. Climbing the learning curve is an ongoing process, but the need to climb it will decrease over time.

The first projects undertaken will be projects with the very highest IRR – they are the most obvious projects and should of course be looked at in the beginning. Projects that will provide a lower IRR should be looked at later. At that point, some of the learning and starting costs have been covered by the projects that could afford it and will therefore not influence later projects.

Figure 1 illustrates how this difference in IRR could be used for different purposes. The percentage mentioned to the left in the figure will differ from project to project, from city to city and be different depending on for example, the number of projects already completed/started.

Figure 1. Illustration of how the difference in levels of IRR can be used by a council led DH company for different purposes. The obvious could be simply to lower the price for the end user, but it is assumed that the price in both cases is fair and correct.

A DETAILED DISCUSSION OF HOW LOWER IRR COULD BE "USED"

Price reductions

The simplest way to reduce the IRR is to reduce the cashflow i.e. simply lower the price for the end-users. The definition of IRR mentions "all cash flows". This means that if the cash flows are reduced, the IRR will go down. Here, the local DH company can simply calculate backwards and find the price (cash flow) that would result in an IRR that is acceptable. In this article, this option is less relevant as we assumed the price to be fair from the beginning.

Expansions of the network

Another opportunity is to expand the project further into areas that are less economically viable – i.e. provide a smaller IRR. In this example, the DH company would increase the scope of the projects into areas with a lower IRR. The larger project would therefore be more expensive, requiring a larger investment. The cash flow would increase as more end users are connected at the specified price, but the IRR would go down as the investment grows faster than the cash flow.

Improve quality to minimise operation and maintenance cost

Project developers will always seek to find the right balance between investing into high quality to avoid operation and maintenance costs or vice versa. The effect to IRR could be neutral as an increase in investment would be offset by an increase in net cash flow, as costs would decrease. To the extent that the first projects will be developed as part of the backbone in future projects, it may be relevant to "overdo" quality over operation and maintenance. If the project is again among the first undertaken by the municipal lead ESCO, overdoing focusing on quality to avoid trouble and uncertainties on maintenance and operation costs may be relevant until the organisation has climbed/completed the learning curve.

Build in extra network capacity to support future expansions - Future proofing

Another option is for the city DH company to build in future proofing of the network. If the plan is to create citywide projects, the first projects (of course the ones with the highest IRR) should be dimensioned to be the backbone of the future system. Here cash flow would remain unchanged (if we assume that operation cost is not affected), but the investment would increase and thereby lower the IRR. This will help future projects to reach an acceptable IRR, as the first project has already acquired investments that will benefit the next projects.

Build a surplus to balance income from year to year

Many DH companies prefer to offer stable prices over the years and avoid price fluctuations. Many DH companies have a standard price for the whole season to allow the end users to budget correctly. Others change their price from month to month depending on their actual cost ensuring that all costs will be covered. It is common to create an income-buffer that allows a DH company to run a small surplus one year (if the winter is colder or warmer than expected) so as to cover for a small deficit the next year; this in turn balances the price over time.

Build equity to support future developments

This is the same as creating a surplus to balance income from year to year. Here the surplus is earmarked to building equity to support future projects with a much lower IRR – this may be projects that will connect existing areas to low-cost surplus heat.

Create the local DH company – the Council ESCO

If this project is the first project undertaken by a city run DH company, the city will need to establish and develop a DH company – this may be at a substantial cost. This would be a one time cost and only influence the IRR for the first project. Here, the first project "pays" for the total cost of establishing the DH company, to the benefit of future projects, who then have access to an experienced DH company that is already well established.

Climb the learning curve

If the project is the first project, it would be expected that small and big mistakes will be made. As more projects are being completed/undertaken, it must be assumed that the company will climb the learning curve quicker and make fewer mistakes. Again, the first few projects pay (and can afford) to climb the learning curve to the benefit of other future projects.

CONCLUSION

This article does not give guidance to which business model is the best or most relevant in different countries or under different framework conditions. It simply demonstrates the effect on the roll out of DH in a city dependent on the accepted level of IRR.

It is clear that a high level of IRR jeopardizes a city-wide development of DH and could also make access to large low carbon heat sources difficult or impossible. Besides the theme of this article, a local authority should also consider the benefits of having just one company in charge of developing DH city-wide, as opposed to having several companies and being responsible for supporting the cooperation and coordination between several independent entities.

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FOCUS
FINANCE & ECONOMY

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TOTAL COST OF OWNERSHIP ANALYSIS SHOULD ALWAYS FORM THE BASIS OF INVESTMENTS IN PRE-INSULATED DISTRICT HEATING NETWORKS

SECURE THE BEST POSSIBLE LONG-TERM INVESTMENT

It ought to be a matter of course to include a Total Cost of Ownership (TCO) analysis when investing in a pre-insulated district heating network, whether it is to expand in new areas or replace old systems, and then choose the system with the lowest costs during the service life. However, this is not always the case. We still see many examples of people investing in the cheapest possible system or continuing to build their district heating network on the same principles as always, regardless of whether it actually results in higher Total Cost of Ownership.

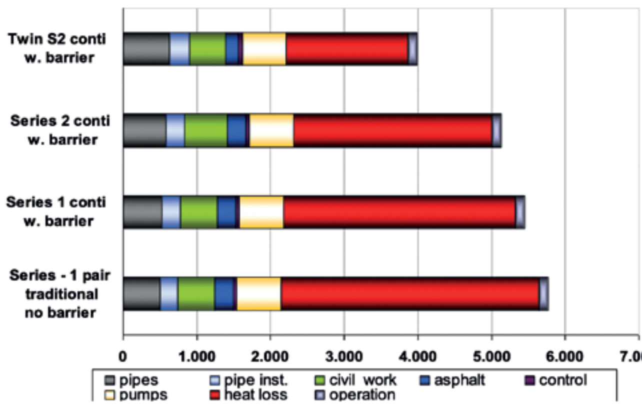
COSTS TO INCLUDE IN A TOTAL COST OF OWNERSHIP ANALYSIS

The following elements are natural to assess in a Total Cost of Ownership analysis of establishing a pre-insulated district heating network:

- Investment in the pre-insulated materials
- Investment in the welding work, installation of casing joints, and handling of pipes and components
- Investment in excavation/backfilling, asphalt, and other pavements
- Control and inspection
- Heat loss costs during the period, which is analyzed
- Maintenance and repair costs during the period, which is assessed
- Pipe dimensions and derived pumping costs

The duration of the period the analysis is based on must be determined. Normally, the period of a Total Cost of Ownership analysis is 30 years, but more and more energy companies calculate with a 50 years' period. On the other hand, there are also many examples of investments, which are assessed over a much shorter period.

The analysis will give an overview of the Total Cost of Ownership as shown in below diagram, based on an analysis of 4 different pipe systems in a case-project. The costs of the single elements of an actual project are stated in 1,000 Euro.



In the following, the essential elements in the Total Cost of Ownership analysis are outlined.

PIPE DIMENSIONS AND DERIVED PUMPING COSTS

The hydraulic dimensioning of the district heating network shall ensure that there is capacity for future expansions and connections to the district heating network. At the same time, it must be ensured that the pipes are not overdimensioned, as this will only result in too large investment costs, subsequently higher heat loss costs, and too large temperature drops in the network. In relation to the Total Cost of Ownership, the investment in pumps and the resulting annual operation costs for pumps (power consumption) are naturally important.

The hydraulic dimensioning of a district heating network and the consequent pumping costs is a complicated matter, which should be carried out by consulting engineers, specialized in this field.

In the following considerations on the Total Cost of Ownership in connection with different choices of pre-insulated district heating systems, it is a pre-condition that the hydraulic dimensioning is optimized and has been determined. That is, the service pipe dimension will be the same in all comparable systems.

INVESTMENT IN PRE-INSULATED MATERIALS

There are more aspects to take into consideration when choosing pre-insulated pipe systems. Which pre-insulated pipe system you choose has a large influence on other elements in the Total Cost of Ownership analysis, such as the contractor costs of establishing a district heating system (welding, handling pipes, casing joint work, excavation/backfilling, asphalt etc.), as well as the heat loss costs.

- Is it a TwinPipe or a single pipe system you want to establish?
- Are flexible pipes used for minor dimensions?
- Are mastic-sealed shrink joints or weld joints used?
- Which surveillance system is chosen to ensure that damages, if any, are detected in due time?
- Which insulation series is chosen?
- How is the static design of the system made and how are the movements absorbed in the system?

When choosing products for a district heating network, you must demand that the materials and product properties ensure that you get the system service life you expect.

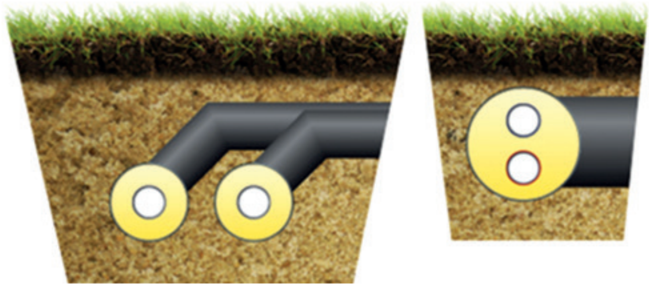
The European standards EN13941, EN253, EN448, EN488, EN489, EN14419, EN15632, EN15698 define the minimum requirements to components, system and design to be complied with, in order to obtain a minimum service life for the district heating system of 30 years, provided the continuous operating temperature is 120°C, and the peak load temperature for individual periods are up to 140°C. On average, the sum of these peak load temperatures must not exceed 300 h per year.

Most energy companies have a considerably lower load on the district heating system as regards temperature, load cycles, pressure etc. than prescribed in the European standards, and the service life is therefore expected to be higher than 30 years – up to 50 years..

TWINPIPE VERSUS SINGLE PIPE

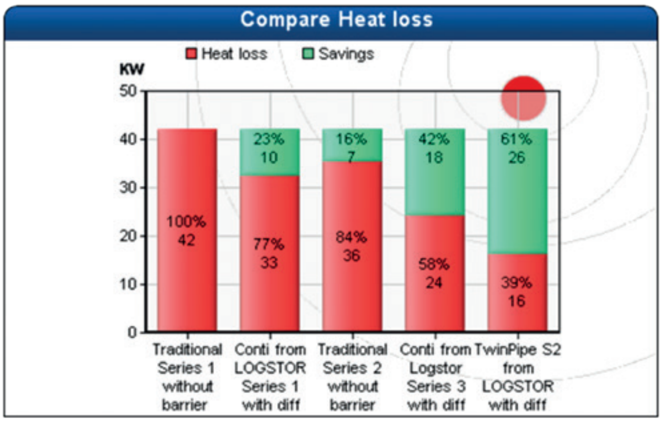
This is an essential choice, as it influences the contractor costs (investment) and the heat loss costs. Today TwinPipe systems up to DN250 are available.

By using TwinPipes the contractor costs for excavation/ backfilling can be reduced, compared to single pipes due to a smaller trench profile.'



In addition, the costs of casing joint work will typically be lower, because the number of casing joints is halved, but the dimension of the casing joints is bigger.

When using TwinPipe systems, the heat loss will be considerably lower than that of a single pipe in similar dimension, what appears from below figure, in which the heat loss in kW is stated for 1,000 trench meters DN50 in different systems.



RIGID STEEL PIPE SYSTEM OR FLEXIBLE SYSTEMS

It must be assessed whether it is advantageous to establish the minor dimensions with flexible systems in coils or not. There are flexible systems with different service pipes like Alupex, steel, copper, and PEX, which can be used dependent on temperature, pressure, and dimension.

The contractor costs of excavation/backfilling, and handling, and joining pipes are typically lower for flexible pipe systems.

The exercise is to compare this to the difference in investment in the pre-insulated pipe materials and the difference in heat loss costs.

CASING JOINT SYSTEM TO CHOOSE

Historically, statistics show that damages in a system typically occur at casing joints, and that the majority is due to faulty installation.

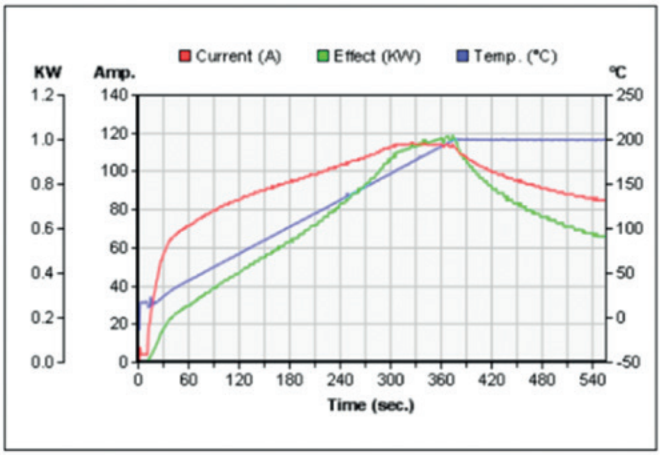
The casing joint system you choose is important to ensure that you get the system service life you expect and not unforeseen expenses for repairing damages. So it is important to choose a casing joint system with the same service life as the rest of the pipe system. The casing joints must also be easy to install to minimize the risk of faults and it must also be possible via inspection of the installed casing joints to ensure they have been installed correctly.

Typically, you can choose between the following casing joint systems

- Shrinkable PE casing joints, which are mastic sealed
- Shrinkable cross-linked PEX casing joints, which are mastic sealed
- Weld casing joints, which are fusion-welded with the outer casing of the pipe

Weld casing joints are considered by the market to be the ultimate, but also the most expensive casing joint solution. Weld casing joints require more installation equipment, but also enable the energy company to require independence of persons as regards weld data input by scanning data by means of a QR code on the casing joint as well as requirements to documentation of the welding process.

See below example where a GPS localization of the installed casing joint is possible:



No matter which type of casing joint is chosen, it is pivotal for the quality of the installation and the expected service life of the system that the casing joints fitters are trained and certified to install the casing joints in question. Therefore, the project owner should always require that fitters have completed a certifying course at the supplier's and make requirements to the contents of the course.

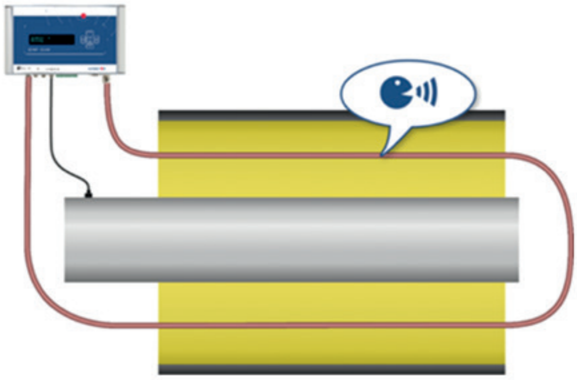
SURVEILLANCE SYSTEM TO CHOOSE

To establish a well-functioning, active surveillance system is crucial for receiving information in due time and localize any damage where moisture enters the PUR insulation. This enables you to repair the damage before it spreads, and ensures that the damage does not influence the expected service life of the pre-insulated pipe system. So, the surveillance system is a very important tool for asset management.

The surveillance system must ensure that the following faults are reported quickly:

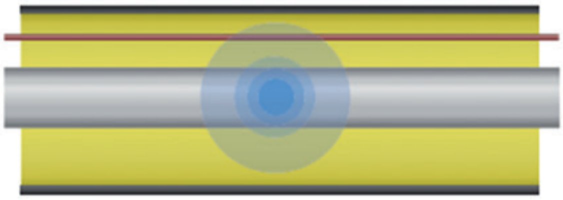
- Weld faults
- Installation faults, casing joint installation
- Product faults
- Excavation/backfilling damages
- Fatigue damage of steel
- Corrosion of service pipe

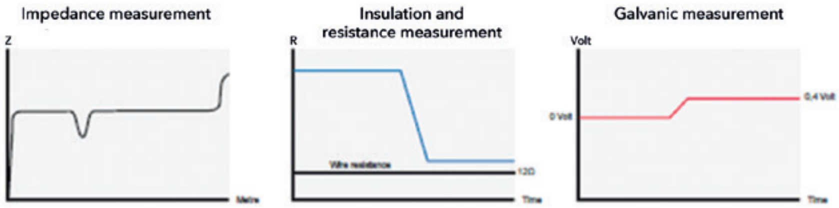
The most widely used surveillance system is the so-called Nordic system with 2 uninsulated 1.5 mm2 copper wires in the pre-insulated components. The fundamental function of the surveillance system is to give a signal, if moisture enters the insulation.



Surveillance systems can be designed after very different principles:

- Passive system. Measurements of the system are made manually by a measuring technician at preset intervals e.g. once or twice a year. No active surveillance of the system between these measurements. Fault detection is carried out by the measuring technician.
- Active system that is based on the resistance measurement principle with information as to whether there is moisture in the insulation or not. It is possible to carry out further analyses of resistance values and galvanic resistance to assess whether the insulation is wet or dry, and whether moisture, if any, comes from inside the service pipe or outside. Any fault finding is carried out by a measuring technician.





- Active system, based on the impedance principle. In addition to the above possibilities, the system can locate any faults in the system.
- Web-based management system where a single click on your PC gives you an immediate overview of the different detectors in the surveillance system – resistance measurement, galvanic resistance, localization of any faults.

HEAT LOSS COSTS

Heat loss costs are a critical element in the Total Cost of Ownership analysis of the district heating system.

Various factors influence the heat loss costs:

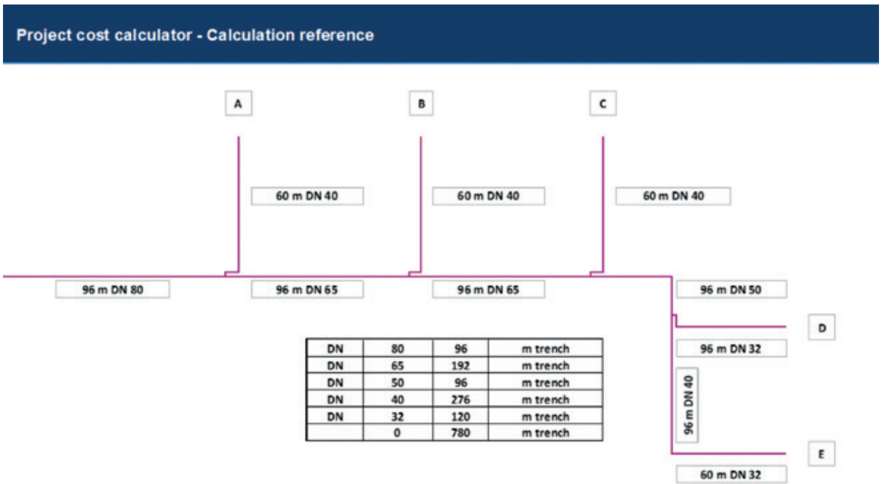
- Whether TwinPipes or single pipes are chosen. TwinPipes have a lower heat loss than single pipes in the same service pipe dimension.
- The insulation series. The standard insulation series are series 1, 2, and 3.
- The production method is of huge importance for the insulation properties of the foam. Continuously produced pipes have better insulation properties than traditionally produced pipes.
- Whether the pipes are produced with diffusion barriers or not, to ensure that the insulation properties are not deteriorating during their service life. Pipes without diffusion barriers will age and the insulation properties deteriorate over time.

TOOLS FOR ANALYZING TOTAL COST OF OWNERSHIP

There are different tools to assess the Total Cost of Ownership of different pipe systems.

Below is an example of a tool to analyze a pre-defined pipe system. The tool gives an indication of which type of pipe system gives the lowest Total Cost of Ownership, and whether you, as the pipeline responsible, make the right choices for the pipe system.

The pre-defined pipe system is as follows:



It is crucial for Total Cost of Ownership analyses that the conditions that apply to the individual energy company are used in the calculations.

A decisive condition is to settle the price of the energy cost of producing district heating to cover the heat loss.

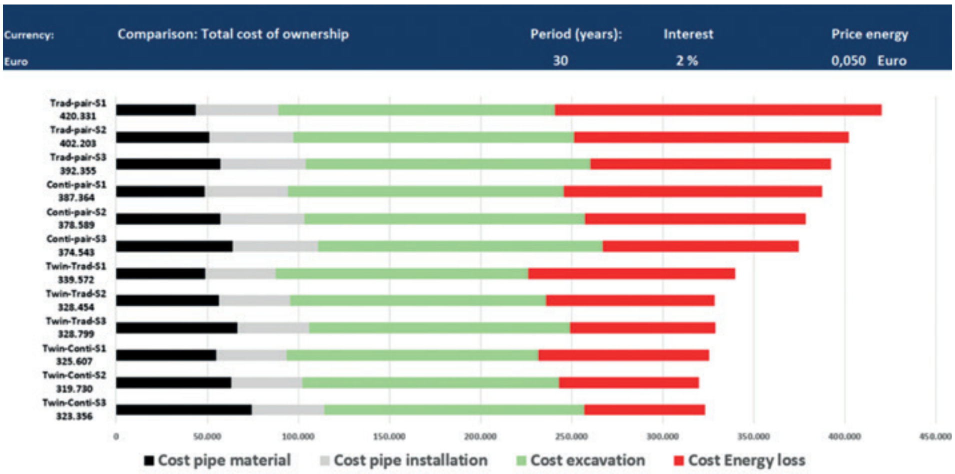
Project cost calculator - Total cost of ownership comparison

Choose language:	UK (€)		Currency:	Euro	Factor for complexity	
			Change rate	1	Factor for pipe installation (1-3)	1,25
T flow:	80	°C	Interest	2	Factor for excavation (1-5)	1,50
T return :	40	°C	Period (years):	30	(Lowest factor is very easy; highest is extremely complicated)	
T soil:	10	°C	Price energy	0,050	Euro / KWh	

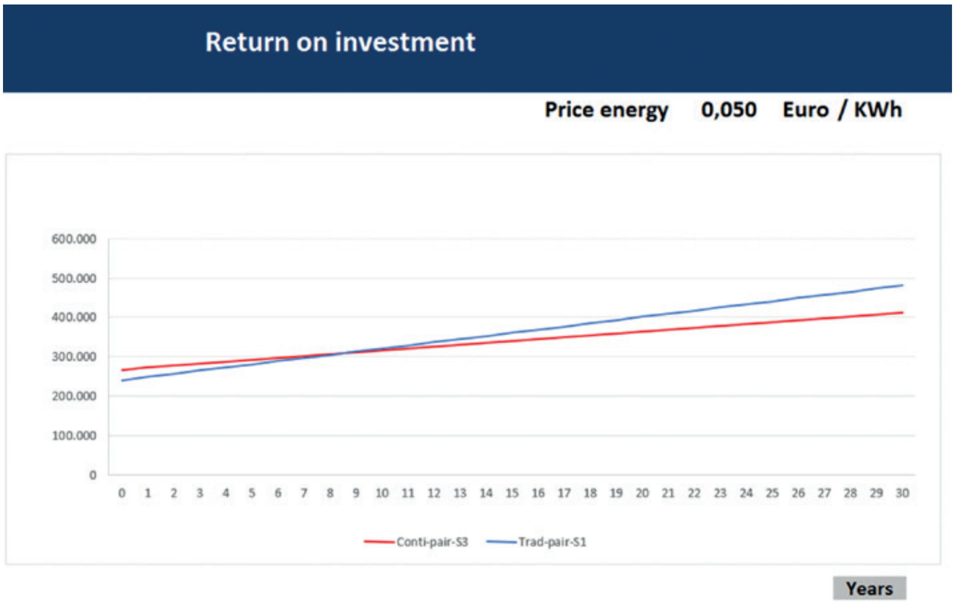
Total Cost of Ownership is calculated instantly for 12 different pipe scenarios for the same project, when above conditions have been entered. (Single pipe, TwinPipe, traditionally produced pipes, continuously produced pipes).

It is also simple to make sensitivity analyses on other conditions e.g. the price of the energy.

The investment costs for materials, installation work, and excavation/backfilling can be adjusted, so they comply with the energy company in question. See below as an example of the calculation result:



The energy company also has the possibility of comparing two different pipe scenarios and calculate the return on investment, ROI, by investing in a system with a lower heat loss.



If the analyses of the pre-defined system show that it is interesting to the energy company to choose another insulation series, TwinPipe instead of single pipe, or a pipe produced after a specific method, detailed calculations of the Total Cost of Ownership of specific projects can be carried out by means of available tools.

For further information please contact:

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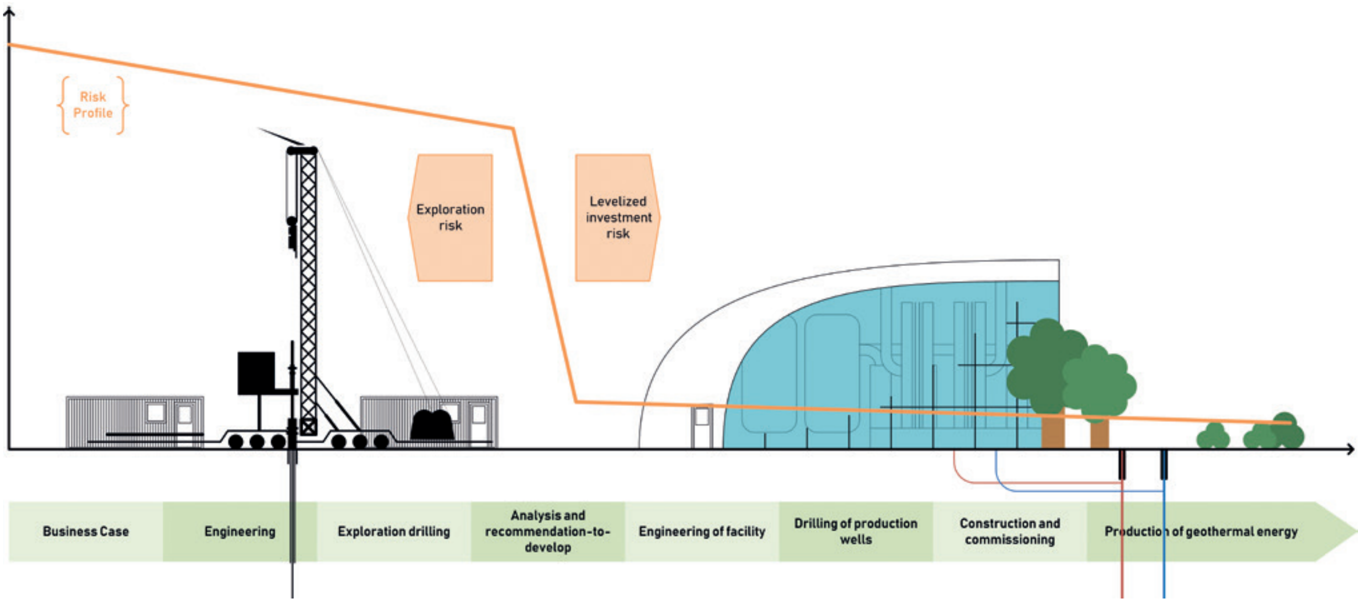
FOCUS FINANCE & ECONOMY

By Lars Andersen,
CEO, Geotermisk Operatørselskab A/S

GEOTHERMAL ENERGY
FOR DISTRICT HEATING



Geothermal energy is sustainable green energy source from the subsurface. Management of the exploration risk is key to successful geothermal projects. Once the geothermal resource has been confirmed in the exploration phase, the price of financing the geothermal project is crucial to producing the most cost-effective heat for the consumers. Geothermal energy is capital intensive in the exploration and development phases. The optimal financing scheme in the development phase turns out to be a combination of financing provided by the district heating companies and financing provided by industry partners.

THE OPTIMAL FINANCING AND OWNERSHIP MODEL

Geothermal energy production is a technical product that requires a robust financing and ownership model in order to be successful.

It all comes down to developing geothermal resources as inexpensively as possible, so that geothermal energy is competitive with alternative heat sources. This requires experienced professionals with the appropriate technical skills, inexpensive financing and a robust organization. The purpose of this article is to illustrate the considerations and parameters involved to meet the goal of supplying the consumers with the lowest heat price.

BUILD OWN OPERATE VS. TURNKEY WITH A VIEW TO CONSTRUCTION CONTRACTS

The different contract models support the goal of inexpensive heat to the consumers less or more. The most commonly used types of contracts, their characteristics and the pros and cons of each contract type are presented on the next page.

	Characteristics	Pros	Cons
Build Own Operate	The district heating company buys the heat from a supplier. The license to explore and produce geothermal energy is most likely held 100 % by the supplier / professional industry partner. The supplier carries the exploration and operational risk. The supplier owns and operates the plant for 30 years.	The supplier carries the exploration risk. The district heating company only has to pay for the heat – in principle everything is included. So, the district heating company signs a heat contract and pays an agreed price per MWh for 30 years (with some escalation built into the contract).	The consumers pay too much for heat due to high interest rates on external financing. The district heating company does not own the plant. The district heating company may not be able to reduce the interest rate with an up-front payment. The district heating company has little influence on the execution of the project.
Turnkey	The district heating company buys a turnkey geothermal plant from a supplier. Option: operations agreement with supplier The license to explore and produce geothermal energy can be held 100 % by the supplier / professional industry partner or jointly by the district heating company and the supplier.	The supplier carries the exploration risk. Turnkey gives a lower price to the consumers. The district heating company owns and finances the plant. The district heating company has to sign only one or two contracts for the whole project.	A turnkey contract is very complex as it has to take into account all situations. The district heating company has little influence on the execution of the project.
Construction contracts	The district heating company holds the license for exploration and production of geothermal energy. The district heating company manages the geothermal project from start to end and has the overall coordination of the project. Inhouse competences are required. The district heating companies in Denmark will most likely not want to go this way – especially due to the complex technical tasks such as designing and drilling the wells.	In this case the district heating company has the most influence on the project. If the project is well managed, this can lead to attractive prices to the consumers.	The district heating company carries the exploration risk. Requires that the district heating company has a high level of technical competence within several disciplines. The district heating company has to manage a large number of contracts for products and services which a typical district heating company is not familiar with. The district heating company has to coordinate activities between the different service companies.

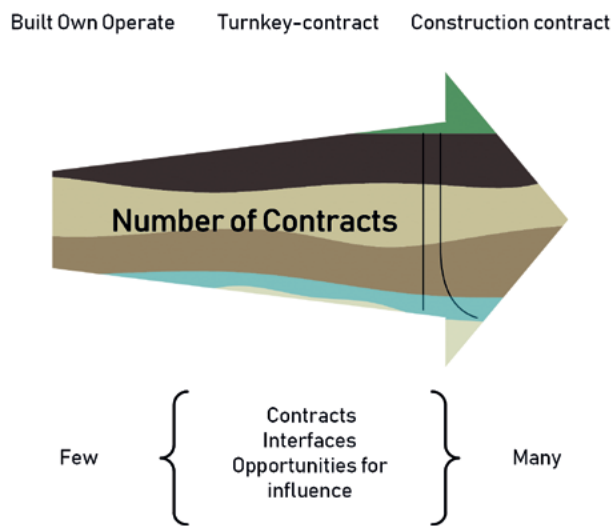
RISK – REWARD

The key question is who is willing to take the exploration risk. Geothermal projects are capital intensive in the exploration and development phases. The successful path to geothermal energy production for district heating is to involve a professional partner who is willing to carry, as a minimum, the exploration risk. Once the geothermal reservoir has been characterized and its geothermal production potential has been confirmed, the risk associated with a geothermal project has been greatly reduced.

The most significant risks in a geothermal project are:

- The exploration phase where the quality of the geothermal reservoir and its geothermal energy production potential have to be confirmed. The quality of the reservoir influences the number of wells to be drilled and the capital expense of the project.
- The interest rate on the capital invested in all phases of the project. If the district heating companies contribute with low-cost financing (up-front payment) the heat price decreases significantly.
- The consumers end up paying too high of a heat price due to improper risk management and expensive financing.

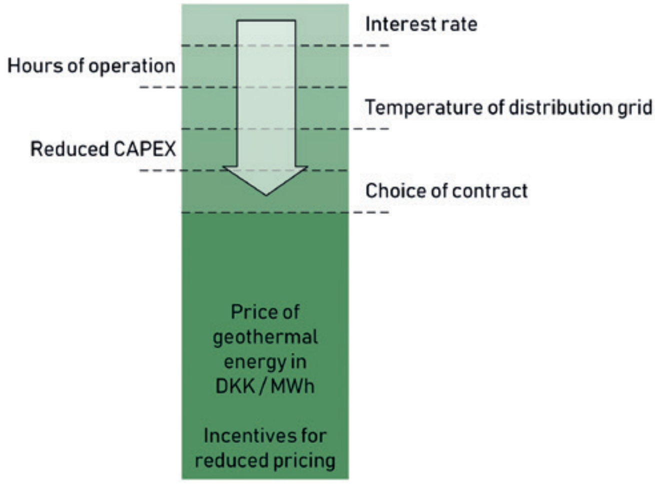
There is a significant financial reward for the consumers if the exploration risk is carried by a professional partner and the district heating company contributes with an up-front payment in the development phase. The project risk decreases significantly after the exploration phase, which makes it attractive for a district heating company to participate financially in the project starting in the development phase.



COST DRIVERS

The major cost drivers in a geothermal project are listed below along with examples of actions that can be taken in order to reduce the heat price:

- The interest rate
  By reducing the interest rate by 1 %, the heat price can be reduced by up to DKK 20 per MWh
- Number of hours
  By increasing the number of hours in operation from 5,000 to 5,500 per year, the heat price can be reduced by additional DKK 20 per MWh
- Lower temperature in the district heating network (increased COP)
  By increasing the COP from 6 to 7, the heat price can be reduced by approximately DKK 15 per MWh.
- Reduced CAPEX
  If CAPEX is reduced by 10 %, the heat price can be reduced by approximately DKK 15 per MWh. The reduction cannot be calculated until an exploration well has been drilled.
- Contracting
  If an organization has experience managing all of the complex aspects of a geothermal project, the price per MWh can be reduced by up to DKK 100. However, district heating companies in Denmark traditionally do not have experience managing all aspects of a geothermal project, such as evaluation of the subsurface and the design and drilling of wells. This is something a professional operating company would clearly do since they have the experience and competences to manage the contracts and interfaces between the various suppliers. An oil and gas operator would never choose a Build Own Operate model due to the price.



CONCLUSION

The conclusion is that if district heating companies do not want to take on any of the risks associated with a geothermal energy project, then the heat price to the consumers will be too high. If district heating companies engages a professional partner to carry and manage the exploration risk and participate with some of the financing starting in the development phase, it is possible to end up with a heat price which is competitive with other green energy sources.

The way to a successful geothermal project is through partnerships between district heating companies and experienced geothermal operating companies, thus ensuring the lowest cost financing and efficient risk and project management.

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FOCUS
FINANCE &
ECONOMY

By Tom Diget,
Chief Operating Officer, Viborg District Heating Company

MOTIVATION TARIFF

– THE KEY TO A LOW TEMPERATURE DISTRICT HEATING NETWORK

Viborg District Heating Company constantly works to improve the efficiency of the network. Lowering the temperature is an important part, but to lower the temperature the company needs the customers to also lower their return temperature. To this end, the district heating (DH) company has developed a motivation tariff, which gives some customers a discount, whereas others will have to pay more. The direct economy of the tariff is a loss of app. 270,000 EUR per year, but the efficiency gain in the whole network adds up to more than 670,000 EUR per year. This means a net benefit at around 400,000 EUR per year - a surplus, which is converted into lower general heat costs.

MOTIVATE THE CUSTOMER TO LOWER RETURN TEMPERATURE

A DH company has many good reasons to lower the temperature in its network. Lower temperature gives a lot of different possibilities compared to a network with high temperatures. Not least, lower temperature will help stay competitive against other heating technologies. The DH company is in control of the supply temperature and can reduce it in times of lower heat consumptions. But when the supply temperature has reached a certain level, the return temperature sets the limit to how much further it is possible to lower the supply temperature.

In the city of Viborg, as in many other cities, the domestic hot water demand sets the minimum supply temperature in the DH network most of the year. In existing systems with older more inefficient housing stock, there are limits to how low a supply temperature can be reached.

The return temperature is in the control of the consumer. The DH company therefore has a clear interest in helping the consumers to lower the return temperature. However, to a consumer "low return temperature" is, at best, of very low interest. The consumers simply want comfort, i.e. warm homes in the most simple, secure and cost-efficient way. Of course, the cost of heating must be low enough to be competitive against other options. Thus, the consumer will act disloyally if another opportunity calls.

So, to be able to lower the temperature substantially, the DH company must find a way to motivate the consumers to lower the return temperature even more

THE BENEFITS TO THE END COSTUMERS

In order to be able to motivate the consumers, it is important that the consumers understand what the benefits to them as a consumer of lowering the temperature is. The list of benefits to the DH company is long and includes lower heat loss, longer life time of pipes, higher flue gas condensation and many more. But to most consumers the real motivation will always be saving money through lower heat cost. Some will have an interest in other aspects (general benefits to society, climate change) and they should not be forgotten, but for most the real motivation will be to save money.

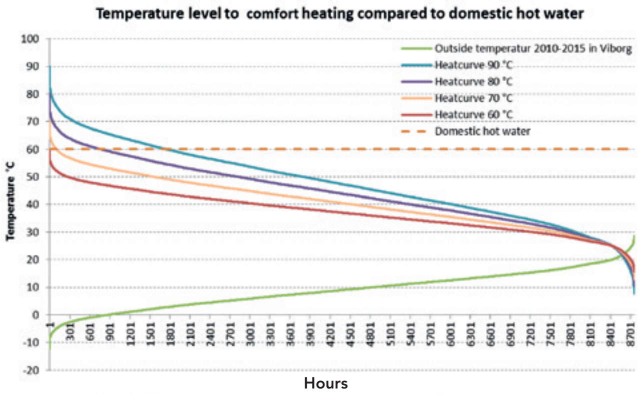
SETTING THE GOALS FOR SUPPLY AND RETURN

Supply temperature

The short-term goal for the supply temperature must be a temperature high enough to supply a well operated network. The long-term strategic goal should be to aim at the lowest temperature level possible with the use of the best available technology; and then even a bit lower, as technology evolves and will allow for even lower supply temperature in the future. In Denmark, the DH companies supply heat to cover primarily two heat demands: The domestic hot water and the comfort heating of the building.

During a year, the required supply temperature is set by one of the two heat demands. The comfort heating sets the required temperature during the winter when the outside temperature is coldest. When the temperature outside rises above a certain level (round zero degrees Celsius), the domestic hot water demand starts to influence the required temperature level in order to deliver safe domestic hot water.

The figure below shows the normal supply temperature at the consumer over a year in different building types. The different heat curves show the supply temperature for comfort heating in different buildings, where the heating system has been dimensioned to different supply temperatures – mainly based on energy efficiency of the building and the radiator system. If it is possible to divide the heat network into separate sections, then it is possible to take advantage of the different demands for supply temperature in the design of the different heat network. Read more of Viborg's thoughts on their website *www.viborg-fjernvarme.dk/nyheder/ny-rapport-fra-niras/*



As is shown in the figure, the demand for domestic hot water (supply temperature at 60°C) will set the temperature demand most of the year. Even with the 90°C-degree heat curve only around 1,800 hours a year, it will require a supply temperature above 60 to provide comfort heating.

RETURN TEMPERATURE MUST BE LOWERED

In essence, the DH company in Viborg has to deliver a supply temperature of 60°C degrees in more than 7,000 hours every year. Hence, it is of interest to find ways to motive the consumers to lower the return temperature.

The return temperature is more or less set by the temperature level of the two heat demands. It is recommended to have a comfort heating in houses at around 21°C. The theoretical return temperature is therefore close to this temperature. Normally, around five degrees higher is possible. So a goal of 25°C from the comfort heating is not impossible to reach.

The domestic hot water has a temperature need for circulation at 50°C degrees, so normally the return temperature from this is higher than from comfort heating. If there is no circulation, the domestic hot water can have a return temperature at the same temperature as comfort heating, since the temperature on the cold side is the domestic cold water.

THE GOAL IS SAVING MONEY FOR THE CUSTOMERS

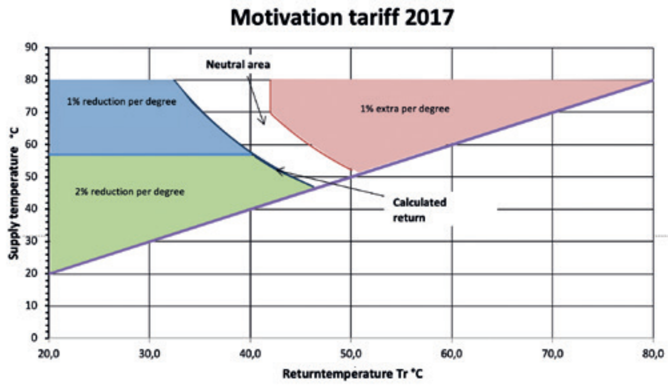
To be able to motivate the consumers, there must be a goal for them individually. In Denmark, there are different models on how to do that. Some of them are used because the energy meters cannot collect the data needed for a model as described below.

The motivation tariff used in Viborg is a model, where the supply temperature as a yearly average is used to calculate the goal for the return temperature. Both the average supply and return temperature can be collected from the Kamstrup energy meters used in Viborg.

Viborg DH Company also works closely with their customers to help them save money, improve comfort and thereby add to the substantial saving for the district heating company.

MOTIVATION MODEL – EFFECT FOR THE CUSTOMER

The motivation model used in Viborg is straight forward. If you cool the water well, the DH company offers a bonus. If your installation is old and inefficient, you will have to pay extra – a strong incentive to improve your system.



If the return temperature from a consumer is at the calculated level or up to 6° higher, the consumer simply pays the standard price for DH. He is a normal consumer with a normal heat installation that is functioning normally. The customer is within the neutral zone, where he simply pays the standard price.

If the consumer can deliver a lower return temperature, there is money to be saved. If the annual average return temperature is below the calculated return temperature, the consumer will get 1 % discount per degree that he is below the calculated return. For some home owners this is an important saving compared to their overall energy bill. The saving can finance improvements in the heating system – and potentially also provide a better comfort in their home.

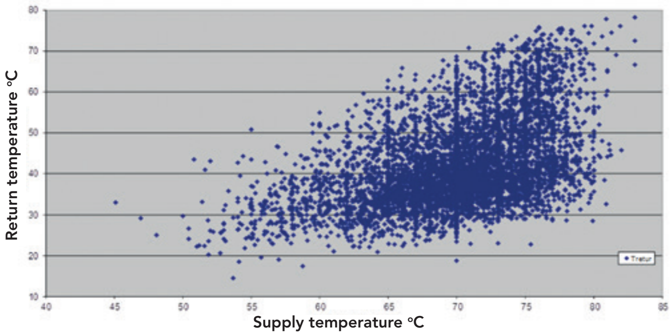
Tip! The saving area has been divided into two areas, where the highest reduction is when the supply temperature is below the promised by the DH company, to remove the customers' focus from whether the supply temperature is always above what has been promised, and to whether they can actually heat their homes properly and simply be a happy customer, as they save even more.

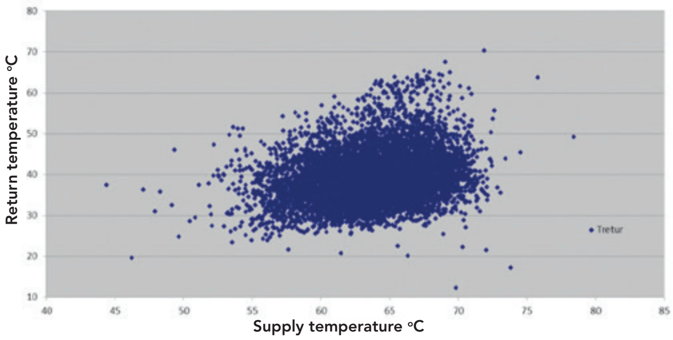
If the consumer has a heating installation that delivers a return temperature above the calculated temperature plus 6 degrees, they will have to pay extra. The extra cost is 1 % per degree that they are above the threshold. The extra cost can often finance needed improvements in the heating system that can potentially also provide a better comfort in their home. This extra fee has proven very effective to motivate building owners to upgrade their heating system, and the reduction is the red area that has the biggest effect on the over all system.

CUSTOMER INTERACTION IS KEY

The intention of Viborg DH Company is NOT to make their customers pay more. The intention is to develop the heating system and thereby lower the cost for all customers. Therefore, Viborg DH Company actively approaches the customers with the worst delta-T (the highest return temperature) and assist them with advice on how to modernise and upgrade their system. The result is that the customers save money, and at the same time the DH company saves money, which then again can be transformed into lower prices for all customers.

The customers who pay more due to the motivation model are not just left hanging there, paying more year after year. They are offered help to lower their heating bill by the DH company, which approaches the customers to offer assistance and guidance.



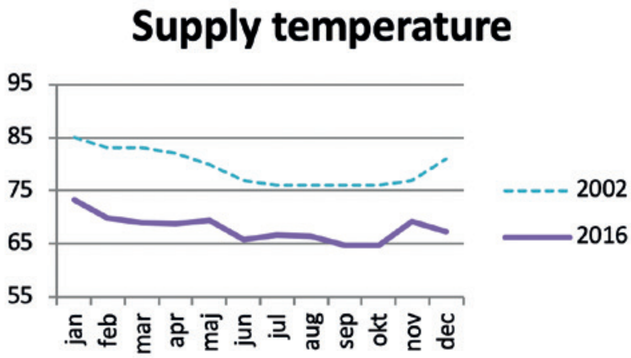


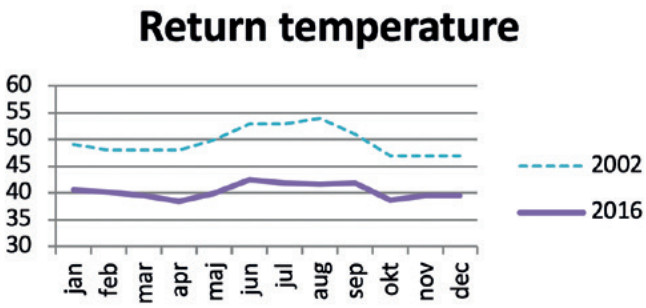
The two pictures illustrate the supply- and return temperatures set for all the customers of the DH company. In 2002, it is clear that many customers need a very high supply temperature and only manage to lower the temperature a bit. Whereas the picture from 2009 shows that there are very few customers in need of the very high supply temperature, and that many have managed to decrease the return temperature. In short, the motivation tariff has helped a lot.

From this picture it is also very clear who will be approached by the DH company to help in lowering the return even more – the ones with the highest return temperature and the ones in need of very high flow temperatures.

RESULTS FOR THE DH COMPANY

In Viborg DH Company, this has been a constant focus area since 1995. The motivation tariff has done a lot of good for the customers and the company – but there is still some way to go. So, the motivation tariff is here to stay for a long time to come. The motivation tariff was introduced in 2002, and since then the temperature has dropped step by step over the years. In 2002, the yearly average supply temperature was 80°C, and in 2016 it was 68°C. In 2002, the annual average return temperature was 50°C, and in 2016, it was 40°C. This is illustrated above.





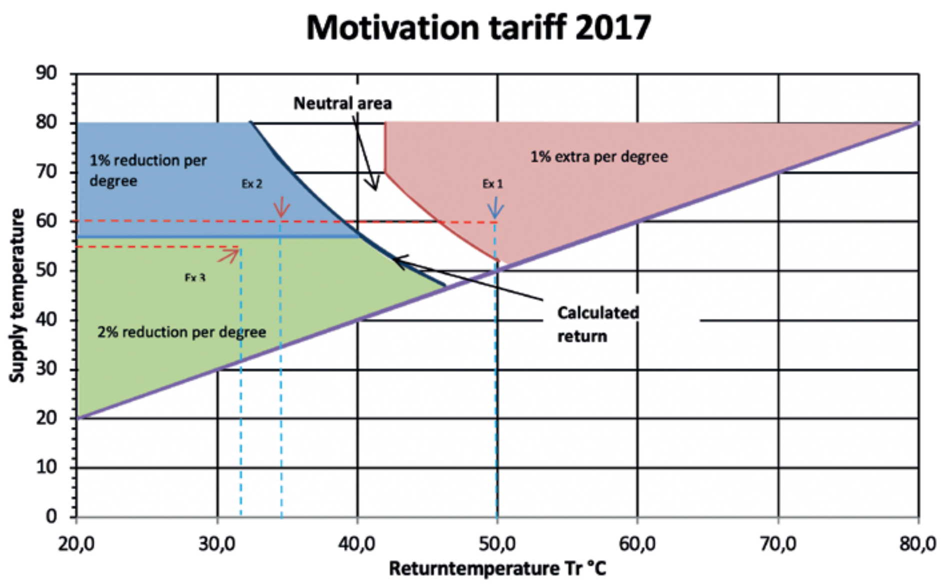
It has been calculated that the average supply temperature can be lowered by another 4-5°C over the coming years, and still cover the comfort needs of all consumers. But at the same time, the return temperature has to go down as well.

The overall economy for the DH company is very positive. The motivation tariff costs the company more in reductions than what is paid extra from the customers who have to pay more based on the motivation tariff. Looked at this way, the motivation model actually costs the DH company around 270,000 Euro per year.

But that is not the entire picture and definitely not the correct way to look at the model. The reduced heat loss, due to the possibility to deliver at a lower temperature, more than compensates for the loss in the simple economy. The reduction in heat loss saves Viborg DH Company around 670,000 Euro per year. The overall effect of the introduction of the motivation tariff is savings of around 400,000 Euro per year. Savings that will lead to reduced prices for all customers in the Viborg DH company. The reduction is as much as 10 % of the cost of heat losses in the network.

EFFECT OF MOTIVATION TARIFF – EXAMPLES

Below are a few examples of the effect of the motivation tariff for 3 different customers. The examples are all based on a 130 m² standard house, using 18.1 MWh/year of heat. Viborg can deliver heat at a price at 50 € /MWh and the fixed cost is 2.6 €/m².



Only 10°C cooling

Supply 60 °C and return 50 °C. Calculated return 39 °C, but with the 6 °C neutral band

Heat price (18.1*50)	905 €
Fixed cost (130*2,6)	338 €
Motivation (50-(39+6)= 5 °C = 5 % -> 18.1*50 €*5% =	45 €
Total bill	1288 €

25°C cooling

Supply 60 °C - Return 35 °C. Calculated return 39 °C

Heat price (18.1*50)	905 €
Fixed cost (130*2.6)	338 €
Motivation (35-(39)= -4 °C = -4 % -> 18.1*50 €*-4% =	-36 €
Total bill	1207 €

23°C cooling, but with a higher expected return as supply is below the 60°C

Supply 55 °C - Return 32 °C – Calculated return 41 °C

Heat price (18.1*50)	905 €
Fixed cost (130*2.6)	338 €
Motivation (32-41)= -9 °C *2 = -18 % -> 18.1*50 €*-18% =	-163 €
Total bill	1080 €

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By Torkil Hvam Sørensen,
Member of the World Association of PPP Units and PPP Professionals (WAPPP)

FINANCING THE 2030 AGENDA: PEOPLE-FIRST PUBLIC PRIVATE PARTNERSHIPS IN RENEWABLE ENERGY

THE 2030 AGENDA AND PUBLIC-PRIVATE PARTNERSHIPS

The 2013 Agenda for Sustainable Development and the 17 Sustainable Development Goals (SDGs), adopted by all UN Member States in 2015, provided politicians with a new compass for addressing global economic, social and environmental issues, and has set off a myriad of new strategies.

In the energy domain, a new strategy for public-private partnerships is currently being spearheaded by the European Economic Commission for Europe (UNECE). Energy is central to the 2030 Agenda, and UNECE is developing a new innovative concept called People-First Public Private Partnerships, which will help finance and develop new renewable energy projects. Although district energy (DE) – district heating and/or district cooling - is not specifically covered in these initial drafts, many related elements, such as solar, wind, geothermal, hydropower, bioenergy and ocean power, are considered. The World Bank is partnering in this endeavour, and with DE projects in the pipeline, e.g. in Ukraine, it is likely that DE projects will be influenced by the 2030 Agenda. There are a number of indicators of this, including the recent announcement by the Investment Fund for Developing Countries (IFU) of a solar project in Ukraine linked to the 2030 Agenda.

This article intends to present the reader with an overview of the new terminology and thinking in the public-private partnership domain emanating from the intergovernmental stage. At present, DE is not mentioned directly but it could affect the political environment surrounding larger renewable energy projects, particularly given forthcoming funding from the World Bank and other donors expected in the foreseeable future. Furthermore, the article will elaborate on the surprising role of China in this endeavour.

RECEPTION OF THE 2030 AGENDA

The 2030 Agenda was never envisaged to be neither financed nor achieved by governments alone, and with the Agenda came an unprecedented responsibility on the business community to make the world a better place. At present, the Agenda seems to have gained a footing amongst both governments and businesses alike. For example, the Confederation of Danish Industry has launched a two-year project entitled "From Philanthropy to Business", where companies are supported in designing business models aligned with the 2030 Agenda. In the financial sector, the EU is discussing a potential loosening of the fiduciary regulation towards institutional investors, such as pension funds and banks, which would liberate more institutional capital towards sustainable projects with riskier profiles.

Picture 1 - The 17 Sustainable Development Goals

In this context, the term Impact Investing has emerged as a popular description of private capital mobilised for sustainable investments, often aligned with the SDGs and ESG (Environment, Social, and Governance) considerations. Some institutional investors have already taken active steps to invest more sustainably. As an example, six Danish pension funds have signed an agreement with the Investment Fund for Developing Countries (IFU) to establish a Danish SDG Investment Fund.

Picture 2 – Signing-ceremony of the Danish SDG Investment Fund, June 2018

BRIDGING THE FINANCIAL GAP - BLENDED CAPITAL AND PARTNERSHIPS

While the SDGs have certainly mobilised more private actors to take part in the development agenda, a massive financing gap in achieving the 17 goals remains. One widely recognised figure estimates an annual financing gap of USD 2.5 trillion in reaching the SDGs. It is against this massive financing gap that public-private partnerships (PPPs) are gaining popularity on the intergovernmental stage. Governments cannot finance the SDGs alone, and therefore the need for more blended capital. Then, UN Secretary-General, Ban Ki-moon, remarked at the 2016 World Economic Forum in Davos that PPPs should be made to work for sustainable development. Goal 17 further validates partnerships as a key tool for implementing the SDGs, which has created an impetus for increased public and private collaboration.

UNECE'S PUSH FOR GLOBAL PPP STANDARDS

The United Nations Economic Commission for Europe (UNECE) has spearheaded the global discussion on PPPs during the last 15 years, among others, when it opened the International PPP Centre of Excellence (ICoE) in 2011. The ICoE brings together experiences of companies and governments through Specialist Centres, which are set up by governments around the globe within different sectors. It is their responsibility to develop and disseminate best practices in their sector and then transmit these to the UNECE to make them into a standard.

There has been a tremendous interest by governments globally to host Specialist Centres and to be a part of developing the political quality surrounding PPPs. Hong Kong has a Specialist Centre on Public Transport, Lebanon has one on Ports, Spain on Smart Cities and Sustainable Cities, and Morocco and India are expected to open Specialist Centres on PPPs in Renewable Energy and Roads, respectively. It is against this high level of intergovernmental participation and involvement that it becomes feasible to talk about global standards.

WORKING PARTY ON PEOPLE-FIRST PUBLIC PRIVATE PARTNERSHIPS

What is new and what may change the dynamics of PPPs is the influence of the 2030 Agenda. UNECE recently established a Working Party on PPPs in direct support of the SDGs. The Working Party has proposed the concept entitled People-First Public Private Partnerships (PfPPPs) that seeks to counter some of the criticism levelled at conventional PPPs and to better harness the SDGs.

The term "People-First" perhaps says it all: People's rights and needs are put higher on the agenda. PPPs have often suffered from a lack of values with an exclusive focus on financial criteria. The People-First framework seeks to harmonise the value-for-money and value-for-people criteria by addressing critical challenges facing humanity, such as climate action, lack of economic opportunity and marginalisation.

NEW STANDARDS IN PARTNERSHIP WITH CHINA

Under the leadership of then Executive Secretary Christian Friis Bach, the former Danish Minister for Development Cooperation, UNECE embarked on a strategic partnership with China on PPPs. Through the signing of two MoUs, UNECE and China will identify ten flagship projects along China's Belt and Road initiative (BRI), which include substantial infrastructure through Central Asia, the Middle East and Europe. The idea is to support Member States along the BRI with national PfPPP policies and to use the ten projects as best practice models for other countries and regions to follow.

Picture 3 – MoU signing-ceremony between UNECE and the City University of Hong Kong and Tsinghua University, January 2016

CHANGING DYNAMICS FOR PPPS

Observers may pose the question: Is PfPPPs not just business-as-usual using new words? It is a valid question as the PfPPP talk has yet to move beyond the walls of the United Nations. The chief of the PPP Programme at UNECE, Geoffrey Hamilton, emphasises that PfPPPs is a new governance system that incorporates civil society to a much higher degree and listens to their needs. In the draft for standards on Renewable Energy (RE) projects developed by the UNECE, it is noted that Renewable Energy PfPPPs not only achieve clean energy but also improve health, the environment, the local economy, and make the cost of energy affordable to all levels of society.

Going forward, projects will need to incorporate the SDG-thinking from an early stage and to work closely with civil society, governments and other stakeholders to identify what constitutes good impact in the local context and to then incorporate this in the project.

Time will tell how these new standards will affect and impact government decisions. However, if the strong welcome of and supportive approach to the SDGs by governments is any indication, it is reasonable to suggest that the PfPPP-framework will become a standard mechanism in future PPPs.

IMPACT ON DISTRICT ENERGY

HOT COOL has in earlier publications touched upon how the DE industry synergises with international development. In the Stan-countries and in Eastern Europe, several energy efficiency projects are carried out with funding from development banks. The World Bank is an ICoE partner, and it can be speculated that the PfPPP terminology will anchor itself onto projects around energy efficiency when public funds are involved.

The aforementioned SDG Investment Fund made its first investment in a 19.1 MW Ukrainian solar park developed by the Danish company 'Better Energy' through a Power Purchase Agreement with the Ukrainian authorities in January. While the project was not articulated as a PfPPP-project it is nonetheless a PPP, designed in direct support of goal 7 (Affordable and Clean Energy). DE harmonises nicely with several of the SDGs, particularly goal 7 and goal 11 (Sustainable Cities and Communities), why a first DE PfPPP could be on the horizon.

It would be interesting to explore the possibilities for Denmark to open a Specialist Centre in one of its areas of specialty. One area where Denmark has many years of institutional knowledge and where it could be argued to be in a position to develop good standards is in integrated energy designs. It would provide Denmark with an interesting position in the design of global standards and allow for further promotion of its expertise, moving beyond already existing export promotion platforms.

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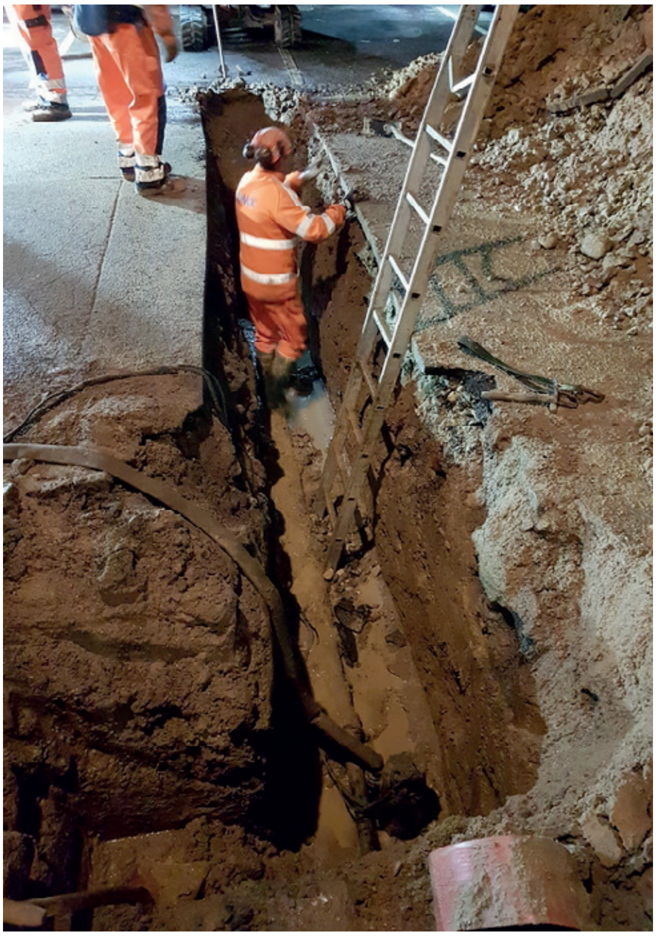
AN INDISPENSABLE TOOL IN SUPPLY CHAIN MANAGEMENT

By Michael Søndergaard,
CEO of Pernexus



A new internet-based tool can integrate with almost all devices – smartphones, laptops, and tablets and can, with a single touch, create transparency in the supply chain industry workflow.

A lot of companies, people, figures and facts are involved in projects by utility companies – making it difficult to keep an overview of the entire process. HOFOR (former Københavns Energi known as Copenhagen Energy) needed to solve this problem, which led to the idea to build "Entrepriseportalen", a work portal collecting all data in the supply chain. There soon proved to be a huge demand in the market for a system like this.

The goal for the portal was to develop a single and extremely user-friendly system for the industry of utility companies – in cooperation with the utility companies themselves. Clients have different needs, but the fundamentals of the system are the same.

The work portal is today a software-as-a-service (SaaS) platform, where many of the different parties that make up a construction project come together and work through the same shared procedures and data. The portal ensures that all participants have the same drawings, work specifications, budgets, contract information etc. The parties can also invoice each other through the portal and fulfill the public standards for electronic commerce and case management. The portal can be used by the contractor delivering excavation work to utilities and may itself use sub-contractors for parts of the work. Another example could be a consulting engineering company that manages projects on behalf of clients. Estimates, project plans and tenders are instantly shared with all relevant parties. Everything is done using the portal – you only need internet access and an account to get started.

ASSET MANAGEMENT IN THE CLOUD

An RFID (radio-frequency identification) license plate is mounted on all components, either during production or at a central warehouse. When ordering online, the customer will receive an order number and a unique item number on the ordered components. The customer receives an electronic delivery note, in which each component with its own unique RFID number plate and the technical specifications, is coupled to the order. When the components arrive at the construction site, the handheld RFID reader will scan all the RFID number plates easily, and the delivery notes are automatically updated via the construction manager's smartphone. The construction manager does not have to press any key on his smartphone.

Organizing all the stakeholders in an orderly fashion allows one link to supply the next link in the chain, with information in exactly the right format and at the right time. The work portal organizes and manages information flows in the supply chain from the beginning to the end.

John C. Olsen, Project Manager for heating and cooling in Copenhagen, has worked for HOFOR (Copenhagen Energy) for the past eleven years and was one of the first users of Entrepriseportalen. "I am extremely satisfied with the system that I use on a daily basis to manage our suppliers and contractors. The system allows us to work in different digital areas, allowing for transparency of the individual projects for all participants – including all data that has been uploaded by suppliers and contractors. All in all, a very valuable system that ensures that nothing slips through the cracks", says John C. Olsen, who also uses the system to plan new projects.

"Today, it is difficult to imagine starting a new project without the portal, which holds all the data. It gives us insight into the budget of a project, and how much and what kind of material our suppliers are using, creating value in the decision-making process. It also allows us to go back and see what has previously been agreed upon and, in that sense, it can reduce potential claims that are not beneficial to any of the parties in any industries", says John C. Olsen.

Today the work portal is not only used for heating and cooling – it has spread into other areas in HOFOR – such as water and drainages.

READY FOR THE FUTURE

What is important for such a system is that it is not only focused on the process right now and secures that the project is running in a structured, precise and transparent way. The system can also be very useful later on as drawings, figures and facts are kept in there. Imagine a failure that occurs on a pipeline a couple of years after a project has been completed. In that situation, you can easily pinpoint the problem and reduce the cost and time spent.

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By Britta Kleinertz,
Dr. Götz Brüh and
Dr. Serafin von Roon,
"Forschungsgesellschaft für Energiewirtschaft mbH"

HEAT-DISPATCH-CENTER

SYMBIOSIS OF HEAT GENERATION UNITS TO REACH COST EFFICIENT, LOW EMISSION HEAT SUPPLY

Renewable heat sources underlie various constraints; hence, their interconnection is crucial for an efficient and low emission heat supply. In the so-called Heat-Dispatch-Centre, various heat generation and storage units are smartly interconnected. With the system a primary energy factor of 0.09 and a specific CO2 emission factor of 27 gCO2/kWhth can be reached, while the heat generation cost lies at about 12 €ct/kWh.

INTRODUCTION – FUTURE ENERGY SUPPLY AND LIMITATIONS OF RENEWABLE HEAT SOURCES

For the transition of the energy supply towards a low emission system, the provision of heat from waste heat and renewable energies is as measure with main importance. Especially in cities, due to limitations in free space and relatively high heat demand density, district heating networks based on low-emission heat sources are expected to cover the demand more cost-efficiently than decentralized solutions. Relevant renewable heating sources include solar thermal, geothermal and biomass energy. Another relevant energy source is electricity from renewable energies. However, market available renewable heat sources underlie various constraints regarding e.g. availability, target temperatures and costs, which makes an interconnection of several heat sources essential.

In this research, the focus is on an efficient integration of renewable heat supply technologies in a Heat-Dispatch-Centre. The concept was investigated within a feasibility study on the transformation of an existing into a fourth generation district heating network.

AWARD WINNER FROM THE ANNUAL CONFERENCE ON SMART ENERGY SYSTEMS AND 4TH GENERATION DISTRICT HEATING

By Poul Alberg Østergaard, Professor in energy planning, Aalborg University

The annual conference on smart energy systems and 4th generation district heating, which has been alternating between Aalborg and Copenhagen since 2015, has turned out to be one of the main venues for discussing innovative district heating systems from perspectives, ranging from grid analyses via system integration with smart energy systems to policy and economic framework conditions. The 2018 conference was no exception to this with 325 participants from 25 countries. Through sponsor contributions from one of the main energy technology providers Danfoss and the metering solutions provider Kamstrup, the conference is able to bestow special honour on two of the many presentations. This year, the Kamstrup and Danfoss awards went to Britta Kleinertz from the FfE Research Center for Energy Economics in Germany and Benedetto Nastasi from the Delft University of Technology in the Netherlands.

Britta Kleinertz addresses in her research, a so-called Heat-Dispatch-Centre allows the interconnection of multiple heat sources, which deliver thermal energy at different temperature levels. In the case study, also consumers with different temperature requirements are included.

CONCEPT OF THE HEAT-DISPATCH-CENTRE

In Figure 1 the, (in the following stepwise explained), connection of two consumers, three storages and four heat generation units is visualized. The relevant components of the Heat-Dispatch-Centre are the generation and storage units as well as their control.

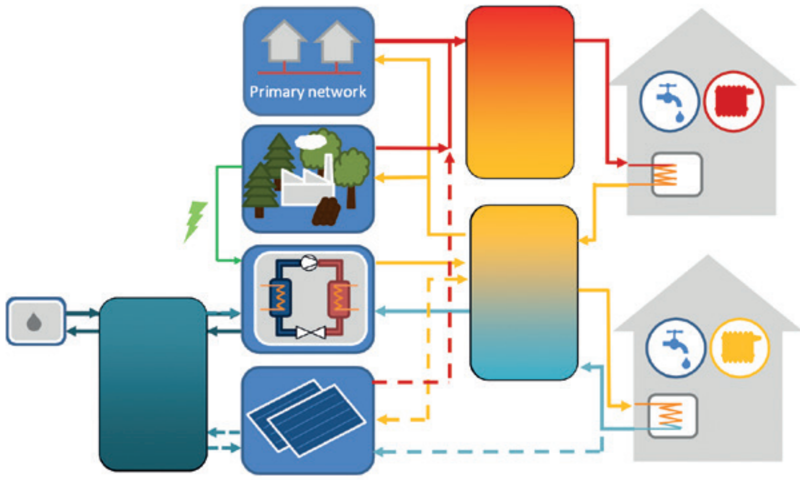

Figure 1: Interconnection of different renewable heat sources in the Heat-Dispatch-Centre

On the right side, the heat customers are illustrated. The one at the bottom is a high-efficiency building, requiring a low supply temperature, and the other at the top a low-efficiency building with a high flow temperature. In order to increase the difference between the overall flow and return temperature, these customers are connected in series.

The required flow temperature can easily be provided by the two high-temperature heat generation units, namely primary heat network and biomass gasification with CHP (top left). Below these, the low-temperature generation unit, namely the wastewater heat pump, is depicted. It increases the temperature of the return of the high-efficiency building (blue line) to a level below the flow temperature of the low-efficiency building (yellow line). The preheated energy stream serves as input stream for the two high-temperature heat generation units. This interconnection of the heat generation units allows an efficient use of the heat pump, due to a low target temperature, and a decrease in energy demand from the high-temperature heat sources. The simultaneous operation of electricity generating (gasification with CHP) and consuming unit (heat pump) is favourable to avoid grid levies and make the generated heat 100 % renewable.

The top storage tank is a buffer for high-temperature heat and allows a continuous operation of the gasifier with CHP, while the lower storage tank especially serves as hydraulic compensator between the heat pump and the high-temperature heat sources. For balancing the fluctuating wastewater stream, a third storage tank for low-temperature heat might be suitable (left to the heat pump).

Derived from the fluctuating nature of solar thermal heat generation units (middle bottom), their smart integration depends on solar irradiation and the resulting outlet temperature as well as load. At times of high solar irradiation, the return from the high-efficiency consumer is directed to the solar system and reaches the low-efficiency consumers flow temperature. At times of medium irradiation, the solar thermal plant provides a share of the overall temperature lift. Lastly, at times of low irradiation, the solar thermal low-temperature heat is added to the low-temperature storage and serves as energy source for the heat pump, allowing a more efficient operation of the heat pump.

TECHNOECONOMIC RESULTS FOR THE CASE STUDY

With a calculation tool, the reachable share of heat supply by heat generation unit for an exemplary customer is calculated. Here the provision of heat from heat pump and wood gasification with CHP is prioritized over heat supply from the primary heating network. In this case study, due to limitations in space for seasonal storage tanks, the usage of solar thermal energy is neglected, also no low-temperature storage tank is included. For the case study scenario, funding of 20 % on all investments is available.

The composition of final energies for heat supply for the case study is represented in Figure 2. In the set configuration and operation logic, the main heat source is the wood gasification with CHP. Here the heat provided by the heat pump is the sum of the two energy sources "Electricity from CHP" and "Environmental energy for heat pump".

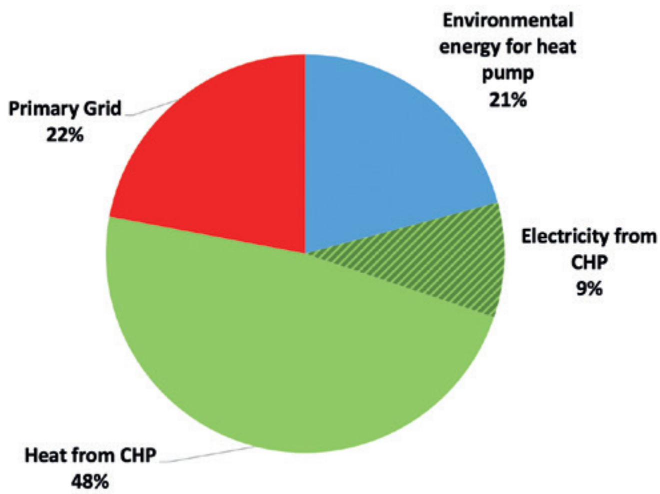

Figure 2: Composition of heat supply by generation unit of overall 4.4 GWh

With this composition, an overall primary energy factor of 0.09 and a specific CO_2 emission factor of 27 g_{CO2}/kWh_{th} can be reached, while the heat generation costs including funding lie at 12 €ct/kWh_{th}. In contrast to this, network-based heat supply from gas with losses of overall 20 % lies at a primary energy factor of 1.32 and a specific CO_2 emission factor of 242 g_{CO2}/kWh_{th}.

OVERALL CONCLUSIONS REGARDING FUTURE ENERGY SUPPLY

The concept of the Heat-Dispatch-Centre was designed for a real case heat supply system. Although the potential of all renewable heat generation units was investigated, only few sources are available on-site. Moreover, efficiently these mainly provide low temperature heat. In the case study, the implementation of a supply system based on several heat sources (multienergetic) and technologies running simultaneously (multivalent) combined in temperature cascades was mandatory. In order to succeed with the heat transition to a system based on renewables, the same approach is recommendable. This is not only true for provision of domestic thermal energy demand but also for industrial sites.

ACKNOWLEDGEMENTS

This research was funded by the Stadtwerke Rosenheim GmbH & Co. KG and the fund „4th Generation District Heating", which was provided by the German Federal Office of Economics and Export Control.

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Internationally, our strategic focus is a consolidation in the sector to create a leading one-stop partner on renewable energy technology from idea through installation, operation and maintenance of energy plants. Furthermore, we are a leading trader and supplier of biomass to the largest utilities and their combined heat and power (CHP) plants when converted from coal.

Verdo deliver ideas, technology, installation, service and operation to energy plants connected to district heating networks and to customers within the private industry.

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- Biomass-fired energy plants
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We are dedicated specialists with deep industry insight and ensure effective and profitable solutions for the industrial market and utility companies.

> *"Verdo Energy focus on optimizing and streamlining energy solutions. Our energy specialists support with everything from consultancy and project planning to development, fuel purchases and the operation and servicing of energy plants. Our aim is to give our customers a complete understanding of their energy needs and the solutions that create real value,"*
> Bo Johansen, Sales Director Verdo Energy explains.

The energy plants we supply are from 1 to 25 MW per boiler line, of course they can also be connected in parallel. One of our areas with high focus in our work are the installations for the generation of waste energy. We have developed four standardized plant sizes - 4, 7, 10 and 15 MW thermal output. These boiler installations can burn all types of waste - from industrial plants, from urban landfills, and RDF residues from recycling facilities. By burning in our installations, all these types of wastes can lead to the combined production of significant amounts of electricity, steam or hot water.

For a long time Verdo have been focused on Scandinavian markets. The experience we have, however, allows us to see a good future for this kind of installations in the Central European and the Balkan region. All our boiler installations, including those burning waste, comply with EU directives, regulations and requirements. This enables us to deliver and install them successfully throughout Europe.

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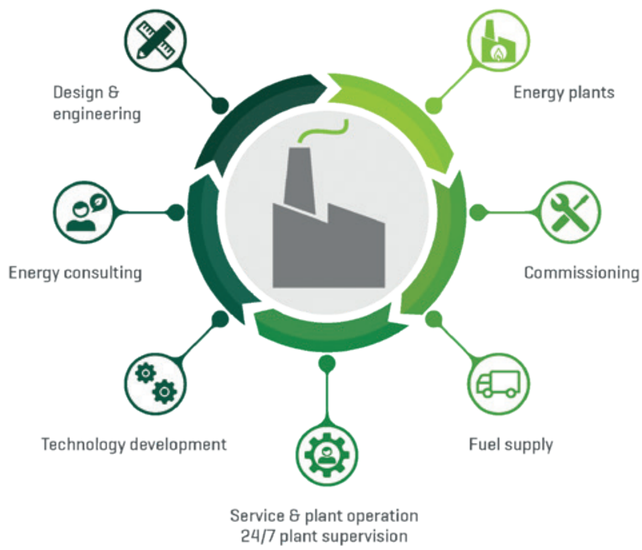
Verdo has around 500 employees and an annual turnover of around EUR 349 mill.



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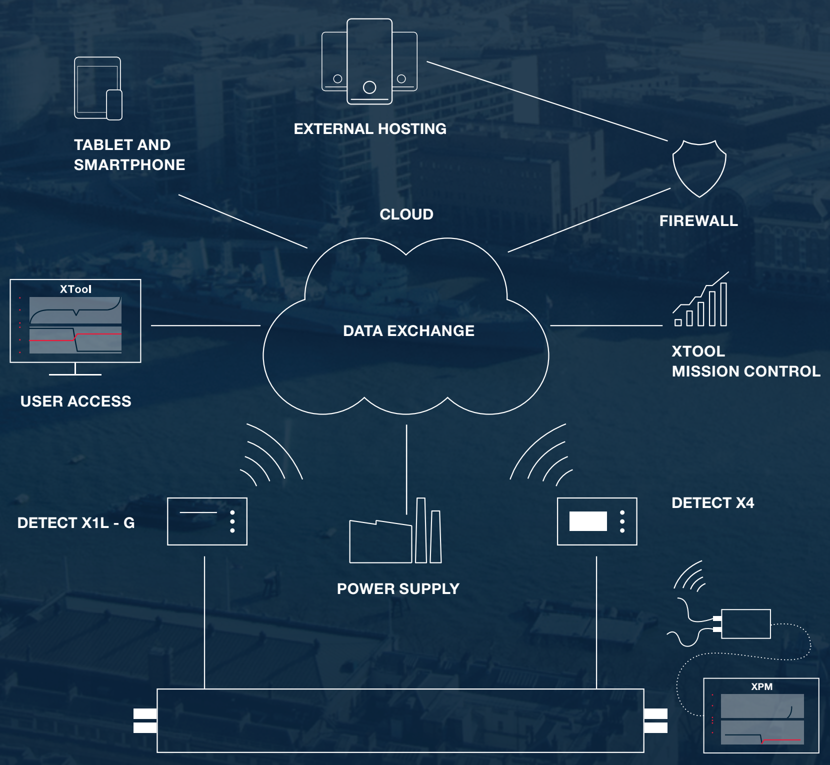

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