



Final report :

# Wärmeverbund als Lösung für die Luftverschmutzung in den Städten im Süden von Chile

Heat networks as a solution to air pollution in the cities of southern Chile

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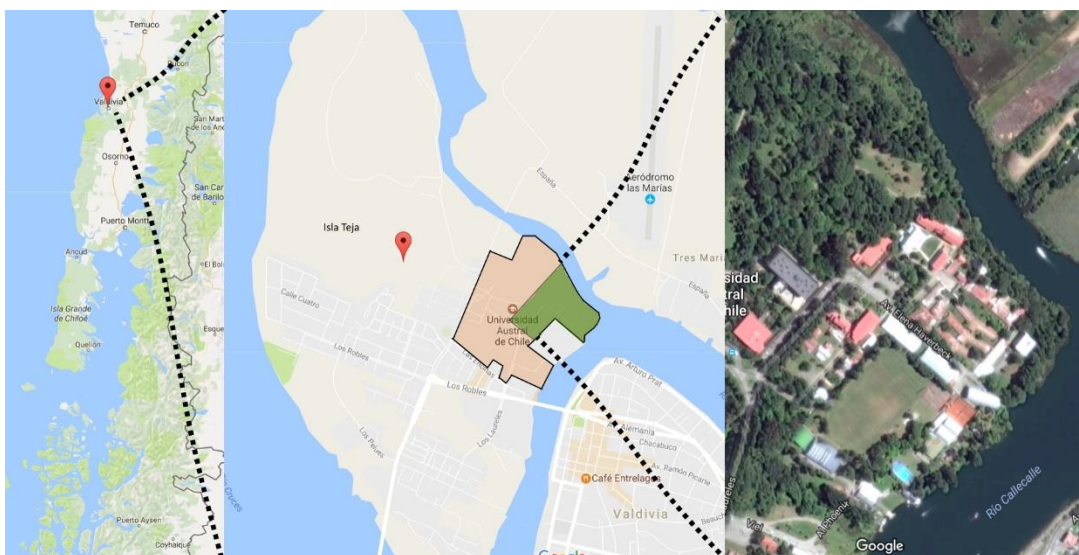
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## 1. Summary

The main objective of this project is to achieve the necessary conditions for the implementation of a district energy pilot in Chile. The relevance of this pilot is justified by the high levels of contamination by particulate matter that exist in southern Chile, which have costs of millions of dollars annually associated with premature deaths, hospitalizations, lack of productivity, and morbidity. Although there are public policies that have helped to reduce critical episodes of contamination, district heating is expected to have a much more significant impact in the medium term on the reduction of concentrations of particulate matter in the air.

For this project, in the first instance an attempt was made to develop a district energy project on the Isla Teja campus of the Austral University, since it was considered that many favorable conditions were met for the development of the project (single person responsible for administration; high thermal and electricity demands, land availability, interest and commitment of the University board)

A formal commitment was obtained from the Chancellor of the University for a total of CHF 600,000 in existing and future infrastructure, as well as a total of CHF 13,500 in human resources to support the project.

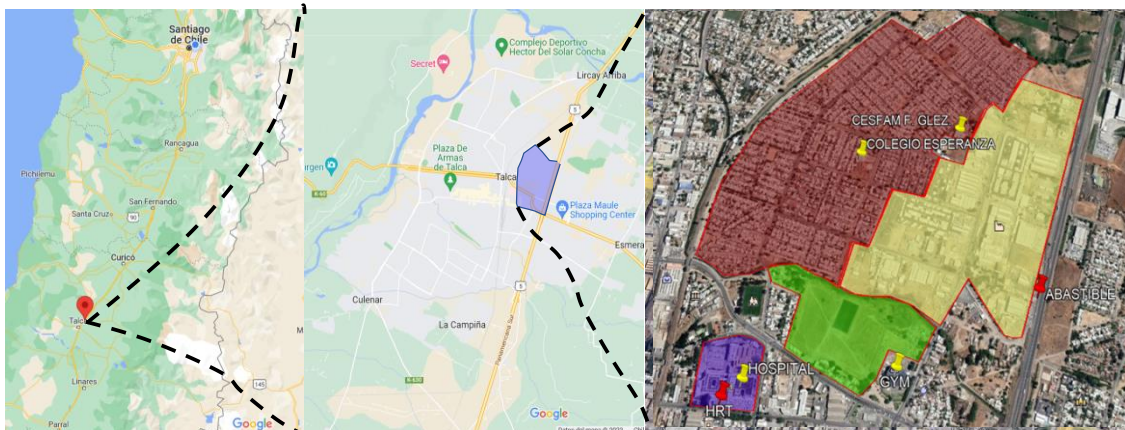


*Figure 1 Location of the Isla Teja Campus of Universidad Austral in the city of Valdivia. The orange area corresponds to the Campus in its entirety, while the green area corresponds to the sector considered in the first stage of the project to be supplied by the district energy network.*

Technical and economic pre-feasibility study and terms of reference were developed for the university. The final version of the project considered a number of buildings incorporated into the district network considerably higher than initially projected (10 buildings considered initially, against 45 in the final version)

Once the terms of reference were developed, it was not possible to continue with the bidding process and the selection of a supplier for the execution of the project due to the period of instability suffered by the university, including the resignation of the university dean due to the accusations of mismanagement.

Given this situation, REPIC was asked during 2022 the possibility of focusing the resources planned for the execution of the unfinished milestones at the Universidad Austral, in the development of a district heating project in Talca, located 240 kilometers south of Santiago.



*Figure 2 Location of Talca at the south of Santiago, and detail of the zone to be studied*

As in Valdivia, Talca has high levels of air pollution associated with high concentrations of particulate matter. In the same way, current measures are still insufficient to achieve satisfactory air quality.

The development of this second phase began with the formation of a District Energy Board, in which the main relevant stakeholders of Talca participated, such as the local offices of the Ministries of Energy (Minenergia), Housing (MINVU) and Environment (MMA) as well as the Municipal Government, the Regional Hospital of Talca, the regional office of the Corporation for the Promotion of Production (CORFO) and the National Institute of Professional Training (INACAP).

As the final result for the project in Talca, the project was funded to develop its detail engineering and implementation.

## 2. Starting point

### 2.1. District heating in Chile

In Chile, the concepts of "District Heating" and "District Energy" are used interchangeably, the first of these being the most common since it is the one that has historically been projected as a solution to the problem of firewood in southern Chile, while that the second term is used in government documents so as not to neglect the option of using heating and cooling systems in cities that also have cold demands, such as Santiago, or cities in the north of Chile.

Currently in Chile there are some district energy projects, but they have major drawbacks that do not allow them to be a pilot that serves as an experience or example to replicate this type of initiative.

Table 1 Existing District Energy Projects in Chile.

Project name	Location	Thermal power [MW <sub>th</sub> ]	Fuel used	Connected buildings	Heated surface [m <sup>2</sup> ]	Distribution network length [m]	Start up year
Torres de San Borja	Santiago	3	Biomasa	1.512	115.000	7.600	1969 <sup>1</sup>
Cumbres del Cóndor	Santiago	0,8	Biomasa	58	14.500	500	2015
Departamentos de Hacienda	Colina, RM	N/D	Gas Ciudad	80	18.200	N/D	2015
San Sebastián	Temuco	2,32	Biomasa	224	20.000	4.800	2016
Frankfurt	Temuco	0,14 <sup>2</sup>	Electricidad	34	5.200	1.630	2008
Universidad de Concepción	Concepción	10,5	Biomasa	23	88.000	N/D	1961 <sup>3</sup>

In the case of the University of Concepción and the San Borja Towers, these are several decade old, large-scale projects with low-efficiency equipment, deficient control systems, poor thermal insulation of the distribution system, and problems in thermal energy monitoring that have led to an opinion that is not entirely favorable. The other existing district energy systems in Chile, although they have efficient and modern systems, with better monitoring and distribution, they are limited to private housing condominiums, so they are not representative of an urban network that would effectively allow to reduce the particulate matter concentrations for southern cities.

## 2.2. Universidad Austral de Chile

In the case of the Universidad Austral de Chile (UACH), it has independent heating systems for each building, all of which have a water distribution system. Among the different buildings, there are boilers that work with firewood, diesel boilers and wood-fired boilers adapted to work with diesel.

In its initial version, around 30,000 m<sup>2</sup> of buildings were considered to be users of the district heating. In its final version, the following surfaces and energy consumption were incorporated into the project:

Table 2 Area incorporated into the project and estimated thermal energy to supply

Parameter	Value	Unit
Area to supply	101.562	[m <sup>2</sup> ]
Heating required	6.677.600	[kWh]
Domestic Heat Water required	319.692	[kWh]
<b>Total energy demand</b>	<b>6.997.292</b>	<b>[kWh]</b>

<sup>1</sup> La central original terminó de ser construida el año 1969. La caldera que está operando actualmente entró en operación el año 2012.

<sup>2</sup> En el caso de la central térmica del condominio Frankfurt, se trata de una bomba de calor geotérmica, a la cual solo se tuvo acceso a la información sobre su potencia eléctrica.

<sup>3</sup> De acuerdo a «El Campus de la Universidad de Concepción – Su desarrollo Urbanístico y Arquitectónico», Jaime García Molina, Ediciones Universidad de Concepción.», los estudios para el desarrollo del proyecto comenzaron en 1961, pero no se encontraron antecedentes sobre su año de implementación.

Regarding the expenses that these consumptions represent for the University, it was possible to disaggregate them into those related to heating and those related to the consumption of sanitary hot water, as shown in the following table:

*Tabla 1 Initial operating costs for heating and ACS at the Austral University*

Parameter	Value [USD/yr]
Heating expenditure	376.230
DHW expenditure	17.410
<b>Total</b>	<b>393.141</b>

### 2.3. Talca

In the Valley area of the Maule Region, where Talca is located, high levels of fine particulate matter PM2.5 have been measured, exceeding the environmental standard. 83% of emissions come from wood heating. Its misuse has negative impacts on health and quality of life associated with atmospheric and intra-domiciliary pollution.

The project will incorporate buildings of various uses to be supplied by the district energy network, which are currently supplied in various ways:

*Table 3 Initial situation of the buildings users of the district energy system considered for Talca.*

Building name	Annual energy consumption [kWh/año]	Energy source
<b>Hospital de Talca</b>	2.541.612	LPG, electricity
<b>Escuela Esperanza</b>	63.262	LPG
<b>Gimnasio Regional</b>	28.426	LPG
<b>CESFAM Faustino Gonzalez</b>	42.210	LPG
<b>Total</b>	<b>2.675.510</b>	----

## 3. Objectives

### **General objective**

- Establish the necessary conditions that allow the implementation of a district heating pilot in Chile, so that it serves as a reference for its replication in other cities with high concentrations of particulate matter.

In a first instance, efforts were made to comply with the general objective through the development of a project at the Universidad Austral de Chile. Due to the resignation of the University's dean and a change in the University board of directors, it was not possible to comply with the milestones committed to in this case. Subsequently, a request was made to REPIC so that the consulting team could be able to continue with a second instance to comply with the objective through the implementation of a project in Talca.

The specific objectives of first and second instance are as follows:

First instance:

- Prepare the technical and economic pre-feasibility studies necessary to make the decision to implement the district heating project.
- Develop the basic engineering of the district heating pilot project using modern technological standards and best engineering practices.
- Establish what are the current legal and regulatory instruments for the implementation and operation of the pilot project.
- Implement a pilot project on the Isla Teja campus of the Austral University.
- Develop a manual for the implementation of district energy projects in Chile.

#### Second instance

- Prepare the technical and economic pre-feasibility studies necessary to make the decision to implement the district heating project.
- Develop terms of reference to bid the implementation of the district heating project in Talca.
- Obtain additional financing for the implementation of the district heating pilot project in Talca.

## 4. Project review

### 4.1. Project implementation

#### **Universidad Austral - First instance project**

The first milestone M1 («The district heating project for Talca is accepted to be entered in line 1 of technical support of the National District Energy Office».) was achieved obtaining the Austral University commitment to determine the buildings to be incorporated into the district energy network and also the transfer of available land for the location of the plant (see annex 8.1).

The milestone M2 («The district heating manual and the tender documents for the university are completed») required the development of a manual for the implementation of district energy projects, and the elaboration of terms of reference for the subsequent bidding for the implementation of the district Energy System at the Austral University.

#### ***District Energy Handbook***

The District Energy Handbook was developed together with various organizations relevant to the development of district energy projects:

- Ministry of Energy
- Ministry of Environment
- Ministry of Housing and Urban Development
- Energy Sustainability Agency (ASE) - former Chilean Energy Efficiency Agency
- Deutsche Gesellschaft für Internationale Zusammenarbeit GIZ

GIZ was the only non-governmental organization and was involved in the development of the manual, mainly contributing ideas and content in the topics associated with Combined Heat and Power (CHP) technologies.



Once the content of the manual was finished, it was published on the websites of the aforementioned institutions. The manual was very well received in the public sector, and has been used in various tenders and projects, among which the following can be mentioned:

- Detailed engineering project for the construction of macro-infrastructure in the Agricultural School of Coyhaique.
- Methodological Guide for Thermal Districts in Colombia
- Development of a strategy for the penetration of sustainable thermal technologies in Chile.
- Development of pre-feasibility studies for district energy project in Temuco.
- Development of pre-feasibility studies for district energy project in Pto. Williams and Coyhaique.

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Figure 3 Example of the District Energy Manual being used as a reference in the study "District Heating Project Evaluation for the Cities of Coyhaique and Puerto Williams".

It is important to note that the district energy manual had two stages of validation: in the first stage, an invitation was made to different relevant actors, and they were distributed in discussion tables. The actors were separated into the following groups: energy distributors, consultants and developers, and the public sector. A total of 20 people attended, and in a 90-minute session the various topics that could be improved or added to the manual were discussed.

The second instance of validation of the district energy manual was through a web consultation, which was published in the Ministry of Energy (<https://www.energia.gob.cl/mini-sitio/consultas-publicas>). In this instance, approximately 10 observations were received from various institutions, which were incorporated into the manual.

With the collaboration of the Ministry of Energy, around 150 copies of the district energy manual were printed and distributed to various public institutions, including municipalities, regional headquarters of the ministries of energy and environment, technical teams from the ministries at the central level and to private actors.

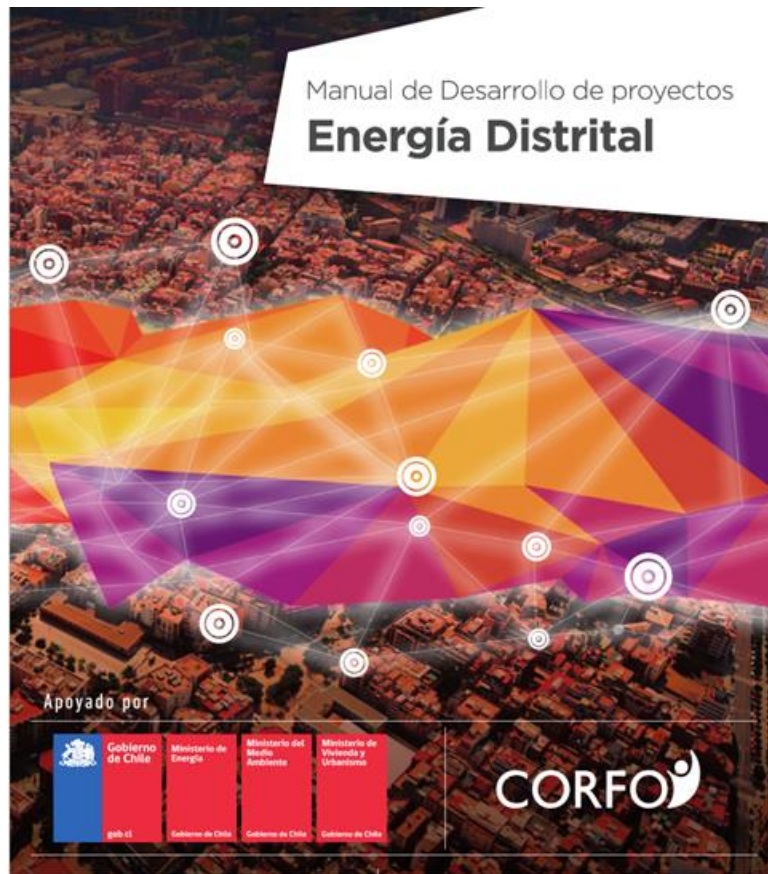


Figure 4 District Energy Manual Cover Page.

To promote this manual, an international seminar was planned in which the Minister of Energy of the incoming government, Susana Jimenez Schuster, would participate, so that she could introduce the subject of district energy in her agenda.



Figure 5 Launch of the district energy manual. From left to right: Edgar Dörig, Swiss Ambassador to Chile; Susana Jimenez, Minister of Energy; Nicola Borregaard, General Manager of EBP Chile SpA; Rainier Schröer, Director of GIZ in Chile.

The seminar was also attended by Swiss expert Bernhard Eggen, who spoke about district energy in Switzerland and how the use of manuals to standardize planning procedures is essential.



*Figure 6 Bernhard Eggen, from Belmont Energie Raum GmbH, speaking on the international seminar on district energy.*

Attendance at the seminar to launch the district energy manual was in the order of 300 people, and included the public sector, private sector and academia.



*Figure 7 Attendance at the launch of the district energy manual.*

### **Terms of reference for the district heating project at Austral University**

The development of the terms of reference for this milestone began with the evaluation of the pre-feasibility of the project. An important step for this was the identification, together with the University counterparts, of which buildings would be supplied with sanitary hot water and heating. Additionally, a site was identified for the location of the thermal power plant, and information was gathered on current fuel consumption.

The University considered that a suitable option for the implementation of the project would be to work under an ESCO model of energy services. EBP Chile contacted several national suppliers to find out if this business model made sense to them and if they were interested in participating in a bidding process launched by the University. The companies Engie, Energías del Sur, W Energie, Veolia, KPA Unicon, Nueva Energía Chile, LSolé (now Vyncke) were consulted, and an investment family with strong ties to Valdivia and Switzerland was also consulted. The results of this simple round of informal expression of interest were virtually unanimous and all but one indicated that the business made sense to them.

The terms of reference contain all the conditions that the contractor should meet for an energy sales model. There are technical criteria such as the water temperatures to be delivered to the different buildings, the delivery pressure, the availability of the system, the measurement methods, the accuracy and frequency of the measurements, etc. The terms of reference also include contractual conditions, such as the operator's obligation to indicate the formula for updating energy prices, maximum amounts, energy prices, etc.

### **Talca – Second Instance Project**

#### ***Technical, regulatory and financial support program for the implementation of district energy projects in Chile.***

Chile is currently developing various initiatives for the development of district heating. Among other, different aspects associated with the distribution of thermal energy, the legal aspects for the use of the subsoil, the location of thermal power plants, etc. are being simplified.

An important milestone in this series of initiatives has been made by the National Agency on Energy Sustainability (Agencia Nacional de Sostenibilidad), through the award of GEF resources for the project "Technical, regulatory and financial support program for the implementation of district energy projects in Chile" which, among other things, has granted financing for the creation of the National District Energy Office (ONED), whose objective is to provide technical and financial support to this type of project in Chile.

The support provided by the ONED is carried out through two "support lines", defined as follows:

- Line 1 of technical support: In order to apply for technical support, project promoters must have a minimum starting technical development. Once the project has been declared as a beneficiary of this line of support, ONED fulfills the role of technical and regulatory counterpart of the project, without getting involved in its development. The ONED establishes that in order to continue the work on line 1, it is necessary for the beneficiary to have a technical team (internal or external) with the capacity to carry out the engineering and technical evaluation of the project, a role that EBP Chile fulfilled. The technical assistance of the ONED corresponds to a guide, orientation or review of the aspects that must be considered so that the promoters of the project develop it correctly.
- Line 2 of project execution: Once a beneficiary of line 1 has prepared the feasibility engineering of the project, as well as its economic evaluation and regulatory analysis, they may apply for line 2 of project execution, which considers financing for the development of basic engineering, detailed engineering and execution of the project.

As can be deduced from the definitions of the support lines, the institutions that apply require external support or financing to be able to apply for line 1 and move towards line 2 of financing. This external financing is a barrier for municipalities and other public entities to enter the program. This is why the technical support provided by EBP to the city of Talca is relevant, and has been recognized by ONED itself, who initially told EBP that they would like to receive support to include a municipality.

#### ***Adjusted project progress***

##### **Milestone M1**



The first milestone («The district heating project for Talca is accepted to be entered in line 1 of technical support of the National District Energy Office»), was successfully completed.

To achieve compliance with this milestone, the following points were completed:

- Coordination of stakeholders: A work group was created for the development of the project, in which different relevant actors participate, such as the Regional Secretariats of the Ministries of Energy, Environment and Housing, the Municipality of Talca, the regional headquarters of the Corporation of Promotion of Production, the local headquarters of the National Training Institute (INACAP), the Regional Hospital of Talca and the Energy Sustainability Agency.

Within the work group, three work teams were defined to facilitate the assignment of tasks and responsibilities. The work teams correspond to the Technical Aspects group, the Stakeholder Involvement group and the Financing Search group.



Figure 8 Logo created for the District Energy Board, to be used in promotion or communication.

- Definition / layout of the system: In conjunction with the actors of the district energy table, various sectors were evaluated where the development of the district energy project would be feasible, incorporating variables such as demand density, urban growth, existence of anchor clients and existence of public sector buildings.



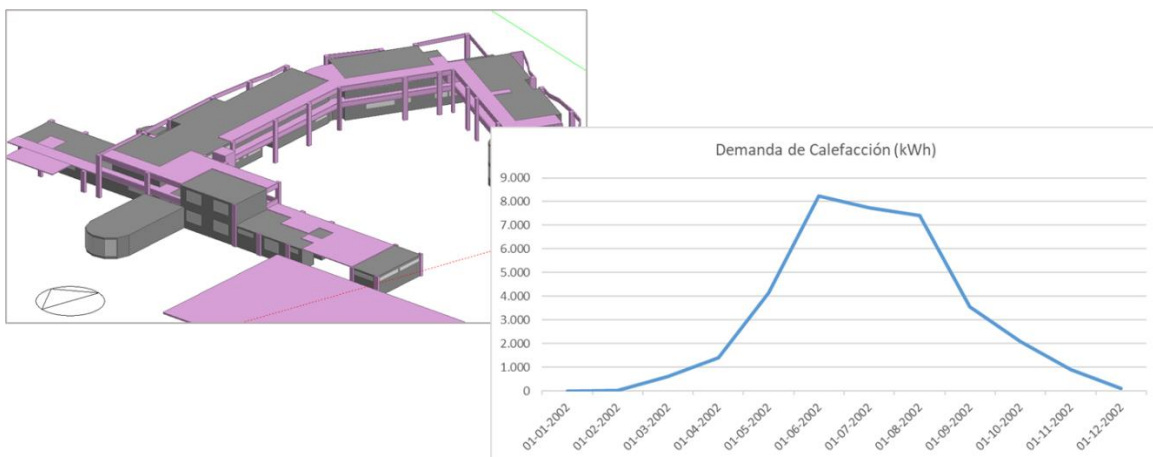
Figure 9 Scope of the district heating project in the Faustino Gonzalez sector of Talca.

The area selected for the development of the project has several public buildings that can be considered as users in the first stage, in addition to an industrial area very close to it that was evaluated to incorporate it as a supplier of residual heat and as a user, although without success. Another favorable point for the selection of the development area is the existence of a project of approximately 2,000 homes developed by the Ministry of Housing and Urbanism, which verbally promised to carry out all the pertinent steps so that this development incorporates the district network from his design.



Figure 10 Proposal for the urban housing project "Barrio Cornelio Baeza", to be developed by the Ministry of Housing and Urban Development.

- Definition of demand from anchor users: Information was collected on the demands for heating and sanitary hot water for the different buildings considered as users of the project. Based on these demands and defining potential use profiles for each building, an hourly demand curve was determined for all the buildings.



- **Definition of residential user demands:** In addition to the existing buildings, estimates were made of the demand for heating and domestic hot water expected for the housing project to be developed by MINVU and for 50 nearby houses.

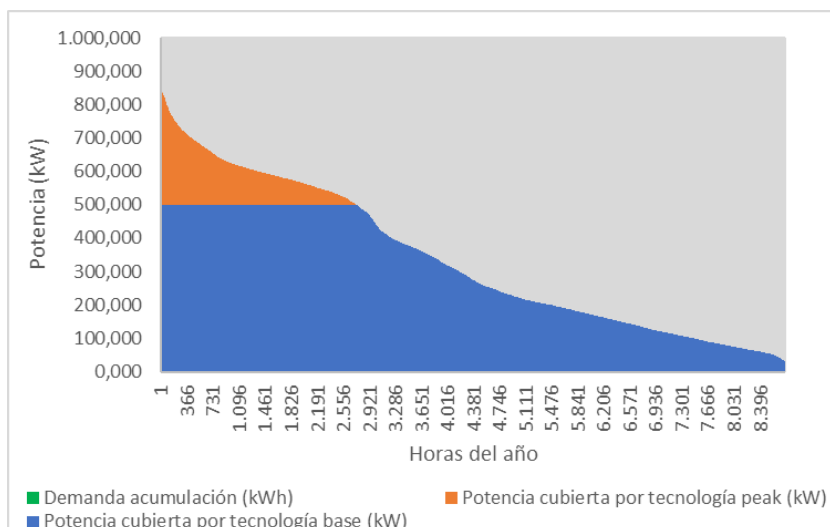


Figure 11 Hourly demand curve obtained for the district heating project in Talca.

- **Definition of the location of the plant:** Negotiations were made with the Municipality and with the Regional Hospital of Talca to define a possible location for the plant. As a result, the Municipality committed to the delivery of land for the location of the plant in the vicinity of the buildings that use the system.

## Milestone M2

To achieve milestone M2 («The technical support for the project is completed, so that it can apply for line 2 of financial support from the National District Energy Office»), the following activities were carried out:

- **Entry of the project to phase 1 of technical support from ONED:** The development made during milestone M1 to enter the project to phase 1 was presented.
- **Energy availability study:** A brief study was carried out on the energy availability to supply the thermal power station of the district heating system. This study was mainly focused on biomass, since it is a local, low-cost energy source that, under the right conditions, can be neutral in greenhouse gas emissions, and have particulate matter emissions well below the requirements of the air decontamination plan.
- **Definition of potential technologies to be used in the thermal power plant:** Four different technological alternatives for the boilers of the thermal power plant of the district network were technically and economically evaluated. Cogeneration and biomass options were evaluated.
- **Definition of the business model:** Together with ASE, different business models were evaluated, which are limited by the administration models that are possible according to national regulations. A first business model evaluated was a concession managed by the Ministry of Public Works, but it was determined that it is only justified in larger projects. A municipal concession business model was also evaluated, which was discarded due to the lack of technical and economic capacities of the municipality. Finally, the selected option was a shared

urban financing, where the municipality assigns an asset to be used by the project developer or operator, so that the project can reduce its capital expenditure and have a positive financial evaluation.

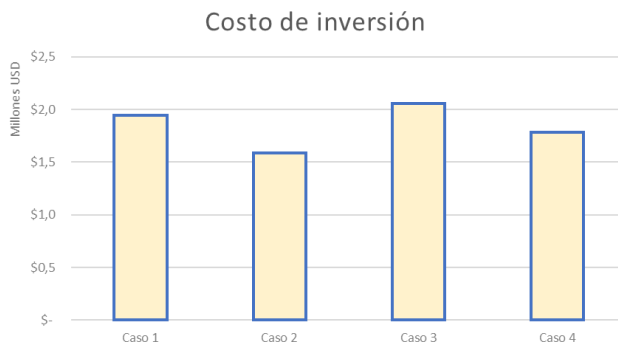


Figure 12 Estimated capital costs for the 4 cases evaluated in the district energy project

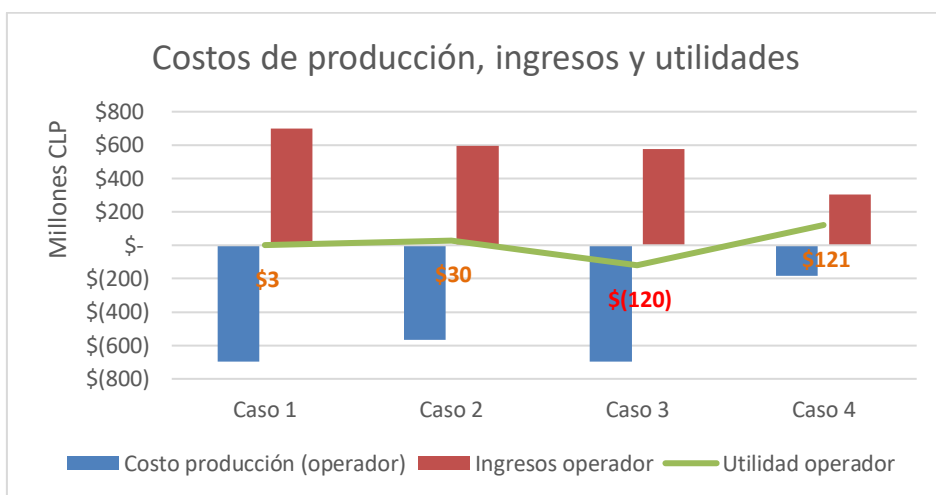


Figure 13 Costos de producción de energía para el operador, ingresos y utilidades.

- Proposal for growth stages: It was determined that in its first stage the district energy system would only connect the four indicated buildings (school, hospital, CESFAM, and the regional gym) and 50 homes, while in a second stage would connect the new residential complex of 2,000 homes developed by MINVU.

**Milestone M3**

In order to comply with the M3 milestone («The project successfully enters line 2 and the terms of reference are developed to be used in the bidding»), the project was successfully accepted into ONED line 2, which consists of the development of detailed engineering of the project presented, and the financing of the execution of the project. The financing committed by ONED is an investment subsidy and is of such an amount that it allows the project to be financially sustainable from the point of view of



the investor or operator of the system. The financial sustainability of the project considered to determine the amount of the subsidy is evaluated according to typical parameters of private evaluation of projects<sup>4</sup>.

The project presented by EBP requested 630MM CLP, equivalent to USD 736,500 at the time of writing this report. The total amount that the project will obtain as a subsidy will depend on the result of the detailed engineering that will be carried out in the second semester of 2023.

As a reference, a total of 26 district energy projects applied to line 1 of technical support of the ONED, of which 16 obtained this technical support. For ONED's line 2 of financing, the Talca project has been the only one that obtained this co-financing.

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<sup>4</sup> In Chile, there is a project evaluation methodology for projects carried out by the public sector that values, in addition to cash flows, decreases in negative externalities; Additionally, a discount rate of 6% is used, a lower value than what a project developed by private actors could typically use.

## 4.2. Achievement of objectives and results

The table below provides an overview of the main goals of the project and the degree of goal achievement:

Main Goals of the project (1st instance project)	Goal achievement
M1: The option for the heat network is selected and the university formally takes the decision in the district heating project	High
M2: The district heating manual and the tender documents for the university are completed	Very high
M3: The district heating tender has been carried out, the contracting company has been selected and the contract has been signed.	Not implemented
M4: The heating system is in operation; REPIC final report and financial report are fully redacted.	Not implemented

Main Goals of the project (2nd instance project)	Goal achievement
M1: The district heating project for Talca is accepted to be entered in line 1 of technical support of the National District Energy Office.	Very high
M2: The technical support for the project is completed, so that it can apply for line 2 of financial support from the National District Energy Office	Very high
M3: The project successfully enters line 2 and the terms of reference are developed to be used in the bidding	High

### 4.3. Preparation of multiplication and replication

For the first stage of the project, replication and multiplication can be evaluated for the two main products developed:

- *District Energy Manual*: It is considered that the manual has fulfilled its mission very successfully. It has been used on various occasions as a bibliographical reference for the preparation of studies, reports and tenders. The EBP team has also released the manual in Colombia, where the Ministry of Environment and Sustainable Development carried out a similar initiative ([https://www.districtoenergetico.com/wp-content/uploads/2020/11/Guía-metodológica-VF\\_2020-2.pdf](https://www.districtoenergetico.com/wp-content/uploads/2020/11/Guía-metodológica-VF_2020-2.pdf)) and where the Manual developed by EBP Chile appears within the bibliographical references
- *District energy project at the Austral University*: In the case of the Austral University project, various dissemination instances were carried out for the project (<https://diario.uach.cl/empresas-suizas-estudian-prefactibilidad-para-implementar-calefacción-distrital-con-un-modelo-nico-en-chile/>), meetings were established with the Ministry of Energy to commit their support in the implementation of the project and various suppliers were contacted who had the technical and financial capacity to finance, execute and operate the project. Despite this, the main objective at the University, which was the implementation of the pilot project, was not achieved, and that this pilot served as an experience of a modern district energy system, with a reasonable business model and high availability standards, so that other university campuses or cities will take it as an example for its replication.
- *District energy project for Talca*: As seen in the case of the Austral University, for the definitive implementation of a project the coordination of many relevant actors is required, all committed to making the appropriate efforts to make this happen. The implementation of the district energy table has been a success in terms of multiplication and replication, since the initiative has been imitated by other cities such as Temuco and Coyhaique. It is expected that the final implementation of the project will be an important element for the replication of this type of project, since it will demonstrate that it is possible to start with a small/medium-scale project and that it can then be expanded through the incorporation of users. futures.

### 4.4. Impact and sustainability

The main impact sought by both projects (Universidad Austral / Talca) is the reduction of particulate material emissions for the generation of thermal energy for heating and sanitary hot water. This decrease in emissions has, in turn, effects on the decrease in the average concentrations of this pollutant in the air. The high concentrations of particulate matter in the atmosphere have systematically shown to have very negative effects on people's health, so it is estimated that in order to achieve a radical change in air quality in southern cities, solutions must be implemented to on a large scale, such as district heating at the city level, but to achieve this, it is necessary to start with a pilot project, on a much smaller scale, and then look for its replication and/or expansion.

Regarding the expected avoided emissions for the project developed for the Austral University, its implementation is expected to mean a decrease of 70.000[kgMP2.5/yr] and 1860 [t CO<sub>2</sub>-eq]/year. This reduction will also mean savings in the university's operating costs, since according to the information collected, the thermal energy generated through biomass can have a much lower value than that obtained with diesel or firewood.

In the case of the Talca project, the reduction in particulate matter emissions in its first stage is low, mainly because the use of liquefied gas is being reduced. However, for its second stage it is expected that the implementation of the district energy system generates a decrease of 7,9 [ton MP2.5/year].

The following table shows some indicators of the project. We will only account emissions from Talca project, as we expect that the Universidad Austral project won't be implemented in the short or medium term.

<b>Ecological</b>	<b>Unit</b>	<b>At the REPIC Project's Completion</b>
Installed renewable energy capacity	[kW]	850
Renewable energy produced	[kWh]/year	3.818.000
Amount of fossil fuel energy saved	[kWh]/year	2.612.248
Greenhouse gas reduction	[t CO <sub>2</sub> -eq]/year	699
Newly collected and separated waste	[t]	N/A
Newly recycled waste	[t]	N/A
<b>Economic</b>		
Energy costs (LCOE)	[ct/kWh]	12
Triggered third-party funding/investments	[CHF]	700.000
Local private income generated	[CHF]	1.181.422
<b>Social</b>		
Number of beneficiaries	[Number]	N/A
Number of new jobs	[Number]	N/A
Number of trained personnel	[Number]	N/A

## 5. Outlook / Further Actions

### 5.1. Multiplication and replication

*District energy manual:* The use of the district energy manual is already being applied for various bidding processes.

*District heating project Universidad Austral and Talca*: The developments carried out within the project have served as a reference for the development of other projects, some of which are in the bidding process, and others in the design process.

*Investment subsidy*: It is expected that the social evaluation of district heating projects may allow public sector investment in the investment stages of the project, thus allowing replication of district energy projects that can also supply homes.

## **5.2. Expected impact and sustainability**

It is expected to incorporate at least the Faustino Gonzalez neighborhood to the district energy system demands, with which the thermal power plant could supply an additional 1,040,000 [kWh/yr]. No CO<sub>2</sub> reduction is estimated for this scenario, since typically homes use biomass as the default fuel for heating, and biomass is carbon neutral in a regulated market such as the existing one in Talca.

On the other hand, the incorporation of homes as users of the district heating system will mean a significant reduction in the emission of particulate matter. To estimate the reduction of emissions of this pollutant, the average emission level of the wood-burning stoves in Chile is considered, which corresponds to 1.98 [g/hr], and a total of 2,000 equivalent hours of use of the 2,000 homes is considered. With these data, the estimate of avoided emissions corresponds to 7.9 [ton MP<sub>2.5</sub>/year].

## **6. Lessons Learned and Conclusions**

### **6.1. Lessons Learned**

The main lesson learned is that the development and implementation of a district energy project is a long-term process, requiring the full commitment of all stakeholders. Failure to take this into consideration may cause a hindrance or delay of the project.

There is great interest at the national and Latin American level for the development of district energy solutions, but there are still several financial and regulatory barriers.

There is an important interest of private actors to invest in this type of developments, which also have the capabilities to operate and manage this type of services.

There is an important institutional framework that can be exploited to finance larger projects, which was identified during the development of the District Energy Manual. This institutional framework corresponds in particular to the concession system of the Ministry of Public Works. There are currently two large-scale projects entered into this system.

In the case of Chile, the development of district energy projects can be facilitated if the negative externalities avoided by the development of the project are quantified and valued. This requires the involvement of the public sector, which is obliged to evaluate projects from a social perspective, incorporating the valuation of avoided externalities into the cash flow of the economic evaluation.

### **6.2. Conclusions**

The development of a district energy project is a long-term process. The processes of coordinating stakeholders, seeking financing and defining users can take up to several years.

Although the Universidad Austral project could not be taken into completion, significant progress was made in the development of the project and it is expected that this progress can be taken up by the University itself for implementation at a later date.

The Talca project was put on track for execution by obtaining financing for the development of detailed engineering and its implementation. It is expected that this will be the first district energy project at the city level, with current technologies for the generation and distribution of thermal energy.

The development of the district energy manual was a great contribution to spotlight the various legal, financial and other barriers that exist at the national level for the development of these projects. The Ministry of Energy is currently implementing various measures to mitigate these barriers, for example: Modification of the General Law of Urbanism and Construction in order to facilitate the location of thermal power plants on land with residential land use; the creation of a district energy law that allows investors to have adequate regulatory support when implementing these types of projects; the Shared Urban Financing model has been reused as an appropriate business model; international financing has been successfully applied for the implementation of these projects, etc.

## 7. References

Chile District energy manual - <https://www.agenciase.org/energia-distrital/>

Colobia thermal district guide [https://www.distritoenergetico.com/wp-content/uploads/2020/11/Gui%C3%ACa-metodolo%C3%ACgica-VF\\_2020.pdf](https://www.distritoenergetico.com/wp-content/uploads/2020/11/Gui%C3%ACa-metodolo%C3%ACgica-VF_2020.pdf)

Project evaluation methodology ministry of social development <https://sni.gob.cl>

## 8. Annexes

### 8.1. Universidad Austral

Attached as separate documents:

- - Commitment letter from Universidad Austral de Chile
- - Pre-feasibility report
- - Terms of reference

### 8.2. Talca

Attached as separate documents:

- - Approval Report for entry to funding line
- - Terms of Reference for Basic Engineering Development