SDH solar district heating

Case study n°5 (ITALY)

A/ Context of the study

A.1/ Motivations

The utility plans a solar integration with the aims of:
- Covering the summer needs to limit gas boilers operations
- Increasing renewable energy share
- Social and political purposes

A.2/ Description of the existing DH

The whole district heating network pipelines extend for about 116 km, but the present case study takes into accout only a part of te network. The heating needs of the district heating is provided by 5 gas boilers of 70,3 MW (total installed power) and a combined-cycle power plant of 23,6 MW. The total thermal power installed is about 94 MW.

Temperature and flow in winter are:
- Tforward 120 °C
- Treturn 60 °C
- Flow (nominal) 800 m3/h
- Flow (max) 1'200 m3/h

while in summer are the following:
- Tforward 100 °C
- Treturn 60 °C
- Flow (nominal) 100 m3/h
- Flow (max) 120 m3/h

The total annual thermal energy consumption has been 152 GWh.

A.3/ Environment data

For what concerns the weather conditions, we used Meteonorm (meteonorm.com) hourly data of air and ground temperatures, air relative humidity and solar irradiation in Piacenza. Here a summarizing table of average monthly conditions:

MONTH	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
n° Days	31	28	31	30	31	30	31	31	30	31	30	31
n° Hours Day	281	305	378	408	465	474	469	454	380	350	298	280
n° Hours Night	463	367	366	312	279	246	275	290	340	394	422	464
T ext. air max [°C]	12.3	16.7	22.0	23.5	27.2	30.6	33.5	32.8	29.9	23.9	17.8	13.9
T ext. air min [°C]	-5.3	-4.2	-2.9	-0.8	5.4	8.0	11.1	12.2	8.5	4.0	-1.2	-5.8
T ext. air ave [°C]	2.9	4.4	8.3	11.3	16.2	19.6	22.8	22.3	18.8	13.4	7.3	3.6
T ground ave [°C]	7.0	6.5	6.8	8.0	9.7	11.5	12.9	13.5	13.2	12.0	10.2	8.4
Relative Humidity [%]	81.6	75.6	70.7	75.3	72.9	73.4	71.8	72.7	75.1	78.0	80.5	81.2
Irr max H [W/m²]	406	591	740	860	1005	973	963	877	824	655	439	399
Irr ave H [W/m²]	133	197	292	318	367	392	414	368	307	194	127	110
Rad tot H [kWh/m²]	37	60	110	130	171	186	194	167	117	68	38	31

A.4/ Opportunities and barriers

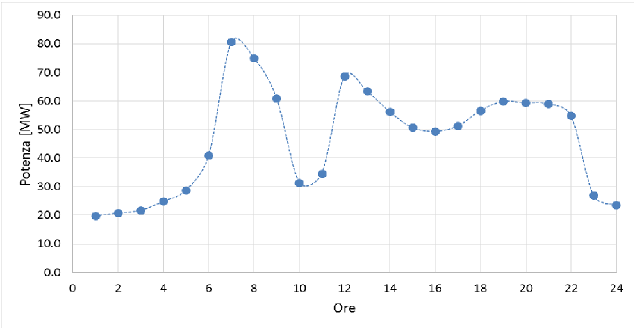
OPPORTUNITIES: high motivation in solar DH and also a large availability of land near the power station. The fact that the large cogeneration plant is working much less than expected is a strong reason for using solar.
- High motivation and interest in solar DH
- High ground availability near the DH generation plant
- Low convenience of operating cogeneration means higher use of boilers

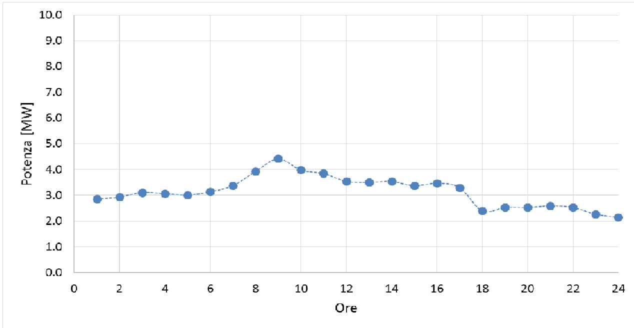
HURDLES
- The incentives scheme covres a maximum collector surface of 1'000 m2, that means low solar fractions
- The non-optimal disposition of the available land (tilted ground surfaces around the generation plant) limits the solar collector production

B/ Methodology and tools used in the study

B.1/ DH load profile

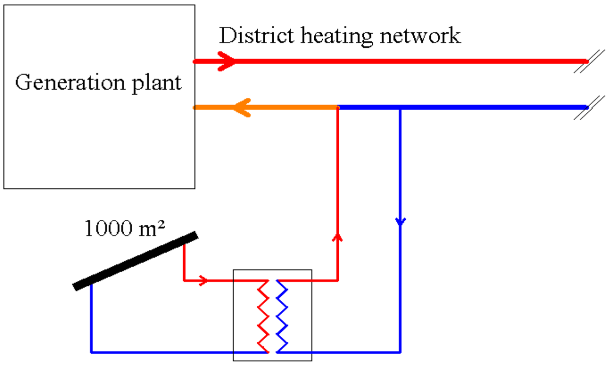
An example of load profiles in winter (left) and summer (right), with a hourly timestep, has been provided directly by the DH supplier.





B.2/ SDH design and sizing, energy balance

The integration of the solar plant into the DH grid is "feed-in return-->return".
TRNSYS has been used because it is more flexible than other softwares (e.g. TSOL): it's easier input meteo data and load profiles.
The solar collector field has been modelled like one single, large collector of the total field surface.



We processed two integration hypothesis:
- The first has the target of exploiting the maximum available incentive (1'000 m2)
- The second is intended to cover the whole available land (2'012 m2)

The energetic indicators taken are:
- *solar energy produced by the solar thermal system (Esol);*
- *efficiency of the plant (Eta plant);*
- *solar fraction(fsol).*

B.3/ Economics

All the following economic indicators have been calculated internally by the utility according to technical results provided by the case study.
- Pay-back time,
- Internal rate of return (IRR),
- Net present value (NPV).

C/ Results of the study

C.1/ SDH system design, energy balance and performance

In the following table, main energy results from TRNSYS simulations:

	U.M.	*Ipotesi 1*	*Ipotesi 2*
Esol	MWh	459	901
$\eta_{impianto}$	%	38	37
f_{sol}	%	0,29	0,57

C.2/ Heat production management at network level

Solar energy is mainly used in summer in order to avoid using boilers.

C.3/ Economics at SDH level and at network level

The utility calculates the economic indicators only for the first hypothesis, because of his higher consistency with the actual incentive scheme.
The total investment cost (with 1'000m2 of solar collectorfield) is about 322'000€. This value is between 200€/m2 and 400€/m2 that represents the unit cost of typical ground installation in Europe.
The O&M costs are estimated on the basis of a double scenario:
- Conservative scenario: 5'780€/year (1,8 % of the investment, 1,26€cent/kWh solar production).
- Optimistic scenario: 2'500€/year (0,8 % of the investment, 0,54€cent/kWh solar production).

Since in Italy there are national incentives, for 1'000m2 of solar collector (with the limit of 65% of the total investment) there are 209'300€ distributed in 5 years.
Considering the presented values, the utility calculated the following indicators:

Conservative scenario
- Pay-back time is about 19 years.
- IRR is 6,48%
- NPV is near to 0

Optimistic scenario
- Pay-back time is about 12,5 years.
- IRR is 10,27%
- NPV is 35'951€

Authors

Case studies and factsheet have been performed by Alice Denarie, Matteo Muschera, POLIMI in June 2015

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