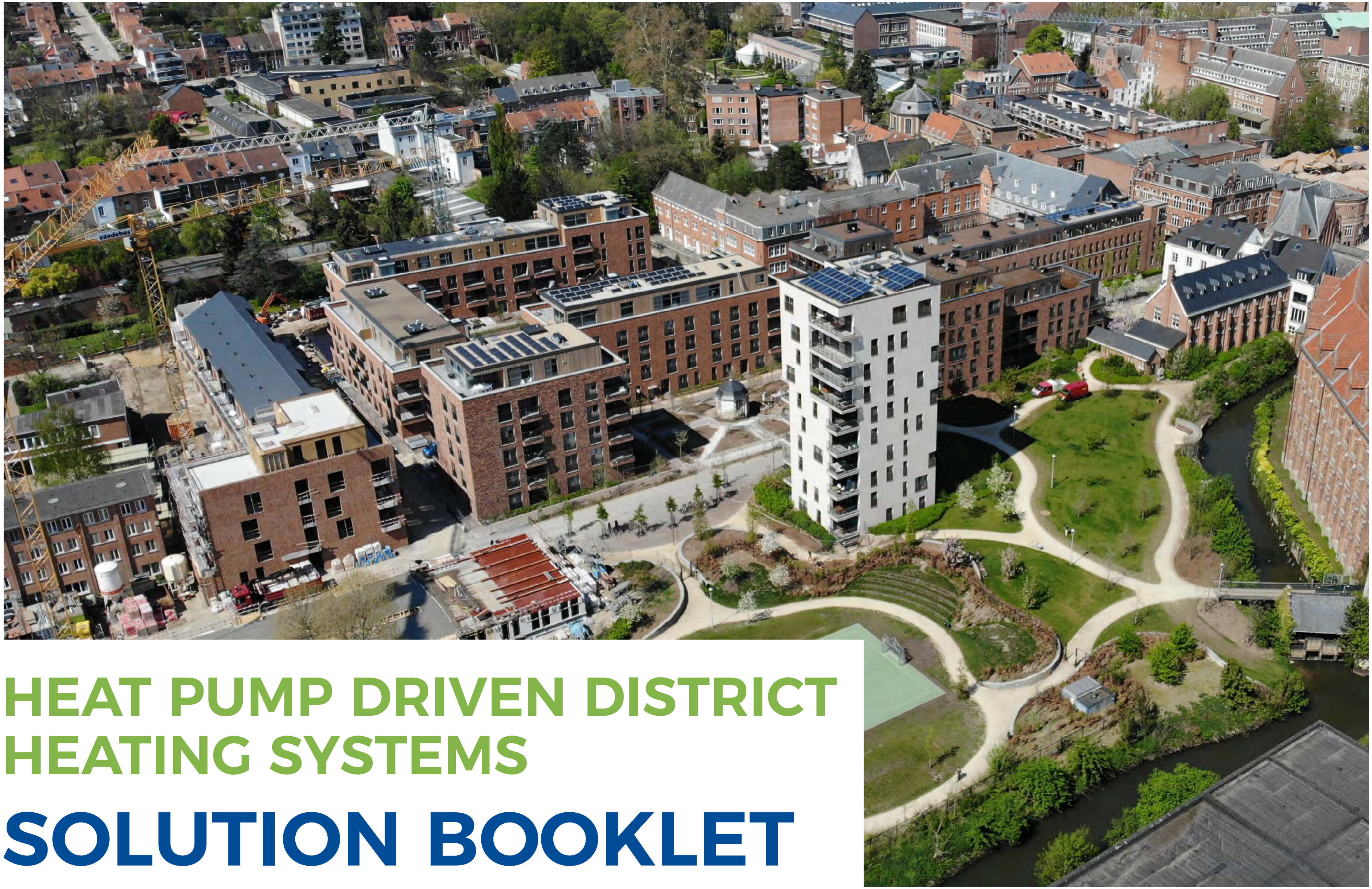

HEAT PUMP DRIVEN DISTRICT HEATING SYSTEMS

SOLUTION BOOKLET

EU Smart Cities Information System

SCIS Smart Cities Information System | October 2019 | version 1.0

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WHAT IS THE SMART CITIES INFORMATION SYSTEM?

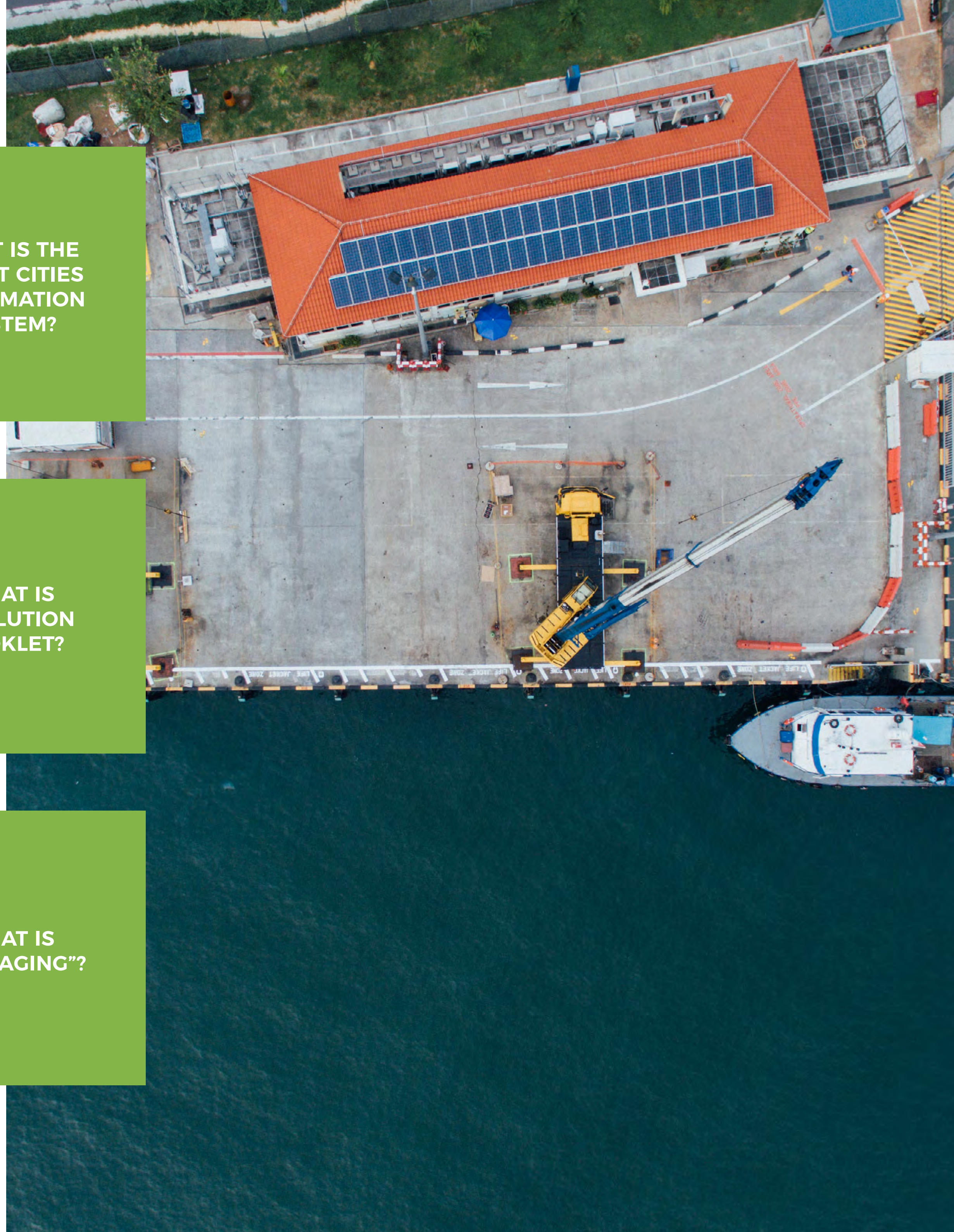
The Smart Cities Information System (SCIS) brings together project developers, cities, institutions, industry and experts from across Europe to exchange data, experience, know-how and to collaborate on the creation of smart cities and an energy-efficient urban environment.

WHAT IS A SOLUTION BOOKLET?

A summary of the management framework, primarily written for cities. It seeks to reduce the effort, speed up the process, strengthen quality and confidence in outputs, align across disciplines, and generally prepare a city to engage the market to acquire a solution.

WHAT IS "PACKAGING"?

'Packaging' addresses the societal needs, technical solutions, business models and financing for a measure – and offers ways to put these in the particular context of the city/ cities in question. It is supported by a growing number of templates to speed up and make the resulting output consistent.



WHAT & WHY

WHAT & WHY

In Europe, heating of buildings is one of the biggest sources of CO_2 emissions. After lowering the heating demand of buildings, heat pumps are a promising technology in the transition towards climate neutral cities and improved air quality.

Heat pumps use an amount of "free" renewable energy, i.e. thermal energy available in the outside air, the ground or water. Heat pumps need a small amount of energy to turn the free thermal energy into energy at useful temperature levels. The ratio of useful energy delivered to electrical energy needed is called Coefficient of Performance (COP). The factor depends mainly on the temperature difference between the free outside source and the required temperature for heating: the larger that difference, the more electrical energy is needed. Heat pumps can deliver both heating and cooling.

There are many different types of heat pumps that could be used, but they all have in common that they need a low temperature heat source. While some of these heat sources can

be very interesting with regards to temperature or amount of energy available, they can be expensive to get access to. In this case, it can be interesting to use this heat source to feed a large scale heat pump or several smaller scale heat pumps all supporting or driving an overall district level heating system. This way, the low temperature heat source can be used in an optimal way and costs can be spread out over multiple users.

Depending on the design of network and the selected temperature levels, (passive or active) cooling can be delivered to the end-consumers as well.

AIR QUALITY

DURABILITY

RENEWABLE ENERGY

ENERGY EFFICIENT BUILDINGS

CITY CONTEXT

CITY CONTEXT

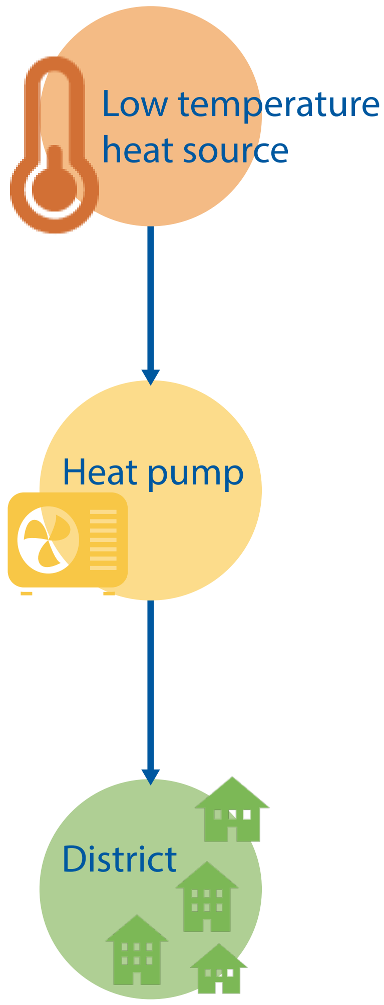
Several new or renewed city districts aim at reducing or even banning fossil fuel based energy systems because of climate ambitions and air quality. Leveraging heat production to a neighbourhood or district scale enables the investment in alternative systems with an often higher investment cost. Heat pumps can provide this alternative in a broad range of applications.

Heat pumps are associated with low temperature heating and hence energy efficient buildings. While such lower temperatures indeed positively impact the efficiency of the heat pump operation, more and more manufacturers present high temperature heat pumps as alternative to fossil-fuel based heating systems. Generally, these high temperature heat pumps include a first increase in temperature using the available low temperature source and consequently one or more internal cycles that each deliver a temperature increase as efficiently as possible.

The availability of the low temperature heat that serves as the renewable energy source to feed the heat pump is key, both in the temperature levels as in the accessibility of the source in relation to the demand. This context specificity as well as the increasing attention to energy efficiency imply that each district heating solution and especially the heat pump driven district heating networks require a sound context-based engineering.

District heating networks have been used for over hundred years. However, the steps that are taken in the last decades are in line with the above mentioned shift to more focus on energy efficiency and the drive to fossil-free solutions. The first relevant shift came near the end of the first decade of this century, where lower temperatures were used to provide heat more efficiently. Today, temperatures as low as 10°C are used to further decrease distribution losses and enable provision of cooling as well as heating with a single network.

Heat pump driven district heating further provides a direct interaction with the electricity grid. The flexibility in the operation of the heat pumps, further boosted through a potential interaction with thermal storage, could be valuable for the integration of more variable renewable energy sources in the electricity generation system. Besides an environmental benefit, it could enhance the profitability of the heat pump operation.



SOCIETAL & USER ASPECTS

SOCIETAL & USER ASPECTS

Stakeholder support, citizen engagement & co-creation

While PV panels or charging stations are more visible, heat pump driven district heating systems are not prominent in a neighbourhood or district. End-consumers are generally not aware of the way their heating is prepared, as long as it is available when needed. The general public does understand the shift to renewables and hence away from the conventional fossil-fuel based alternatives. Aspects as improved air quality or concerns on noise might be risen.

BENEFITS THAT APPEAL TO PEOPLE:

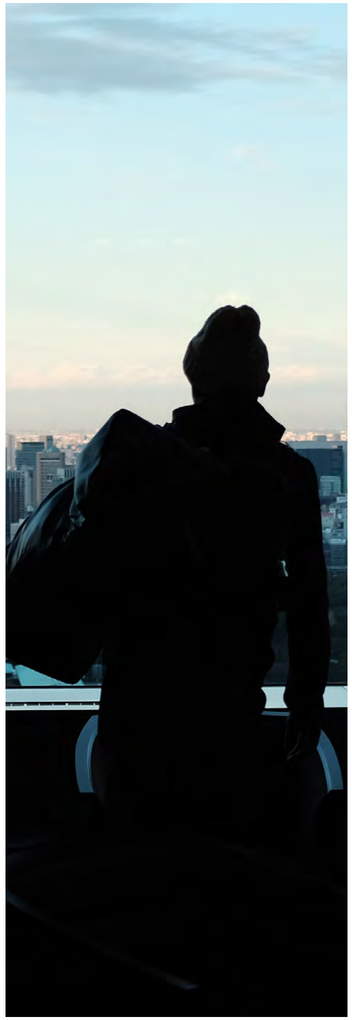
- Interesting/feasible way to become climate neutral
- No gas bill
- No local exhaust/no chimneys
- Very good energy performance of buildings assessment, hence a better energy label for the buildings connected
- Increasing popularity – higher selling price for properties
- Correlation with low temperature heating delivery system – high comfort satisfaction

The effective market uptake is strongly influenced by the ambition level of the investor. The “**no more than usual principle**” is leading the decision, although a shift is observed to include the marketing value of a more sustainable approach. The effective business case depends on the scale of the solution and on the ratio between electricity prices and gas prices. Providing cooling as well, offers additional value and allows for an increased sale of thermal energy that should be considered.

Lessons learned

To realize the roll-out of heat pump driven district systems, several stakeholders need to be convinced that a positive roll-out and operation is possible for all relevant aspects. Important considerations are:

- Develop a **clear and long-lasting sound legal structure** with regards to ownership and operation guarantee for the heat pump driven district heating system, in line with common district heating approaches. Add a clear addendum with regards to the availability and access to the low temperature heat source.
- **Optimise the cooperation between the different components**, including the users of the heat pump driven district heating system in order to deliver heating (and potential cooling) in the most efficient and economic manner, considering the long term impact on the low temperature heat source.
- **Unburden the end-consumer** with regards to technical and legal matters and ensure a transparent communication.
- Develop and present a **correct and clear business case**, including investment and operational cost for delivering heating and cooling. Provide price guarantees and explain both the impact on investment and use for the connected end-consumers.
- Ensure that the **electricity is provided by a 100% green supplier** in order to be correct and consistent with the presentation of a renewable alternative to fossil fuels.
- Establish a **good communication with all permitting bodies and environmental agencies** to assess impacts on noise levels, temperature levels of water and/or ground. Ensure to get long term commitments for the use of the low temperature source and the operation of the heat pumps within the district.
- Initiate the **dialogue with the grid operator** in an early phase and include other future electricity usage on the district level, such as car charging. The impact of the heat pump operation on the grid and on the local power quality is to be assessed timely to ensure grid reinforcements can be executed before the activation of heating network.



TECHNICAL SPECIFICATIONS

TECHNICAL SPECIFICATIONS

Description – components of the system

The main components of a district heating system include the low temperature heat source, the heat production system(s), the heat distribution system (including piping, substations, pumps, valves, ...), the heat delivery system (distribution of water at the desired temperature or a common heat exchanger per building or apartment with local smaller scale heat pumps), potential thermal storage and an overarching control.

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Heat production system: the heat pump

The principle of a heat pump is already known and used since the 19th century. **A heat pump extracts heat from a medium on low temperature and delivers it to a medium on a higher temperature.** In order to realize that increase in temperature, the heat pump uses extra energy. This extra energy is generally electricity but could come from other sources such as gas. This solution booklet focusses on electrical driven heat pumps.

Refrigerators are a common example of this technology: the small heat pump that is installed in fridges extracts heat from the air on low temperature inside the fridge and releases the heat through the heat exchanger on the backside of a fridge to the air in the kitchen.

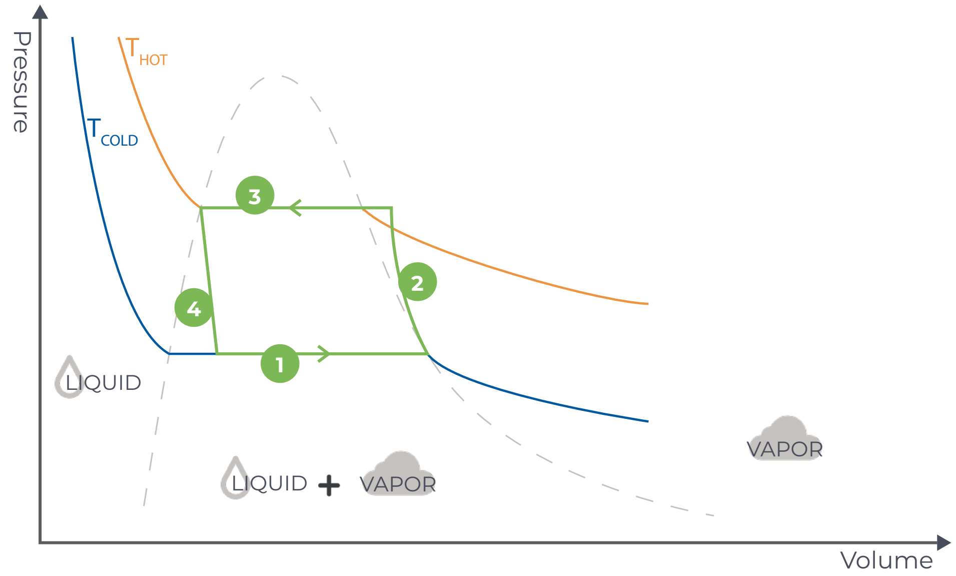
The heat pump works on four main principles: liquid or gaseous state, temperature, pressure and volume. In principle, energy flows from a medium at high temperature to one at low temperature and increases the temperature of the latter. However, it could also lead to changing the latter medium from a fluid to a gas. The gas particles, equal in number to the fluid particles before, have a higher energy content and take up a larger volume. A liquid is considered incompressible. As the liquid temperature increases, this results in an increase in pressure. However, a gas can be compressed by decreasing its volume and as a consequence increasing its pressure. Pressure then relates to temperature and the compressed gas particles now have an even higher energy content. This interrelation between pressure, volume and temperature has to be seen in relation to the physical state of the medium, i.e. gas or liquid. The particles at gaseous stage at a certain pressure and temperature and in a certain volume, can be cooled down to become fluid again and keep the same pressure only if the volume decreases.

For the heat pump, these interrelations between pressure, temperature an physical state define the operation:

In the **first step**, heat at low temperature is extracted from a low temperature heat source. The heat at low temperature is used to increase the energy content of the heat pump medium by evaporation: the liquid phase is leveraged to a gas phase. This can only happen if a heat pump medium is selected that can effectively and efficiently evaporate at the temperature of the low temperature heat source, and immediately explains why there is no single heat pump selection for all potential heat pump driven district heating systems.

In the **second step**, the now gaseous state is increased in temperature by increasing the pressure. This is done by a compressor. The compressor uses electrical energy to push the medium to the temperature level needed to deliver the heat on the high temperature side. Again, the case dependency comes in: the selection of the compressor has to be such that the temperature increase from the cold source to the level needed for the heating application can be delivered.

In the **third step** the gas at high temperature has to transfer the heat to the building's heating system with as medium air or water. Through a heat exchanger, the high temperature gas transfers energy to the colder air or water. This release of energy reduces the energy content of the particles and while the pressure does not vary that much, the main release is through the change from gaseous to liquid phase.



In the **fourth step**, the pressure on the liquid is released, leading to a drop in temperature. This temperature drop ensures that the same medium will now start evaporating at lower temperature. And hence, the cycle can restart.

The only active component in this cycle is the compressor. Hence, the efficiency of the heat pump is defined by the useful heat delivered on the warm side compared to the active energy consumption (i.e. electricity) of the compressor. This efficiency is expressed by a coefficient of performance (COP). The calculation is done for a set of predefined conditions, following EU standards. The higher the COP, the better the efficiency under the specified boundary conditions.

Heat sources

For the heat pump to produce heat, it needs a heat source. The higher the temperature of this heat source, the better the energy efficiency of the heat pump.

Several mediums can be used as a **low temperature heat source** for the heat pump, however, not all sources are universally available or have the same temperature level (impact on energy efficiency):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While in all cases the specialized expertise is needed to prepare and design the overall system, the use of ground water requires specific attention to avoid mixing of water from different underground water tables. Generally, local regulation will define the needed precautions to be taken.

Heat Source	What	Availability	Impact on energy efficiency
outside air	An outdoor unit extracts heat from outside air.	+++	+
soil	Closed loops extract heat from soil through boreholes up to 100m deep or more. This system is often named borehole thermal energy storage (BTES).	++	++
ground water	Open loops extract ground water from a warm well (e.g. 10 - 15°C), deliver heat to the heat pump and inject the ground water in a cold well (e.g. 5 - 10°C). In summer, the cold ground water can be extracted again to cool the building and be injected in the warm well. This system is often named aquifer thermal energy storage (ATES).	++	++
low temperature waste heat	Some processes (cooling installations in industrial process, datacenters, cooling storage, etc.) have low temperature waste heat (< 30°C) throughout the year.	+	+++
waste water	The effluent in sewage systems and wastewater treatment plants contains a lot of heat from domestic, tertiary or industrial hot water that is flushed away	+	++
surface water (river, lake, ...)	Through a heat exchanger, heat can be extracted from surface water.	+	+
combination of geothermal system (ATES or BTES) and surface water	If the heating demand significantly exceeds the cooling demand, the thermal imbalance in the geothermal system may be solved by using surface water to regenerate the geothermal system during summer. As a side effect, the surface water will be cooled down a little which helps countering the heat island effect.	+	++

Heat and temperature

Before discussing how the heat produced by the heat pump can be emitted to the buildings and which types of buildings can be served, there is an important parameter that is decisive for both the efficiency of the heat pump cycle (COP) as well as for the losses in the heat distribution systems. This parameter is the temperature of the heat.

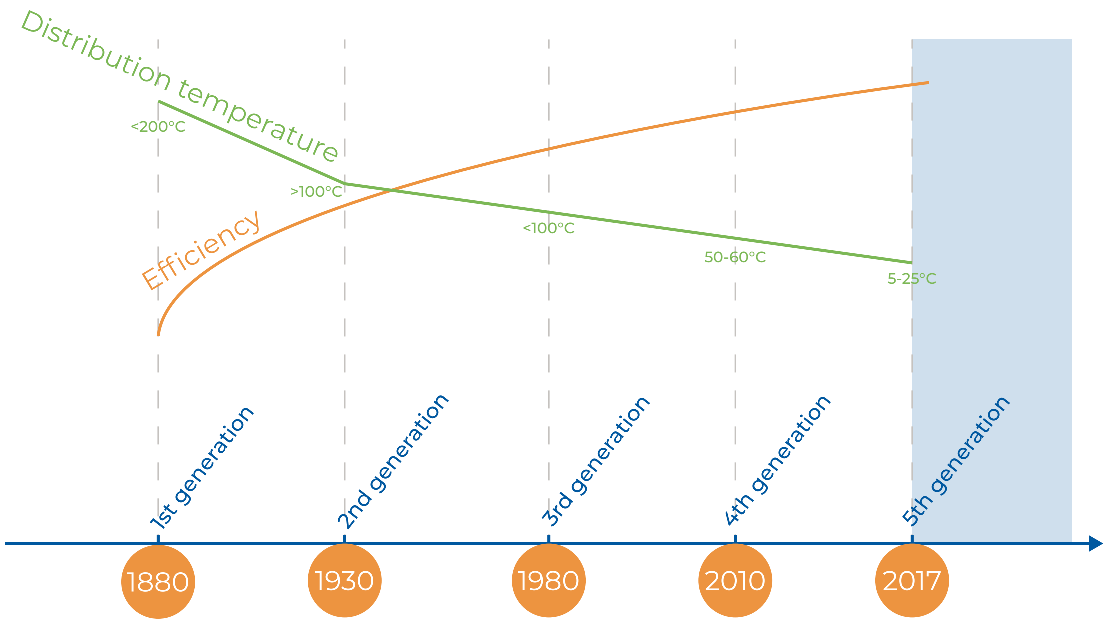
Additionally, the selection of the temperature determines the potential for and the way to enable cooling.

District heating systems used to operate at high temperature, even steam was used. This ensured that a wide variation of buildings with different heat emissions systems could be connected. As buildings became more efficient and energy and environmental consciousness increased, alternatives were being developed. Today, mainly fourth generation but also fifth generation district heating systems are being rolled out. Research is even analysing the so-called sixth generation looking into the renovation of district heating systems up till the fourth generation.

Sanitary hot water is prepared using specific appartment-level heat pumps, electrical heating or heat pump boilers on the ventilation system.

The selection of temperatures is also to be evaluated in relation to the geographical concentration or density of the heating and potential cooling demand as well as the potential need for a thermal balance of the low temperature heat source in case of a geothermal source.

District heating systems of the fourth and fifth generation are within the scope of the heat pump driven heating networks described in this booklet. An important difference with earlier generation district heating is that fourth and fifth generation networks are often smaller. Low temperature heat sources are not centrally available at sufficient power in a city. Instead they are spread out in different areas, which implies a need for decentralized, small-scale heat distribution.



Heat pump driven district heating

As temperature of district heating networks as well as temperature demand of buildings vary, different lay-outs of heat pump driven heating networks have been developed. Different potential configurations are:

- **District heat pump**

The simplest lay-out is a conventional approach with a central heat pump and heat exchangers in the different buildings.

- **Building heat pumps**

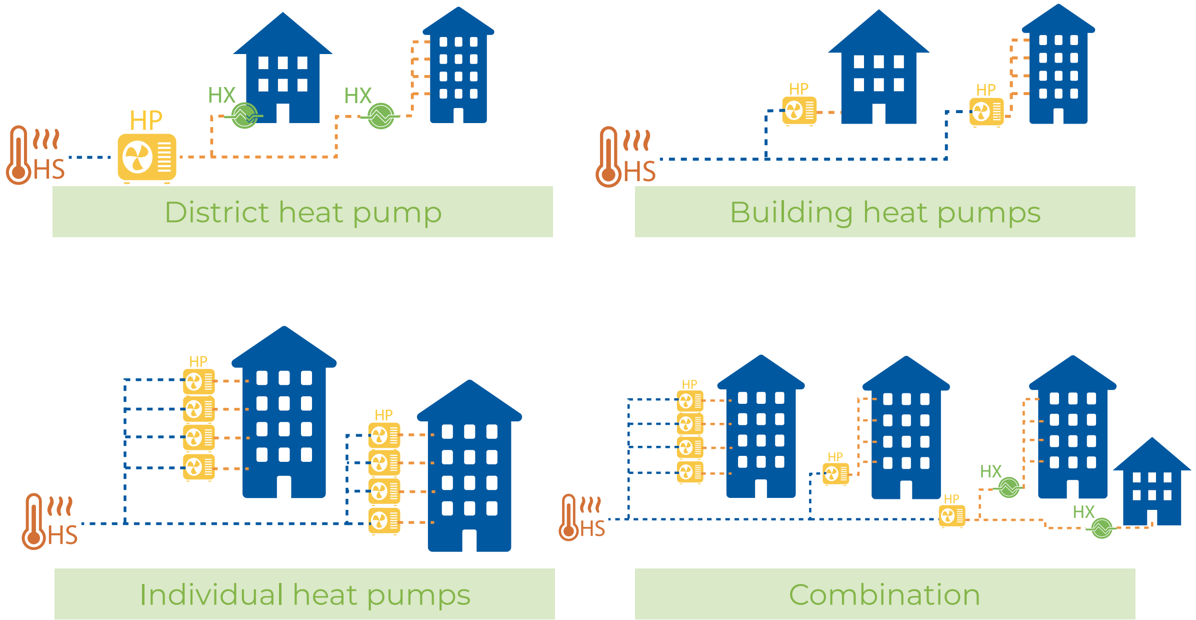
Another approach is to have the low temperature being distributed in a network, combining that with a heat pump at building level. The advantages are that the different buildings can have a wider variation in the supply of temperature as well as the reduced losses in the heat distribution network. The drawback is mainly in the increased investment cost of decentralized systems compared to central systems. However, it becomes possible to provide cooling with the same system.

- **Individual heat pumps**

Similarly to the scheme above, the district heating network distributes the low temperature heat. The individual users each have their own heat pump. Thermal losses in the building are further reduced, but the advantages on both investment cost as well as centralized control and maintenance are decreased. However cooling is standardly available.

- **Combination**

A combination of previous systems allows an even wider flexibility in fulfilling the heating demands of various end-consumers and optimising the operation and efficiency of the network.



Note that more advanced systems are being exploited already today where e.g. the heat is injected from a builing in the network, solar thermal systems are included and storage provides flexibility to enable reducing peak loads.

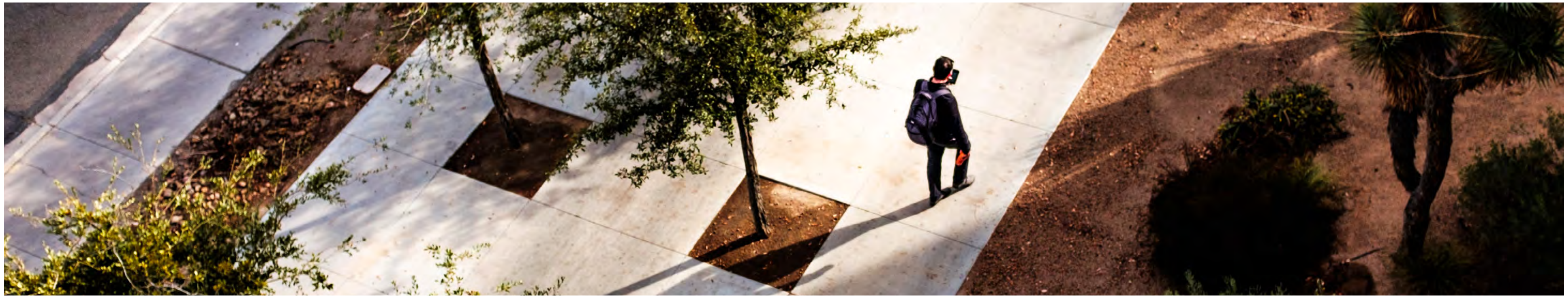
Which configuration fits best strongly depends on each specific project. Aspects that should be considered include:

- Amount of connections and their geographical spread
- Building types connected (office, hospital, school, residential...)
- Heating demand
- Cooling demand
- Thermal losses
- Investment cost for heat pumps and heat exchangers
- Investment cost for distribution network (both for heating, cooling and heat source side)
- Available heat source(s)

		Heat Pump	
		Centralized	Individual
Initial investment	Heat Generation	+	−
	Distribution system for heating	−	+
	Distribution system for cooling	−	+
Maintenance		+	−
Control	Optimised operation of the overall system	+	−
Thermal distribution losses		−	+
Availability of cooling		−	+

+ Advantage

− Disadvantage



Smart control and flexibility

The control of the heat pump driven district heating system is specific per case and several players have solutions for that. In today's electricity grid additional opportunities could be exploited: the flexibility in the electricity use of the heat pump. Advanced controls embed this flexibility to:

- Stabilize the electricity grid: for instance, during the evening peak in electricity demand in residential areas, the heat pump can be turned off to limit peak demand.
- Increase the share of renewables in the electricity mix through flexibility in the demand for heat. This can be done in two ways: a (large) thermal storage as part of the district heating system or in various connected buildings or through the activation of the thermal mass of the connected buildings.

The activation of building thermal mass means that thermal energy is stored in the building materials such as concrete, bricks and even massive wood. The charging of the thermal mass is done by inreasing the indoor temperature. In very well insulated buildings, a dead band for indoor temperature can be chosen around a fixed indoor temperature setpoint. This dead band can be 1, 2 or even 3 degrees, depending on the comfort demands of the inhabitants. When a lot of renewable energy is available, heat pumps can use this deadband to heat the building to the upper setpoint temperature. When no renewable energy is available, the heating systems can be shut down until the building has reached the lower setpoint temperature. The higher the insulation level of the home, the longer it takes before the heating system has to turn on again.

Lessons learned

Heat pumps are a perfectly feasible solution to provide heat in a district heating network. Although high temperature heat could be supplied by specific heat pumps, the efficiency is better with temperatures below 50 or even 40°C.

Designing a heat pump driven district heating network requires an experienced multi-disciplinary team. It should include an experienced engineering company, experts in environmental permitting and ideally business developers with experience in electricity markets.

The engineering company needs to

- assess the available low temperature heat sources: to what extent and at what cost it is technically feasible to access them and extract the needed energy and power
- investigate potential waste heat near the planned network or the location of solar thermal energy systems

- evaluate the heat demand: the required temperature levels potentially function of the outdoor conditions as well as the flexibility due to the use of buildings' thermal mass or the addition of thermal storage
- weigh off the potential for delivering cooling and to what extent this would improve the thermal balance of geothermal energy systems such as ATES or BTES
- size the heat pumps and all parts of the district heating systems according to present and future needs
- design the principles of the control

Environmental permitting experts need to

- engage with the engineers to ensure the effective administrative acceptance of the intended use of the low temperature heat source
- initiate the dialogue with the permitting bodies timely to avoid delays due to missing or incomplete permits

Business developers experienced in electricity markets could further

- cooperate with the DSO to assess the impact of peaks and assess the potential of providing services with relation to power quality, load balancing and peak shaving at low and medium voltage levels
- engage with electricty suppliers to optimise tariffing compared to the electricity use profile of the district heating system
- evaluate the valorization of potential of flexibility by aggregators

Practical example

In Grenoble, France, the river Isère causes the groundwater level to be very high in a part of the city. Therefore, the groundwater is extracted from the soil and discharged in the river. In this area, they have built a heat pump grid for the EU project City-Zen. Each apartment building has its own heat pump and its own groundwater source where they extract the groundwater from. In winter operation, the ground water is cooled down as it serves as the low temperature heat source for the heat pump. A collective drainage network then collects the used groundwater from all the apartment buildings and discharges it into the river. The extraction of water from the ground and discharge in the river takes away the need for an annual thermal balance.

This specific technical solution is tailor made for an environment where the groundwater level is excessively high. In most regions where the groundwater level should be respected, the groundwater should be reinjected in the same water layer after usage. This illustrates how this kind of solutions should be well designed to fit in a specific context.

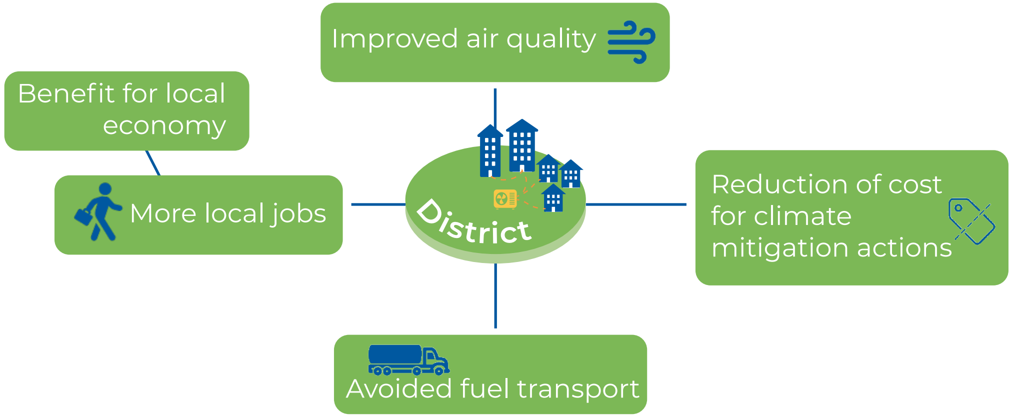
Innovia, Presqu'île, Grenoble

BUSINESS MODELS & FINANCE

BUSINESS MODELS & FINANCE

Description – possible business models

Earlier generations of district heating networks have business models based on economies of scale, i.e. large scale production, an extensive distribution network and a large number of often institutional consumers. New low temperature networks are developed on the low temperature resources available at the district level, enriched with local waste heat or solar thermal systems. From producing and selling, the model now changes to a more distribution and trading oriented approach. The change to lower temperatures enables a diversification of the value that is proposed to the end-consumer and prosumer. Where the large scale production and distribution networks from the earlier generation benefits from a higher margin on the heat source and lower investment costs, the small scale production and low temperature distribution benefits from lower losses in the distribution and non-monetary values related to among others sustainability and air-quality.



The lower heating demand of the new and renewed buildings shifts the price model from a unit-based approach to a connection fee with a minor share of unit-based cost. Such an approach ensures that the end-consumers are less sensitive to changes in the electricity tariff.

Business and value

A number of heat driven district heating networks identify the projecs to only have been implemented due to subsidies or commitments from local governments. To a large extent, this is based on applying the business models developed for conventional district heating systems, working with a push strategy delivering heat at large scale to the customer. New technical concepts require novel business approaches where selling on a unit-basis advances selling services and enabling trading as well as valorization of the electrical flexibility.

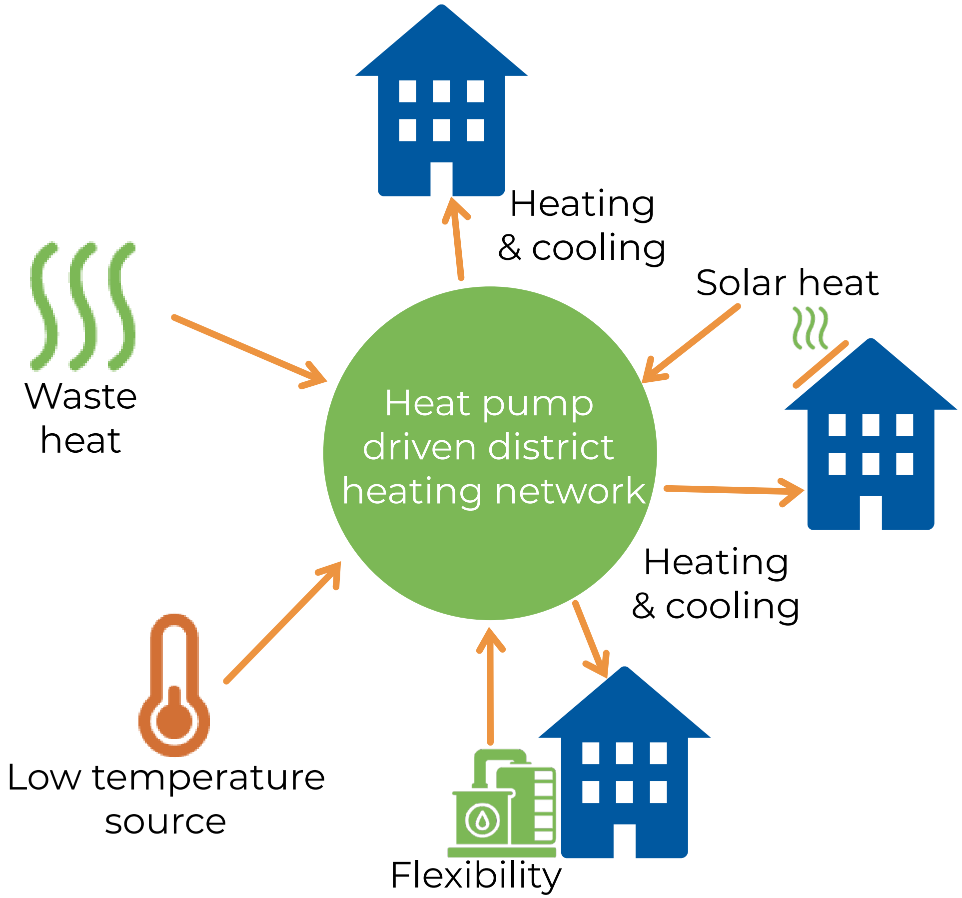
Non-monetarized values such as contribution to improved air quality and reduction of climate change, creation of local jobs, avoidance of fuel transport are not part of an effective investment and business model. However, policy measures could be developed that create a context favouring these values.

Revenue

Heat pump driven district heating systems can use various sources of low and medium temperature available within the district. This shifts the business model from a unit-based sales mode to a more trading based model. Production, distribution and maintenance are now combined with a more challenging control and a more active and pro-active relation with the end-consumer. Changing towards an interactive model enables a reduction of the higher upfront costs that heat pump driven district heating is subject to.

Regional policy and regulation can support the decision making for heat pump driven district heating.

- Important investment risks are related to the uncertainty of the effective number of end-consumers connecting to the network. In order to overcome that risk, several member states make connections in new developments obligatory.
- Access to low temperature heat sources is not self-evident. Regulation is often missing and several local governments lack experience and confidence in heat pump driven district heating. A clear regulatory framework could lead to more projects being effectively realized.



- Support from local governments is a key element in the acceptance creation and the commitment of project developers and key future clients.

Lessons learned

Heat pump driven district heating systems fit perfectly well in a transition towards a more efficient and sustainable building stock. While investment costs could be higher, these new type of district heating systems offer additional benefits:

- Enable end-consumers to become prosumers and hence take a more active role in the energy market
- Provide end-consumers a tariffing scheme that is less dependent on the electricity price
- Optimise the production and distribution of heat to minimize losses
- Enable cooling to offer additional services to a broad variation of end-consumers and avoid the use of air-conditioning
- Increase the value by providing flexibility to aggregators and/or distribution system operators
- Maximise the potential to develop the heat pump driven district heating bottom up, starting with a small number of buildings and expanding in the future

The engagement of project developers, municipal or city administrations, utility and end-consumers is a key element in the successful uptake.

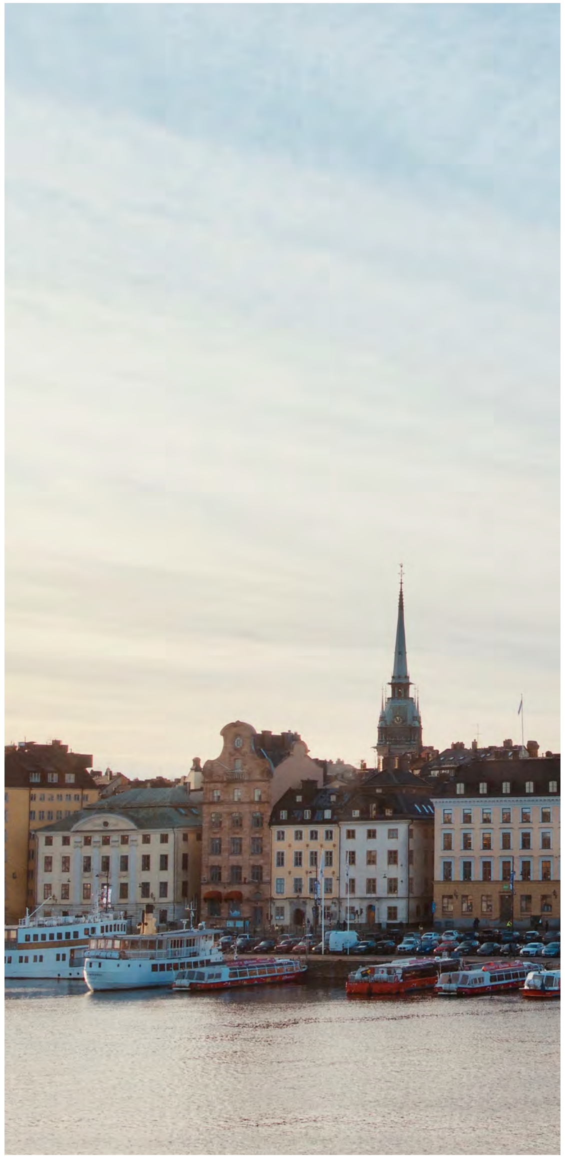
Example from Stockholm

Stockholm Exergi produces district heating, district cooling and electricity in the Stockholm metropolitan area.

The company has approx. 10,000 district heating and cooling customers in Stockholm which provides heat to over 800,000 citizens.

Stockholm Exergi is equally owned by a private company and the City of Stockholm and the joint commitment is to advance to a thermal energy system entirely produced from renewable or recovered energy no later than 2030.

Stockholm Exergi has its own heat pumps and CHPs, but also buys waste heat from datacenter heat pumps. The price for the heat makes it interesting for Stockholms Exergi to choose for recovered heat rather than heat from CHP-plant. The model ensures datacenters get remunerated for cooling rather than having to pay for it.



GOVERNANCE & REGULATION

GOVERNANCE & REGULATION

Description – governance and regulatory barriers

Heat pump driven district heating systems require a substantial investment, as for most district heating systems. The benefit of the ability to develop a positive business case even with smaller bottom up networks, enables less traditional ownership and governance structures. Five ownership models are identified: public company, public-private partnerships, private cooperatives, network model of large enterprise and energy service companies (ESCOs). Linked to each ownership model is a specific revenue model ranging from long-term standard contracts to complimentary partnerships and subcontracting arrangements.

Governance structures to manage operation and needed investments are linked to the ownership models, however new EU-wide regulation enables additional governance structures. The latter refers more specifically to the Renewable Energy Directive's concept of Renewable Energy Communities where renewable based energy can be shared amongst members and governance structures have to be fair and transparent, not led by large scale entities not having energy supply is their main activity.

Diverse ownership and operation models have proven their effectiveness, but they indicate to be case and culture dependent. The most common approaches include:

- **Investment and operation split**
  The investment is part of the project development and once the operational phase is to be initiated, a procedure is launched to identify an operator for a specific period of time. The tender can include targets on price and efficiency. There is no specific risk with such governance structure if all components and their interaction as well as the overall control, the price settings and the guarantees, are well-defined.
- **Investment and operation by a private entity, whether cooperative or not**
  This model ensures a balanced equilibrium between investment costs (CAPEX) and operational cost (OPEX). Although end-consumers generally lack the expertise, some level of cooperative governance could be positive to ensure the decision making includes aspects other than profit maximisation, i.e. effective use of renewable energy and ambition level. Small (apartment level) as well as large (i.e. city-wide) district heating networks successfully operate under this governance structure.
- **Investment and operation by a public utility company**
  Public utility companies in general have a longer timeframe to evaluate assets and investments. With large scale investments in new and potentially expanding district heating networks, the investment model of a large scale utility might fit well. Several networks today are already operated by existing public (or cooperative) utility companies. Today, a limited number of them are heat pump driven, but this is changing.

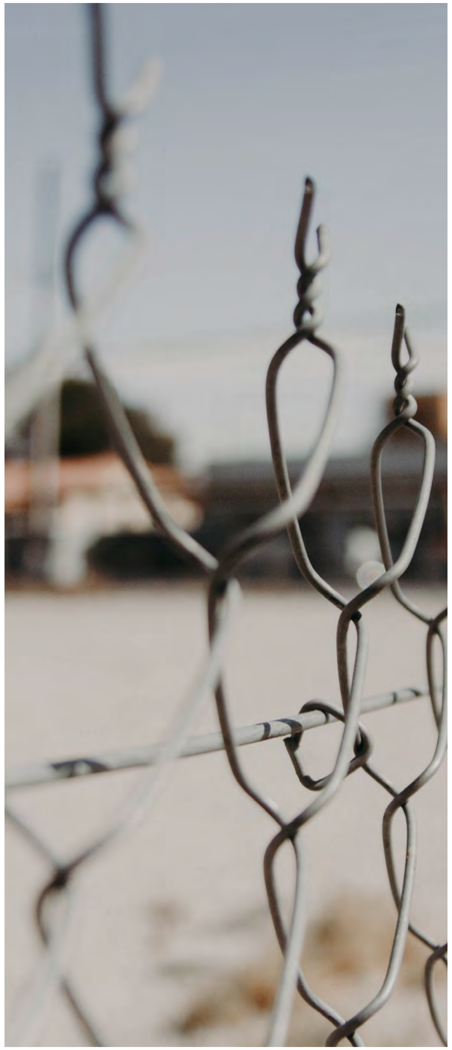
Description – Regulatory barriers and opportunities

Regulation

In most European member states neither district heating systems nor the access rights to low temperature heat sources are regulated, contrary to electricity distribution. A number of barriers have been identified that hinder a smooth roll out or even prevent an effective design being realized.

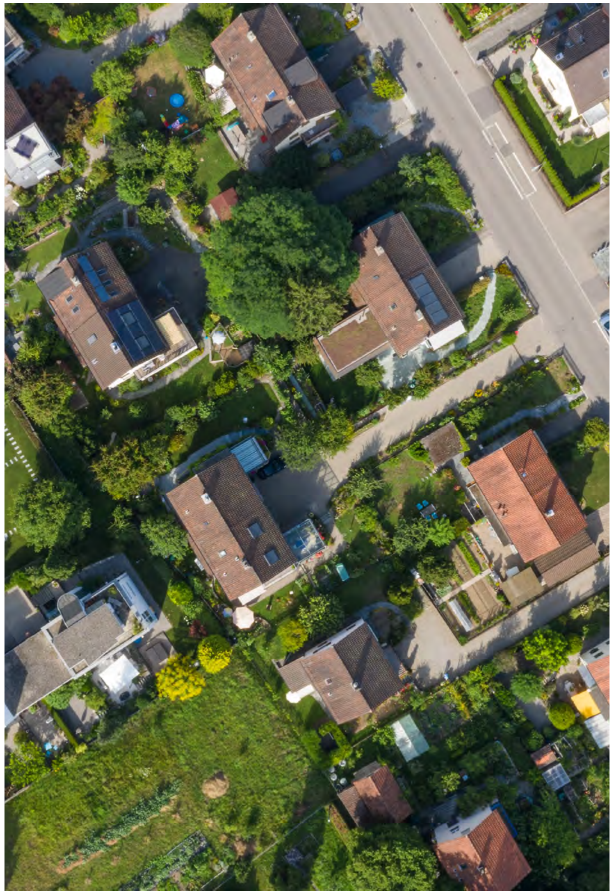
Barriers include:

- Licensing, the awarding of concessions and environmental permits are key mechanisms for a predictable, transparent and fair implementation model. Especially the environmental permitting often imposes substantial administrative barriers. An open mindset as well as a good documentation of accepted and implemented innovative heat pump driven district heating projects could enable a faster acceptance by local municipal, city or regional administrations.
- Uncertainty on number of connections is a high risk aspect for investors. Mandatory connections (where customers are obligated to connect to a district heating network where available) can ensure sufficient heat demand. This can be a decisive element to encourage investment in the network development. A clear upfront planning with potential provision of intermediate alternatives, a financial incentive for coupling, could alternatively positively impact the number of connections in the absence of an obligation.
- Long term commitments for delivery of waste heat require guarantees for 2 sides: (1) the waste heat provider has to get a clear context on the further development opportunities of his business on site and (2) the district heat pump network developer has to get a price and delivery assurance. Furthermore, the regulatory obligation for a useful application of waste heat would increase the opportunities and avoid endless discussions on price settings leading to substantial delays and even cancellation of otherwise sustainable projects.



- Regulation of pricing is in place in several European countries. Inflexible price regulation can have an impact on the developer side as well as the end-consumer side:
  - Developers can be disincentivised from implementing sustainable heat pump driven heat networks and upgrading or altering current systems. It can also limit innovation and lead to domestic customers not connecting at all or disconnecting from district heating network for cheaper alternatives.
- To the end-consumer, heat can be considered as a service at a fixed price or sold per energy unit, i.e. per kWh of heat delivered. This openness provides a barrier as well as an opportunity. The main barrier is related to the potential risk of non-transparency and inconsistent price settings and price increases towards the end consumer. The main opportunity is related to the model provided: heat as a service forces the operator to maximise his profit through efficiency which makes the pricing less prone to changes in the electricity pricing or regulatory changes on energy efficiency obligations.

An opportunity lies in the Renewable Energy Directive: Renewable Energy Communities are allowed to share renewable energy, including renewable heat and electricity amongst their members. Energy communities are defined through their operation and governance, enabling citizen to take an active role in the energy system. Citizen, public organisations, non-for profit and companies who do not have energy production or trading as main activity are allowed to participate. The main objective is supposed to be other than profit-making.



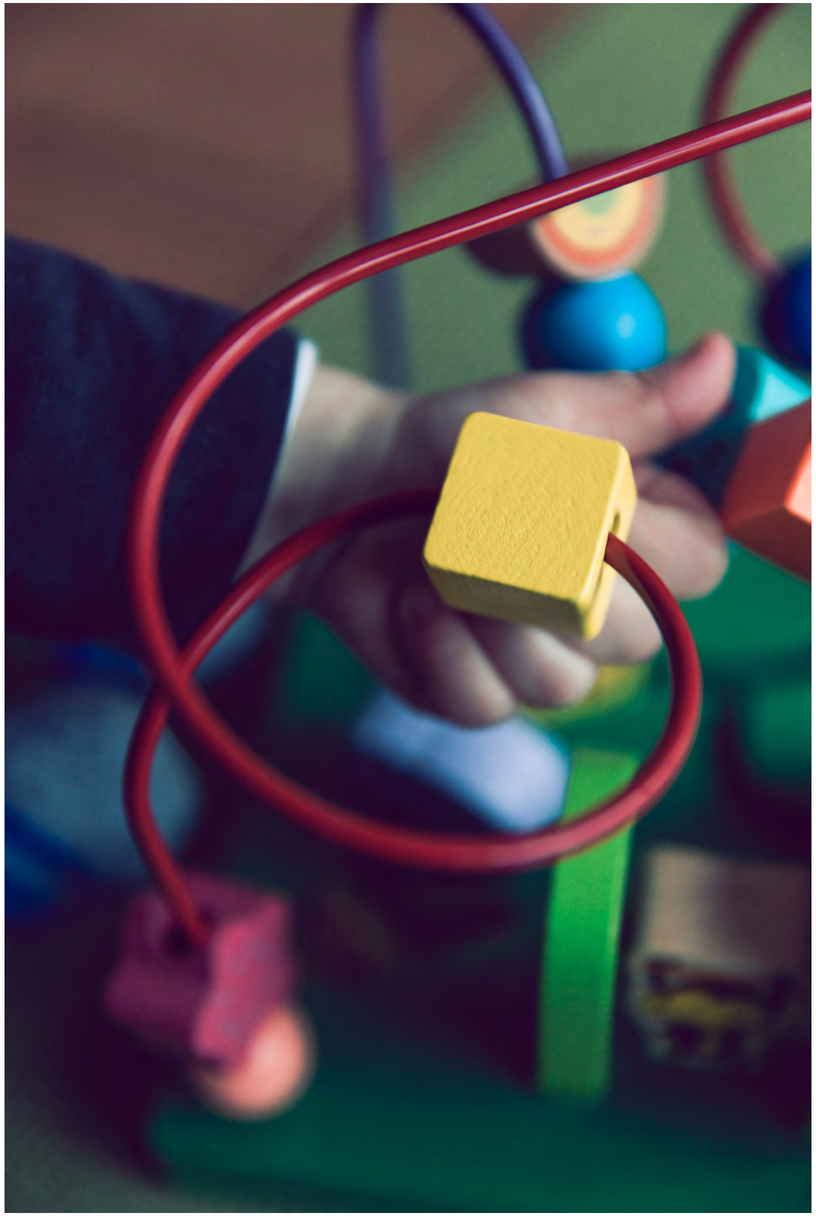
Lessons learned

Heat networks have been implemented and operated since over 100 years. It is mainly the shift towards heat pump driven networks, using low temperature heat sources and integration of waste and renewable heat, that poses challenges but also provides opportunities.

New EU regulation enables alternative operational models where end-consumers are not only becoming more active prosumers, but can also participate in the decision making process. This model can complement the already existing structure of private ownership, public ownership, public-private partnerships, private cooperatives and ESCOs.

The cooperation of diverse stakeholders is needed to advance from concept to realization. Municipal or city administrations can act as facilitators opening opportunities and organizing dialogues. Heat pump driven heat networks should be seen as an opportunity for emission reduction and increased shares of RES.

The need for long-term planning and buy-in and collaboration from industry and political areas is key for regulation to be effective. However, given continuous changes to the energy market as a consequence of increasing shares of renewables in an often older infrastructure, there is a need for flexibility and therefore a proactive identification and smooth implementation of changes to the regulation.



GENERAL LESSONS LEARNED

GENERAL LESSONS LEARNED

Heat pump driven district heating systems perfectly fit in the transition to more efficient energy provision to a broad variation of buildings: existing buildings, energy-renovated buildings and new low-energy buildings all can be served at the adequate temperature level. Additionally, a good design can integrate client's with a cooling load.

While investments might be higher, the concept provides substantial benefits:

- **Decrease in thermal losses in the distribution system**
- **Enabling end-consumers to take a more active role in the energy system**
- **Provide alternative pricing models with a lower dependency on electricity prices**
- **Include waste heat**
- **Create local jobs**
- **Contribute to improved air quality by avoiding the use of fossil fuels**
- **Increasing share of renewables directly through the use of heat pumps and indirectly through the link with aggregators and potential services to the distribution system operator**

It is important to reduce risks by engaging all relevant stakeholders from the design phase onwards. Engineering companies, experts in environmental permitting, business model developers with profound knowledge of the electricity market, project developers, building owners and the local city or municipal services.

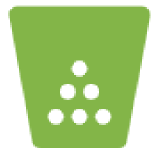
Incentive schemes could be beneficial to overcome the price difference between electricity and fossil fuels to enable offering the end-consumer a product at a price at maximum equal to that of conventional heating. Additionally, regulation that requires end-consumers to be connected within a certain timeframe, would be beneficial to reduce risks.

A sound and attractive communication campaign is key, focussing on the potential of heat pump driven district heating to unburden the end-consumer, a neighbourhood with cleaner air and a contribution to reducing climate change.

DECREASE THERMAL LOSS

ACTIVE ROLE FOR END-CONSUMER

PROVIDE ALTERNATIVE PRICING MODELS



INCLUDE WASTE HEAT

INCREASE SHARE OF RENEWABLES

IMPROVE AIR QUALITY

CREATE LOCAL JOBS

USEFUL DOCUMENTS

USEFUL DOCUMENTS

City-zen

EU-GUGLE

GrowSmarter

CONTRIBUTIONS

EU Smart Cities Information System

SCIS

The Smart Cities Information System (SCIS) is a knowledge platform to exchange data, experience and know-how and to collaborate on the creation of smart cities, providing a high quality of life for its citizens in a clean, energy efficient and climate friendly urban environment. SCIS brings together project developers, cities, research institutions, industry, experts and citizens from across Europe.

SCIS focuses on people and their stories – bringing to life best practices and lessons learned from smart projects. Through storytelling, SCIS portrays the “human element” of changing cities. It restores qualitative depth to inspire replication and, of course, to spread the knowledge of smart ideas and technologies - not only to a scientific community, but also to the broad public!

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