Task 55 Towards the Integration of Large SHC Systems into DHC Networks

SWOT analysis of ST integration in DHC systems

IEA SHC **TECH** SHEET 55.A.2.2, page 1 of 10

Subject:	SWOT analysis of solar thermal integration in district heating and cooling
Description:	Background and motivation SWOT analysis Rating of the identified SWOTs
Date:	February 12th, 2020
Authors:	Paolo Leoni, Ralf-Roman Schmidt, Roman Geyer, Patrick Reiter
Download possible at:	http://task55.iea-shc.org/fact-sheets

Contents

Solar thermal (ST) energy is one of the few renewable heat sources that is available almost everywhere and can bring multiple benefits to district heating and cooling (DHC) networks (on an environmental and systemic level) with very low operation costs and risks. However, the current share of ST in DHC networks is almost zero on a global scale.

The international cooperation between IEA SHC Task 55 Subtask A, IEA SHC Task 52, and the IEA DHC|CHP led to a holistic understanding of strengths, weaknesses, opportunities, and threats (SWOT) for the integration of solar thermal (ST) systems in district heating and cooling (DHC) networks up to a high solar share. The result is a SWOT analysis relying on the work performed in both TCPs, on additional literature review, and on stakeholder interviews.

Background and motivation

In recent years, megawatt-scale ST supply to DHC systems have gained increasing attention. This alternative energy is available almost everywhere (unlike e.g. deep geothermal energy or industrial waste heat) and, thus, it can contribute to satisfy the increasing energy demand of districts and cities. Further on, the integration of ST in DHC networks leads to benefits on both environmental and systemic levels: in fact, it acts positively from the one side reducing emissions and air pollution, and from the other side supporting among others the DHC infrastructure and the local economy. ST technology can take the advantages of possible synergies in the urban context and can increase the security of energy supply, as it allows the reduction of fuel imports and the diversification of the energy mix.

A breakdown of fuel use in DHC systems worldwide shows that 43.2% are fueled with natural gas, 43% base on coal and its products, followed by oil (4.3%), biofuel and waste (6.5%), and nuclear energy (0.2%). Solar based energy supply accounts for far less than 0.01% globally. Still, the share of energy from renewable sources has been growing (IRENA, 2017). However, the value of the ST share in DHC systems is highly diverse in the single countries: for example, Denmark is well known for its integration of large ST plants into local DH networks, and other countries, such as Austria, are about to implement even bigger ST systems for DH.

A simulation study[1] for Austria, Denmark, Germany and Italy, estimated a technical potential between 3% and 12% solar share in 2050, where the solar share is defined as:

solar share = heat supplied by solar thermal collectors / overall heat supply to the end customers

However, the integration of large solar thermal systems into existing and new DH networks faces several challenges, especially the high operating network temperatures and the seasonal mismatch between supply and demand (e.g. BDEW, 2017). This is especially relevant as soon as the solar share reaches a level that influences significantly the operation of the network and of the other supply units.

The SHC (Solar Heating and Cooling) Technology Cooperation Programm (TCP) of the IEA was established in 1977 to promote the use of all aspects of ST energy by international collaborative effort of experts from various countries[2]. Its primary activity is to develop research projects (Tasks) to study various aspects of SHC. IEA SHC Task 55 provides a platform for practitioners and scientists to elaborate the benefits and challenges of solar district heating (SDH) and solar district cooling (SDC) systems. As part of IEA SHC Task 55, Subtask A focusses on the assessment of the impact of solar thermal technologies on the overall DHC network and integration aspects in order to analyze barriers and opportunities for increasing the ST share. To this Subtask belongs the SWOT analysis here presented, performed in collaboration with other SHC Tasks (e.g. Task 52 on "Solar Heat and Energy Economics in Urban Environments"[3]) and the IEA TCPs on District Heating and Cooling (DHC) and Combined Heat and Power (CHP)[4]. Both TCPs show significant expertise, which in the past had

---

[1] http://www.sunwindenergy.com/solar-thermal/solar-thermals-role-2050-energy-mix

[2] https://www.iea-shc.org/

[3] http://task52.iea-shc.org/

[4] http://www.iea-dhc.org

mainly been focused on each system individually. In a future energy system, the different sectors have to be highly integrated to reflect developments not only in Task 55, but also in other IEA TCPs.

SWOT analysis

The here presented SWOT analysis (analysis of the strengths, weaknesses, opportunities and threats) for the integration of ST energy into DHC networks bases on the work performed in both IEA SHC and DHC|CHP TCPs, including past activities and additional literature review and stakeholder interviews. Also, a review process involving experts from both TCPs ensures a high relevance and acceptance of the analysis in both fields.

Strengths

- Very low operating costs compared with current sources of heat generation
- Well-known and developed and standardized technology
- Easy to install and highly scalable (from very few kW to MW-scale)
- Low investment risk – fuel is the sun, which is abundant in nature and a free good leading to (long-term) stable and predictable heat generation costs (€/MWh)
- Good fuel availability, political independence, security of supply
- Easy supply logistics, particular advantageous for regions where transport of other sources is difficult
- Emission free (CO_2, NO_x, noise) – it contributes to reduction of emissions
- High efficiency of land use, no land sealing is needed, which allows a (limited) agricultural co-use and guarantees preservation of biodiversity
- The specific land use ranges typically from 3 to 6 m^2/MWh year generation, including land use for storage and storage losses:
    - 3 m^2/MWh e.g. in the favorable circumstances of annual radiation 2 MWh/m^2, annual production 1 MWh/m^2, land area / collector area 1.5
    - 6 m^2/MWh e.g. in less favorable circumstances of annual radiation 1 MWh/m^2, annual production 0.4 MWh/m^2, land area / collector area 2.5

  The specific land use can be even smaller for high-efficiency systems or negligible heat losses. In any case, the value is lower than other renewable energy sources (ca. 20 m^2/MWh for PV, ca. 50 m^2/MWh for wind power, ca. 200 m^2/MWh for biomass are reported in SDH Fact sheet 2.2, www.solar-district-heating.eu)
- As a consequence of the former strength, ST is no threat to food production (
- The lower network temperatures in the summer operation improve the ST efficiency
- Thermally driven absorption chillers can absorb summer surplus heat from ST
- ST components and integration concepts in district heating are well proven, also in old networks with high temperatures and high pressures
- Possibility of using local suppliers

- In most cases, land use for solar thermal is economically more attractive than farming for food production
- New technologies allow a good efficiency even at high operating temperatures

Weaknesses

- High specific investment costs and capital expenditure (CAPEX), reflecting in long payback times. Costs for simple systems without storage or with small storage ranges from 200 to 300 €/m^2, for systems with seasonal storage from 300 to 400 €/m^2
- Little availability of reliable performance guarantees for the overall system (collectors, storage, possible heat pumps, etc.); it complicates the feasibility analysis and increases the uncertainties forecast of the heat generation cost
- Economically optimized solutions are very site-specific, e.g. because of large varying parameters such as solar radiation, land price, land availability, policy framework, etc.
- DH always requires at least an additional heat source to ST, what affects and may set constraints to all the phases of ST projects (planning, operation, optimization, retrofitting, etc.)
- The yearly solar generation profile is the opposite of the heat demand profile of DH (ST sized for the winter demand produce too much in summer and ST sized for the summer demand produces too little in winter); so, storages are needed to meet high ST share, reflecting in increased investment costs and land usage
- Competition (especially in summer) with other renewable sources, waste heat, and waste incineration
- Seasonal heat storage systems can be expensive and need suitable conditions (e.g. suitable underground) for an economic realization
- Long-term storage systems are difficult to realize in urban areas
- Network temperatures can be too high (>95°C in many cities in winter) to reach effectively with ST alone and additional heat pumps with seasonal storage may be considered
- Decentral absorption chillers (which could help in using the summer waste heat) require high network temperatures to operate efficient
- Suitable areas for ST installations are limited in the cities and, on the other end, areas outside of the cities require a transport pipeline, which reflects in higher costs, besides possible hydraulic limitations
- ST is often an “add-on” to existing systems, and the overall system is often not optimized for ST integration (e.g. network temperatures); optimization measures may be expensive and, furthermore, as ST is often not the dominant source, measures to optimize other sources may have higher priority

Opportunities

- The increasing utilization of renewable energy and excess heat supports the integration of seasonal storages, which are a key-component to reach high solar shares
- Increasing need for reducing CO_2 and by trend increasing direct/ indirect subsidies for renewables

- Optimized concepts for integrating more heat sources in DH (e.g. cascading) support ST, as they allow ST to operate at lower temperatures and thus at higher efficiency; additionally, optimized integration concepts can also increase the revenues from subsidies
- In recent decades CHPs were main drivers for many DH networks. CHPs become economically less feasible in many areas due to cheap renewable electricity → SDH could become new business model for utilities
- Low interest rates facilitate investments in renewables and others
- Raising interest in civic participation and locally produced renewable energy, as well as customers demanding zero-CO_2 heat, facilitates investments in ST for DHC
- Fossil fuels phase out on the long run
- On a holistic cross-sectoral view, SDH will be one of the most reasonable choices for heat generation from renewables: biomass (apart from questioned CO_2-savings) is too valuable for low-grade heat and results more suited to high-temperature applications, mobility etc.; geothermal is highly site-depending and only in few places economically feasible
- Waste incineration is not everywhere accepted, and, in some places, it shows a decreasing trend, what opens potential for more ST
- The investment costs can potentially decrease when the market increases (learning effects on large-scale, bigger standardized collectors, etc.)
- Increasing trend of green financing

Threats

- The long payback times reduce the flexibility and the chance (many investors often prefer shorter payback times)
- Large and exposed collector areas might be damaged (e.g. due to natural disasters)
- Land price might increase as soon as its strategic importance gets public
- Electricity (power-to-heat) becomes cheaper and cheaper
- Overall uncertainty on the price of competitors in the long period (gas, biomass, etc.)
- Little public awareness of the technology, lack of marketing, difficult to understand for decision makers (policy, private, etc.)
- Additional factors may increase the uncertainties of the economic feasibility analysis, such as the long-term forecast of subsidies and salaries

Rating

The identified strengths, weaknesses, opportunities, and threats were rated by 14 experts present at the seventh IEA SHC Task 55 meeting in Härnösand (Sweden) in October 2019. In the rating, each expert assigned to each point a value ranging from 0 (not relevant) to 5 (highest importance).

The results are illustrated in the following diagrams, with the blue bars representing the averages and the black segments the standard deviations.

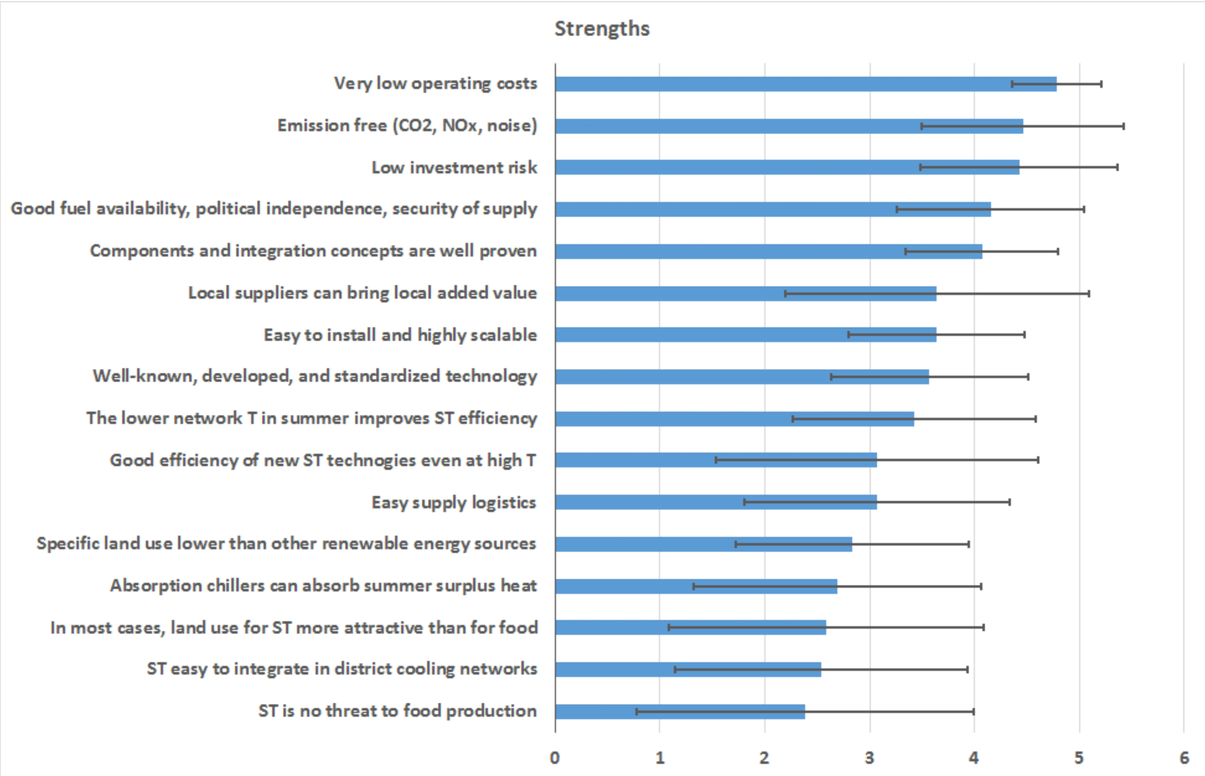

Figure 1. Rating of the strengths of ST integration in DHC

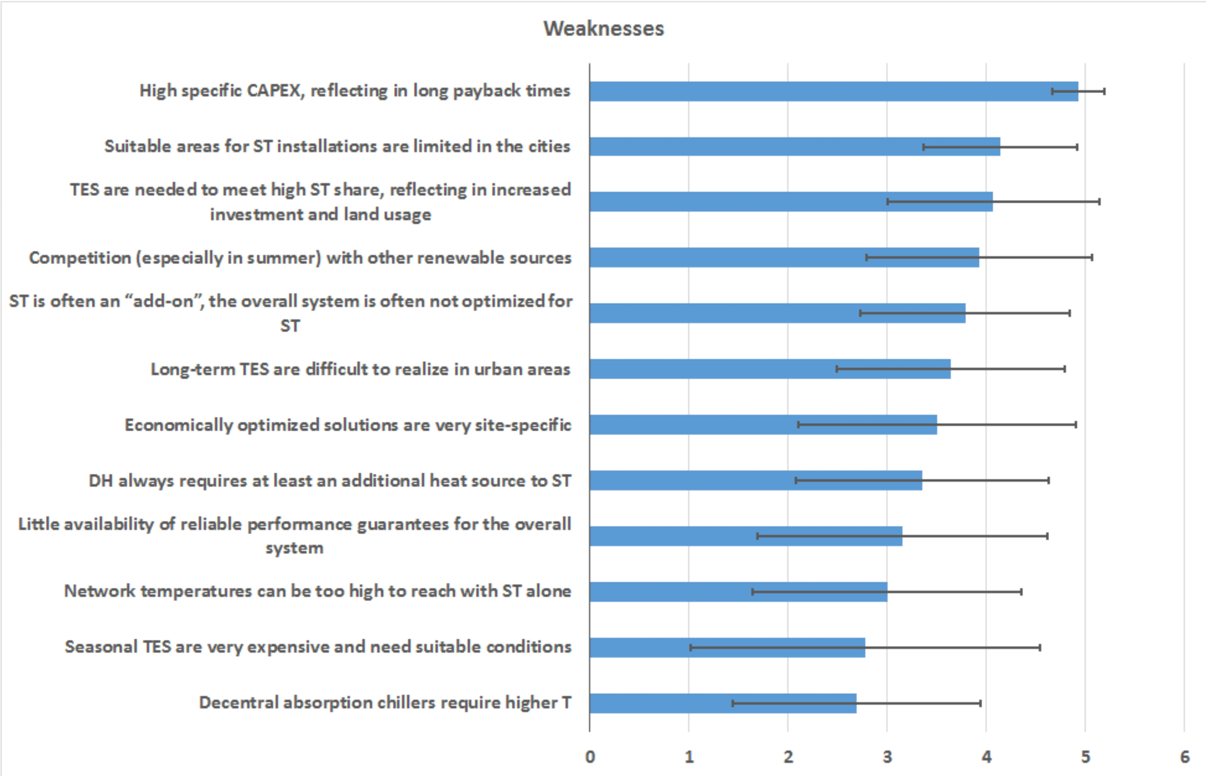

Figure 2. Rating of the weaknesses of ST integration in DHC

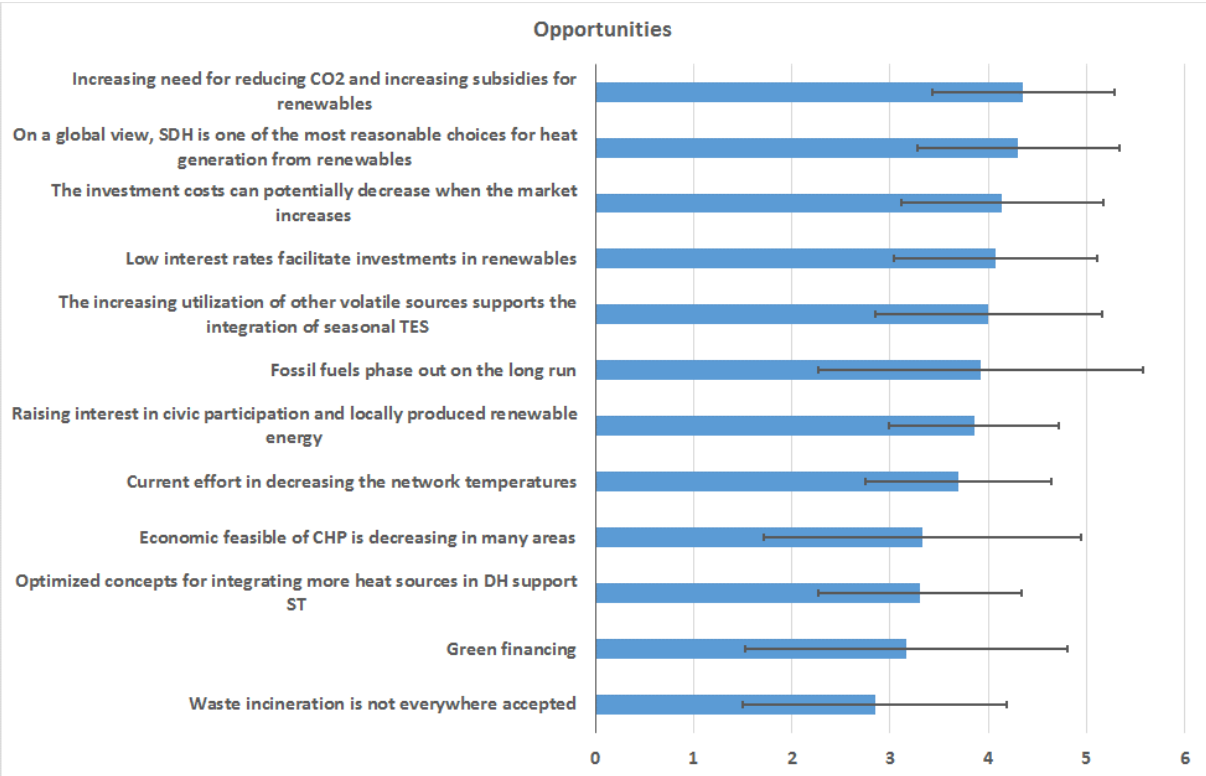

Figure 3. Rating of the opportunities for ST integration in DHC

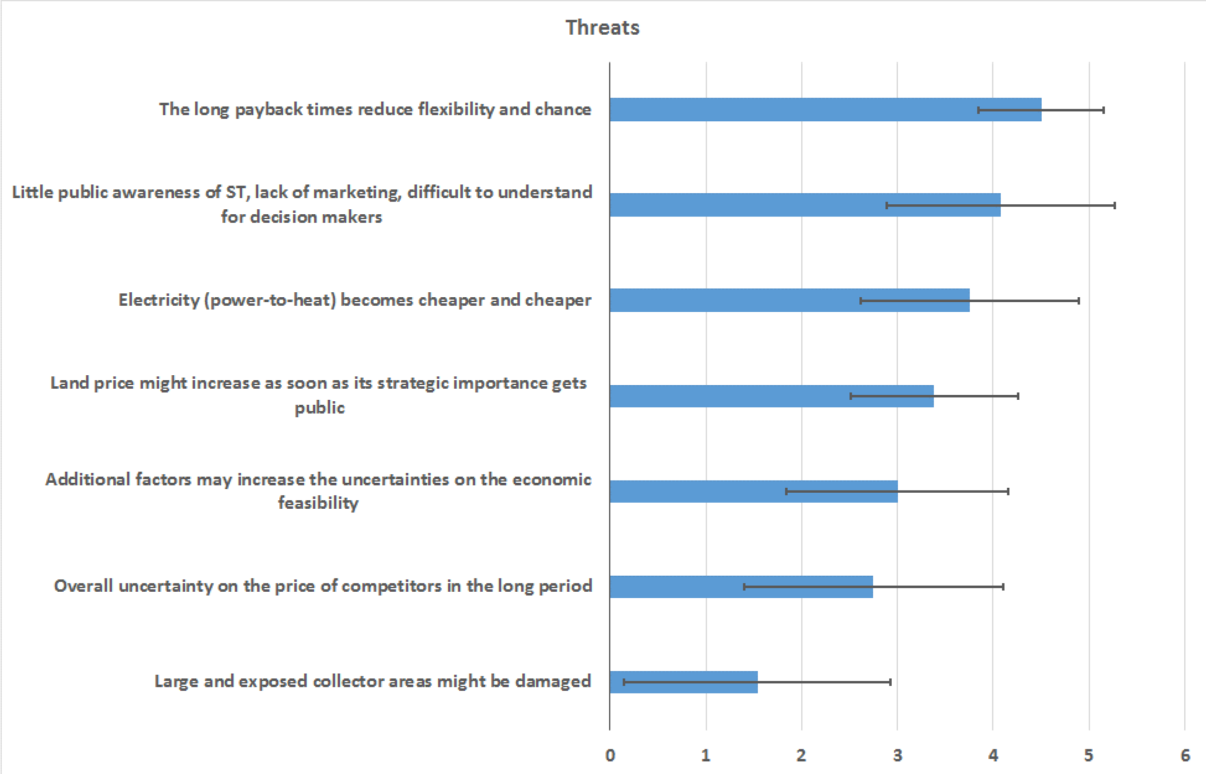

Figure 4. Rating of the threats for ST integration in DHC

Conclusions

The international cooperation between IEA SHC Task 55 Subtask A, IEA SHC Task 52, and the IEA DHC|CHP led to a holistic understanding of strengths, weaknesses, opportunities, and threats (SWOT) for the integration of ST systems in DHC networks up to a high solar share. The result is a SWOT analysis relying on the work performed in both TCPs, on additional literature review, and on stakeholder interviews.

ST is one of the few renewable heat sources that is available almost everywhere and can bring multiple benefits on an environmental and systemic level with very low operation costs and risks. However, the current share of ST in DHC networks is almost zero on a global scale.

The SWOT analysis identified 17 strengths, 12 weaknesses, 12 opportunities, and 7 threats for the integration of solar thermal in DHC networks. The importance of each identified aspect was rated by 14 experts present at the seventh IEA SHC Task 55 meeting in Härnösand (Sweden) in October 2019. In the rating, each expert assigned to each point a value ranging from 0 (not relevant) to 5 (highest importance). The resulting average values allowed ranking those aspects in order of importance. Figure 5 summarizes the results.

SWOT analysis of ST integration in DHC systems

Strengths	1. Very low operating costs 2. Emission free (CO_2, NO_x, noise) 3. Low investment risk	***Weaknesses***	1. High specific CAPEX, reflecting in long payback times 2. Suitable areas for ST installations are limited in the cities 3. TES are needed to meet high ST share, reflecting in increased investment and land usage
Opportunities	1. Increasing need for reducing CO_2 and increasing subsidies for renewables 2. On a global view, SDH is one of the most reasonable choices for heat generation from renewables 3. The investment costs can potentially decrease when the market increases	***Threats***	1. The long payback times reduce flexibility and chance 2. Little public awareness of ST, lack of marketing, difficult to understand for decision makers 3. Electricity (power-to-heat) becomes cheaper and cheaper

Figure 5. SWOT analysis of the ST integration in DHC

The three most important strengths resulted:

1. ST in DHC has much lower operating costs than other sources currently used
2. ST is emission free (CO_2, NO_x, noise) and contributes to the emission reduction
3. ST has low investment risk, since the fuel is the sun, which is abundant in nature and a free good leading to (long-term) stable and predictable heat generation costs (€/MWh)

The three most important weaknesses resulted:

1. ST has high specific investment costs and capital expenditure (CAPEX), reflecting in long payback times. Costs for simple systems without storage or with small storage ranges from 200 to 300 €/m^2, for systems with seasonal storage from 300 to 400 €/m^2
2. Suitable areas for ST installations are limited in the cities and, on the other end, areas outside of the cities require a transport pipeline, which reflects in higher costs, besides possible hydraulic limitations
3. The yearly solar generation profile is the opposite of the heat demand profile of DH (ST sized for the winter demand produce too much in summer and ST sized for the summer demand produces too little in winter); so, storages are needed to meet high ST share, reflecting in increased investment costs and land usage

The three most important opportunities resulted:

1. Increasing need for reducing CO_2 and by trend increasing direct/ indirect subsidies for renewables
2. On a holistic cross-sectoral view, SDH will be one of the most reasonable choices for heat generation from renewables: biomass (apart from questioned CO_2-savings) is too valuable for low-grade heat and results more suited to high-temperature applications, mobility etc.; geothermal is highly site-depending and only in few places economically feasible

3. The investment costs can potentially decrease when the market increases (learning effects on large-scale, bigger standardized collectors, etc.)

The three most important threats resulted:

1. The long payback times of ST reduce the flexibility and the chance (many investors often prefer shorter payback times)
2. Little public awareness of ST technology, lack of marketing, difficult to understand for decision makers (policy, private, etc.)
3. Electricity (power-to-heat) becomes cheaper and cheaper, gaining in competitiveness