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Planning for the integration of solar thermal and thermal storage into district heating and cooling

Sije Gorter

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SOLID references worldwide

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Customer references

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PEPSI

GATORADE

AVL

United World College South East Asia

facebook

VE RI TAS HARVARD UNIVERSITY

IKEA

HYATT REGENCY

Southern California Gas Company

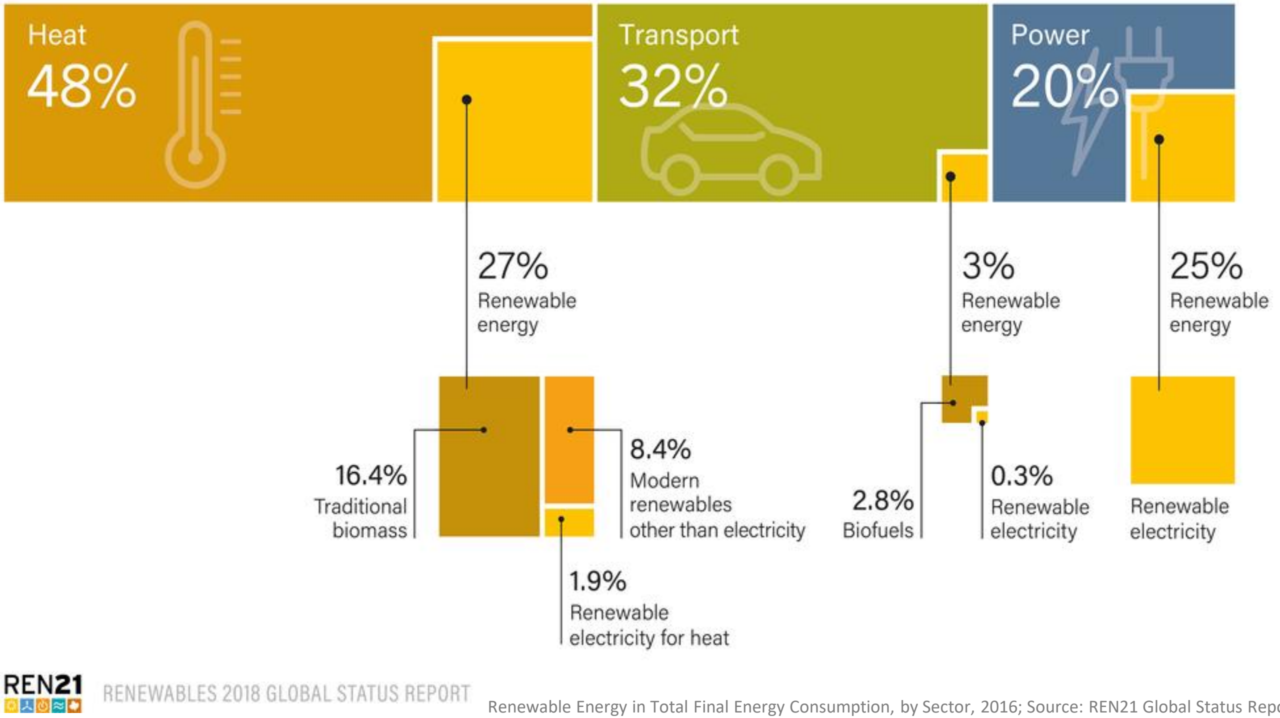
A Sempra Energy utility

Stonyfield Farm ORGANIC

Desert Mountain High School

MAUI BREWING CO

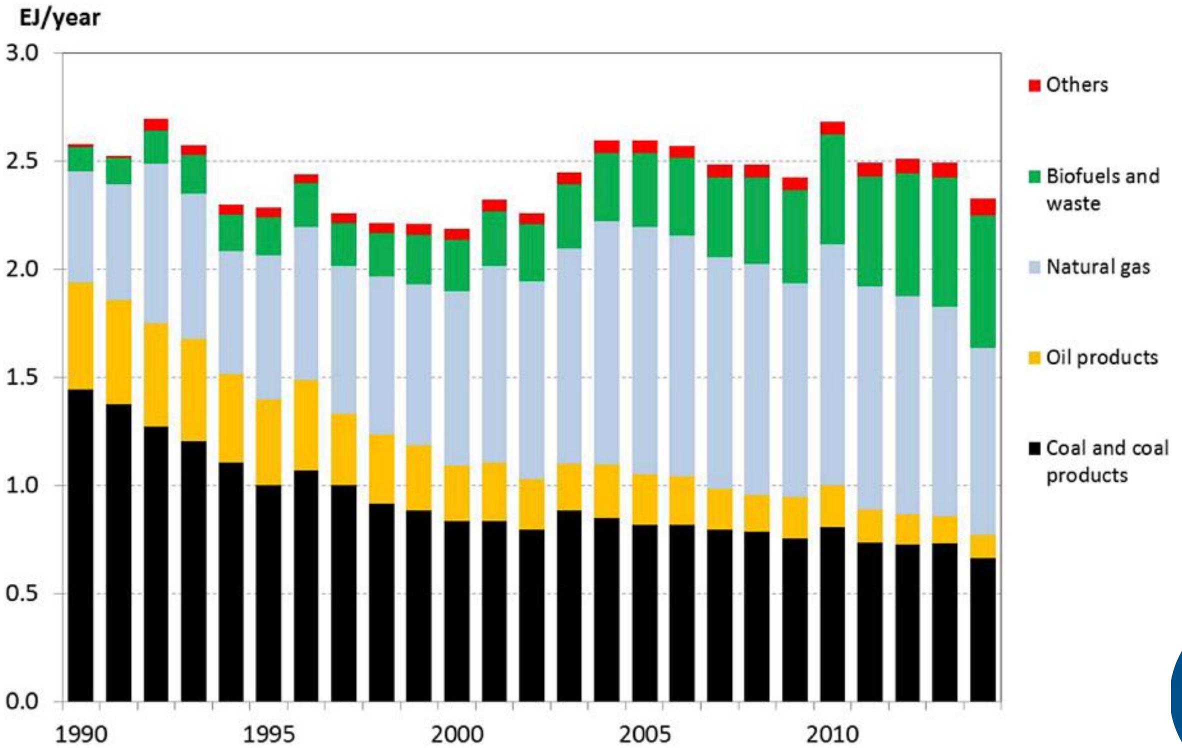
Energy used by sector: heat – mobility – electricity



Renewable Energy in Total Final Energy Consumption, by Sector, 2016; Source: REN21 Global Status Report 2019

Current district heating supply in Europe

- Large share still from non-renewable generation
- Biomass share is growing, but will be necessary for peak load supply in future
- Solar thermal has great potential for base load supply



Werner (2017), https://doi.org/10.1016/j.energy.2017.04.045

Heat supply by solar thermal
Overview of benefits I

1. **Infinity availability without CO_2 emissions**

2. **Efficiency**
   - The efficiency of solar thermal is about 4-times higher than that of PV modules, the area efficiency compared to biomass is about 50-times higher.

3. **Stable prices & long-term clalculability**
   - Even 25 years from now, heat from the solar system will not cost more than it does today!

4. **Low maintenance and operating costs**
   - Solar thermal systems have hardly any highly stressed or moving parts.
   - The use of electricity for pump operation in the system is 0.5 to 1% of the heat generation.

5. **Competitive heat price**
   - Solar heat (in large systems) is already competitive to current fossil-based heat generation.
   - CO_2 reduction can be sold on EU-ETS

Heat supply by solar thermal
Overview of benefits II

6. **Security of supply**
7. **Greater independence from fossil fuels**
8. **Increase the image of DH companies**
   - Showcase effect & advertising value through green marketing
   - Pioneer and innovator for a stustainable energy future
   - Impressively shows a building block of the heat transition

Solar District Heating

Brief description of the system:

The large-scale solar thermal system essentially consists of the following components:

- Collector field uses high-performance flat-plate collectors
  Collectors are mounted on ground (Mounting on buildings roof causes additional costs).
- Pump stations and connection pipelines
- Regulation of solar circuit and feed-in to DH grid

Solar heat is fed into the flow of the district heating grid at up to 95°C.

(higher temperatures on request, the supply of a heating circuit with a lower temperature or temporary feed into the return line reduce the solar heat price)

Collector field test in Graz

Fernheizwerk, Puchstrasse

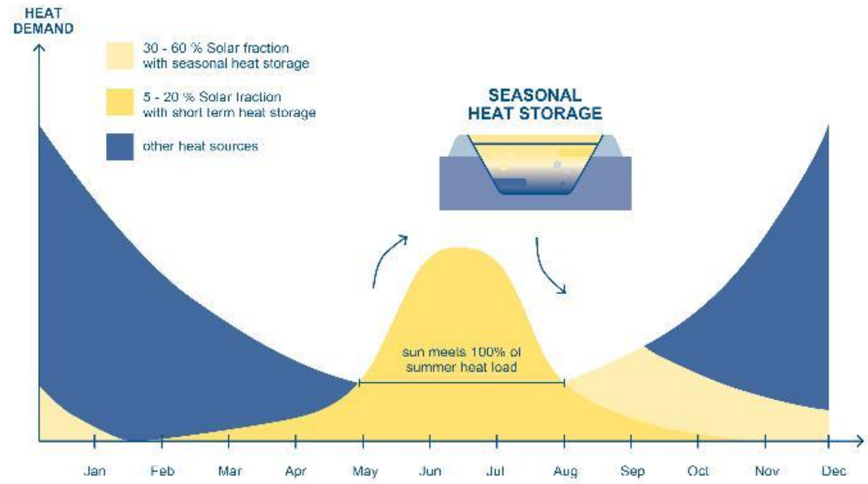
3,215 m²

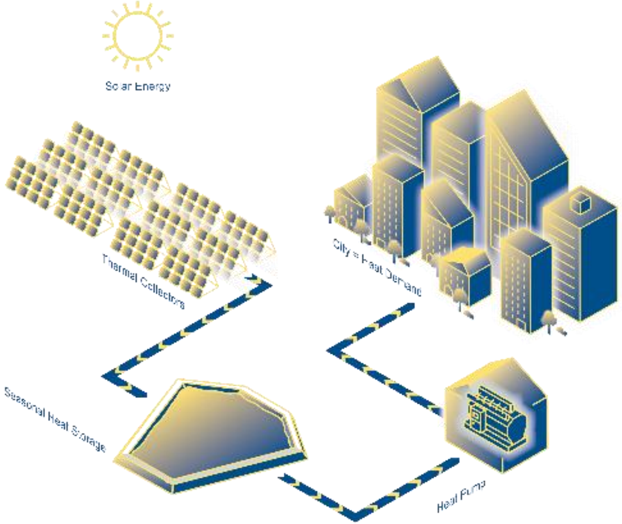
Collector test under real conditions of 10 types from 7 different manufacturers:

- Flat-plate collectors
- Vacuum-tube collectors
- Concentrating collector

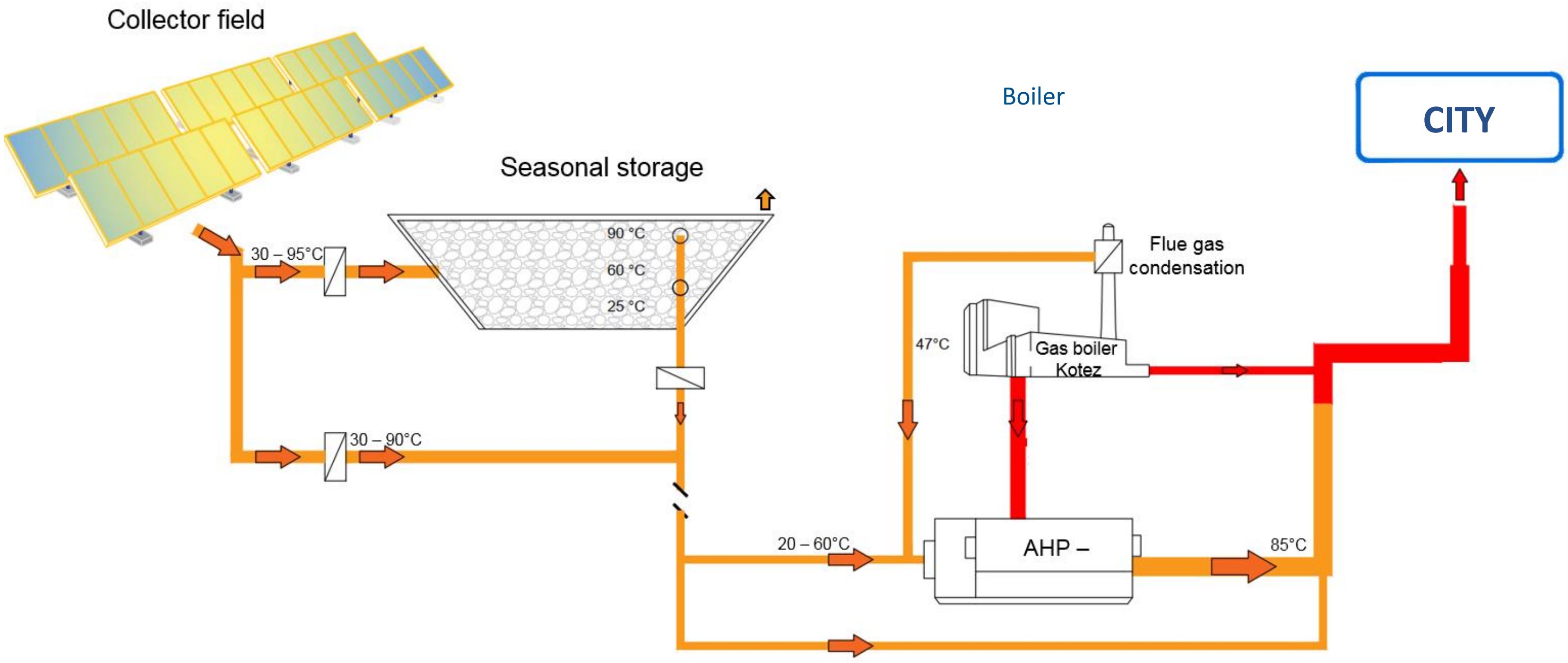
SOLID closely collaborates with all leading manufacturers in the industry!

BigSolar for using solar in winter



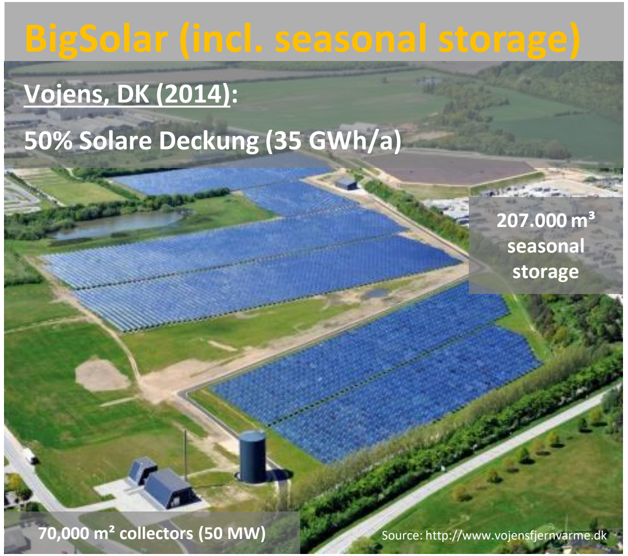


The BigSolar concept



Seasonal storage for shifting solar heat into winter

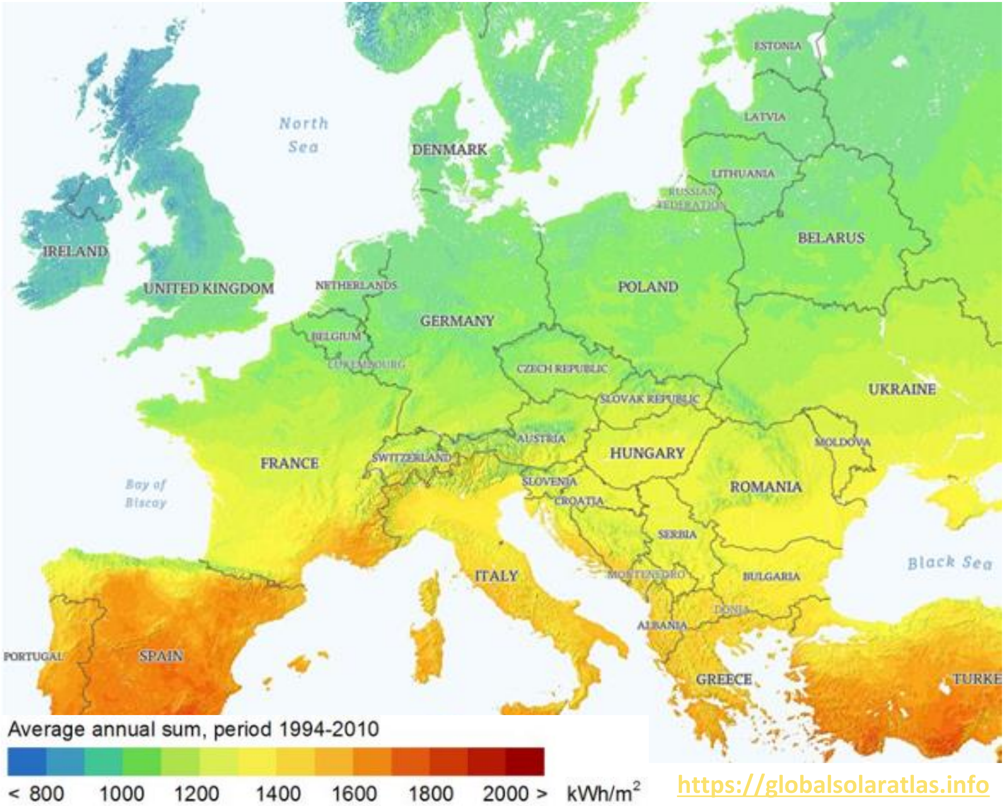
Potentials with high solar coverage ratios



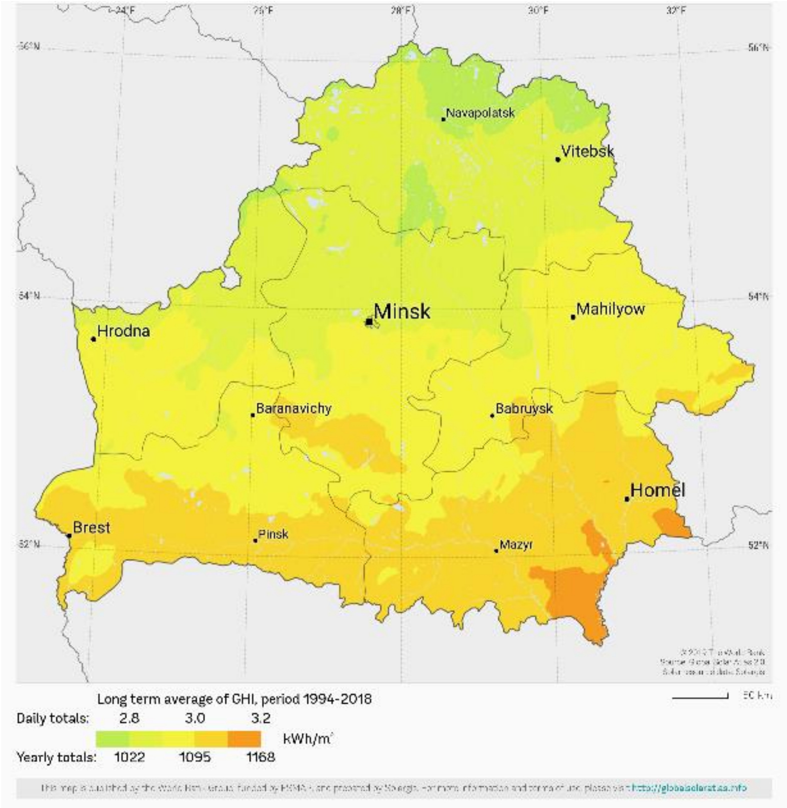
Different framework conditions (to Central Europe):

- Organizational (i.e. DH well developed, also in small municipalities)
- Technical (i.e.: low DH temperature, other load profile, availability of free land, easy soil conditions for storage)
- Economical (i.e.: high taxes on fossil fuels)

Solar radiation in Europe and Belarus



https://globalsolaratlas.info



Economy of BigSolar examples based on small, medium and large DH grids

		Unit	Small	Medium	Large
	Annual DH demand	GWh/a	35 - 150	150 - 800	800 - 1,500
	Potential of BigSolar coverage	%	20 - 60 %	15 - 50 %	10 - 40 %
BigSolar system examples	Collector field area / [Theoretical power output]	m^2 / [MW_{th}]	35,000 / [24.5]	195,000 / [136.5]	450,000 / [315]
	Storage volume	m^3	150,000	975,000	1,800,000
	AHP capacity (feed-in)	MW	15	80	100
	System yield (Solar + FGC)	GWh/a	21 – 26	125 – 140	220 – 240
	CO_2 savings[1]	t/CO_2	8,000 – 9,100	43,750 – 49,000	77,000 – 84,000
	CO_2 benefit by EU ETS[2]	T€/a	226 – 255	1,225 – 1,372	2,156 – 2,352
	CAPEX (Investment costs)	M€	14 – 16	80 – 85	160 – 175
	OPEX (Annual O&M)	T€/a	60 – 70	315 – 360	530 – 600
	Specific heat generation costs[3]	**€/MWh**	**23 – 30**	**24 – 32**	**26 – 35**

[1] Depending on current based heat generation: Used reference CO_2-emission factor is 0.35 t/MWh.

[2] Reference price from Jan.2020: 28 €/t CO_2.

[3] Depending on CAPEX, OPEX, system yield, discount factor and additional benefit (i.e. CO2 benefit) at a BigSolar system's lifetime of 25 years.

Project implementation plan for BigSolar

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Concept	Design	Engineering	Execution	Operation
(1) Customer needs identification ✓ Communication with customer ✓ Stakeholder assessment **(2) Analysis of DH grid** ✓ Collection of basic data ✓ Consideration of technical, economic and legal boundary conditions **(3) Techno-economic evaluation** ✓ Evaluation of technical optimum design ✓ Development of different system design options ✓ Estimation of costs and levelized cost of heat **(4) Location assessment** ✓ Potential land analysis ✓ Definition of favorable land for different system design options	**(1) System design** ✓ Execution of static system simulation model ✓ Elaboration of system integration options **(2) Land investigation** ✓ Definition of best suited land ✓ Analysis of geo- & hydrogeological conditions ✓ Clarification of land dedication & ownership **(3) Economic and financial analysis** ✓ Dynamic financial analysis & Sensitivity analysis ✓ Comparison to current heat generation options **(4) Investigation of legal aspects** ✓ Check of legal framework conditions (e.g. environmental, fauna, construction,..) ✓ Check of possible tender requirements **(5) Definition of business model** ✓ Risk analysis & Due Diligence ✓ Elaboration of financing model ✓ Establishment of construction & operation consortium ✓ Elaboration of PR-activities	**(1) Detailed system design** ✓ Execution of dynamic system simulation model ✓ Layout design for components & system integration ✓ Hydraulic concept **(2) Detailed economic and financial analysis** ✓ Detailed breakdown of costs (CAPEX & OPEX) & financial analysis ✓ Elaboration of tariff structure for ESC **(3) Land acquisition** ✓ Geo- & hydrogeological assessment for construction ✓ Communication with land owners ✓ Preparation and signing of land contracts **(4) Authority procedures** ✓ Provision of relevant legal aspects for construction & operation ✓ Obtainment of permits for construction & operation **(5) Project implementation plan** ✓ Elaboration of detailed project implementation plan ✓ Definition of PR-support	**(1) Project management** ✓ Coordination ✓ Supervision ✓ Communication ✓ Quality, time, cost & risk management ✓ Change control reporting **(2) Procurement** ✓ Purchase and delivery of components **(3) Construction** ✓ Construction of defined BSx-system **(4) Commissioning** ✓ Commissioning of defined BSx-system ✓ Transfer to operating consortium	**(1) Plant Operation** ✓ Supervising plants operation ✓ Ensuring efficient, effective and safe operation of the plant ✓ Safety & risk management ✓ Supervise automatic system control **(2) Maintenance** ✓ Scheduled and preventive maintenance of system ✓ Functional checks ✓ Servicing ✓ Keep equipment ready for operation **(3) Monitoring & Visualization** ✓ Monitoring system ✓ Interactive data visualization ✓ Statistical graphics ✓ Visualize performance indicators and trends **Failure detection & fault diagnosis** **(4) Optimization** ✓ Detailed monitoring for optimization & product development ✓ Data analysis for optimization ✓ Control systems engineering ✓ Improve automatic control systems

01 Project Development Phase
1,5 – 3 Years

02 Realisation Phase
0,5 – 2 Years

03 Operation Phase
30 Years

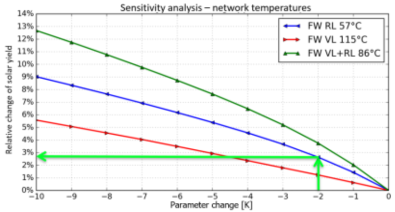
Relevant success factors and challenges

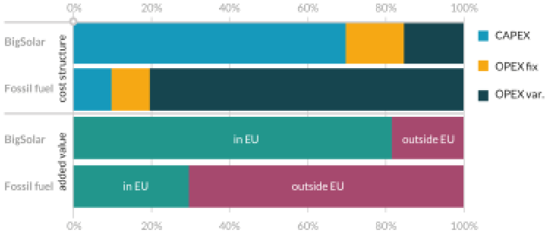
- **Lowering grid temperatures of DH**
  - The lower, the better for solar!

- **Competitive heat supply**
  - Coal and natural gas
  - Biomass
  - Waste heat (from CHPs)

- **Land requirement is important**
  - Use of areas with restricted possibilities for collectors (former land fill, side areas of traffic, water protection area, …)

- **Integration of seasonal storage/heat pump leads to additional benefits**
  - Additional loading of storage from waste heat (CHPs, industrial processes)
  - Peak load shaving
  - Flue-gas condensation of heat boiler for higher efficiency





Important success factors for boosting solar energy in district heating

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- Improvement of district heating grid (e.g. refurbishment of pipes, automatization of substations)
- Energy efficiency measures in buildings
- Land availability as central part of urban planning
- Capacity building for solar thermal
- Public funding not only for implementation, but also for concept development (e.g. pre- & feasibility studies)
- Focusing on carbon trading and air pollution reduction

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