W.E. DISTRICT
Heating & cooling solutions

# D6.17

## Lessons learnt from DHC demonstration

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[1] PU = Public

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# Executive Summary

WEDISTRICT project is born with the objective of demonstrating 100% fossil free heating and cooling solutions by optimally integrating multiple sources of renewable energies and excess heat in new or existing DHC systems.

This document includes reflections on the main challenges encountered in the project, specifically related to the selected of demo-sites for implementing DHC networks in Europe. For each demo-site, this report describes observations and experiences, the main caveats and finally “lessons learned” and a set of best practices and recommendations during the preparatory works stage.

This report is complemented with **D6.11 Results of retrofitted DHCs demonstration – Bucharest demo, D6.13 Results of WHR in DHCs demonstration – Luleå demo and D6.14 Results of new DHCs demonstration – Córdoba demo** which include the main difficulties encountered during the construction and operation of the demonstration sites.

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# Table of Contents

**1. BACKGROUND ........ 9**
1.1. POLAND ........ 9
DHC State of the art ........ 9
Historic of WEDISTRICT alternative locations ........ 11
1.2. SPAIN ........ 13
Historic of WEDISTRICT alternative locations ........ 14
1.3. SWEDEN ........ 14
1.4. ROMANIA ........ 16
**2. LESSONS LEARNED ........ 20**
2.1. LICENSES AND PERMITS ........ 20
Polish experience ........ 20
Spanish experience ........ 21
Swedish experience ........ 22
Romanian experience ........ 24
2.2. OTHER REQUIREMENTS ........ 26
Polish experience ........ 26
Spanish experience ........ 27
Swedish experience ........ 28
Romanian experience ........ 28
2.3. PARTICIPATION IN H2020 PROJECTS AND INTEGRATION OF R&D PROJECTS IN COMMERCIAL ENVIRONMENTS 29
Polish experience ........ 29
Spanish experience ........ 31
Swedish experience ........ 31
Romanian experience ........ 31
2.4. FINANCING OF DHC NETWORKS ........ 32
Polish experience ........ 32

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

Spanish experience ..... 33

Swedish experience..... 34

Romanian experience..... 35

**3. BEST PRACTICES & RECOMMENDATIONS ..... 38**

**4. CONCLUSIONS ..... 39**

**5. REFERENCES ..... 42**

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

# Acronyms

| Abbreviation | Description |
|---|---|
| AD | Advanced Digitalisation |
| API | Application Program Interface |
| CPU | Central processing unit |
| DC | District cooling |
| DH | District heating |
| DLL | Dynamic Link Library |
| EDA | Exploratory Data Analysis |
| ERF | Energy reuse factor |
| FC | Fuel cell |
| HP | Heat pump |
| IP | Intellectual property / Internet Protocol |
| IT | Information technology |
| kCO2 | CO2 emission factor |
| KPI | Key performance indicator |
| LST | Local Standard Time |
| LSTM | Long-Short-Term Memory |
| Pe.ren | Renewable primary energy |
| PV | Photovoltaics |
| QDC | Energy delivered to district cooling network |
| QDH | Energy delivered to district heating network |
| RER | Renewable energy ratio |
| SFTP | Secure file File Transfer Protocol |
| SOC | State of charge |
| TMY | Typical meteorological year |
| UPS | Uninterruptible power supply |
| WP | Work package |

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# 1. Background

The target of the WEDISTRICT is to demonstrate 100% fossil free heating and cooling solutions by optimally integrating multiple sources of renewable energies and excess heat in new and existing DHC systems. For this, 9 upgraded renewable solutions for DHC generation were to be integrated into 4 real DHC sites in different EU locations and climates: Spain, Romania, Poland and Sweden. The demonstration activities were foreseen for 1 full-year operation period.

During the preparatory works stage, the most suitable location for each demosite was selected among diverse alternatives studied. In addition, requirements necessary to build the installations were identified. However, during the course of WEDISTRICT project, some of the initial demonstration sites were replaced or withdrawn. These are the cases of Poland and Spain:

- In Poland, up to 4 locations were selected and analysed as potential demo sites. However, due to diverse problems encountered during the preparatory works stage, the project could not proceed with in any of them. Due to the time constrains of the WEDISTRICT no further locations were identified to replace the pilot as any new location would not manage to deliver the expected tasks within the timeframe of the WEDITRICT project even if a few months extensions would be considered.

- In Spain, the initial demo site was not progressing as planned, diverse caveats prevented the construction of the installation. Due to time constraints, an alternative demo site was proposed during month 30, requiring 18 months project extension for completing the 1 full-year operation for the demonstration.

This section presents the state of the art of DHC in Spain, Romania, Poland and Sweden in terms of History, regulations, tariffs, etc. to set the starting point of the project and the base to understand why some of the alternatives chosen were not successful. The different alternatives considered in Poland and Spain are also summarised.

## 1.1. Poland

### DHC State of the art

The beginning of the development of district heating in Poland was in the post-war years and was closely linked to socialist mass housing programs. Due to the local availability of fuel, this district heating was 100% based on hard coal. In the 1950s and 1960s, each newly built housing development (neighbourhood) of multifamily blocks was equipped with its own boiler plant fired by coarser fractions of hard coal or coal dust. Only in the largest cities there were systems based on coal cogeneration

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established. The advantage of small and dispersed district heating systems was the low organizational requirements for their construction, as well as the reduction of infrastructure construction expenses, at the expense of their efficiency, convenience of operation and emissions. Such boiler plants usually operated only during the heating season. Domestic hot water was prepared on the basis of (gas) individual sources. With the qualitative but, above all, quantitative development of the national economy, the necessity of converting this system to one in which heat would be produced in a more centralized manner, less burdensome for the environment and making greater use of economies of scale became obvious.

Beginning in the late 1970s, but especially in the 1980s, a central heating plant fired by pulverized coal was put into operation in every county town. Such a heating plant was located outside the residential area, had all the necessary associated equipment, as well as basic flue gas filtration systems. These heat plants used standardized technical solutions, in particular, standardized water boiler systems and building designs. In provincial cities, the construction of CHP plants began, although due to economic problems, many were not completed before the system transformation (e.g., Radom, Katowice). Central heating plants replaced district boiler plants through the construction of long distribution networks. Because of the need to integrate many small systems into one, as well as because of the high heat needs of consumers, urban district heating networks were designed for standard winter/summer operating temperatures of 150°C/70°C, which also translated into high heat losses.

The aforementioned reconstruction, so to speak, defined the shape of Poland's district heating system, which in most cases continues to function without major changes to this day. Modifications carried out after ‘89 were mostly limited to the completion/construction of cogeneration units in some of the country's cities and the introduction of gas as fuel in gas-fired cogeneration units. In cities where, for some reason, a central heating plant was not built, local coal-fired neighbourhood boiler plants were replaced with oil and gas boiler plants. District heating systems began to switch more to year-round operation and produce energy also for domestic hot water. Mostly, however, the only significant investments during this period were the replacement of ducted district heating networks (sometimes characterized by heat losses of several tens of percent) with pre-insulated networks, but without significant changes in system operating temperatures.

To reduce losses and due to the requirements of the new network technologies, there was a gradual reduction in the operating temperatures of district heating systems, during the winter (nominally up to 110-130°C), most often while maintaining relatively high return temperatures (about 45-55°C). Due to the relatively low price of hard coal and the high cost of potential modernization of heat sources, the incentive for district heating companies to abandon coal was low.

The European Union's climate policy, tightening emission requirements and, in particular, the surge in the price of ETS allowances have resulted in a strong increase in interest in building alternative heat sources. These activities, often still directed only at a quick and ad hoc improvement of the economic situation of enterprises with the lowest possible investment costs, without a fundamental change in existing paradigms such as:

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- preserving the existing high-temperature nature of the system and heat sources adapted to its conditions,
- using the technically simplest possible and widespread (but hardly innovative) solutions, preferably proven for many years in the West,
- maintaining existing coal-fired boilers as an important heat source.

In practice, this means the dominance of solutions based on gas-fired cogeneration operating as the primary source, and a second-tier source in the form of a biomass boiler. Other solutions, although present, are relatively rare.

According to Polish District Heating Chamber, only 12% of all district heating systems in Poland are currently energy efficient. These are primarily systems in the largest cities using mainly coal-fired cogeneration, as well as a small number of smaller district heating companies that have managed to complete some, or all, of their heat source modernization work. For economic reasons, small gas-fired cogeneration based on reciprocating engines and biomass currently occupy a key place in smaller cities with efficient systems.

In terms of energy planning, Poland was and still is the complete opposite of other European countries . Due to the practical lack of high-quality urban planning and efficient coordination with private investors, grid expansion is costly and fraught with the construction of long stretches leading to "lonely" buildings far from other development. This increases heat loss, and the lack of technical coordination makes it difficult, if not impossible, to use innovative low-temperature systems.

In Poland, the tariff regulation is important from the point of view of district heating companies in determining heat prices and, consequently, profits from their operations. The revenue generated directly affects the ability to finance and implement investments. By law, the Energy Regulatory Office (ERO) approves the proposals submitted, deciding how much users will pay for heat and whether the DH company earns reasonable revenues. Unfortunately, the ERO's excessive focus on keeping heat prices low has led to the fact that district heating today is heavily decapitalized, dependent on coal and in a tough financial situation. The main problem I this system is lack of reflection of market realities in the price of heat, lack of incentives to reduce heat production and transmission costs and increase efficiency and lack legislative stability and no idea for the heat industry.

# Historic of WEDISTRICT alternative locations

The first location selected at the stage of the WEDISTRICT application - Kuźnia Raciborska is a city with 12,500 inhabitants, with a district heating system based on coal. The housing community, which consists of over 20 multi-family buildings and local commune authorities, has declared great interest in replacing the coal source with RES-based heating without a significant increase in heat prices. The challenge of the WEDISTRICT project was to meet end-user requirements by demonstrating the economic and

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environmental benefits of the new solutions. The project also required obtaining the necessary formal consents and building permits, based on the final design documentation. In addition, on the basis of previous arrangements, it required the city to provide a building plot on which PV panels would be located.

The proposed technologies for Kuźnia Raciborska included biomass boilers, installation of photovoltaic panels powering a ground-source heat pump and a heat storage system for a wider use of heat accumulated in the summer. The system is perfectly adapted to local installations and guarantees 100% coverage of heating needs from renewable energy sources.

During the implementation of the project, a number of technical problems were identified and solved, such as:

- optimization of operating parameters of the heating system,
- adaptation of the existing coal-fired boiler house to the needs of new technological solutions,
- optimization of PV power supply from the nearest available location,
- extending the scope and working time of the system by connecting additional hot water installations

Ultimately, KAPE and PTER were forced to look for other locations for the project, because the problems with the location of building plots intended for photovoltaic panels would require changes in the local spatial development plan, which could not be implemented within the required period of time.

The second analysed alternative in Poland was Bierutów. It is a city with 4,867 inhabitants, with a district heating network with a capacity of approx. 1 MW (coal-based). The housing community and local commune authorities have declared great interest in replacing the existing coal source with RES-based district heating without a significant increase in heat prices. The challenge of the WEDISTRICT project was to meet end-user requirements, demonstrating not only the economic but also the energy and environmental impact of the proposed new system.

The proposed technologies for Bierutów included biomass boilers, installation of photovoltaic panels, powering a ground-source heat pump with thermal energy accumulation.

The Bierutów demo site was included in the project at the end of January 2021 and it was expected that the implementation process in the new location would be quick, because from the technical point of view the project had the same scope as for the previous location in Kuźnia Raciborska and seemed to require only minor adjustments. The project required final arrangements and signing of the contract between the heat supplier - PTER and the housing community. However, such an agreement was not concluded in the planned period of time, as the housing association required long-term guarantees of low energy prices, and additional ownership conditions, difficult to agree on, appeared.

Sejny, the third alternative location, seemed doomed to success. Technically, it was a copy of the project prepared for Kuźnia Raciborska (a city of similar size). However, despite the full support of the local heating company and the mayor of the city, it turned out that in each of the several indicated locations it

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will not be possible to implement the investment without the need to change the entries in the local spatial development plan. Only after passing the related procedure could we apply for a building permit. Unfortunately, it would be impossible to meet these requirements within the required timeframe.

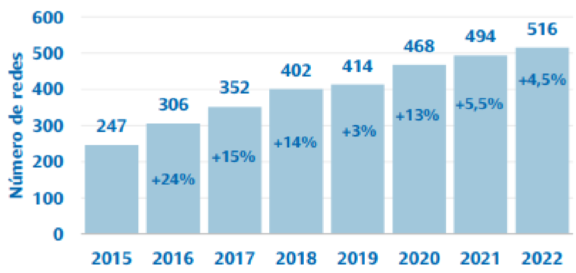
The fourth location indicated by KAPE, which could potentially join the project, was Dzierżążno. It is a small town in the Kartuzy commune, with a population of just over 1,500. The existing heating network is powered by a 1.5 MW coal source. The heating system supplies heat to 10 buildings - 9 multi-family and 1 commercial. As in the previous locations, the location was chosen to make the most of the previously developed documentation and partially prepared biomass units.

As in previous locations, the project included biomass boilers, installation of photovoltaic panels powering the heat pump and heat storage. In this case, we managed to overcome almost all obstacles in the previous locations and the only missing link was a positive decision of the Supervisory Board of the heating company, which includes representatives of the City Council, i.e. the company's owner. Their negative attitude and lack of knowledge about R&D projects implemented under H2020 settled the matter and suspended the project.

## 1.2. Spain

The DHC networks began to establish around Europe during the first part of 20th Century. However, their presence in Spain is still quite incipient. The first count of the DHC networks was done in 2011, when Adhac started collaboration with IDAE to increase the awareness of DHC. By that time, only 56 DHC networks were registered; mainly due to the lack of knowledge about this technology. The number of DHC networks have duplicated since the census was created in 2015 by Adhac. The latest data from 2022 cense 516 networks with a total length of pipes of 900km.

**Number of DHC networks in Spain. Source**: Censo de redes 2022 (adhac.es)




Almost the totality of networks (92%) are designed to provide only heat, 7% heating & cooling and the remaining 1% supply cooling only.

In terms of end-users and facilities, the 74% of the network belong to the services sector, following by 20% of the network that belongs to the residential sector and only 6% belongs to the industrial sector.

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It is worth noting that only the 39% of the networks have private owners, the 59% is public and the remaining is mixed. However, there is little information on the final price applied to the customer.

The rapid growth of DHC systems during the last decade can be related to the development of more efficient insulating materials, increase of competitiveness, flexibility and digitization.

In may 2021, Spain launched the "Climate Change and Energy Transition Law" ambitious objectives for a practically decarbonised economy by 2050. The use of renewable sources contribute to reducing the GHG emission. In particular, in 2022 in Spain 276,138 t CO2 have been avoided by the use of the DHC networks.

Spain can exploit solar technologies at high efficiencies, as is one of the most attractive countries in terms of solar energy, having the greatest amount of available sunshine in Europe. It is the perfect location to integrate district heating and cooling making DHC efficiencies to increase and is why in Spain most of the DHC networks uses renewable sources. On top of that, DHC networks allow more efficient use of local renewable resources, for example, using local fuel and sources that otherwise could be wasted. Biomass is the most extended fuel source at the 76% of the network, followed by natural gas (17%) which is a fossil fuel.

Despite all the above, Spain is still a country with low production by DHC in relation to the population, when compared to other countries in the European Union. Has a clear shortage of DHC networks. The population is still unfamiliar with the advantages of DHC.

## Historic of WEDISTRICT alternative locations

The original WEDISTRICT proposal was to integrate different technologies in the CEPSA R&D centre in Alcalá, Madrid. The city of Alcalá suits perfectly for a 100% Renewable District Heating and Cooling due to the high Direct Normal Irradiation and high DHW demand in the sports facilities in summer, so the aim was to supply all the needed energy from the solar field. Furthermore, the biomass is available on regional scale.

However, despite the verbal agreement was given by the Alcalá municipalities, the permitting procedures to construct the demonstrator were not completed during the 30 first months of the project duration.

After several months of delay in the start of the construction of this demosite, and all the effort from the partners involved engaging and trying to accelerate the process, we decided to start exploring different options as a contingency plan. The final Spanish demosite consists of a DH&C network located in the University of Cordoba (UCO) facilities.

## 1.3. Sweden

District heating is a widely used heating system in Sweden, with a long history dating back to the early 20th century.

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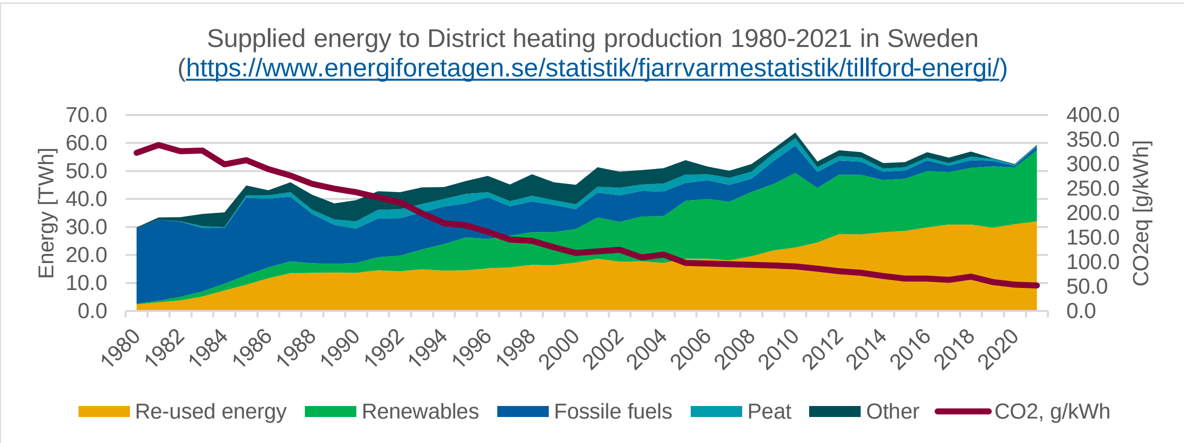
The first district heating system in Sweden was established in 1929 in the city of Västerås. It was a small-scale system that used waste heat from a local power plant to heat a few buildings. However, the concept of district heating did not gain widespread popularity until the 1950s when there was a shortage of fossil fuels and a need for more efficient heating systems.

During the 1960s and 1970s, district heating systems spread rapidly throughout Sweden, thanks to government subsidies and favourable policies, but also district heating growth corresponded with the buildout of efficient electricity production in combined heat and power (CHP) plants. The Swedish government recognized the potential of district heating in reducing greenhouse gas emissions and increasing energy efficiency, and they invested heavily in the development of the technology. The district heating developments in Sweden have also been supported by the high acceptance for community-wide technical solutions and systems that have had a good reputation for providing heat reliably and at a competitive price compared to other sources of heat.

Today, district heating is used in almost 50% of Swedish households, making it one of the most common heating systems in the country. There are over 400 district heating systems in Sweden, with a total installed capacity of more than 20 GW.

In recent years, Sweden has focused on increasing the use of renewable energy sources in district heating systems. Many plants are now using biomass, such as wood chips and pellets, as fuel, which has significantly reduced carbon emissions. This is readily seen in the graph below depicting the energy mix and the carbon emissions for district heat production. where the carbon intensity has dropped seven-fold in 40 years with most of the heat coming from both re-used and renewable energy sources. The Swedish government continues to push for lower environmental impact approaches and has set ambitious targets to further reduce carbon emissions and increase the share of renewable energy in the district heating sector.

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# 1.4. Romania

Before 1989, the solution of centralized heat supply (SACETs) of urban localities was practically generalized in Romania. More than 60 such systems were built during that period, most of them being installed in cogeneration energy production units.

In Romania, SACET began to be developed in the 70s, with the development of the condominium housing construction program. At the beginning of 1990, more than 250 urban centres in Romania were supplied with thermal energy from large-scale SACET, having as sources CHPs equipped with condensing steam turbines and adjustable outlets, producing thermal energy in cogeneration mode. To cover load peaks, hot water boilers were installed. Residential and tertiary consumers as well as large industrial consumers in the immediate vicinity of residential areas were supplied with thermal energy [1].

After 1989, with the restructuration and even the partly disappearance of the Romanian industry, the demand for thermal energy related to these SACETs decreased every year and they became more and more economically inefficient.

After 1991, the demand for thermal energy began to decrease at a fairly rapid pace by disconnecting industrial consumers from SACET, mainly for the following two reasons:

- replacing the centralized source with own, local sources, consisting of steam boilers or hot water in many cases, also realizing the recovery of own secondary energy resources.
- reduction and reorientation of activities on industrial platforms, as well as the decommissioning of some capacities or entire production units. This decrease in the demand for thermal energy had as a consequence the shutdown of some production units within the CETs, with an important unfavourable influence on their economic indicators, the reduction of energy efficiency and the increase of the price of the delivered energy.

The transport and distribution networks with an age of 20-45 years, have an inadequate degree of thermal insulation, or have leaks generating large losses of thermal energy and agent.

The temperatures of the thermal transport agent in centralized systems are between 95ºC/75ºC – 90ºC/70ºC. The current trend is to reduce them as the classic pipes are replaced with pre-insulated pipes, thus increasing the energy efficiency of the system.

After 1995, a second stage of disconnections began, that of residential consumers (the population) who considered more attractive the solution of heat supply from individual sources, especially apartment or, more rarely, apartment block boilers, supplied with natural gas. There was also support for the idea of disconnection from SACET by creating a false image of the savings that could be made through such a solution.

Around 22% of all cities and towns in Romania (320 cities and towns) use a district heating system but there is a continuous trend of decrease in the number of localities connected to district heating (e.g. from

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1997 to 2003, 40 % of district heating in urban areas were removed) leading to a 10% annual decrease in localities connected to district heating services, mainly in smaller towns and cities. The reason behind this disconnection process is linked to the poor management of local district heating network prior to 2007 (before joining EU). Therefore, many citizens opted to disconnect from DH and to use a small heating system, usually individual gas fired central heating system, resulting in a poor economic use of energy. It is to be noted that in last years this trend is decreasing because the DH companies are retrofitting and expanding the networks. The investments in DHC systems don't seem to be a priority amongst other lively business opportunities existing in the country in other sectors [2].

In recent years, a large part of SACETs' cogeneration production capacities have been withdrawn from the operation and even decommissioned due to the financial impossibility of making environmental investments, but in some cases, also due to the constructive mismatch of these groups (designed in especially for industrial cogeneration) with the current requirements of the thermal energy market.

For these reasons, the municipal heating systems (SACET) have faced massive disconnections of consumers in the last 20 years, choosing individual heating solutions.

More closely to the DHC sector, it is interesting to quote that the climate conditions in Romania make the cooling demand relevant only for 3 months per year; therefore, in residential buildings cooling energy needed is ensured through split-type air conditioning devices, powered by electricity, mounted individually by each consumer. In the non-residential sector, old buildings use a similar approach as residentials, but new buildings are equipped with centralized chiller-type cooling facilities.

The EU Heating and Cooling Strategy promote the construction of cogeneration and trigeneration units (electricity, heating and cooling). In consequence, distributed production is encouraged, to the extent that it proves economically feasible.

The public service of thermal energy in centralized system includes all the activities regarding the production, transport, distribution and supply of thermal energy, carried out at the level of administrative-territorial units under the leadership, coordination and responsibility of local public administration authorities or associations for community development, as appropriate, in order to provide the thermal energy necessary for heating and preparation of hot water for consumption for the population, public institutions, social - cultural objectives and economic operators.

According to the regulations in force, the public service of thermal energy supply in centralized system is performed through specific technical-municipal infrastructure, belonging to the public or to the private domain of the local public administration authority or the community development association, which forms the centralized system of thermal energy supply of the locality or of the community development association.

During 2021, 47 operators of centralized heat supply systems were active, operating a number of 49 SACETs in 50 cities, located in 28 counties and the Municipality of Bucharest [3].

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At the level of the year 2021, based on the data reported by the SACET operators resulted a total thermal capacity installed in thermal power plants belonging to SACET of 7,501.03 MW, from which 4,174.43 MW represent the cogeneration production capacity and 3,353.59 MW represents the thermal capacity of separate production of thermal energy. These data do not include the thermal energy production capacities of the independent producers from which the SACET operators have bought thermal energy in 2021, these being reported to ANRE (Romanian Energy Regulatory Authority), by the independent thermal energy producers [3].

In 2021, the SACET system included 17 cogeneration plants and 615 thermal power plants, of which 69 area thermal power plants, 281 neighbourhood thermal power plants and 265 block thermal power plants.

At national level, from the data reported by the SACET operators resulted that at the end of 2021, the public service of thermal energy supply in centralized system amounted to a total of 150,095 existing thermal connections (thermal connections of hot water from the transport system, thermal heating connections, hot water and steam) of which 128,493 in operation [3].

Following the process of data centralization collected from the reports submitted by operators, at national level there is a total number of 1,095,551 of consumers supplied from SACET, of which 10,902 are economic operators, 2,437 public institutions and 1,082,212 consumers representing the housing sector (apartments and/or houses). From the 47 centralized systems of thermal energy supply, 15 of them have a large dimension, with over 10,000 consumers, 18 of them are medium-sized, from 1,000 to 10,000 consumers, and 14 of them are small-sized, with up to 1,000 consumers [3].

ANRSC (National Regulatory Authority for Community Services of Public Utilities) approves local prices and tariffs for the operators supplying or providing public services of heat supply, excluding cogeneration heat, as well as local prices and tariffs for public institutions and economic operators. Local prices of heat invoiced to the population are approved by the local authorities and they can approve lower prices by covering the difference from the local budgets. GD No 1215/2009 defines the criteria and conditions required for the implementation and promotion of high-efficiency cogeneration based on the demand of useful heat as well as scheme applicable to the producers having units with installed electric capacity above 1 MW [3].

Between 2019 and 2021, the average thermal energy prices applied in different SACETs in Romania (grouped in the 7 regions) increased from 22 to 46 euros/MWh [1].

Efficient thermal energy supply systems involve [4]:

- in the case of central heating (DH) systems, to inject at least 50% of renewable sources, or 50% of residual heat, or at least 75% of the heat produced in high efficiency cogeneration, or at least 50% combination between renewable sources and residual heat.
- heat production sources to have at least 80% efficiency, and for biomass, at least 70%.
- technological losses in the thermal networks to be of maximum <15%.
- increasing the energy efficiency of thermal substations (TS).
- implementation of local thermal modules, for the elimination of secondary thermal networks.

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- hydraulic balancing and reduction of losses of thermal energy and thermal agent in buildings.
- complete the metering at the level of the thermal points, and at the level of the building.
- complete the individual metering and installing thermostatic valves.
- implementation of automation and dispatching systems for permanent monitoring and control of the operation of the installations, on the entire system, from the final consumers to the manufacturer.

The implementation of the WEDISTRICT project in Bucharest will strengthen the actions in relation with building an energy efficiency sector set in: the draft National Energy and Climate Plan 2021-2030; implementation of the projects included in the Energy Strategy of Romania 2019-2030, with perspective of 2050; Law No 121/2014 on energy efficiency; Government Decision No 129/2017 (laying down the criteria and conditions required for the implementation of the support scheme for promoting high-efficiency cogeneration based on the useful heat demand; Gazette No 192/17 March 2017 and Government Emergency Order No 24/2017 amending (establishing the system for promoting energy production from renewable energy sources and amending certain legislative acts).

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# 2. Lessons Learned

## 2.1. Licenses and Permits

### Polish experience

#### Zoning and Land Use Planning

There are many technical problems in the modernization of heating systems, especially concerning use of low-temperature heat from RES. These issues are indicated in the next point 2.2.

Ultimately, it turned out that the biggest problem in the rapid implementation of our WEDISTRICT projects were:

- dense buildings in small towns and problems with the location of e.g. ground-source heat pumps, PV panels or even new biomass boiler plants,
- provisions in the existing spatial development plans limiting the possibility of locating RES on them, such as PV panels, geothermal heating plants
- lengthy administrative procedures related to updating spatial development plans and obtaining building permits.

The situation requires urgent corrective action by government and local government authorities in this regard, with particular emphasis on:

- Polish cities require updates of plans (or assumptions for plans) of heat supply, with an indication of local sources of energy from RES
- spatial development plans should take into account the potential location of RES (PV panels, ground heat pumps, geothermal intakes, biomass heating plants),
- spatial development plans should not block the possibility of locating the above-mentioned solutions where it is not really necessary
- the duration of administrative procedures related to obtaining building permits and possible changes to the provisions of spatial development plans for projects related to RES should be shortened as much as possible

Investors who are currently undertaking similar projects must, however, be aware of the above. potential problems and include them in their work schedule.

- **Polish local spatial and development plans do not foresee space for heat sources (sometimes even current source is not properly included in the plan).**
- **In Poland, procedures for changing zoning and land use plans are extensive in time. They can take up to 1.5 years.**

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- **Polish cities require updates of plans (or assumptions for plans) of heat supply, with an indication of local sources of energy from RES in accordance with local spatial development plans**

# Spanish experience

## Zoning and Land Use Planning

The main caveat related to the Alcalá demosite relates to the justification of the current urban planning with the power plant and DHC network installation which was required by Alcalá City Council. The WEDISTRICT partners met the relevant authorities and prepared technical-legal reports justifying that the building and the activity complied with the regulations of the urban planning, both in terms of Industrial R&D use and Infrastructure services.

Spain lacks DHC specific regulation and this urban plan is very old (as happens with most of municipal urban plans), there is no reference to install this kind of infrastructure (neither it is in the prohibited activities list, which refers to polluting or hazardous activities). There are some sentences in Alcalá´s regulation about infrastructure for services and about R&D activities. In our justification we tackled these two points:

- The power plant and the installation of the DHC network are needed to provide a heating/cooling service to the Technology Park in Alcalá.
- It is a R&D activity, with several involved European partners (private and public ones) which develop, install and validate different technologies in this demo site.

Different Municipal departments asked for further clarifications and we provided answers and information to explain them the benefits of this project and strengthen the idea that the project was in line with the local regulations, and not less important with EU Directives regarding renewables and energy efficiency. But at the end, this undefined scenario due to the lack of specific regulation to interpret the law is critical to approve this kind of projects.

One of the conclusions we got in this process was that Alcalá city council (as happens with other municipalities) does not want to approve licenses when there is not a 100% clear legal situation.

- **Alcalá municipality does not approve licenses unless the compliance with requirements and regulations is 100% clear. As Spain lacks DHC specific regulations, there is no a straightforward justification of such compliance.**

## Building and Activity licenses by the local City Council.

DHECO with the support of ACCIONA prepared the application for the building and activity licenses to be issued by Alcalá City Council. Several meetings were organised with the City Council to understand all the documentation needed and to cover all the concerns of the City Council. Once we received verbally the green light and support to proceed with the project, we officially applied for the licenses to the local

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authorities in May 2021, including the payment of taxes (the 6 months delay -compared to the internal planning- in this request was due to the Covid-19 which postponed all the interaction with the City Council). After the submission in May 2021, the permits approval were expected soon and the construction works were planned to start right after in summer 2021. However, the Alcalá city council required more clarifications and documentation. We answered all the requests, submitted the required documentation and even held some meetings with the relevant departments of the city council until September 22 (when we submitted the last document to the Alcalá administration).

### Network Permit by the board of Alcalá Technological Park

A permit to build the network which connects the Power plant and CEPSA building had to be issued by the board of Alcalá Technological Park, where the demo-site is located. The application for this permit was not processed, because the building license was needed as part of the application documentation. Once we had the building license, the next step was to apply for the network building permit to Alcalá Technological Park. ACCIONA and DHECO had several meetings with Alcalá Technological Park in the meantime, and the board manifested a positive attitude to issue the permit and estimated approximately one month to issue it.

- **Difficulty to obtain licenses and permits from Public Administrations, especially in countries with low experience in DHC networks.**
- **Allocate more time for permits and licenses.**
- **Involve public administrations in the consortium helps to accelerate the licences approval process but it is not a solution that completely corrects or solves the problem. There are many different factors that can complicate this approval (e.g. there are changes in the local government which unfortunately may complicate some bilateral agreements). However, this is the best solution to avoid risks in this stage. The option of asking beforehand the municipal licenses is not feasible since these license permits have a defined length (usually they need to be executed in a 6 months period).**

## Swedish experience

### Zoning permits and planning.

Unlike the other demosites in the WEDISTRICT project, the Luleå demosite was always planned to be a temporary installation to develop a proof-of-concept solution for consideration in the future. As a temporary installation the demosite was made up of three containers, the data centre container containing a novel cooling application for the digital systems, the fuel cell container which housed the solid oxide fuel cells that operate as micro combined heat and power sources and the biogas storage container that housed the locally produced biogas from which the fuel cells operated. The containers were installed on land that belonged to the facility, namely NP3, that housed the RISE ICE datacenter facility and therefore

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permission from the facility owners was required to temporarily locate the containers on the grounds of the NP3. The requirements by NP3 were that the other tenants for the facility should agree to allow RISE as one of the tenants to use space from the facility carpark and a grass area more than 12.5m distance from the building. To be specific the data centre and fuel cell containers were 20-foot ISO containers that were to be stacked adjacent to the facility at the location where the facility's district heating connection was housed within the facility.

Beyond the courtesy requirements of RISE as one of several tenants of the NP3 facility, an official permit was required from the local council / the commune to be allowed to temporarily park the containers in the NP3 carpark, the details of which are called the "Bygglov" which was granted in January 2022 with an expiry date of 30th June 2023. The biogas storage required additional permits from the Luleå Kommun's fire department to handle flammable goods (Tillståndsbevis för hantering av brandfarlig vara) due to safety requirements when storing large quantities of biogas onsite and under pressure (of up to 200bar), which was accompanied by the additional constraints of there being an ATEX classified zone where the biogas pressure was reduced. This permit was granted in November 2021 for two years.

Since the permissions and permits were granted based on the installation being temporary, the disassembly of the containers is scheduled for June 2023 before the commune's permission ceases.

- **The construction and commissioning of the demosite experienced 6 months delay, but it was not possible to extend the timeframe for permissions and permits granted for the temporary installation – with a 12 months initial duration.**

## Grid connection and post construction requirements.

The proof-of-concept design of the Luleå demosite was not designed to be operated without being connected to the local electrical grid. Since the fuel cells are sources of electrical power generation and the solution proposed was to be grid-parallel it was necessary that the fuel cell invertors be recognised as safe to use with the local electricity grid. This was achieved in consultation with Luleå Energi and the fact that the brand of invertor (namely band X) used by the fuel cells was recognised as being compliant, even though it was not the same 5kW model that Luleå Energi had in its database being the 1.5kW unit in each of the 9 fuel cells. This process was simplified by the fact that RISE had already sought permission to export electricity to the grid via its PV array, not part of this project.

The export of the thermal energy produced by the Luleå demosite also required equipment that was recognised as safe to operate and whilst in principle the connection would be possible (Luleå Energi had already supported the project at the application phase), the stringent nature of compatible equipment in terms of the pump and valves stipulated by Luleå Energi at the time the connection was to be created, made it both economically and technically improbable.

- **The connection directly to the Luleå district heating grid would be economically more feasible for a larger system (demonstrator), probably of the order of 30 times larger. In the end the**

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**demonstrator was connected to the facility's heating loop, that is the secondary loop that is itself connected to the Luleå district heating network**

# Romanian experience

## Zoning and Land Use Planning

The demosite is located within the University campus, fact that allowed the construction and implementation of the installation without inconveniences.

The Target Building offered enough space for the deployment of the thermal system and part of the electrical system while the building provided a particular demand for both heating and cooling. The borehole heat exchanger, heat pumps, water tanks, solar collectors and part of the PV panels were deployment at the target building location while the other part of the electrical system and associated PV panels was deployed on the rooftop of a nearby building.

The equipment that was deployed at the demo-site required only internal permits since they were deployed within the university boundaries.

- **Materials, resources and time allocated for the adaptation and integration of the new solution in the UPB campus, were in accordance with the imposed local conditions and existing standards.**
- **Challenges with the approval by the Distribution System Operator of the PV system connection to internal grid of UPB, asked for a UPB claim to the National regulatory Agency for Energy (ANRE), which has been solved finally in the favour of UPB. The situation showed that some rules issued by ANRE are not proper interpreted by the DSO and produce delays in implementation.**

## Civil, grid connection and post construction permits

Romanian target for 2030 is to reach a 30.7% share of energy from renewable energy sources (RES). In this regard, green energy and energy efficiency become an important pillar of the National Recovery and Resilience Plan. In other words, the market enters a new wave of development making the sector of RES, more and more attractive. Because an important issue for the investors is to know very well all the steps they need to conduct in an efficient way an energy investment project, in 2021 RWEA released the "Code of good practice for renewable energy in Romania". According to the Code, obtaining the necessary permits for a RES project, can take up to a maximum time of 540 days for complex photovoltaic projects installed on agricultural land. It will involve up to four public institutions (ANRE, City Hall/ County Council, DSO/TSO and the Local Environmental Authority), and three types of permits might be needed (civil, grid connection and post construction) [8]. Of course, these permits are needed according to the complexity

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of the project, its location, the installed power and may vary from case to case. For apartments buildings , since the roof is a common part of the building, a written agreement from all the owners is also needed.

Establishing and obtaining what licenses and permits are required for the implementation of the demo-site was a complex activity in which analysis of the national legislation, discussions with suppliers and subtractors were realized.

For the heat pumps that was installed at the Bucharest demo-site, a number of 12 boreholes were required to be installed in order to satisfy the thermal energy demand. For the installation and exploitation of the boreholes a drilling and a exploitation licenses were required. For both licenses, the following documentation were required: technical memorandum, hydrogeologic study, engineering project.

The photovoltaic panels, that is producing the electrical energy required by the heat pumps, were installed on the rooftops of two different buildings. The PV panels are connected with the local electrical energy grid, therefore for the installation, the following documentation was required, in accordance with national regulations:

- Urbanism certificate
- Telephone notice
- Environmental license
- Fireproof license
- Placement and technical connection license
- Electrical energy production certificate

The local technological partner, ISPE, that was responsible for the electrical subsystem engineering project requested a technical expertise of the buildings. The expertise, ordered by UPB, was required in order to ensure that the installation of the photovoltaic panels on the rooftops of the buildings can be sustained by the existing structure. The documentation requested for the technical expertise is: technical plans for each building (sections, foundation information, reinforcement structure), geotechnical study, destructive attempts (on-site probes).

The connection of the hybrid system with the local district heating system doesn't require any external permits since the local heating network is owned by UPB. For this aspect, an internal permit was obtained, for which technical details were provided (temperature level, mass flow rates and operating regimes) [6].

- **Challenges to determine and obtain licenses and permits required for the implementation of the demo-site. This complex activity involves analysis of the national legislation, discussions with suppliers and subtractors.**
- **Failure to comply with current contractual clauses with third party services made necessary to restart the procedure for subcontracting.**
- **Difficulties in maintaining a suitable schedule of the procurement phase due to delays in purchases.**

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- **Well written clauses then may cover unexpected situations are necessary to avoid potential issues with the suppliers of equipment, materials.**

## 2.2. Other requirements

# Polish experience

### Technical requirements and energy prices

The preparation and implementation of projects related to the modernization of heating systems in Poland is associated with prior consideration of several aspects that cannot be forgotten.

- Energy Regulatory Office and energy prices

  When undertaking the investment, we must remember that the final price of energy from the heating system must be approved by the Energy Regulatory Office (ERO) and the acceptance of energy consumers, if we do not want them to simply disconnect.

- temperatures of the heating medium and heat demand of buildings

  Heating installations in old existing buildings in Poland have parameters of 90/70 ºC and in within distribution networks not lower than the above-mentioned parameters, and the supply temperature in DHN is usually above 100 ºC.

Therefore, if energy is to be delivered in a efficient way to the above systems with low-temperature RES sources, first is should:

- insulate the buildings in accordance with the current standards of the EPBD directive,
- adapt the building's heating system to the lowest possible temperature of the heating medium.

These actions will ensure a reduction in investment outlays for the modernization of the heating system and will reduce the annual fees for heat energy for heat consumers.

- large disproportions between winter and summer time heat demand in DHNs

One of the specific issues that need to be solved as part of the modernization of heating systems in Poland is the large disproportion between the low demand for heat in the system in the summer or its complete absence (e.g. for the preparation of hot utility water or cold production) in relation to the maximum demand warmth in the winter season. Large disproportions between winter and summer reduce the profitability of efficient energy solutions, such as cogeneration, and reduce the possibility of using solar energy. In order to counteract this phenomenon, it is necessary to take into account the possibility of connecting e.g. new hot water installations or cooling installations from absorption chillers.

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- diversification and use of the most available local forms of RES

Based on the analyzes carried out for many locations in Poland, it can be concluded that the key to success is a thorough analysis of the RES forms available in Poland (e.g. shallow and deep geothermal, biomass, biogas) and the use of heat accumulators, which significantly increase the possibility of using RES in the long term period of time.

Other key factors for the success of the project in terms of implementation time, formalities and finances are indicated in point 2.1. and 2.3.

# Spanish experience

## Environmental requirements

The partners leading the Alcalá demo site addressed the environmental procedure to fulfil the regulation. This part does not involve the Alcalá municipality since this assessment is done by an upper public body: Environmental Counselling of Madrid.

This procedure had two steps: “Environmental evaluation” and “Potential polluting activities into the atmosphere”. The documents and environmental acceptance by the Madrid Region were included in the dossier provided to the City Council containing all the relevant information.

- **Environmental evaluation**

From the environmental regulation perspective, based on Spanish regulation, Law 21/2013, of December 9, on environmental evaluation, modified by Law 9/2018 of December 5, the project should not be subject to ordinary environmental evaluation, since:

- it is not classified in Annex I,
- nor it is simplified in Annex II.

In addition, despite it belongs to group 4 "Energy Industry", in no case the installed power will be greater than or equal to 100 MW.

- **Potential polluting activities into the atmosphere**

The requirements for the potential polluting activities to the atmosphere were revised for the biomass boilers.

- Royal Decree 1042/2017, of December 22, on the limitation of emissions into the atmosphere of certain pollutants from medium-sized combustion facilities and by which Annex IV is updating the Law 34/2007, of November 15, on air quality and protection of the atmosphere, exempts in its article 2.4 the research activities such as WEDISTRICT project.

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- Royal Decree 100/2011 describes that the proposed activity falls within the CAPCA code: HEAT GENERATION FOR URBAN DISTRICTS, Ptn <1 MWt and> = 250 KWt. But according to this Royal Decree, and only for this heat power range, as the device is an integral part of the facilities included in the scope of application of the Royal Decree 1027/2007, of July 20, which approves the Regulation of Thermal Installations in Buildings, then it will not be assigned to any group when it is Ptn <1 MWt, (as it was the case of WEDISTRICT biomass boiler), and it would not need to follow any administrative procedure (authorization/notification) prior to installation.

# Swedish experience

## Operating requirements

Beyond the licenses and permits for the temporary installation of the Luleå proof-of-concept demonstrator there was a requirement for operation. This was the necessary appointment of two "GASFÖRESTÅNDARE", persons responsible for the safe storage and use of the biogas – two are required to make sure there is adequate cover. This was achieved by hiring a fire warden from Polargas and another from Boden Kommun, responsible for the local production of biogas. Both wardens had access to the biogas container and were on call for any eventual problems.

The biogas that was supplied was to the standard SS 155438 as used for transport applications and therefore in terms of any environmental constraints, there were none even though the exhaust gas could contain some trace pollutants. The conversation was never initiated over this point, and it is probably due to the small scale of the demonstrator.

# Romanian experience

## Local standards and requirements

**Policy in the field of public heat supply service**

- Ministry of Regional Development, Public Administration and European Funds - which performs the functions of analysis, synthesis, decision, coordination, monitoring, planning and evaluation on the implementation of standards and requirements for accelerating the development of public utilities in accordance with similar European level.
- Ministry of Energy whose role is to stimulate the initiatives of economic operators in the fields of industrial policies or sustainable development and to coordinate and manage national energy resources.
- Ministry of Environment for issues related to environmental conservation and protection.

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- Ministry of Labour and Social Justice for aspects regarding the social protection policy in the field of thermal energy supply.
- National Regulatory Authority in the field of Energy for the activity of thermal energy production in cogeneration.

**Organization and operation of the public heat supply service - In addition to these normative acts, there are a series of documents of the regulatory authorities that establish the conditions of organization and functioning of the public heat supply service, respectively:**

- methodologies for setting, adjusting or modifying prices and tariffs.
- procedures for resolving disputes; sector-specific regulations, procedures and framework contracts.
- procedures for granting the reference bonus for energy produced in cogeneration.
- methodologies for determining and monitoring the overcompensation of the cogeneration energy production activity.

## 2.3. Participation in H2020 projects and Integration of R&D projects in Commercial environments

### Polish experience

A company investing in new heat sources must prepare the project in such a way that the price of energy in the long term is competitive in relation to other available on the market. Formally, this must be reflected in the heat supply contract between the recipient and the energy supplier, and in the approval of the tariffs (proposed by the supplier) by the energy regulatory office.

- The Bierutów demo-site project

In this case, the partner for talks with the heat supplier (PTER) was a housing cooperative, whose members were afraid of cooperation with a rather large company, which is PTER, which has many projects in Poland and in some of them energy prices are at a relatively high level. They demanded from the investor long-term guarantees of the price level in exchange for signing long-term guarantees of thermal energy consumption and the possibility of using the roofs of their buildings for PV locations and the use of the premises of the existing boiler room. Negotiations turned out to be difficult, and the conditions for the heat supplier were unacceptable.

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The cost of energy is just one of the factors influencing the decisions of consumers, residents and other stakeholders. People unaware of the importance of pro-climate measures, the need to eliminate carbon sources, new legal regulations and programs such as H2020 are not positive about such projects and are even afraid of them.

- The Dzierżóniów demo-site project

In this case, most of the technical and formal and legal problems have been resolved. There was no opposition from the residents and even the management of the heating plant approved the project. The only missing link was the decision of the Supervisory Board of the heating company, which includes representatives of the City Council, i.e. the owner of the company. The selection of members of the City Council belongs to local voters, hence they represent a very diverse worldview and are often not up to date with the regulations regarding EU programs, and their lack of knowledge and fears translate into such and no other decisions.

It was difficult for them to understand the idea of R&D and the way of financing the project, comparing the overall cost of the project with simple solutions without R&D elements. They were very reluctant to this possibility and although we confirmed that we restricted all the activity to the technology park (and we agreed to sign any agreement), this was an unrecognized fear they had and somehow influenced the decision. Unfortunately, that was exactly the case here. After a year, the new composition of the Supervisory Board decided to continue the project.

In order to avoid problems related to the above-mentioned examples, each time before starting a project, it would be advisable to:

- carry out an information campaign among residents and stakeholders on the purpose of the project and how it will be implemented,
- indicate the scope of support from European Union funds and highlight the resulting benefits,
- conduct in-depth economic analyzes for all available system modernization options (with sensitivity analysis), so that the selected option is optimal for both energy suppliers and consumers
- the benefits resulting from the selection of the optimal variant should be widely communicated to the local community in order to gain its support for the project.

- **Pressure on keeping the heating costs low.**
- **Reluctancy of the network operators towards more innovative solutions**
- **Reluctancy to join H2020 projects due to lack of familiarity and experience in European R&D projects**
- **Some DH networks provide heat mostly or only for space heating purposes**
- **For small sources not under EU ETS traditional (fossil fuel based) solutions are currently most cost effective (without financial support).**
- **Fear of operators about complexity of the solutions (operation of a network with multiple weather dependant heat sources, maintenance, maintaining the heat parameters, etc.).**

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- **Limited availability for effective use of CHP or solar based solutions (requirements for the investments on the demand side together with introduction of new sources).**

# Spanish experience

The DCH proposed in both Spanish demosite alternatives (Alcalá and Cordoba) were not integrated in commercial environments.

CEPSA in Alcalá and UCO in Córdoba were the only users of the DHC system and they are very focused on decarbonizing the heating and cooling demands in their buildings. They have more “energy culture” than a “standard” client so they are more opened to understand the environmental and financial (at medium-long term) benefits.

However, the Alcalá City Council was concern that, after finalising the R&D project WEDISTRICT, the installation could become a commercial project out of scope for Research and Development Technology Park area. They were very reluctant to this possibility and although we confirmed that we restricted all the activity to the technology park (and we agreed to sign any agreement), this was an unrecognized fear they had and somehow influenced the decision.

- **Administration fears that R&D project may become a commercial one exceeding the agreements**

# Swedish experience

The Luleå demosite presents a proof-of-concept that was operated on a temporary basis to collect the necessary data that is of an open nature in line with the ORD (Open Research Data) policies of the EU’s H2020 funded projects.

The demonstrator was designed, built and operated by RISE which is an RTO making use of a small level of subcontracting and whilst there were many technical pitfalls along the way, as expected with the novelty of the approach, the project could have made good use, during the design and build phase, of a project manager skilled in dealing with building permits, necessary licenses and the intricacies of subcontracting arrangements. This lesson learned has two aspects to it, on the one hand a project manager would have helped speed up the design and build process, but on the other hand using a project manager may have masked the research team at RISE ICE datacenter from some of the detailed aspects that became important during the operation phase.

# Romanian experience

The Bucharest demo-site represents an important contribution to the field of sustainable energy solutions for district heating networks. Its primary objective is to showcase the viability of integrating renewable

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energy sources into existing district heating networks, with the dual aim of reducing greenhouse gas emissions and maintaining the continuity of service for end-users. The hybrid system deployed at the demo-site constitutes a scalable model that can be replicated in a wide range of district heating networks, both domestically and internationally.

The conceptualization and implementation of the Bucharest demo-site represent a comprehensive approach to the development of sustainable heating systems. By combining renewable energy sources with traditional heating infrastructure, the demo-site provides a practical demonstration of how to reduce the carbon footprint of heating systems. The use of a hybrid system not only reduces emissions, but also ensures the stability and reliability of the heating system for end-users.

The successful integration of the Bucharest demo-site into commercial environments has been accomplished through a series of key steps, including:

- Technical Feasibility Assessment: A thorough technical feasibility assessment was conducted to determine the practicality of integrating the hybrid system into commercial heating networks, taking into account the existing infrastructure, available resources, and regulatory requirements.
- Business case development: A clear business case was developed to outline the financial benefits of the hybrid system, including cost savings, improved energy efficiency, and reduced carbon emissions. This helped secure funding and support from stakeholders and investors.
- Pilot Deployment: A pilot deployment of the hybrid system was launched in a university environment to demonstrate its viability and performance, building confidence among stakeholders and customers, and providing valuable feedback for further development and improvement.
- Market Education and Awareness: Efforts were made to educate and raise awareness among stakeholders, customers, and the wider public about the benefits of the hybrid system and the importance of sustainable heating solutions. This helped build support and increase demand for the technology.

## 2.4. Financing of DHC Networks

### Polish experience

The system of tariffs for heat energy supervised by the Energy Regulatory Office is structured in such a way that it does not allow heating companies to accumulate sufficient funds for large modernization investments. On the other hand, heating companies are owned by local communities and cities, which also do not have the money for such large projects. Therefore, the modernization of the Polish heating sector is not possible without the financial support of the state and the EU. The required outlays for this purpose in Poland are many times higher than in other European countries due to the widespread use of coal heating and high-temperature heating systems.

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The problem is particularly difficult in small towns, as exemplified by the locations proposed in the WEDISTRICT program as Demo-sites in Poland. There is an urgent need to continue such programs in Poland

A positive role in the modernization of district heating systems in Poland is played by:

- EU programs such as WEDISTRICT or, for example, another ELENA program implemented by KAPE providing co-financing from the European Investment Bank.
- programs implemented by the National Fund for Environmental Protection and Water Management, which has funds to support such projects

A negative phenomenon is the fact that Poland still does not have funds from the National Recovery and Resilience Plan launched (as for May 2023), which makes it difficult or even impossible to launch many support lines planned for years, especially for small coal-fired heating plants.

- **Increasing of the investment rate in DH networks (companies actively looking for investment possibilities).**
- **Local communities are positive towards changes (local authorities, tenants etc.).**
- **Increasing of the investment rate in DH networks (companies actively looking for investment possibilities)**
- **New financing possibilities and support for investment preparation (e.g. „Ciepłownictwo Powiatowe", "National Integrator of Investment Processes in District Heating Companies in Poland" programmes)**
- **Lack of funds from the National Recovery and Resilience Plan (May 2023)**

# Spanish experience

Investment funds, like other types of investors, are showing a growing interest in funding renewable energy projects for several reasons, including the rise of green bonds and the European Union (EU) taxonomy for sustainable activities.

Investment funds are increasingly recognizing the financial potential of renewable energy projects, as they can provide stable, long-term returns through revenue generated from clean energy production, as well as potential incentives such as government subsidies or tax credits. Additionally, there is a growing awareness and demand from investors and consumers for environmentally responsible investments that contribute to mitigating climate change and promoting sustainability.

However, there are several challenges in the commercialization of the DHC project is the "present time", the current fossil fuel energy costs that the potential client is paying, without seeing the variability of fossil fuels pricing (while the renewable energy prices are much more constant and have a lower average cost at long-term). Even in the economic studies the client should know about the life-time/amortization of the

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existing heating production system in their buildings, the needed re-cap when the old boiler, heat pump, etc fail.

DHC project covers the 3 parts in which the system is divided: power plant, network and thermal substation (which substitutes the existing fossil fuel heating/cooling production system). Comparing just the "energy price" between both systems is not the way to correctly analyse all the economic benefits these projects have (obviating the environmental aspects). For example, do the clients know the Operation & Maintenance costs that are being reduced when they connect to a DHC system?

In addition, there are some uncertainties to size these projects that cause financial problems when developing them. If the project is totally fixed and, from the beginning, all the clients signed energy supply contracts it is very easy. But the reality is that depending on the size of these projects, the construction and start-up can last for more than one year (license approval, engineering projects done, contracts signed with the construction and O&M companies, construction works…), so the end users prefer to wait to see that the construction works are getting closer to the neighbourhood (in case the DHC implies all the city or at least a part of it) because often they are not confident that such a big and centralized project that affects lots of municipal streets ("open" them, install the piping and "close" them again") will become a reality. So finally, only some of these clients sign beforehand these energy supply contracts. This brings a lot of problems to try to convince investors in the profitability of these projects, because the numbers are done based on some hypothesis, being the main one the "successful connecting rate". This leads to some questions:

- "How big should the power plant be sized (for the 100% potential clients or less and be more conservative)?" The more conservative the DHC promotor is, the less profitable is the business.
- "Should the network be extended from the beginning to the door of the client without knowing if the client will sign an energy supply contract now, within a 2 years period or maybe never?" "What happens if the DHC is not extended to some areas?" A later construction of only one part will be more expensive than doing it from the beginning. "Who will pay these extensions: a) the client since at first they did not sign the contract, or b) the DHC owner since they know this extra-cost discourage the potential client to connect to the DHC?"

In this regard, it must be said that for the last years the fossil fuel prices have increased and the District Heating systems have grown very much (now there are many success stories in Spain). This helps the DHC systems to be better understood by the potential end users, not distrust and finally make these projects much more feasible since the clients can more easily be involved in the process from the beginning.

# Swedish experience

There was no agreed financial contract in exporting the thermal energy from the Luleå demonstrator – the connection to the DH network (in fact a secondary network to the main DH network) was used purely

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as a means of gathering data. The waste heat recovered from the demosite does have a value and had the installation been permanent and at a larger scale this would have been a topic for discussion.

Connecting to a district heating system as a third-party heat supplier is controlled by the “District heating law[1]” in Sweden. In paragraph 37, the law states that if someone would want access to the distribution network, this needs to be negotiated with the district heating network owner, if an agreement cannot be obtained, the district heating network owner needs to motivate why they would not give access to the new heating provider. There are a number of following paragraphs in the law explaining the routines for how the access to the network could be provided, and what fees the network owner can charge the new provider, to cover costs. However, referral to the law for legal details regarding detailed information is required.

# Romanian experience

Looking at the Bucharest pilot site, UPB makes use of its internal resources at the Faculty of Energy Engineering and Department of Energy Generation and Use, to design, build and operate the hybrid system. When considering the Faculty and the Department as RES solution providers, the DBO (Design Build Operate) model seems to fit best, although no financial arrangements will be made between UPB and the two entities since they are all part of the same organisation. The necessary technology has been obtained from RES technology providers on a direct sales basis. DBO: this model is similar to the BOT (Build Operate Transfer) model with the main difference being that the DHC operator owns and finances the construction of the RES assets. The RES solution provider who operates the RES infrastructure is taking no or minimal financing risk on the capital and will typically be paid a sum for the design-build of the RES assets and then an operating fee for the operating period [7].

The new installation is built on the premises of the UPB campus and operated and maintained by UPB staff. No service arrangements were made yet with the technology providers apart from the service provided during the guarantee period which runs two years from the commissioning date. The hybrid DH system will not only be used for the generation of energy but will also serve for didactic and research purpose. The system will be used for the training of students and for subsequent research activities. Next to that, the system serves as an example of how a RES based hybrid DH system can be deployed and operated in a viable manner and will be used to promote and stimulate replication of the hybrid concept nation-wide. It will be performed with stakeholders and other interested entities to promote the greener profile. It is expected that such promotional activities will improve the image and visibility of both WEDISTRICT project and UPB, and supporting other organisations with the design and implementation of similar systems.

[1] https://www.riksdagen.se/sv/dokument-och-lagar/dokument/svensk-forfattningssamling/fjarrvarmelag-2008263_sfs-2008-263/

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The new hybrid system reduces the carbon footprint of UPB and makes UPB less vulnerable for fluctuating energy prices. Another advantage from the hybrid system is that it allows for temperature control at room level, thereby increasing the comfort level of the target building. The heat surplus, after ensuring the heating of the targeted building, is injected into the local DH network to be used in other buildings. Even UPB DH network is connected from technical point of view with SACET Bucharest network but currently there aren't commercial exchanges (heat exchange).

The Bucharest demosite currently has a predominant "public" character as the DHC network is owned by UPB which uses the network not only for heating campus buildings but also for didactic and research activities. Only a few private companies are involved in this value web as technology or maintenance providers, but they won't be involved in the day-to-day operational life of the plant.

The added value in terms of benefits for the customer, which is also UPB, include the following factors:

- Economic savings: At target building level, costs for energy generation will be reduced to zero. No purchase of natural gas is needed and electricity generated by the PVs will cover (at least) the consumption of the heat pumps system.
- Comfort: Comfort level of the building occupants is increased because of the possibility to control temperature at room level, something which was not possible with the original system.
- Ease/Control: Less O&M of the DH generation plant is foreseen.
- Environmental benefits: switch to 100% RES triggering 100% reduction in GHG emission linked to heating and cooling of the targeted building.
- Societal benefits: UPB serves as an example for other Universities and organisations who wish to green their energy generation. It can be expected that the barrier for adopting RES in existing DHC networks will be lowered since the real-life case and support and guidance from UPB is available.
- Other: The greener profile will increase the research visibility of UPB into the renewable energy sector. The hybrid system unlocks new types of research and experiments to be conducted.

Saving cost or maximising cost savings is not the first priority since UPB's drivers are not 100% economical. The exploitation of the Bucharest pilot will be twofold. Providing heat and cooling to the targeted campus buildings will fit in the current business model of UPB's DHC operations. Next to that, the hybrid system is also used for didactic and research purposes. Multiple studies and simulations are foreseen with the assistance of the new hybrid system. As the studies will evolve, other stakeholders and local municipalities can be interested in future collaborations. Also on a national level, UPB's aim is to stimulate replication of the hybrid system at national level. Other Universities will be invited to visit the demo site and UPB will offer to provide support to other Universities in the form of exchange of know-how. The system has been developed as a modular concept that will ease the process of replication and scaling. Offering of consulting services is not planned. UPB's primary goal is to have an innovative research and test infrastructure for RES technologies and strengthen collaboration with stakeholders on local, regional and national level. Especially collaboration with rural energy communities is of high interest since decarbonisation is very challenging for these communities. Long term vision is to investigate the

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use of the electrical part of the hybrid system for rural communities to operate in island mode in order to make them less vulnerable for black-outs.

- **Fluctuations of prices in the equipment and materials market necessary for the project implementation (higher budget margin to avoid price fluctuations).**
- **Exchange rate fluctuation for non EUR countries (forecast supplementary budget).**

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# 3. Best practices & Recommendations

In addition to the lessons learned described, this section summarizes key recommendations for research projects and demonstration activities for future projects.

1. Involve public administrations and business agents in the consortium
2. Extra time allowance for permits and licenses; both time for obtaining and duration if temporary permits and licenses
3. Underline to the investor in the legal part of the project from very early stages- ideally in proposal phase
4. Awareness campaigns
5. Partnership development with key players in the industry
6. Form research team with multidisciplinary habilities
7. Double check using multiple methodologies
8. Plan for operating requirements at early stages of the project
9. Collaboration with experts in the field (from industry)
10. Making contracts with very clearly defined obligations (equipment/services)
11. Sensitivity analyzes of the variation of some economic-financial parameters fluctuations (fuel, electricity, thermal energy prices etc.)
12. Target lower TRL for demo-sites

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# 4. Conclusions

This document presents an overview of the current situation of DHC in Poland, Spain, Sweden and Romania, where four real-scale demonstration sites projects were to demonstrate WEDISTRICT technologies integration. For each demo-site, this report describes observations and experiences, the main caveats and finally "lessons learned" and a set of best practices and recommendations.

Having completed the preparatory works stage selecting the most suitable location for all 4 demosites, two of the initial demonstration sites were replaced or withdrawn. These are the cases of Poland and Spain. The blockage preventing the demo-site to be built are summarised below:

| | Demosites | Main Blockage |
|---|---|---|
| POLAND | Kuźnia Raciborska | Zoning and Land Use Planning |
| | Bierotuw | Commercial agreement for heat contract |
| | Sejny | Zoning and Land Use Planning |
| | Dzierżążno | Lack of knowledge and unawareness of H2020 projects |
| SPAIN | Alcalá | Licensing and permits |

A summary table of the main lessons for each aspect is provided below:

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| | LICENSES AND PERMITS | PARTICIPATING IN H2020 AND INTEGRATION OF R&D INTO COMMERCIAL PROJECTS | FINANCING OF DHC NETWORS |
|---|---|---|---|
| POLAND | - Local spatial and development plans do not foresee space for heat sources<br>- Procedures for changing zoning and land use plans are extensive in time. They can take up to 1.5 years.<br>- Polish cities require updates of plans (or assumptions for plans) of heat supply, with an indication of local sources of energy from RES in accordance with local spatial development plans | - Pressure on keeping the heating costs low.<br>- Reluctancy of the network operators towards more innovative solutions<br>- Reluctancy to join H2020 projects due to lack of familiarity and experience in European R&D projects<br>- Some DH networks provide heat mostly or only for space heating purposes (hot water during the summer time should be added)<br>- For small sources not under EU ETS traditional (fossil fuel based) solutions are currently most cost effective<br>- Fear of operators about complexity of the solutions | - Increasing of the investment rate in DH networks<br>- Local communities are positive towards changes<br>-Increasing of the investment rate in DH networks<br>- New financing possibilities and support for investment preparation<br>- Lack of funds from the National Recovery and Resilience Plan |
| SPAIN | - Municipality tends not to approve licenses unless the compliance with requirements and regulations is 100% clear. This complicates justification in Countries without DHC specific regulations such as Spain.<br>- Allocate more time for permits and licenses. | - Administration fears that R&D project may become a commercial one exceeding the agreements | - Growing interest in funding renewable energy projects<br>- Consumers and investors should be more educated on evaluating profitability of DHC networks. Fossil fuels fluctuating prices versus RES solutions which are more stable, despite the investment needed being higher |

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| | | | |
|---|---|---|---|
| SWEDEN | - Difficulties to extend licenses and permits for temporary demo-sites. Plan for an extra time allowance when requesting.<br><br>- Connection to main district heating grids is feasible for large-scale demo-sites. Otherwise consider connecting to secondary (building level) grids.<br><br>- Operating requirements should be planned inadvance. | - Important to involve skilled project manager on the design and construction stage for speeding up the process and for anticipating important aspects for operation. | - Connection to district heating distribution networks should be negotiated with the owner. |
| ROMANIA | - Materials, resources and time allocated for the adaptation and integration of the new solution in the UPB campus, were in accordance with the imposed local conditions and existing standards.<br><br>- Challenges with the approval by the Distribution System Operator of the PV AS<br><br>- Allocate more time for permits and licenses.<br><br>- Additional time allocated for the procurement procedures.<br><br>- Well written contracts with suppliers of equipment, materials and services. | - Successful integration into commercial environment thanks to key steps: Technical feasibility assessment, Pilot deployment and Market education and awareness.<br><br>- Limited availability for effective use of CHP or solar based solutions | - Fluctuations of prices in the equipment and materials market necessary for the project implementation<br><br>- Exchange rate fluctuation for non EUR countries |

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This report is complemented with **D6.11 Results of retrofitted DHCs demonstration – Bucharest demo, D6.13 Results of WHR in DHCs demonstration – Lulea demo and D6.14 Results of new DHCs demonstration – Córdoba demo** which include the main difficulties encountered during the construction and operation of the demonstration sites.

# 5. References

[1] A.M. Bianchi, M. Marinescu, D. Hera, S. Dimitriu, G. Ivan, M. Ionescu, FL. Băltăreţu, Thermal district heating systems in Romania; Research and Development direction. National Thermomechanical Conference with International participation 2017

[2] D2.1. DHCs Due Diligence. Smart and local reneWable Energy DISTRICT heating and cooling solutions for sustainable living Grant agreement N°857801

[3] Report regarding the state of the public service for district heating in Romania 2021 https://www.anre.ro/ro/energie-electrica/legislatie/serviciul-public-de-alimentare-cu-energie-termica

[4] GEO no.53/2019 regarding the approval of the Multi-Annual Financing Program for the modernization, rehabilitation, upgrading and extension or establishment of centralized district heating systems of localities and amending and supplementing the Public Utility Community Services Law no.51/2006.

[5] D6.1 Pre-assessment of demo-sites. Smart and local reneWable Energy DISTRICT heating and cooling solutions for sustainable living Grant agreement N°857801

[6] D6.3 Preparatory works in Bucharest DEMO. Smart and local reneWable Energy DISTRICT heating and cooling solutions for sustainable living Grant agreement N°857801

[7] D8.2 Business models. Smart and local reneWable Energy DISTRICT heating and cooling solutions for sustainable living Grant agreement N°857801

[8] Romanian wind energy association (RWEA), Code of good practice for renewable energy in Romania, 2021 (https://rwea.ro/wp-content/uploads/2021/05/Code-of-Good-Practice-for-Renewable-Energy-in-Romania.pdf)

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