4th International conference on Smart Energy Systems and 4th Generation District Heating
SESSION 4: LOW-TEMPERATURE DISTRICT HEATING GRIDS
13th November 2018 - Aalborg

Technological and non-technological barriers in the revamping of traditional district heating networks into low temperature district heating: an Italian case study

Climate-KIC is supported by the EIT, a body of the European Union

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Analysis of the barriers

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Work in progress…

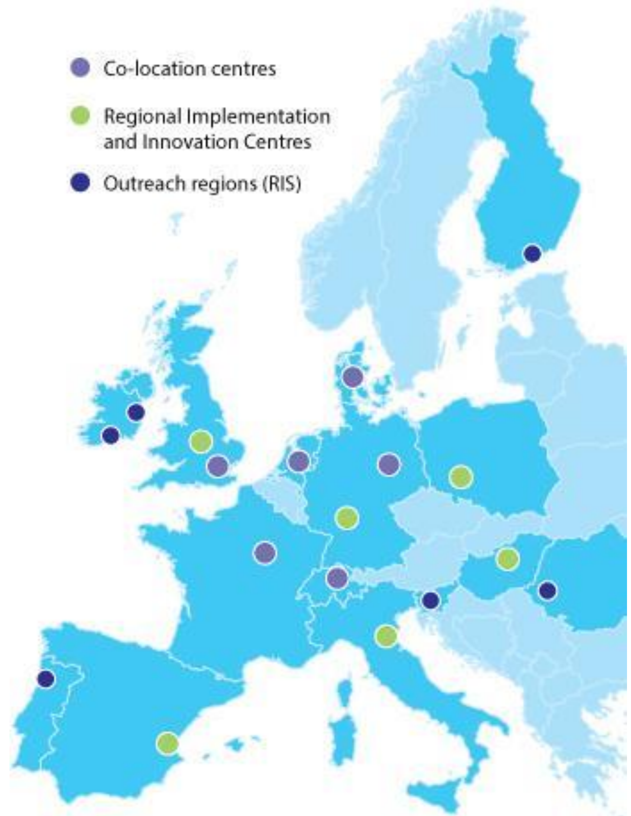
iEnergyDistrict project

Climate-KIC

Climate-KIC is the EU’s largest public private partnership addressing climate change through innovation to build a zero carbon economy.

Climate-KIC is supported by the EIT, a body of the European Union

Climate-KIC runs programmes for students, start-ups and innovators across Europe via centres in major cities, convening a community of the best people and organizations. Climate-KIC operates across 18 locations from 13 European centres, including the major cities of Brussels, London, Paris and Berlin.



Climate-KIC is supported by the European Institute of Innovation and Technology (EIT), a body of the European Union.

The University of Bologna is a member of the Climate-KIC and is actively involved in several projects about energy effiency and renewable energy diffusion.

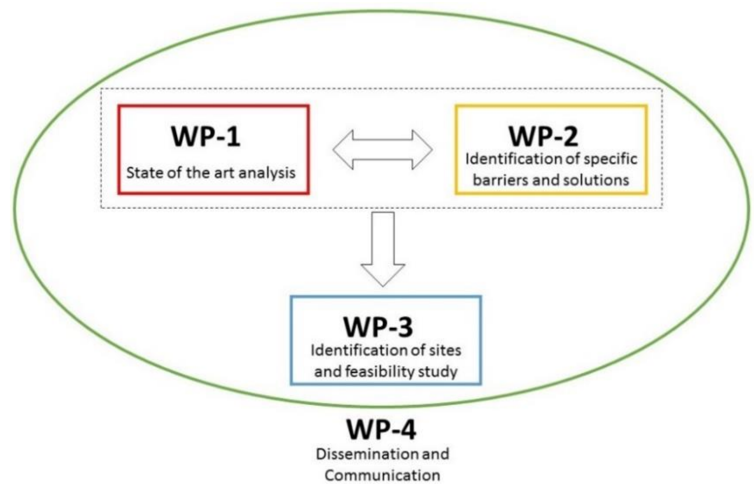
iEnergyDistrict project

The iEnergyDistrict project

The **iEnergyDistrict project** (***Deep retrofit and decentralised low temperature energy generation and distribution at district scale***) **is a so-called "pathfinder project" lead by University of Bologna aiming to:**

- **identify the relevant barriers that are limiting the adoption of low temperature district heating (LTDH) networks in existing DH networks;**
- **provide solutions to overcome the specific barriers;**
- **identify one or more sites for demonstrator(s) realization;**
- **realize a feasibility study and environmental impact of demonstrator(s);**
- **involve municipality and local government authorities.**

Budget: **53.300€**
EIT co-financing: **39.975€**



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Analysis of the barriers

Low temperature district heating (According to IEA DHC CHP Annex XI final report)

LTDH: ***the identified abilities of a LTDH network are the ability i) to supply low temperature district heating to space heating and hot water preparation, ii) to distribute heat with low grid losses, iii) to recycle heat from low temperature sources, iv) to integrate thermal grids into a smart energy system, and v) to ensure suitable planning, cost, and motivation structures*.**

"Warm" LTDH: ***All heat is supplied into the distribution network and no heat is supplied at customer level to meet customer temperature demands. Hereby, the concept of district heating contains supply guarantees for both heat delivery and available capacity. The supply temperature in the distribution network is also always high enough to satisfy all local heat demands*.**

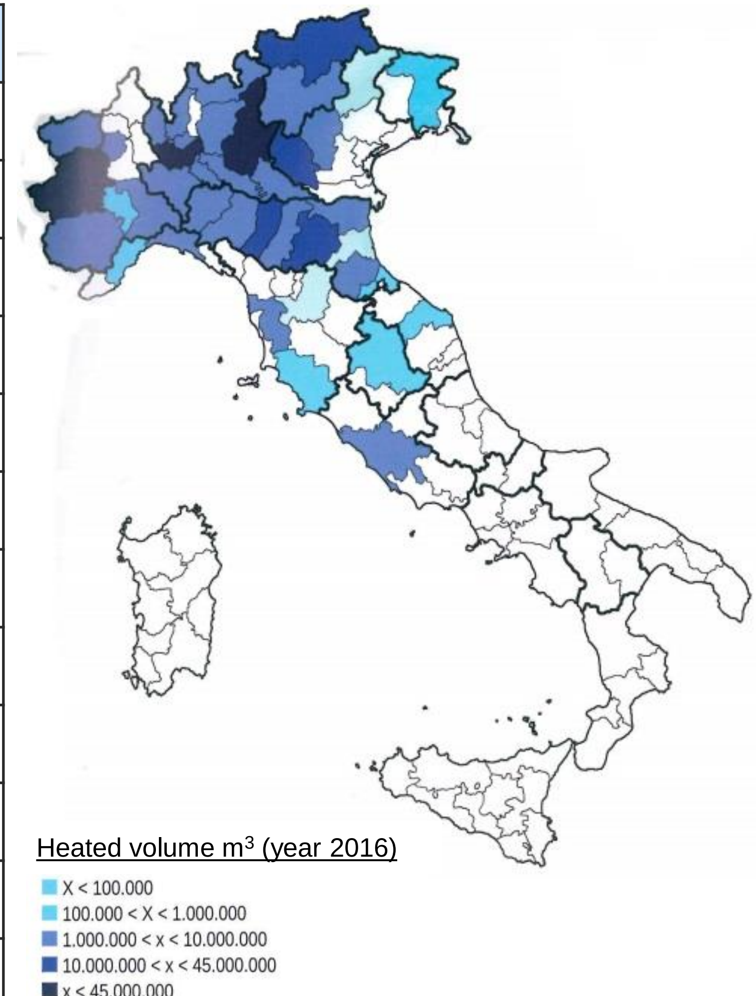
"Cold" LTDH: ***By introducing some additional decentralized heat supply, a hybrid system is created that can use a lower supply temperature in the distribution network. This lower temperature is sometimes called an intermediate temperature, since it is lower than the actual customer temperature demand. The heat supply is then guaranteed by using local temperature boosters, such as boilers or heat pumps*.**

Analysis of the barriers

State-of-the-art of district heating in Italy (source: AIRU annual, 2017)

	1995	2000	2015	2016
Number of cities with a DH system	27	27	182	193
Number of DH networks	45	53	216	236
Hot water (90°C)	26	27	174	192
Superheated water (120°C)	17	22	37	38
Steam	2	4	6	6
Heated volume (Mm^3)	74.4	117.0	329.8	342.3
Heat delivered (GWh th/year)	2,687	3,854	8,551	8,784
Cogeneration	**76.0%**	66.0%	51.2%	**50.7%**
Methane boilers	18.0%	22.0%	23.1%	**23.2%**
Renewable sources (*)	6.0%	12.0%	25.7%	26.1%
DH network lenght (km)	648	1,091	4,098	4,270
DH substations	10,148	18,594	77,482	79,991

(*) includes Waste-to-Energy plant (about 14%).



About 3 millions of equivalent inhabitants served by DH

Analysis of the barriers

<u>State-of-the-art of district heating in Italy</u> (source: AIRU annual, 2017)

(Year 2016)	Heat peak MW th	% of the total
Methane boilers	5,205	**59.6%**
Thermoelectric station (not dedicated to DH)	1,161	**13.3%**
Cogeneration plants (fed by fossil fuels)	959	**11.0%**
Waste-to-energy	555	6.4%
Boilers (fed by biofuels (*))	373	4.3%
Cogeneration plants (fed by biofuels)	250	2.9%
Geothermal	135	1.5%
Heat pump	47	<0.1%
Industrial waste heat	41	<0.1%
Solar thermal	1	<<0.1%
Total	8,727	

83.9%

(*) biomass, landfill gas and sewage sludge

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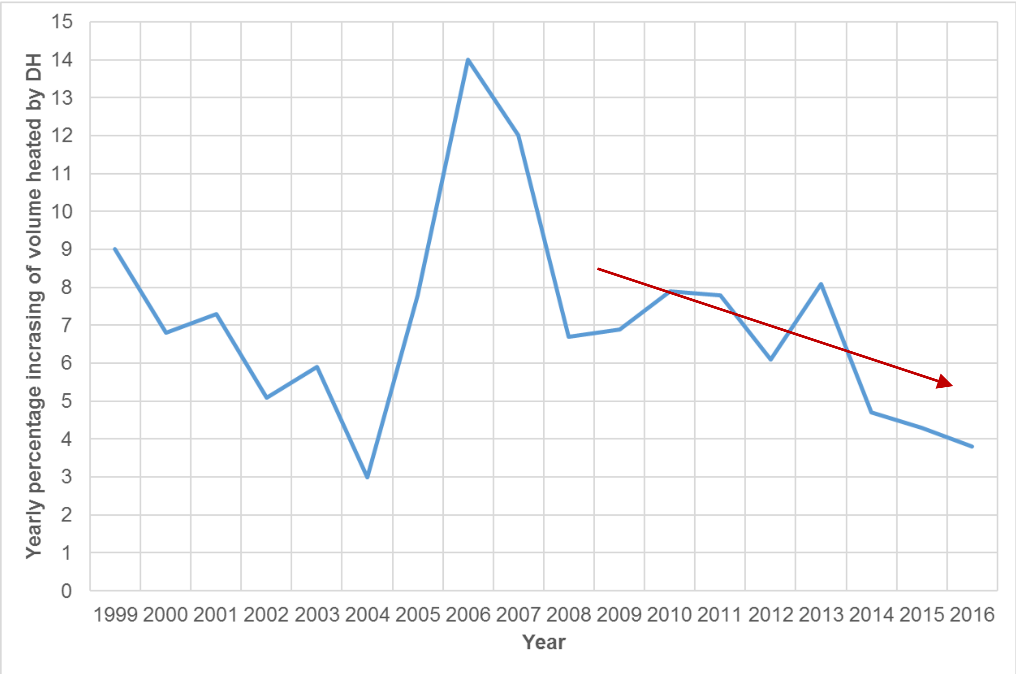
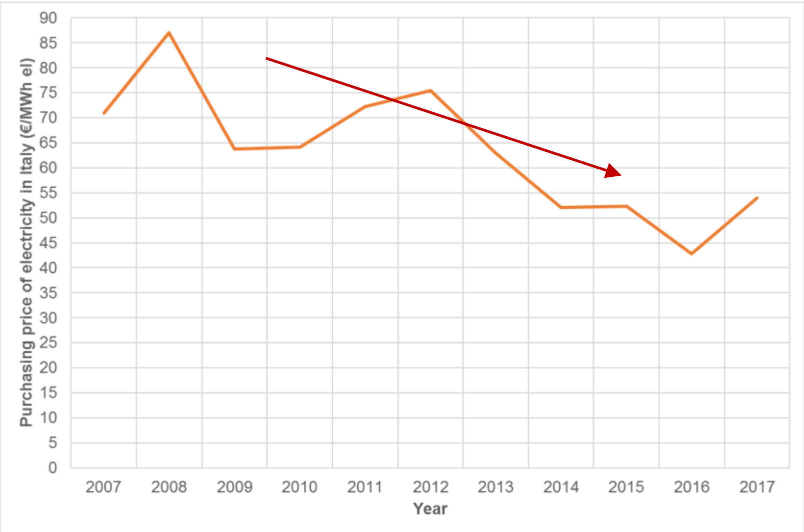
Analysis of the barriers

State-of-the-art of district cooling in Italy (source: AIRU annual, 2017)

(Year 2016)	GWh
Heat delivered	8,784
Cooling energy delivered	**121**

DH market perspective in Italy (sources: AIRU annual, 2017; GME, 2018)



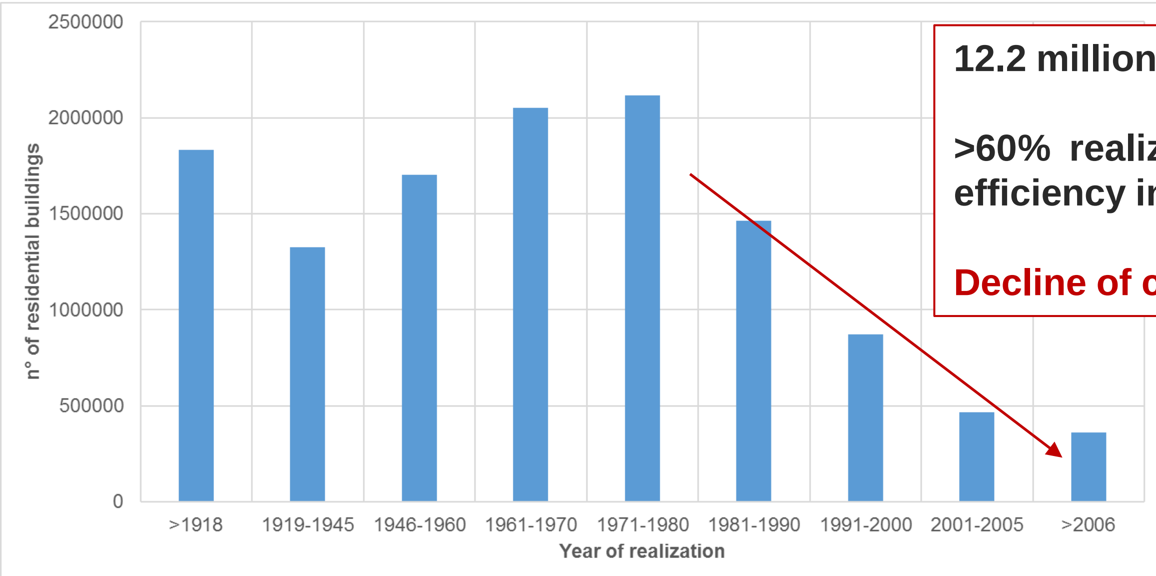


Decreasing trend in DH development starting from 2008:

Cogenaration from fossil fuel is not remunerative anymore?

Analysis of the barriers

State-of-the-art of buildings in Italy



12.2 millions of residential buildings (source: ISTAT, 2011)

>60% realized before 1976 (first Italian law about energy efficiency in buildings)

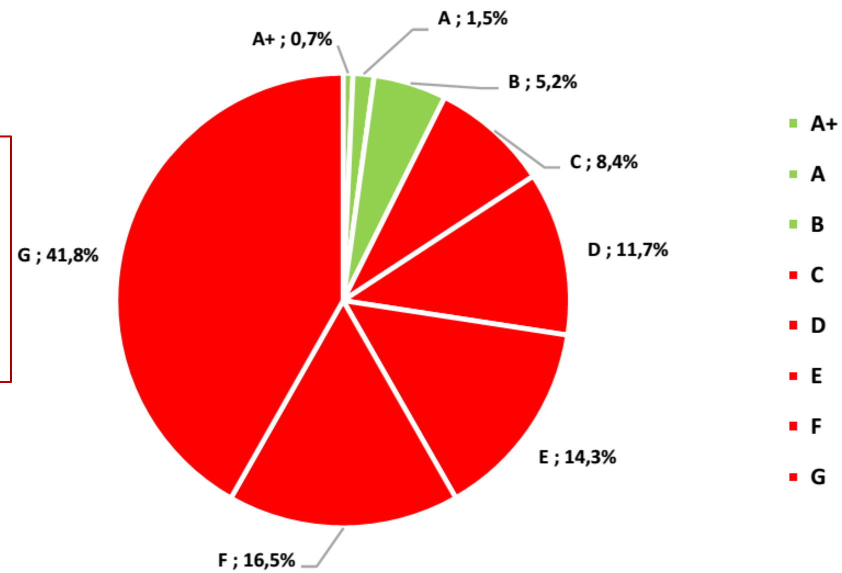
Decline of construction sector started in the 1990s

Only 0.8 millions of residential buildings are public (hosting less than 2 million people) – source (Federcasa, 2014)

Residential buildings assets are predominantly private, and therefore private investments are needed for renovation

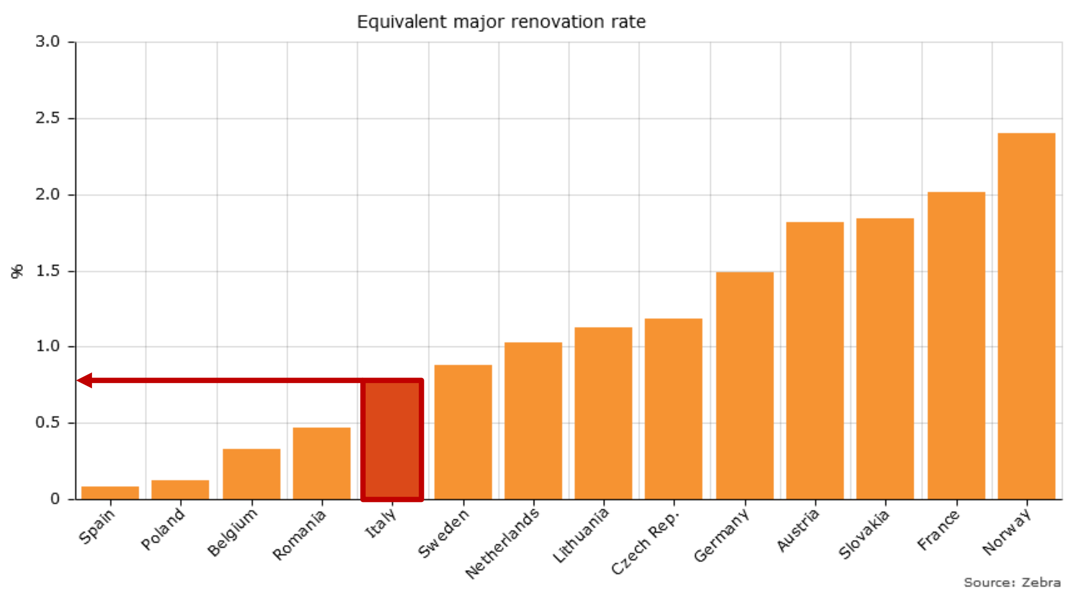
Analysis of the barriers

State-of-the-art of buildings in Italy



About 2.5 millions of residential buildings certified – 20% of the total residential building stock (source: PoliMi, 2017)

>40% class G – (very) low energy efficiency buildings!
>8% over class B (included)



Relatively low equivalent major renovation rate (source: Zebra, 2015)

Analysis of the barriers

Barrier #1 – **TRADITIONAL DH WORKS WELL: WHY SHOULD WE CHANGE IT?**

Traditional DH is a consolidated techno-economic system: it is based on proven technologies and on validated business models. In such a mature market innovation is held back also by the limited numbers of DH companies and by the characteristic of the market (small-medium DH network with local monopoly).

Barrier #2 – **DH MARKET IS IN A DECRASING PHASE: WHY INVESTING ON IT?**

DH systems market is a mature technology market in a decreasing phase. This fact may be seen as an opportunity, indeed it is an obstacle since the DH market is perceived as not remunerative and so relatively high and/or risky investments are postponed or blocked.

What are the current strategy to increase DH efficiency and reduce operation costs?

Low investments with short payback time → **minimize hot water return temperature**
→ **variable hot water flowrate (demand driven)**
→ **stimulate cooling demand (commercial)**
→ **stimulate flat heating demand (commercial)**
→ **smart metering (support tool)**

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Analysis of the barriers

Barrier #3 – LIMITED NUMBER OF BUILDINGS WITH LOW TEMPERATURE SPACE HEATING SYSTEMS

The Italian buildings stock is mainly composed by old buildings (realized before 1976) with low energy efficiency. Therefore, the number of existing buildings that have been designed and realized to work with low temperature space heating system (i.e. under 40°C) is limited.

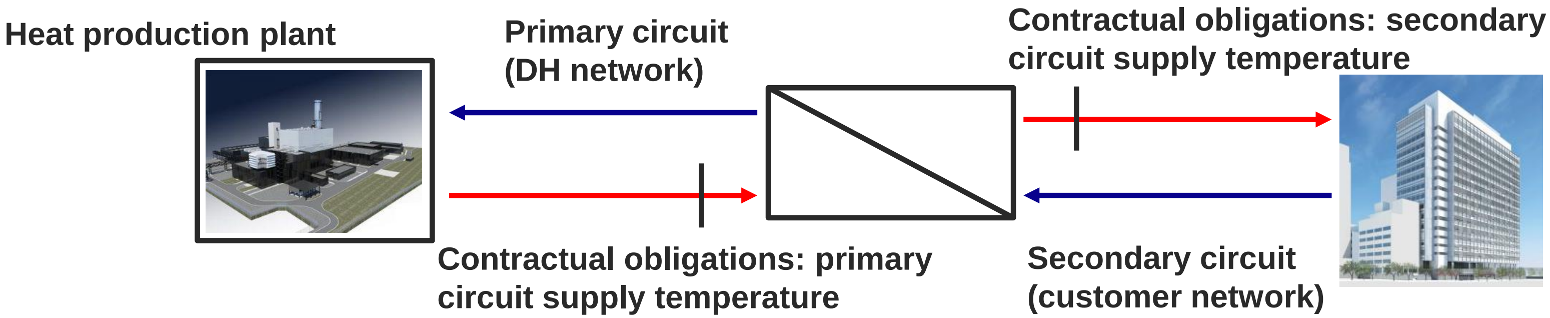
Furthermore, both the long crisis of the construction sector and the low equivalent major renovation rate of buildings contribute to limit the opportunity to connect to DH new or renovated buildings with low temperature space heating systems.

Moreover, most of the buildings are private buildings. So, national and regional policy makers can stimulate or favor private buildings renovation, but cannot directly have an impact on it.

Public sector may invest in the renovation of residential and non-residential public buildings (about 2 millions buildings in total), but high investments are required and relatively low impact can be achieved.

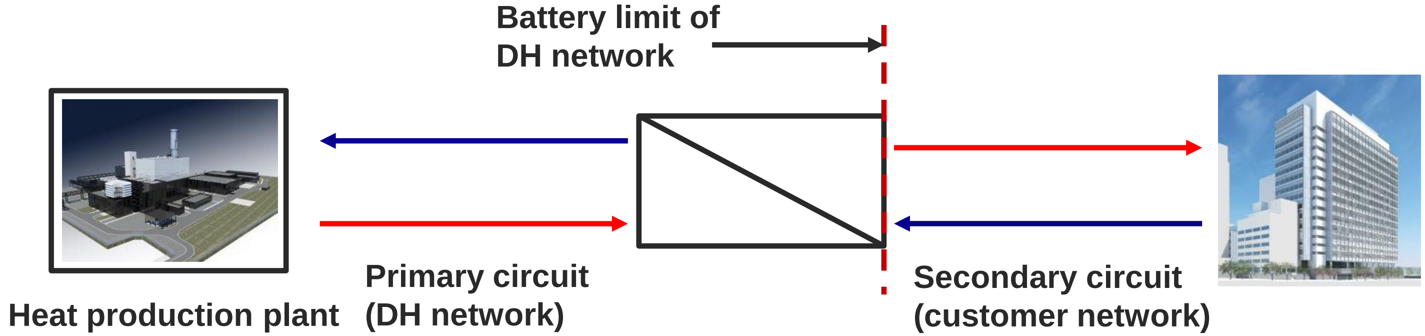
Barrier #4 – CONTRACTUAL OBLIGATIONS

The delivery temperature in the primary and/or secondary circuit is defined by the contract between customer and DH company. Common supply temperatures are: 80-90°C for the primary circuit, 70-75°C for the secondary circuit (limiting contractual clause).



Barrier #5 – BATTERY LIMIT: TECHNICAL ISSUES

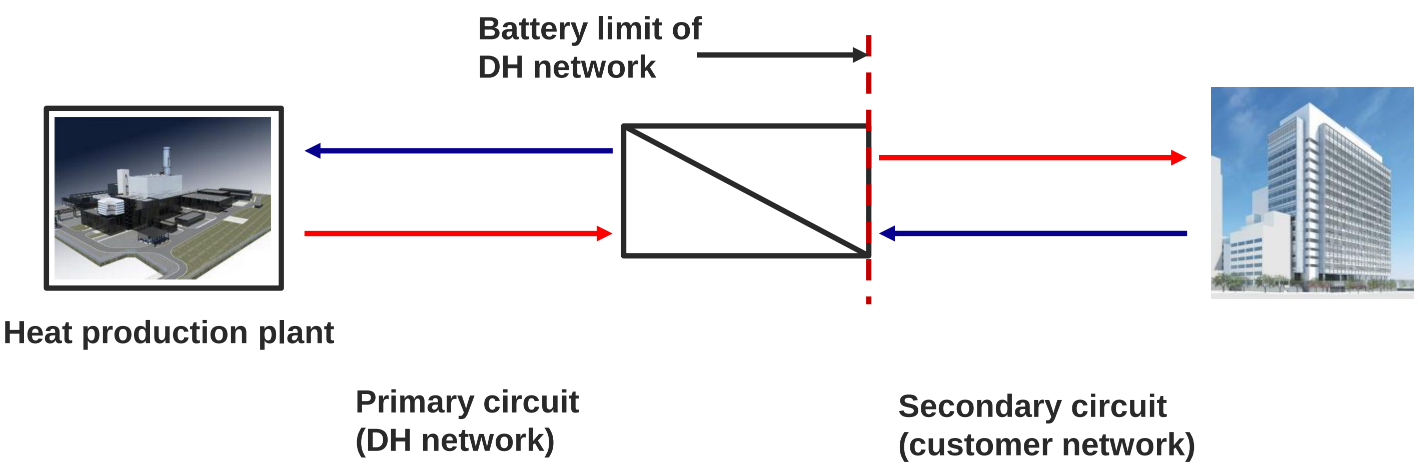
Limited opportunity of DH substation modification and/or integration with other heating sources since there is a battery limit defined by the contract with the customer.



Analysis of the barriers

Barrier #6 – **BATTERY LIMIT: BUSINESS/LEGAL ISSUES**

The presence of a battery limit may be critical: in fact, an integration with other heating sources may be realized on the secondary circuit, but this one cannot be realized by the DH company. So, another kind of company (i.e. ESCo or similar) should be in charge of operating on the secondary circuit. The result may be a complex techno-economic model wherein more actors are involved (i.e. DH network owner, heat producers connected to the primary circuit, heat producers connected to the secondary circuit).



Analysis of the barriers

Barrier #7 – IMPACT ON CUSTOMER

Modifications (not including energy sources integration) may be necessary at customer level to balance a temperature decreasing in the secondary circuit, starting from minor changes (i.e. use of fans to increase radiators heating efficiency) to the highest ones (like radiators size increasing or large interventions on the building envelope).

Barrier #8 – HIGH INVESTMENT COSTS WITH UNCERTAIN PAYBACK TIME

The retrofit of existing DH network moving towards LTDH is perceived as requiring high investment, while operation-maintenance benefits are difficult to foresee. So, the combination of high investment and uncertain payback time is strongly limiting the adoption of LTDH model.

Barrier #9 – NEW SKILLS REQUIRED

Design and realization of LTDH, robust economic evaluation, new business model development, different relationship with the customer, smart metering: the development of LTDH networks requires specific know-how and skills that are not available or not easy to be found on the market.

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Work in progress…

Barriers vs. existing DH systems adaptation to LTDH systems

How can the barriers prevent warm/cold LTDH development in existing DH systems?

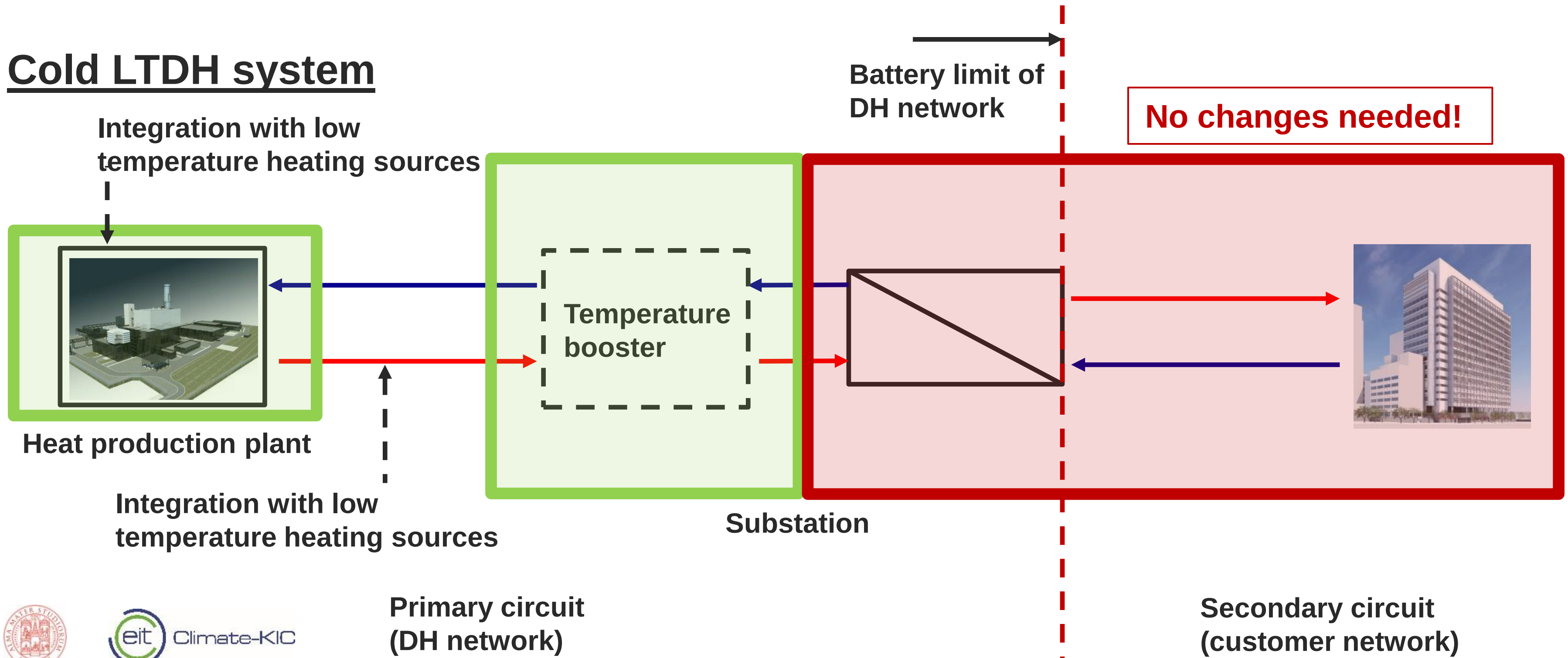
Barriers			Warm LTDH	Cold LTDH
#	**Kind**	**Description**		
1	Technological	Existing DH systems are well-known	**Low**	**Low**
2	Non-technological	Status of DH market	**Medium**	**High**
3	Technological	High delivery temperatures required	**High**	**Low**
4	Non-technological	**Contractual obligations (customer)**	**High**	**None**
5	Technological	Battery limit	**None**	**High**
6	Non-technological	Battery limit	**None**	**Medium**
7	Technological	**Impact on customer**	**High**	**None**
8	Non-technological	High investment and uncertain payback time	**Low**	**High**
9	Technological	New skills required	**Low**	**Medium**

This qualitative assessment will be compared with the results of an on-going questionnaires survey.

Cold or Warm LTDH?

The adoption of a cold LDTH system seems to be more appropriate than warm LTDH in the case of retrofit of existing DH systems since the DH network can be modified without any change required from customer side. Changing on customer side are not dependent upon DH companies and usually need many years and high investments to be fully developed; moreover, raising awareness initiatives are necessary in combination with public incentives/tax reduction and/or law obligations to impact on customer side.

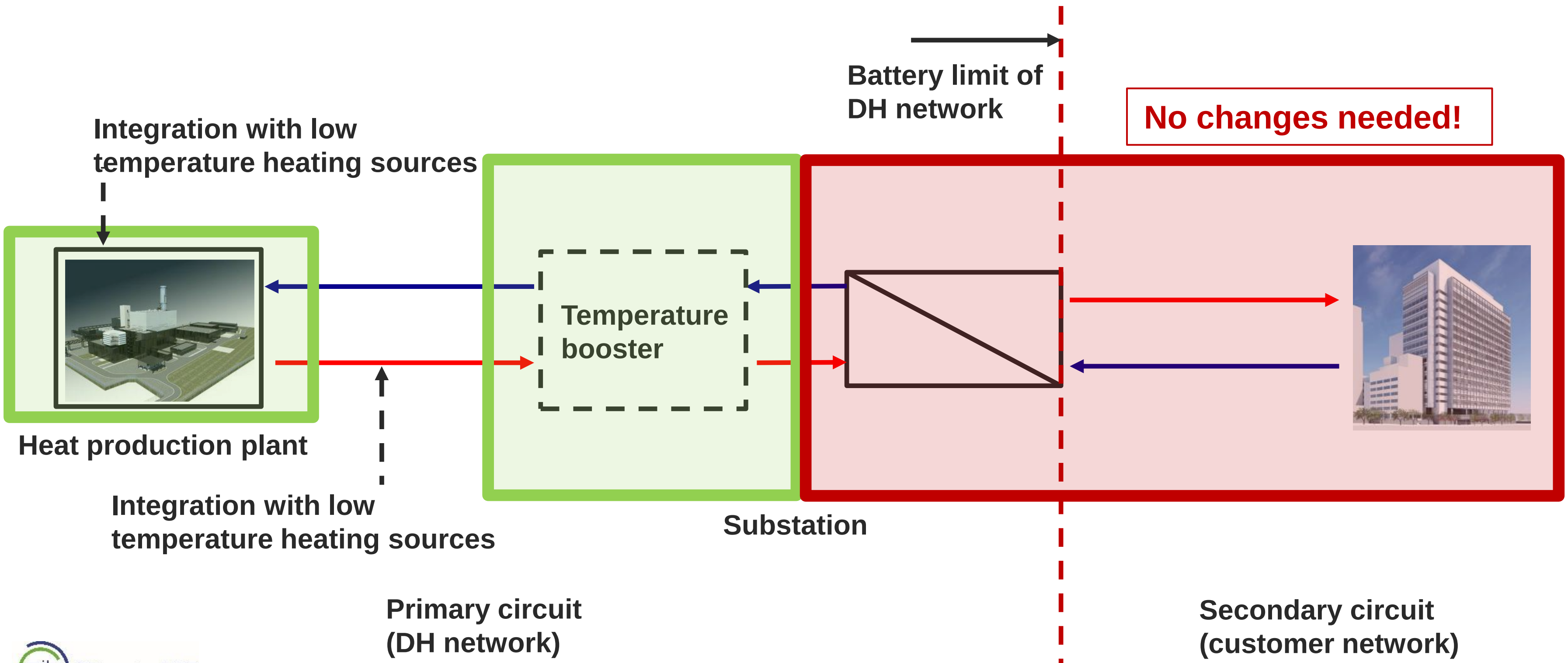
Cold LTDH system



Cold LTDH system

Integration with low temperature heating sources: geothermal, ground source heat pumps (GSHPs), biomass, solar thermal, PVT.

Temperature boosters: heat pumps (+ PV), electric boiler (for DHW production, + PV), solar thermal, PVT. In <u>DHW production</u> considers: storage needs, legionella risk.



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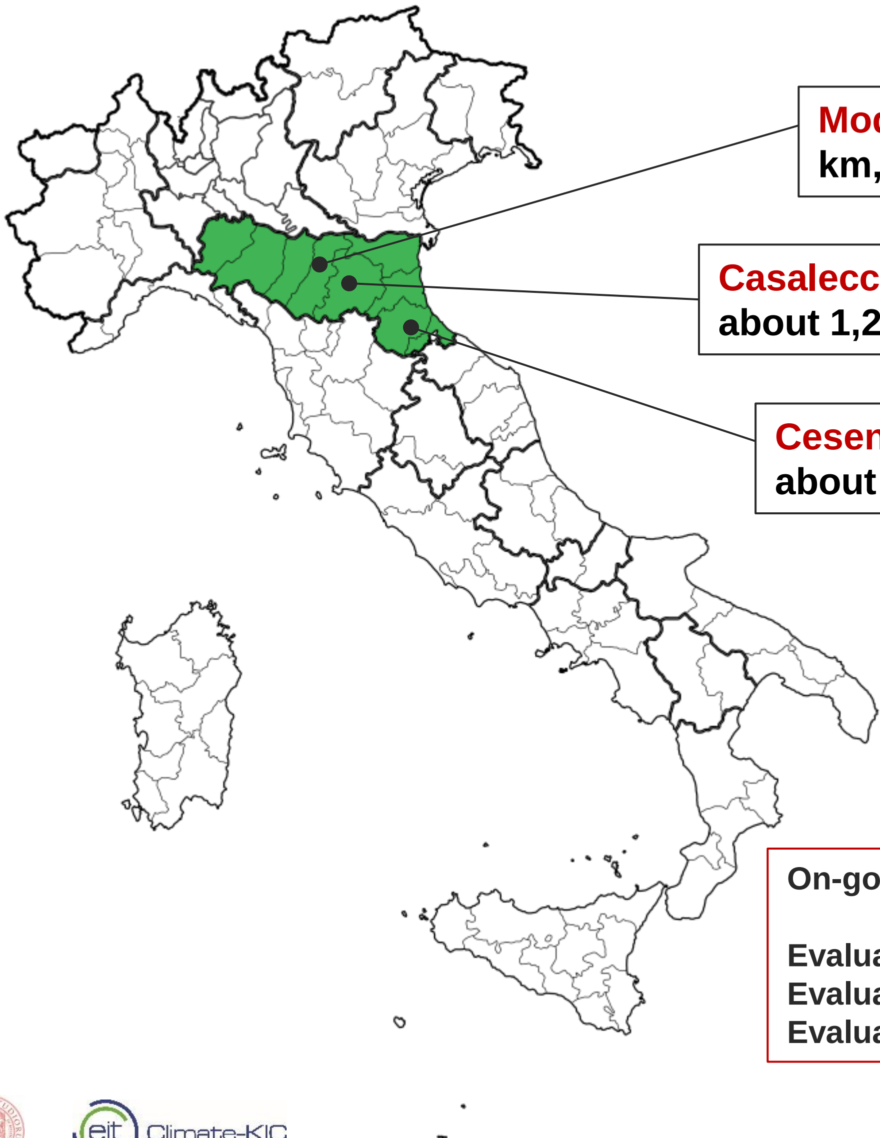
Identification of site(s) for feasibility study



Modena Giardino DH system (1971): 25 GWh th per year, 9.4 km, about 700,000 m^3 heated, 21 substations.

Casalecchio Ecocity DH system (1999): 28 GWh th per year, 7.4 km, about 1,200,000 m^3 heated, 54 substations.

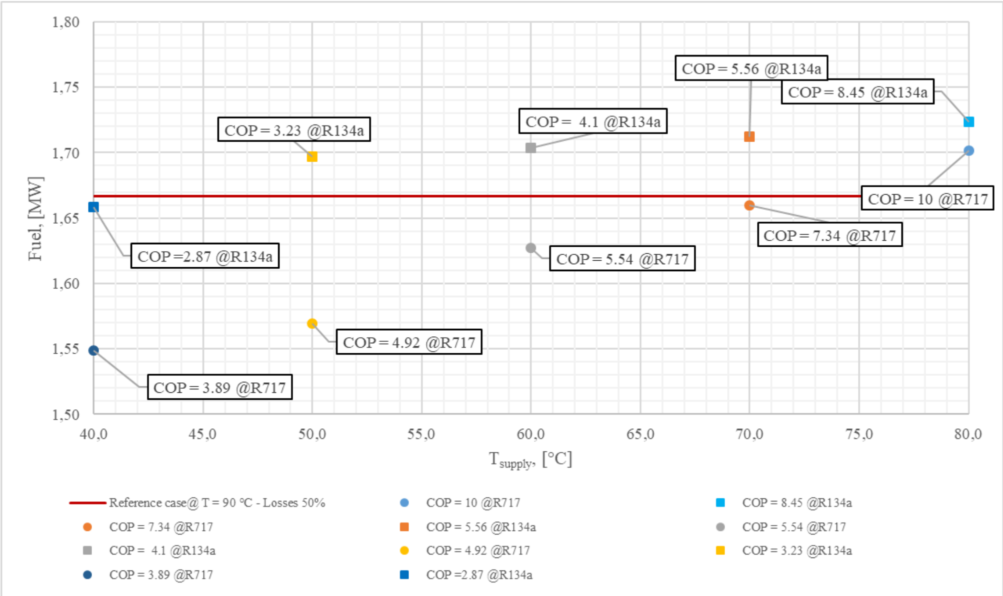
Cesena Ippodromo DH system (1999): 15 GWh th per year, 9.2 km, about 530,000 m^3 heated, 42 substations.

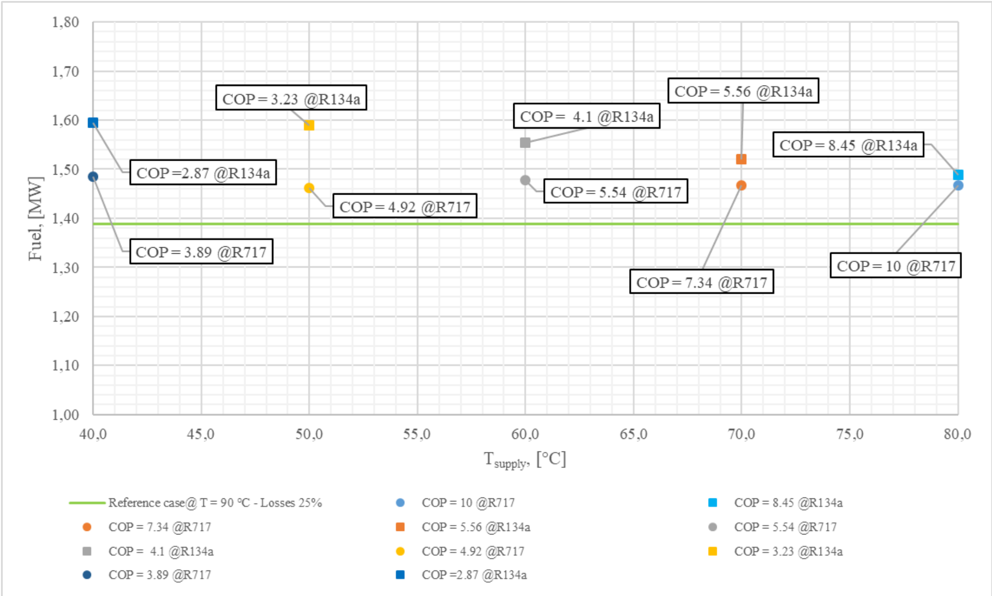
On-going activities:

Evaluation of current performances
Evaluation of substations configuration/characteristics (i.e. available space)
Evaluation of local renewable sources for heating (i.e. groundwater)

Energy balance – general considerations

Energy comparison between current heating supply and the hypothesis of cold LTDH with local temperature boosters. Different scenarios under investigation:

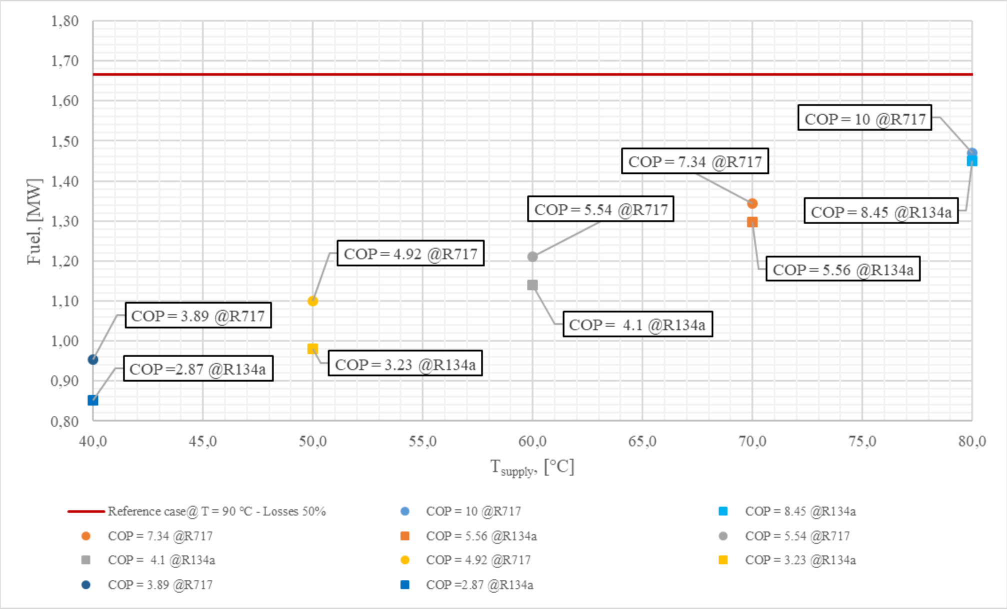


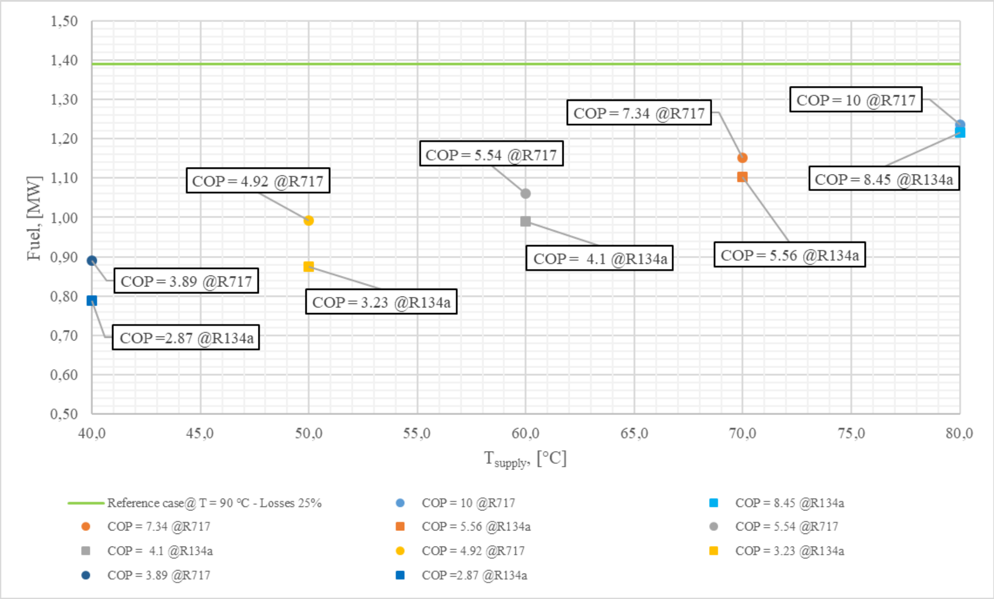


Hypothesis:
1 MW th to be supplied at 90°C
Reference case (in red): methane boiler
Heat losses: 50% of heating supply
Local booster: heat pump

Hypothesis:
1 MW th to be supplied at 90°C
Reference case (in green): methane boiler
Heat losses: 25% of heating supply
Local booster: heat pump

Energy balance – general considerations

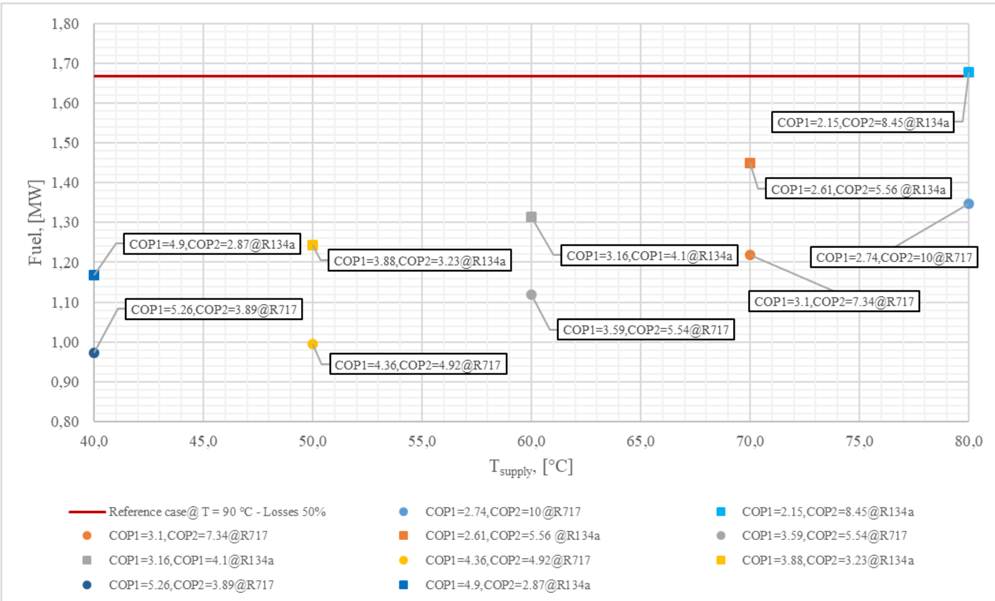


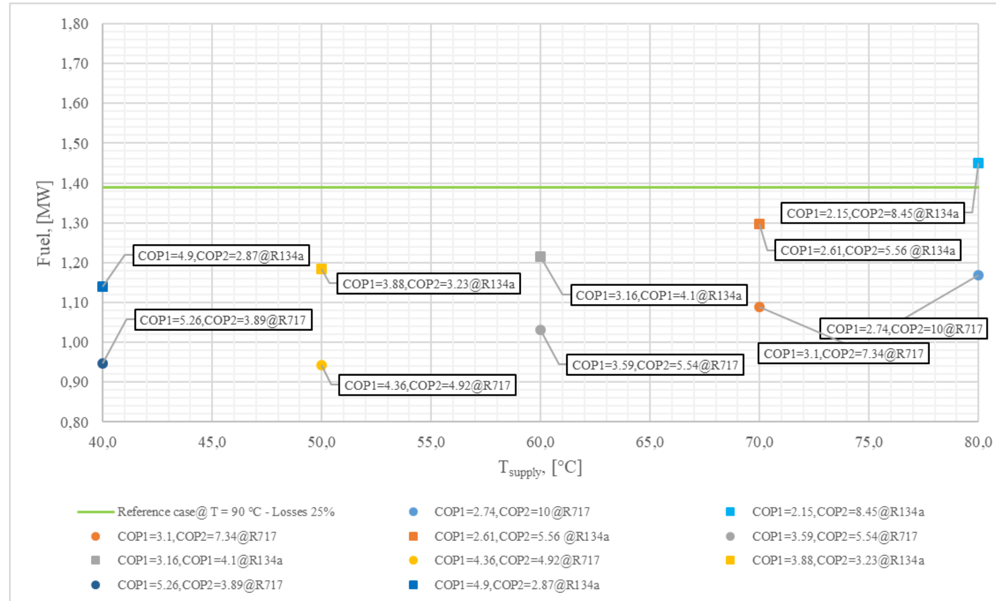


Hypothesis:
1 MW th to be supplied at 90°C
Reference case (in red): methane boiler
Heat losses: 50% of heating supply
Local booster: heat pump + PV (100%)

Hypothesis:
1 MW th to be supplied at 90°C
Reference case (in green): methane boiler
Heat losses: 25% of heating supply
Local booster: heat pump + PV (100%)

Energy balance – general considerations



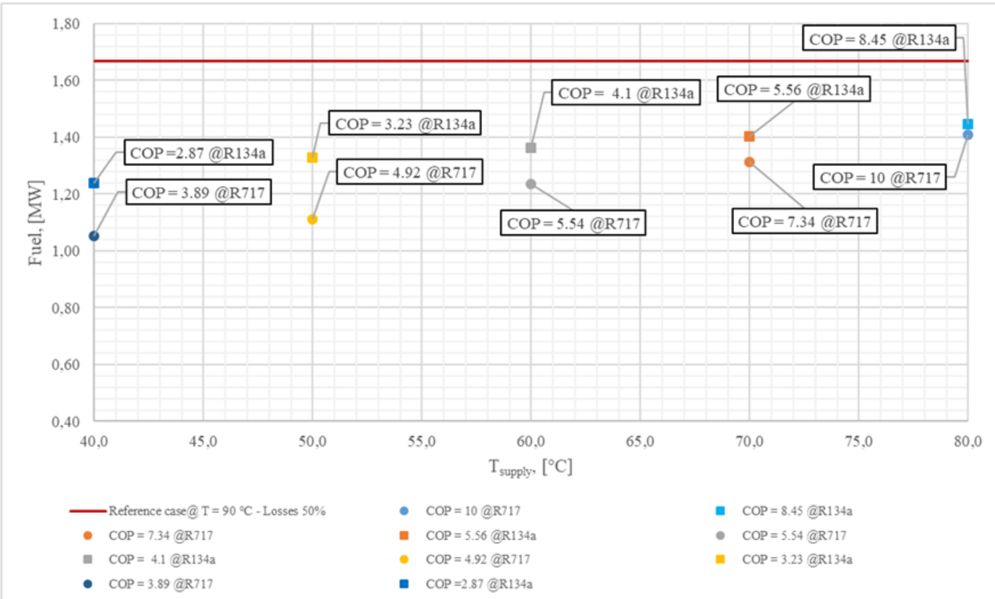


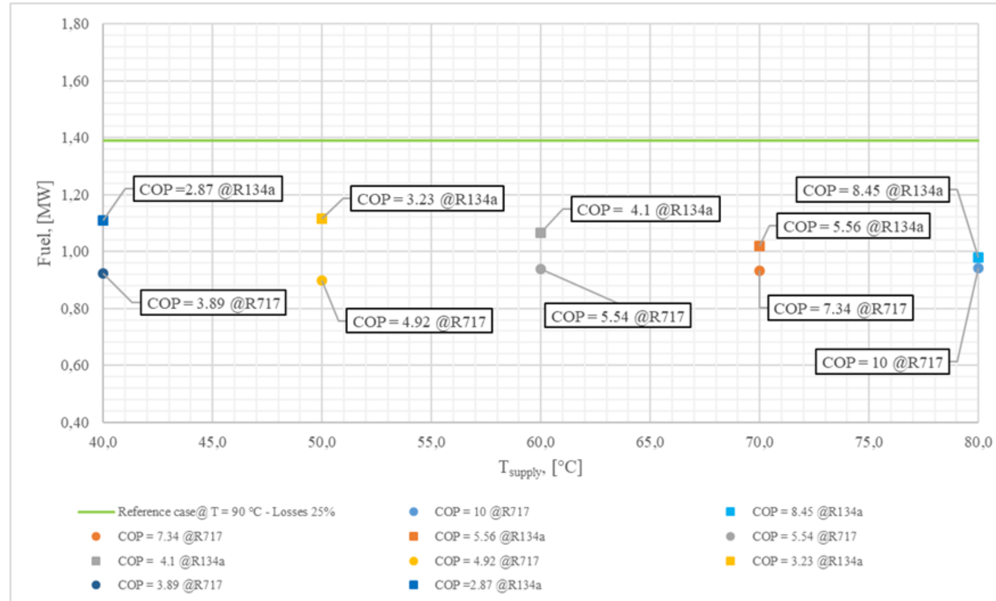
Hypothesis:
1 MW th to be supplied at 90°C
Reference case (in red): methane boiler
Heat losses: 50% of heating supply
New centralized heat production: GSHP
Local booster: heat pump

Hypothesis:
1 MW th to be supplied at 90°C
Reference case (in green): methane boiler
Heat losses: 25% of heating supply
New centralized heating production: GSHP
Local booster: heat pump

Work in progress…

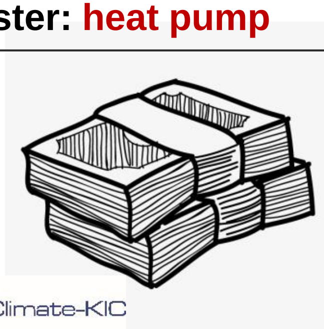
Energy balance – general considerations





Hypothesis:
1 MW th to be supplied at 90°C
Reference case: cogeneration plant
Heat losses: 50% of heating supply
Local booster: heat pump

Hypothesis:
1 MW th to be supplied at 90°C
Reference case: cogeneration plant
Heat losses: 25% of heating supply
Local booster: heat pump



Economic assessment: the identification of one or more energy efficiency solutions will be further investigated also from an economic perspective.

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