THESIS WORK

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GEOTHERMAL ENERGY IN SANTIAGO DEL ESTERO, ARGENTINA: A FEASIBILITY STUDY OF POWER GENERATION FROM MEDIUM ENTHALPY THERMAL SOURCES

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Declaration of Authorship

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Buenos Aires, 13th of August 2018

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Abstract

The Organic Rankine Cycle technology is a reliable way to convert heat into electricity, especially when free heat is available in form of renewable energy (biomass, geothermal, solar) or as exhaust heat from industries. In the present study the attention has been paid on the application of an ORC unit for the production of electric energy in Termas de Río Hondo, north-west Argentina, making use of an existing medium-temperature geothermal source. Earlier explorations of this area have assured a hot source of about 80-90°C at 900 m of depth, thanks to a fractured saturated sedimentary basin of more than 6000 m of depth. Commercial and economic evaluations have been carried out to analyse the ORC units that are available in the market that can work with such low temperature. Three companies have been selected as potential providers of a unit to be installed in Termas de Río Hondo. The potential energy production from these units is calculated and various economic scenarios are evaluated to function as a reference to potential strategic decisions. The units' gross power output ranges from 30 to 300 kWe, with a required hot water flow rate between 10 and 57 l/s, and a cold water flow rate between 15 and 155 l/s. The economic analysis is based on the calculation of their payback period, sale price of produced energy and Internal Rate of Return. In general, it is found that larger units are more profitable, in the face of their higher initial cost.

Resumen

La tecnología de los Ciclos Orgánicos Rankine es una manera confiable de convertir el calor en electricidad, especialmente cuando hay calor disponible en forma de energía renovable (biomasa, geotérmica, solar) o en forma de escape de aplicaciones industriales. En el presente estudio, se ha prestado atención a la aplicación de una unidad ORC para la producción de energía eléctrica en Termas de Río Hondo, noroeste de Argentina, utilizando una fuente geotérmica existente de temperatura media. Las exploraciones anteriores de esta área han asegurado una fuente caliente de aproximadamente 80-90°C a 900 m de profundidad, gracias a una cuenca sedimentaria saturada y fracturada de más de 6000 m de profundidad. Se han llevado a cabo evaluaciones comerciales y económicas para analizar las unidades de ORC que están disponibles en el mercado y que pueden funcionar con temperaturas tan bajas. Tres empresas han sido seleccionadas como posibles proveedores de una unidad para instalar en Termas de Río Hondo. Se ha calculado la producción potencial de energía de estas unidades y se ha evaluado diversos escenarios económicos para que funcionen como una referencia para eventuales decisiones estratégicas. La potencia bruta de las unidades varía entre 30 y 300 kWe, con un caudal de agua caliente requerido entre 10 y 57 l/s, y un caudal de agua fría entre 15 y 155 l/s. El análisis económico se basa en el cálculo de su período de amortización, en el precio de venta de la energía producida y en la Tasa Interna de Retorno. En general, se encuentra que las unidades más grandes son más rentables, a pesar de su mayor costo inicial.

Summary

The present study focuses on the use of medium-temperature geothermal sources, available in Río Hondo, Province of Santiago del Estero, north-west Argentina, to operate an Organic Rankine Cycle (ORC) plant to provide energy for residential uses. In the period 1920-1950, the Argentine Geological Survey (SEGEMAR) investigated the area by boring exploration wells up to 910 m deep. At this depth they obtained outflow water at 80°C with a flow rate of about 27 l/s. Later geothermal explorations allowed the estimation of a fractured saturated sedimentary basin, at a depth of more than 6000 m, which most probably hosts an important hydrothermal reservoir of which just a surface outcropping spot is known. Since the source temperature strongly varies with the extraction depth, three scenarios have been studied, for sources at respectively 75, 85 and 95°C. The necessary water for the ORC cooling system is also available at the place of interest.

ORC systems designed on a tailor-made basis are optimal but of high cost. Therefore, a commercial investigation was carried out to look for commercially available standard ORC units around the world. Three companies have been selected as possible providers: ElectraTherm from the USA, Enogia from France and Zuccato from Italy. Other companies have not shown interest in this project or have chosen different strategies. ElectraTherm is the only company with products suitable to exploit sources at 77°C or more, while Enogia and Zuccato require a minimum of 85°C and 95°C, respectively. The products and prices of these companies and all other associated costs were considered to calculate the ORC plant economic feasibility.

Four scenarios have been assumed: energy self-consumption, participation in the RenovAr program, participation in the "Renewable Energies Private Market" MATER program and a fixed payback period (Chapter 4.2). The profitability of ORC units ranging between 300 and 30 kW gross power production, depends on the scenario taken into consideration. In general, the RenovAr program provides the highest income from the energy sold, but it strongly depends on the strategic decision of what profit to apply to the LCOE (Levelized Cost Of Energy) when participating in the MATER. Self-consumption is generally the least appealing scenario, given by the low cost of the electricity that is paid to the energy provider.

Aims and objective

The integration of available energy resources and energy conversion methods favours the development of research activities in various fields. Geothermal sources are found in Las Termas de Río Hondo, one of the most visited balneotherapy destinations of Argentina. Some hot springs with temperatures over 30°C have made the town a popular spa resort for argentines. It is estimated that water at 75 - 95°C can be accessed through the realisation of wells. The town, with 44000 inhabitants, is located on the banks of the river Dulce, near an artificial lake called Río Hondo, which could provide abundant cold water for the refrigeration system of any ORC plant. The ORC is a binary cycle, with a primary circuit for the working fluid operating a turbine and a secondary circuit for the geothermal water as heat source. There are several possible working fluids, but just a few are suitable to work at low temperatures and are environmental friendly as required by recent legislative actions around the world.

With this in mind, the objective of this Thesis work is to analyse the technical and economic feasibility of installing an ORC plant in Las Termas del Rio Hondo, with geothermal water at 75-95°C as hot source and the river or lake water at 15-25°C as cold source. In each case, the analysis includes the calculus of the required flow-rates from the heat and the cold sources. Different commercially available plants are studied, by carrying out a technical analysis and a commercial/economic evaluation. The technical analysis considers ORC systems offered in the market, way of functioning, advantages and disadvantages. It is worth to mark that ORC plants tailored-made depend on many local conditions, therefore it would be unrealistic to say that there are two exactly equal projects around the world. Companies provide some standard installations that are then customized according to the needs of clients and site. Because of the significant price difference between fully tailored and standard projects, this study only consider standard solutions.

Three scenarios are analysed for hot sources at 75, 85 or 95°C with the same cold source. Each scenario evaluates possible options and how the heat can be exploited optimally. Some technical issues are also discussed to highlight that, although the energy production does not cover large part of the local demand, it is constant and continuous, in opposition to solar and wind plants. In many situations, the entry of a low-power constant energy in the electric grid is much more favourable than a high-power intermittent energy. The present study should enable the Government of the Province of Santiago del Estero to take strategic decisions.

1 Introduction

1.1 Concepts of geothermal energy

Geothermal energy is the energy contained as heat inside the Earth's interior. The origin of this heat is linked with the internal structure of our planet and its physic-chemical processes. Mainly, this heat derives from the continuous decay of radionuclides, chiefly isotopes of uranium (238U and 235U), potassium (40K) and thorium (232Th) (Banks, 2012).

Nowadays it is known that, despite the fact that this heat is present in huge, practically inexhaustible quantities in the Earth's crust, not to mention the deeper parts of our planet, this heat is unevenly distributed, seldom concentrated, and often at depths too great to be exploited industrially.

There are, however, areas of the Earth's crust which are accessible by drilling, and where the gradient is well above the average. This occurs when, not far from the surface (a few kilometres) there are magma bodies undergoing cooling, still in a fluid state or in the process of solidification, and releasing heat. In other areas, where magmatic activity does not exist, the heat accumulation is due to particular geological conditions of the crust such that the geothermal gradient reaches anomalously high values.

The extraction and utilisation of this large quantity of heat requires a carrier to transfer the heat toward accessible depths beneath the Earth's surface. Generally the heat is transferred from depth to sub-surface regions firstly by *conduction* and then by *convection*, with geothermal fluids acting as the carrier in this case. These fluids are essentially *rainwater* that has penetrated into the Earth's crust from the *recharge* areas, has been heated on contact with the hot rocks, and has accumulated in aquifers, occasionally at high pressures and temperatures (up to above 300°C). These aquifers (reservoirs) are the essential parts of most *geothermal fields*.

In most cases, the reservoir is covered with impermeable rocks that prevent the hot fluids from easily reaching the surface and keep them under pressure. We can obtain industrial production of superheated steam or steam mixed with water, or hot water only, depending on the hydrogeological situation and the temperature of the rocks present (Figure 1).

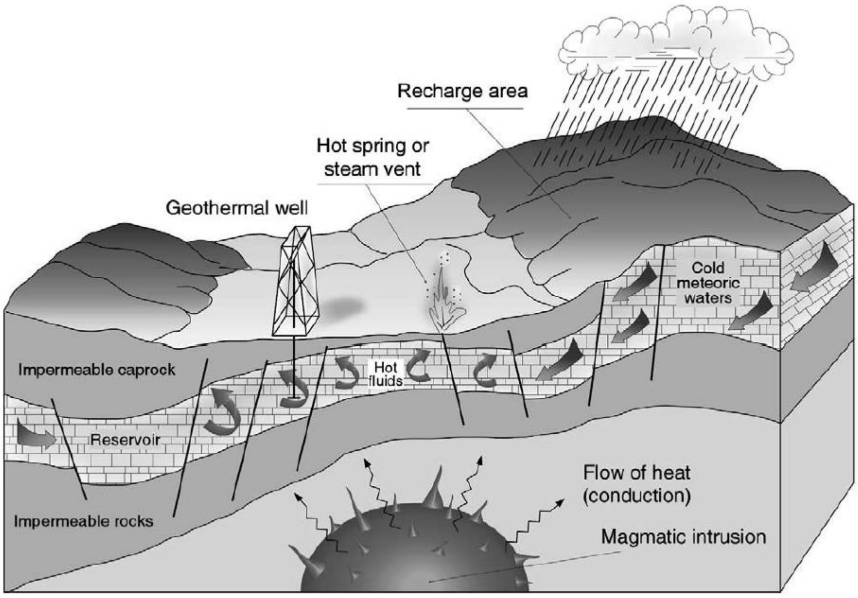


Figure 1: A geothermal steamfield with its elements: recharge area, impermeable cover, reservoir and heat source (Barbier, 2002).

Wells are drilled into the reservoir to extract the hot fluids, and their use depends on the temperature and pressure of the fluids: generation of electricity (the most important of the so-called high-temperature uses), or for space heating and industrial processes (low-temperature uses).

Geothermal fields, as opposed to hydrocarbon fields, are generally systems with a continuous circulation of heat and fluid, where fluid enters the reservoir from the recharge zones and leaves through discharge areas (hot springs, wells). During industrial exploitation fluids are recharged to the reservoir by reinjecting through wells the waste fluids from the utilisation plants. This reinjection process may compensate for at least part of the fluid extracted by production, and will to a certain limit prolong the commercial lifetime of the field. Geothermal energy is therefore to some extent a renewable energy source, even though hot fluid production rates tend to be larger than recharge rates (Barbier, 2002).

1.2 Medium-enthalpy geothermal energy and "binary" systems

Geothermal energy systems can be classified into low, medium (or intermediate) and high enthalpy systems (Figure 2). The term "enthalpy" is closely related to the temperature of the system, and subsequently to its way of application: in general, low-enthalpy systems are exploited for direct-uses related to heat and thermal energy production, whereas medium and high-enthalpy systems are exploited for electric energy production.

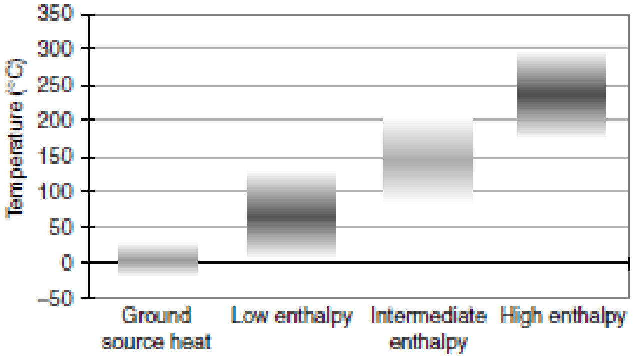


Figure 2: Classification of geothermal systems according to temperature (Banks, 2012)

High enthalpy systems are those that started first to use geothermal energy. This type of development was conventional during the early years of geothermal development and is heavily biased towards electricity production. The plant output was decided on the basis of an estimated reservoir volume, average formation temperature, and porosity. Examples are Lardarello, Wairakei, The Geysers, Tiwi, Cerro Prieto, Ahuachapan, Hatchubaru, and Olkaria. These are found generally on high-temperature areas, located within active volcanic zones or marginal to them. The water or vapour temperature is above 180°C (Elíasson, 2001).

However, electricity can be produced also when the temperature of the source is lower than high enthalpy levels, even lower than 100°C. This is the case where the enthalpy is called *medium* (or intermediate) and a different kind of technology from typical flash steam cycles must be utilized. Binary power plants are the best energy conversion systems to exploit the medium range (80-180°C), both from a technical and environmental point of view (Franco and Villani, 2009). There are many different technical variations of binary plants including those known as Organic Rankine cycles (ORC) and proprietary systems known as Kalina cycles. In binary cycles, since the available temperature difference is less, the cycle efficiency (i.e., approximately 5–9%) is much lower than that of thermal power generation using medium temperature geothermal resources (i.e., approximately 10–15%) (Liu et al., 2002).

Binary plants follow the same principles than the traditional steam Rankine cycle uses in most thermal power plants to produce electricity, with heat from the source being transferred to an organic fluid instead of water. The organic fluid has a low boiling point and high vapor pressure when compared to water at a given temperature. Such a geothermal plant has no emissions to the atmosphere except for water vapor from the cooling towers (only in case of dry cooling) and loss of working fluid. An advantage of the binary technology is that the geothermal fluids (or brines) do not contact the moving mechanical components of the plant (e.g. the turbine), assuring a longer life for the equipment. The geothermal water and the working fluid are each confined in separate circulating systems and never come in contact with each other (Gabbrielli, 2012, and Hettiarachchi et al., 2007).

Figure 3 shows the thermodynamic cycle and the main components making up an ORC plant. The working fluid is first pre-heated (2-7) and evaporated (3-4) using the heat exchanged with the thermal source, then expanded into a turbine (4-5) directly coupled to the electric generator and finally brought back to the liquid state in a condenser (8-1) cooled by water or air. The thermodynamic cycle is finally closed by returning the condensed fluid to the evaporation pressure through the feed pump (1-2). In the case of particular working fluids, a recuperator (a pre-heating heat exchanger) is added downstream of the turbine, which further improves the performance of the cycle (5-8, 2-7) (see Chapter 1.3) (Vescovo, 2010).

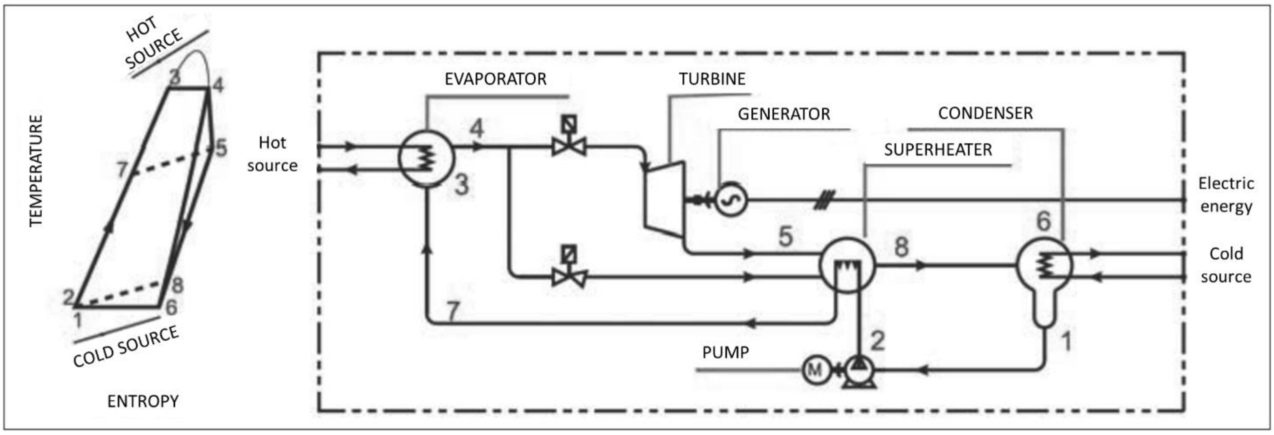


Figure 3: Thermodynamic cycle and main components of an ORC module (modified from Vescovo, 2010)

The recuperator is a component that is actually important in high temperature applications and in those cases characterized by a high minimum temperature of the heat source. Usually, for high temperature sources, complex working fluids are used involving small temperature drops along the expansion and a large thermal power available at turbine discharge (Macchi and Astolfi, 2016).

Two major and largely interrelated components of the cycle are the working fluid and the turbine. Both components need careful consideration in order to optimize the amount of power that can be extracted from a specific resource (Sauret and Rowlands, 2011). The other most relevant factor is the temperature and flow-rate of the geothermal fluid, as it rapidly gives an idea of how much power can be produced with the ORC plant. The generating capacity can be scaled up depending on the flow rate and fluid temperature. For example, as shown in Figure 4, wells with fluid temperature between 90 and 150°C, and with fluid flow rate between 2 and 25l/s can generate electric power anywhere between 50 kWe and 1000 kWe (Chandrasekharam and Bundschuh, 2008).

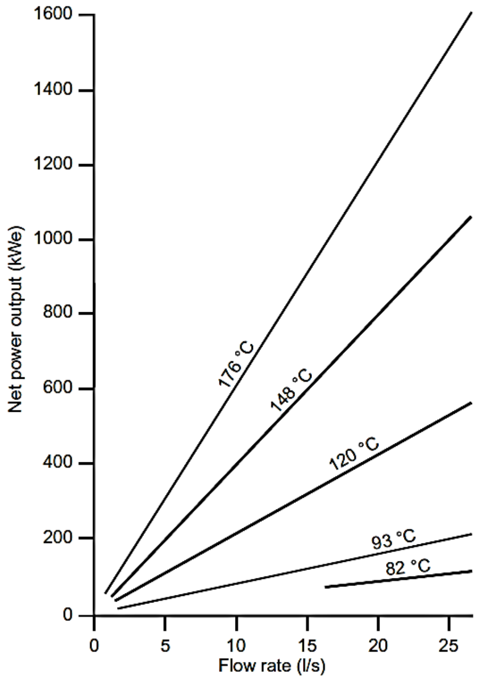


Figure 4: Net power output for medium-enthalpy geothermal fluids with different flow rates. Medium-enthalpy systems with high flow rates can generate >100 kWe. Clusters of several wells with this flow rate are best suited for rural areas (Chandrasekharam and Bundschuh, 2008).

1.3 Analysis of working fluids in ORC power plants and choice of fluid

1.3.1 Thermodynamic considerations

In ORC plants, the wide range of available working fluids and cycle configurations causes a non-univocal selection of fluid and cycle parameters for the exploitation of a given heat source: dedicated optimization analyses are required for each specific application. In addition, the increasing restrictions in the use of fluids with high environmental impact make it important to investigate the performance of new environmental friendly and low risk fluids. All these factors justify the abundant literature recently produced on this topic. (Astolfi et al., 2014).

Considering low temperatures (<150°C), the typical used fluids are those that belong to the family of refrigerants. Heat exchange in these systems is generally one-step between the thermal source and the working fluid, while electrical efficiency can vary in the range 6-18% (depending on the temperature of the hot and cold sources) (Vescovo, 2010).

There are several general criteria that the working fluid should ideally satisfy. Stability, non-fouling, non-corrosiveness, non-toxicity and non-flammability are a few preferable physical and chemical characteristics. Also, the working fluid should have relatively low boiling point to be used in a binary power cycle, since we deal with low temperature geothermal waters (Hettiarachch et al., 2007).

From a thermodynamic performance point of view, the efficiency and/or output power should be as high as possible for the given heat source and heat sink temperatures. This generally involves low pump consumption and high critical point. Vapour density should be high even at low pressure, as low density leads to very large equipment at the expander and condenser level with high pressures usually leading to higher investment costs and increasing complexity. Availability should be good and cost should be low, but of course, in a cycle design, not all the desired general requirements can usually be satisfied (Quoilin and Lemort, 2009).

A first and perhaps most important classification of working fluids is based on the slope of the vapour saturation curve. In fact, from this feature depend the applicability of the fluid, the cycle efficiency and the net power extracted, as well as the structure and system components. This distinction is fundamental to proceed with the selection of the fluid, which must be chosen according to the peculiarities of the available thermal source.

A fluid is called "wet" when its vapour saturation curve in the T-s diagram has negative ds/dT slope, whereas when the gradient of the vapour saturation curve is positive, the fluid is called "dry". When the slope is approximately infinite, that is, there is an almost vertical trend of the saturation curve, we speak of "isentropic" fluid (isentropic) (Figure 5) (Rapone, 2015).

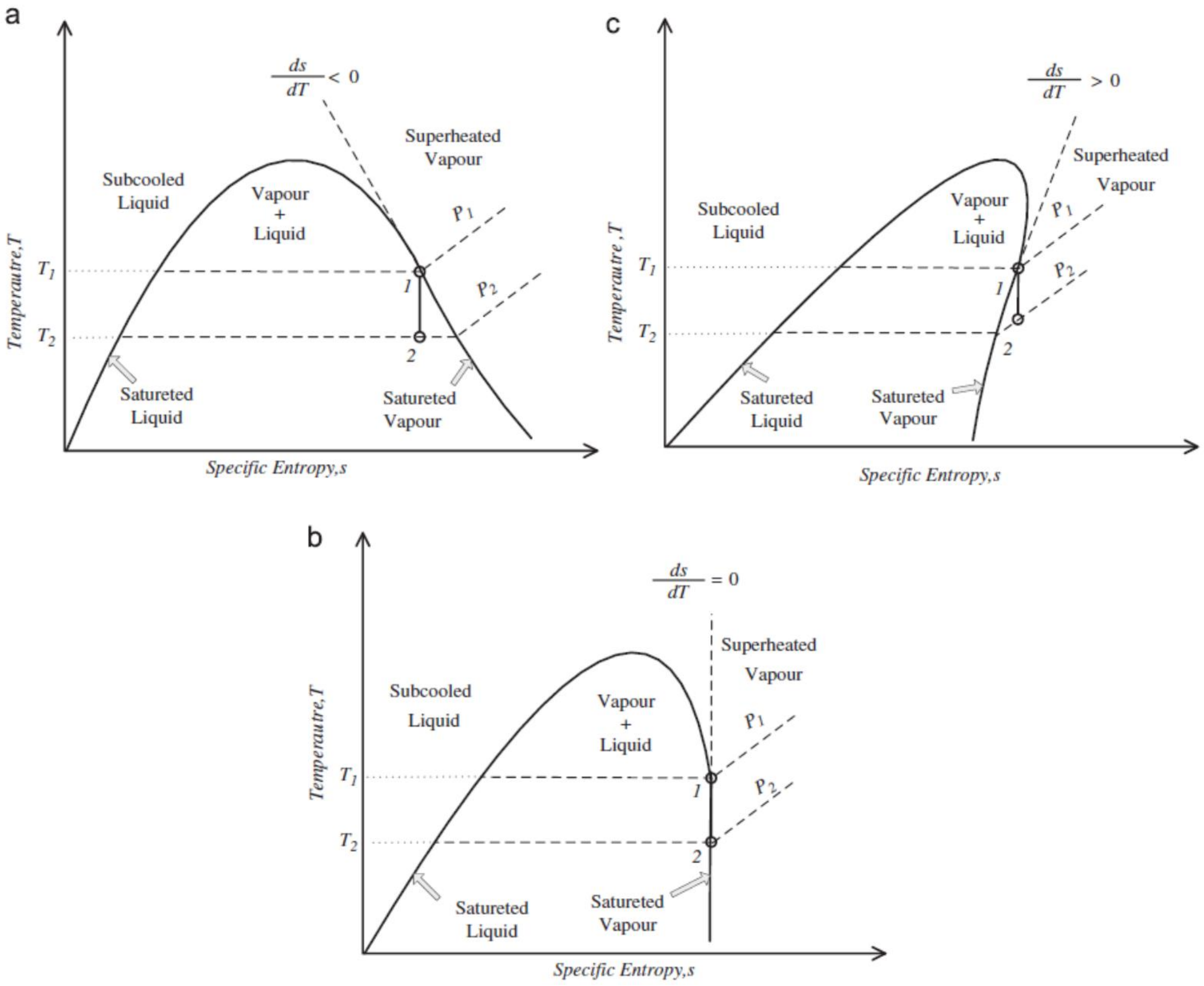


Figure 5: "Wet", "dry" and "isentropic" vapour saturation curves (modified from Rapone, 2015)

Wet fluids, among which water and ammonia, are characterized by a low vapour content at the end of expansion (line 1-2 in the previous figures): there is in fact a progressive condensation of steam during the isentropic expansion. Low values of vapour content are to be avoided, since the presence of liquid droplets dispersed in the vapour phase can erode the turbine blades, jeopardizing the duration and therefore the reliability of the entire cycle. To avoid this problem it is necessary to overheat the saturated steam, so that the vapour quality at the turbine output is not lower than 85%. Given the low thermal conductivity of the vapour phase, the presence of a “recuperator” implies a considerable increase of the evaporator exchange surface and therefore a greater investment of initial capital.

On the other hand, dry and isentropic fluids do not need to overheat. For very dry fluids, with the expansion phase starting from a saturated steam condition, at the end the steam will be strongly overheated. This presents a potential loss, if not exploited, and a greater load to be disposed of in the condenser, being necessary to increase the area of desuperheating exchange, given the low thermal conductivity of the vapour. One possible solution is to resort to one internal regenerative heat exchanger, a “recuperator”, which provides for the desuperheating of the saturated steam at the end of the expansion and preheats the liquid exiting the condenser. In this way, the cycle efficiency increases, but complexity of the plant and the investment due to the presence of the additional exchanger also increase (Rapone, 2015, Quoilin, 2007 and Yamamoto et al., 2001).

1.3.2 Environmental considerations

From the environmental point of view two indexes are usually adopted to characterise working fluids: the Global Warming Potential (GWP) and the Ozone Depletion Potential (ODP). These measure the impact on greenhouse effect and ozone depletion respectively. For a working fluid/refrigerant, the GWP is a relative measure of how much heat it traps in the atmosphere compared to carbon dioxide (GWP of CO_2 is equal to 1). The ODP is the relative amount of degradation to the ozone layer it can cause, with trichlorofluoromethane (R-11 or CFC-11) being fixed at an ODP of 1 (Astolfi et al., 2014).

Among the many refrigerants available in the market, the refrigerating and air-conditioning industry adopted for many decades CFCs (chloro-fluoro-carbons), known as “*freons*”, which were ideal for many aspects (not flammable, not toxic, low cost, and good thermodynamic characteristics), but were progressively banned because of their large ODP together with HCFCs (hydro-chloro-fluoro-carbons). For this reason, CFCs are now being banned by many countries in the world. Afterward, a new family of refrigerants was developed, known as HFCs (hydro-fluoro-carbons), non-ozone depleting, non-flammable, recyclable, and of low toxicity. They are used worldwide, but nowadays new legislations are asking for GWP much lower than those exhibited by HFCs. So the problem is still unsolved and in most cases, the ORC manufacturers must renounce to some of the qualities listed above (Macchi and Astolfi, 2016).

In Europe, usage of gases lower than 150 GWP value has become mandatory for the vehicle air conditioning systems, increasing also the search of new gases for refrigeration, air conditioning, cryogenic, etc, especially in the family of HFO (hydro-fluoro-olefins). Despite of the production of low GWP gases for different systems, most of them are still at the trial stage.

Table 1 shows some of the most used refrigerants in low-temperature ORC systems and some of their characteristics.

Table 1: Most used refrigerant fluids in low temperature applications and some of their properties (Macchi and Astolfi, 2016)

	GWP	ODP	T_{crit} [°C]	p_{crit} [MPa]	Health haz.	Fire haz.	Instability haz.
R123	77	0.06					
R125	3500		66	3.62	1	0	0
R134a	1400	0	101	4.06	1	0	1
R218	8000		72	2.64	1	0	0
R227ea	3220	0	102	2.93	1	0	1
R245fa	1000	0	154	3.65	2	1	0
R1234yf	4	0	95	3.38	1	4	0
R1234ze	1	0	109	3.63	1	4	0
R1233zd	1		166	3.62	2	0	0

T_{crit} is the critical temperature of the refrigerant: this is the temperature above which the refrigerant cannot be liquefied irrespective of the pressure on the vapour refrigerant. The critical temperature should be high enough to permit evaporation at a proper temperature, but low enough to obtain condensing pressures higher than the atmospheric one.

p_{crit} is the critical pressure of the refrigerant: this is the pressure required to liquefy a gas at its critical temperature.

The last three columns of Table 2 represent the safety information according to the U.S.-based National Fire Protection Association classification, as described in Table 2:

Table 2: Safety information levels of chemical elements

	0	1	2	3	4
Health hazard:	Normal Material	Slightly Hazardous	Hazardous	Extreme danger	Deadly
Fire hazard:	Will not burn	Flash point (FP) above 93°C	FP below 93°C	FP below 38°C	FP below 23°C
Instability hazard:	Stable	Unstable if heated	Violent chemical change	Shock and heat may detonate	May detonate

1.3.3 Legislative considerations – the Montreal Protocol

In Argentina, there is no particular legislation that denies the use of refrigerants. What has occurred in practice is that the most widespread refrigerant up to a few years ago, the R22, is being substituted mainly by the R410a, at the moment one of the most common refrigerants in the world for air-conditioning devices. The R32 is also a good alternative, showing even better environmental features than the R410a. However, these refrigerants work at low temperatures, not being suitable therefore where the heat source can reach more than 100¨C.

The only legislative obligation is provided by the Montreal Protocol: the Montreal Protocol on Substances that Deplete the Ozone Layer (MP) is a multilateral environmental agreement adopted in 1987 based on international recognition of the need for firm measures to protect the earth's ozone layer. The Protocol established time-bound targets to phase-out the production and consumption of ozone depleting substances (ODS). Argentina is mid-level ODS consuming country, that falls in the Article 5 parties: developing countries with approved programs and the obligation to report data on the progress of implementation of their programs or their updates to the Fund Secretariat (The World Bank, 2013).

For this classification, Argentina is obliged to decrease the amount of refrigerants with high GWP until reaching a value of the allowed refrigerants' GWPs that is 85% lower in 2045 than what it was in 2015, as it can be observed in Figure 6 (Kuyak, 2017).

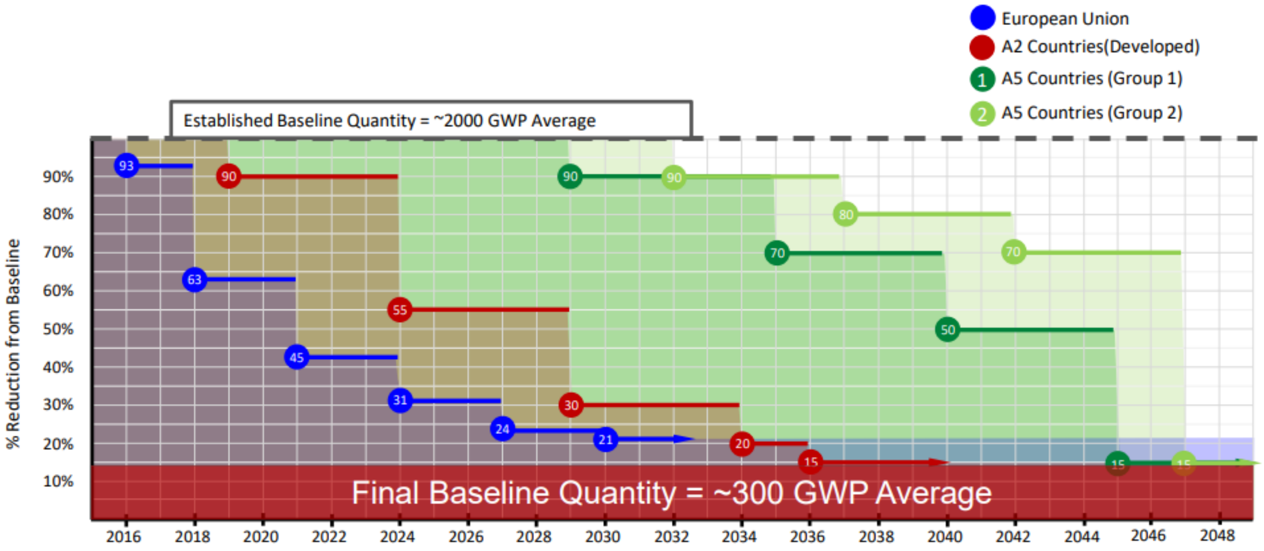


Figure 6: Phase-out program imposed by the Montreal Protocol for various Countries based on their 2015 baseline (Kuyak, 2017)

1.4 Power generation with medium-enthalpy geothermal energy: cases around the world

ORC systems range from micro-scale (a few kW) for domestic cogeneration to large multi-megawatt geothermal power plants. After a slow initial start, the technology has experienced a much stronger development since the 1970s, mainly because of economic incentives and surging energy prices.

There are about 30 companies in the world that provide ORC systems solutions, sharing the 700 projects and 2.7 GW installed worldwide. However, the American company ORMAT and the Italian companies TURBODEN and EXERGY account together for 87% of the installed capacity. Geographically, the United States has the largest installed capacity per country, followed by Turkey and New Zealand (Tartière and Astolfi, 2017).

The vast majority of these plants exploit sources with a temperature above 100°C. There are however cases in the world where hot water between 70°C and 90°C is used, where the registered lowest temperature case is that of Chena Hot Spings, in Alaska (USA), with 73°C hot water.

1.4.1 Chena, Alaska, USA

This plant includes two single-stage centrifugal compressors which run in reverse as a radial inflow turbine to produce 200kW of power, tube and shell heat exchangers originally designed for large chiller applications, and working fluid R134a. The design and production was carried out by the United Technologies Research (UTS), which could use components and hardware from its division Carrier Refrigeration. The heat source water is 73°C hot and has a flow of 34 l/s; the heat sink water is 5°C and has a flow of 102 l/s. The working fluid is R134a. The successful implementation of this 400 kW plant resulted in the reduction in electricity cost at Chena from 30 US¢ per kWh to 5 US¢ per kWh (Holdmann and List, 2007 and Aneke et al., 2011).

1.4.2 Simbach – Braunau, Germany

Another example is a project supported by the sixth framework program of the European Commission and coordinated by CRES (Centre for Renewable Energy Sources and Saving - Greece). The project involved the development and demonstration of an ORC technology for electricity generation from medium enthalpy geothermal fluids with temperatures as low as 70°C. An experimental prototype has been designed, constructed, installed and monitored at the Simbach geothermal plant (Germany), which provides geothermal heat from an 80°C geothermal resource to the common district heating system of the Simbach and Braunau towns. A consortium called LOW-BIN (“Efficient Low Temperature Geothermal Binary Power”) was set up for this task, comprising 9 partners from 8 countries. One of the partners, the Italian ORC plants manufacturer company TURBODEN developed a plant providing 100 kWe net power at nominal conditions. The machine involves the use of R134a as working fluid, a new TURBODEN turbine, high-speed generator, a twin evaporative condenser and a variable speed pump. Its overall conversion efficiency is around 4,5% when supplied by 80°C hot water. It has been studied that doubling the heat exchangers surface would result in conversion efficiencies in the range 6-7%. The heat source water is 80°C hot, has a flow rate between 46 and 61 l/s and is reinjected at 65°C; the heat sink water has a temperature of 18°C. The injection and production wells reach a final depth of 1850m and 1970m respectively. The project budget amounted at around 4 million U$D, approximately 45% of which was funding from the European Union. The revenues correspond either to the electricity costs saved, or to the renewable energy sale price offered by the local power company. Given an electricity price of 0.27 U$D, the simple payback period was calculated as 3.7 years and the corresponding annual return on investment was estimated as 27% (Karytsas et al., 2009). However, due to economic reasons, power production ended with the dismantling of the power stations in 2012 (Weber et al., 2015).

1.4.3 Denizli, Turkey

The plant Tonsular 1, in the location of SaraykÖy, Denizli (Turkey), is a first of its kind ORC plant that uses a turbine with two pressure steps. The radial outflow turbine is a patent of the Italian company EXERGY, that developed this technology for the 105°C hot geothermal fluid, producing a gross power of 3.9 MWe and an gross efficiency of 10.9%. The geothermal fluid is a mixture of steam and brine, with a respective flow rate of 2.5 l/s and 192 l/s. The condensing system is water from cooling towers at 18°C (Exergy, 2015).

1.4.4 TAD’s Geothermal Plant, Nevada, USA

Two plants, installed in 1984 and 1987, are located in Nevada with generation capacity of 750 and 800 kWe. Two wells supply geothermal water at 104°C with a flow rate of 60 l/s to these plants. Initially this plant was using Freon-114 as the binary fluid and due to non-availability of Freon-114, the plant was converted to use iso-pentane as the working fluid in 1998. The plant uses water cooled condensers, with a cooling pond. The units operate automatically, mostly unattended, with maintenance and operation provided by a two person staff. The project was privately financed and is owned by Tad’s Enterprises (Schochet, 2000).

1.4.5 Beppu, Japan

In the city of Beppu, south of Japan, the company ElectraTherm has installed a unit that runs off low temperature geothermal steam from a small district heating system to produce power. Up to 110 kWe are generated from low temperature water ranging from 77 to 122°C.

1.4.6 Matsunoyama, Japan

A micro grid system which utilizes hot spring water for heat source was installed at Matsunoyama in Tokamachi City, Niigata Prefecture, Japan. A 50 kW system was designed with a brine inlet temperature of 98°C and flow rate of 6.5 l/s. However, enough brine heat source could not be used to achieve the designed performance due to limitations of the hot spring resource. The system was then improved to utilize not only brine but also steam from the well. As a result, the plant is now able to produce 45 kW with a 92°C hot source flowing at 5 l/s and a 7°C cooling water (Yanagisawa et al., 2012).

1.4.7 Lompio, Indonesia - *study case*

This is a study carried out in 2015 by researchers at the Research Centre for Electrical Power and Mechatronics – Indonesian Institute of Sciences, to serve as a reference in the development of power generation system using the many hot springs available in Indonesia with temperatures between 70 and 80°C. The hot spring *Lompio 1* was selected as the most promising, for its geothermal fluid flowrate of 50 l/s at 78°C. It has been calculated that a power of 130 kWe can be produced with such conditions. The input temperature at the condenser was set at 25°C (Pikra et al., 2015).

1.4.8 Winton, Australia

A small geothermal plant is projected to start operating in June 2018 in the small Australian town of Winton, Queensland. This plant will be the first grid-connected geothermal plant in Australia and will power a museum, local municipal facilities and assets. The plant will feature two 150 kW geothermal power plants, with a particular kind of innovative new cooling towers developed by the University of Queensland's Geothermal Centre that reduces water consumption. The plant will be using hot water from existing wells providing naturally available hot water at a temperature of around 80°C, but requires drilling deeper to derive hotter temperatures that could be used for power generation. The total cost of the project is estimated at around 2.4 million USD and will create 9 full time jobs. However, the local council expects to save thousands of dollars annually in electricity bills. It has been simulated that the proposed plant will have a payback period of less than seven years and about 12 million USD savings in energy consumption (Richter, 2018).

Winton is a small community in the Australian outback, close to other small communities that are also riddled by transmission issues, as a lot of power is lost through transmission lines. While these communities are small and in the overall scale of things not big at all, the possibility of installing their own plants could have a huge impact on them, providing a sustainable, clean and cheaper source of electricity (Richter, 2016).

2 Study of medium enthalpy power generation at Rio Hondo

2.1 Characterization of the local thermal water resource

According to Pesce, 2015, during the last years, in Argentina, few advances have been made in most of the geothermal fields oriented to power generation (Figure 7). The thermal area *Termas de Rio Hondo*, in the Province of Santiago del Estero, stands out on this scene as the possibility of electricity generation is presently being evaluated.

The *Termas de Río Hondo* is located on the border of center-west of the province of Santiago del Estero, where a strong anomaly of heat is found. A program that consists of 4 stages, ranging from the most expeditious and regional to greater detail, seeks to go reducing the uncertainty, to finally select the most promising area to define a deep exploratory well site. The program aims to assess the future possibilities of electricity generation in a wide area, where a heat anomaly is present. So far it has been interpreted that the continental lithosphere has a thinning of between 8 to 12 km (Febrer et at., 1982) and is fractured, generating an ascent of the asthenosphere and a regional geothermal gradient between 1.5 and 2 times higher than normal. The first stage geology, structure and geochemistry have been evaluated and using maps of heat curves the most promising area for the second stage has been selected. Magneto telluric studies (MT) confirmed the established theoretical scheme. Then, 2D profiling provided information of the lithostratigraphy and bottom of the basin boundary. An area of low resistivity was defined which deepens up to 9.5 km, between two resistive areas that reflect the rise of thermal heat flow coming from the asthenosphere (Pesce, 2014). This information made it possible to delimit a more reduced zone, which has an area of 36 km^2, where the development of the next stage is planned. This area is located in a depression of tectonic origin, limited by the blocks of the Pampeanas Hills, the Aconquija Hills to the west and the Guasayán Hills to the east, where the sedimentary thickness of the entire column can reach values of more than 6000m (Febrer et al., 1982).The third stage, which was under way in 2015, intended to measure variations in the heat flow through gradient wells, to define the location for a deep exploratory well, which is expected to reach a depth of 2000 m. In addition, temperature variations in 25 100m-deep wells within the selected area were being measured (Pesce, 2015).

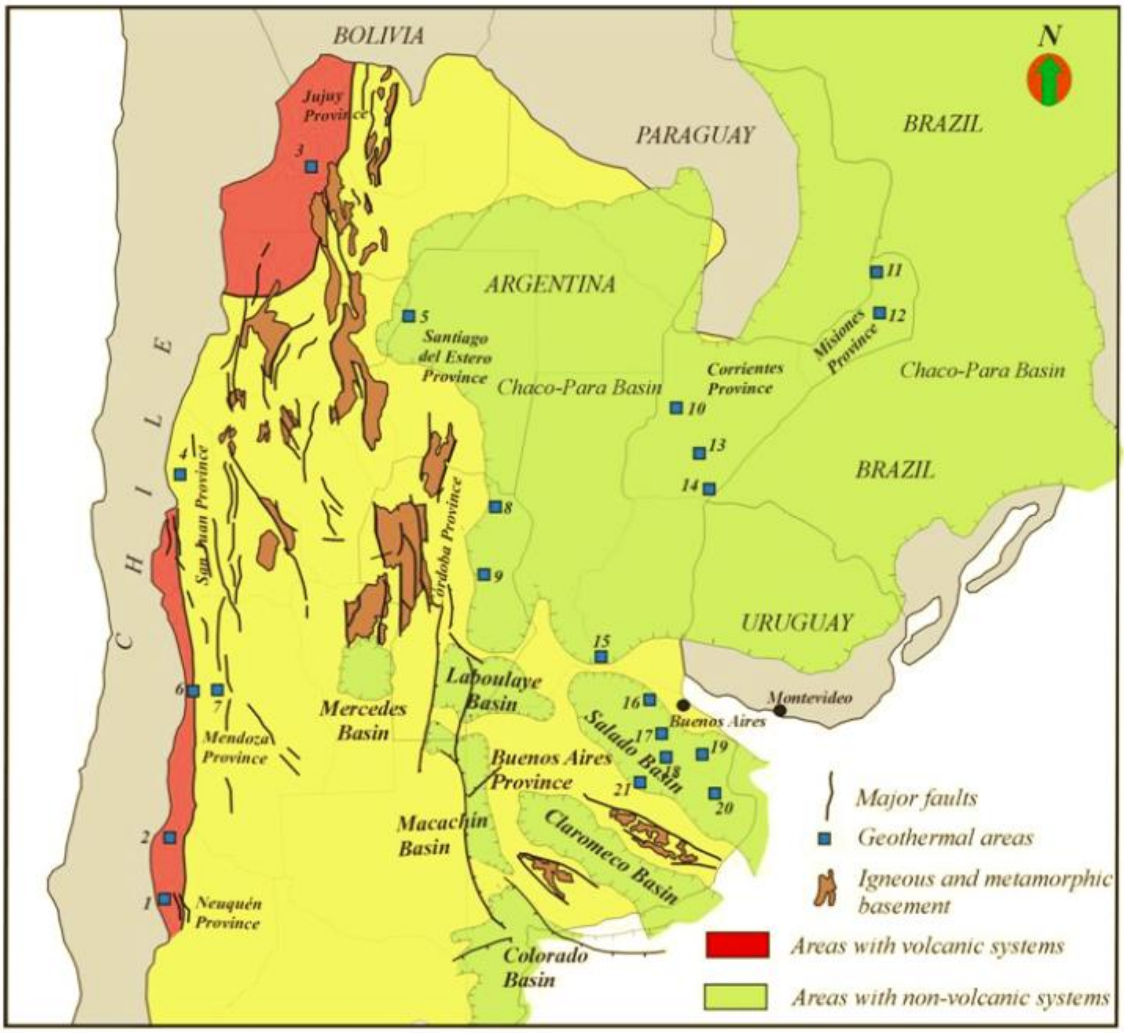


Figure 7: Distribution of thermal projects in Argentina: 1 Copahue, 2 Domuyo, 3 Tuzgle, 4 Los Despoblados, 5 Termas de Río Hondo, 6 Peteroa, 7 Los Molles, 8 Mar Chiquita, 9 Chazón, 10 San Roque, 11 Wanda, 12 2 de Mayo, 13 Curuzú Cuatiá, 14 Monte Casero, 15, Ramallo, 16 Tigre, 17 Navarro, 18 Las Flores, 19 Chascomus, 20 Dolores and 21 Tapalqué (from Pesce, 2015)

According to Febrer et al., 1982, the city of Termas de Río Hondo is simply a point of natural birth of hot springs, favoured by tertiary tectonics, which has shown this anomaly and that does not necessarily coincide with the largest geothermal anomaly of the subsoil.

Most of the aquifers exploited in Termas Rio Hondo are located at depths of less than 250 m, with medium permeability and positive upwelling pressure. The extraction by pumping reaches flow rates ranging between 4 and 21 l/s. The natural upwelling rarely exceeds 2 l/s in the surroundings of the town. However, near the springs area, these values increase remarkably. In the town of Colonia Tineo, 15 km northwest of Río Hondo, the pumping flow exceeds 42 l/s. The deeper aquifer of the well “Las Termas 12”, the deepest well drilled at 900 m depth, was found at 804 m and had a spontaneous upwelling flow rate of approximately 27 l/s. The aquifer system that characterizes the whole sedimentary units of the area originates from a recharge at the foot of the western mountain range of Tucumán. The direction and angle of the dip of the sedimentary rock layers that are found between the hills range and Termas de Río Hondo allow rain water to penetrate to a depth of about 9.5 km, where it is heated do to a low-depth hot body that is found right below Termas the Río Hondo. The ascent of the this heated water is linked to the intense fracturing observed on the surface of the thermal area of Río Hondo, about 150 km east of the foot of the hills and which generates the upwelling in this sector (Martín y Palazzo , 2007).

With respect to temperature and thermal gradient values, a series of chemical geothermometry activites have been carried out in 1975 (Jurio et al., 1975) and 1987 (Inohue, 1987). This technique is based on the hot water dissolving capacity of the rocks' mineral components through which it circulates, used to calculate the maximum probable temperature reached by the water. When the thermal water rises rapidly to the surface its chemical composition does not vary substantially. In such a way the water keeps a record of the temperature reached in the subsoil. A variety of combinations of soluble elements are known to determine the temperature values. In particular, in the region of Las Termas de Río Hondo, different geothermometers have been applied to the thermal waters of springs and perforations.

The method allowed distinguishing the zones with the greatest geothermal potentiality, although it turned out to be somewhat incomplete in terms of the maximum temperature values reached by each sample before its surface capture. In general, it has been possible to verify that the temperature values obtained from the chemical geothermometers correspond to minimum values that the water could have reached in depth, therefore showing a lower limit but not upper (Miró, 2006).

Data from the deepest well, the "Las Termas 12", is shown in Figure 8. It has been confirmed that the geological units that contain the thermal aquifers have different thermal variation curves.

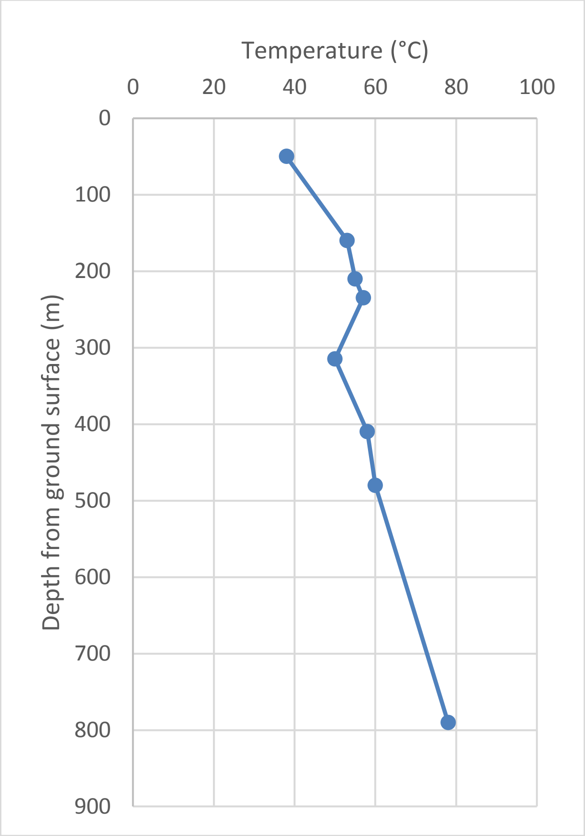


Figure 8: Temperature measured in the Las Termas 12 well (modified from Miró, 2006)

3 Commercial evaluation

The first example of modern ORC was built by D'Amelio in 1936: this plant was based on a simple monochloroethane Rankine cycle heated by solar energy and powered by a single stage impulse turbine. In the following years, the same idea was applied to a couple of low-temperature geothermal plants with 2.6 kW and 11kW power output respectively. In the 1960's, the National Physic laboratory of Israel started an extensive screening of potential fluids that highlighted the advantages of using high complexity freons and defined the regenerative saturated cycle configuration still widely in used today (KCORC, 2013).

These experiences led to the design of several prototypes and to the founding of ORMAT (1964) and Turboden (1970), two companies that are still today the biggest players in the ORC market of high installed capacity (>1 MW). In more recent years, many new companies have developed and implemented their own technology: *Electratherm* and *Calnitex* from the USA, *Exergy* and *Zuccato* from Italy, *Enogia* from France, *Opcon* and *Climeon* from Sweden, and *gTET* from Australia, among others, are the companies that have been contacted with respect to this project. Today, the ORC market capacity in the range of 1–100 kW is small, with an approximated installed capacity worldwide of about 5 MW (Tocci et al., 2017).

Power generation from geothermal brines is the main field of application with 74.8% of all ORC installed capacity in the world; however the total number of plant is relatively low with 337 installations. Other applications where ORC systems are increasingly gaining importance are waste heat recovery, biomass applications and solar applications (Figure 9).

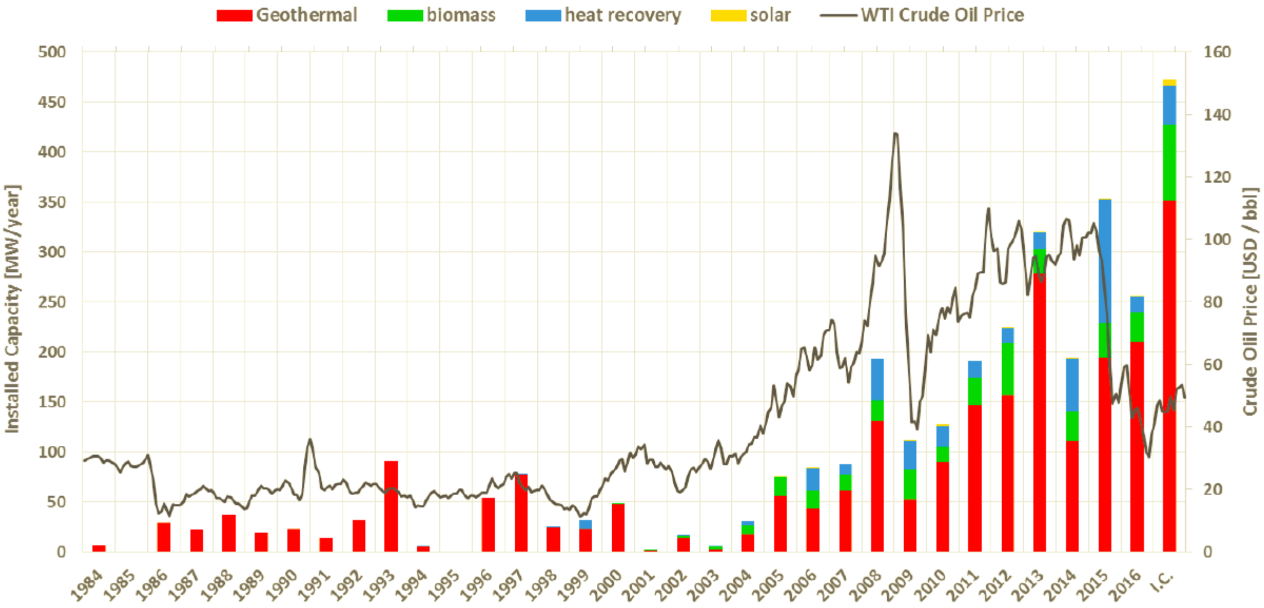


Figure 9: Evolution of installed capacity over time, per application (Tartière and Astolfi, 2017)

After a few decades (from 1980 to 2003) focused exclusively on geothermal applications, the ORC market has experienced a significant growth since the early 2000s, with an average yearly capacity between 75 and 200 MW, reaching up to 352 MWel in 2015. Geothermal power generation has always been the most important application, with a strong increase after 2009 and the entrance of many new companies in the market (Tartière and Astolfi, 2017).

It is interesting to notice that Geothermal ORCs have progressively increased in size following the ability of manufacturers to design and produce larger turbines. Geothermal projects in the 1980s would typically involve multiple ORC units in parallel. For example, in 1987, the Ormesa II project in USA utilized 20 modular energy converters in two cascading levels, for a 20 MW power plant. In the early 2000s, larger units with electrical power above 15 MW have been installed especially in large geothermal applications. A good example is the Velika Ciglena geothermal project in Croatia, currently under construction, with a 16 MW turbine. In recent years, many companies such as the ones mentioned have also built small ORC units for power generation from hot springs (KCORC, 2013).

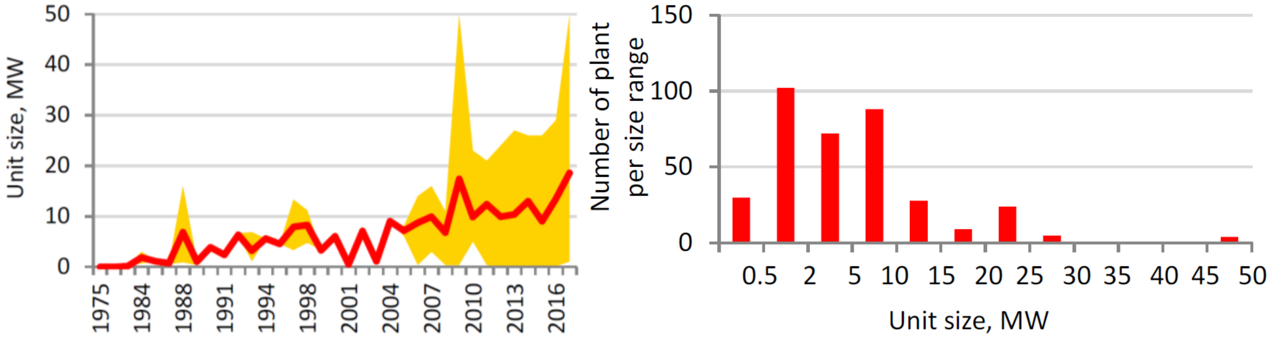


Figure 10: Evolution of ORC unit size for geothermal applications: coloured area defines maximum and minimum unit size per year while the line depicts the average installed size. The bar chart shows the distribution of plants versus the unit size (Tartière and Astolfi, 2017)

Geographically, the USA has the largest installed capacity per country, followed by Turkey and New Zealand. These three countries benefit from abundant geothermal resources. Germany, Austria, Italy and Canada follow in the list due to the combination of available resources and favourable incentives.

3.1 Selected companies

Of the mentioned contacted companies, a selection of the three most promising ones has been made: Electratherm, Enogia and Zuccato. The others have not shown much interest in the project mainly due to various reasons such as logistic issues or lack of available data.

Electratherm (www.electratherm.com)

By Bitzer group and based in Reno (USA), Electratherm is specialised in small-scale waste-heat recovery plants. Its >50 machines operate in 12 countries and the oldest ones have surpassed 75 years of runtime. POWER+Generator, the name given to its units, generates clean electricity from low-grade waste heat utilizing ORC and proprietary technologies. The machines are fully packaged (Figure 11), with outputs up to 110 kW for distributed power generation from low-grade waste heat (77-122°C) utilizing water cooled ORC and proprietary technologies; it licenses two patents from the City University of London and has an additional seven patents issued or in application.

Figure 11: ElectraTherm 110 kW power generator, 2014

With respect to geothermal applications, the main plants are installed in USA, Japan (See Chapter 1.4.5) and Romania. In USA, the unit was manufactured with a cleanable heat exchanger, a power output of up to $75kW_e$ and $660kW_t$, and a fully-containerized solution for ease of transportation and installation through a grant from the Department of Energy for 982000 U$D. Here, ORC provides power generation as a metered service. The hot source has a temperature of 110°C and flow rate of 10 l/s, condensation is with air. In Romania, an ORC plant produces $50kW_e$ (gross) from the geothermal hot water (105°C, 10 l/s). To further increase the application's efficiency, once geothermal water has passed through the heat exchangers, it continues on to heat nearby residential buildings in the winter. The POWER+Generator uses R245fa as working fluid, a hydrofluorocarbon with formula 1,1,1,3,3-pentafluoropropane, non-flammable and nontoxic.

Enogia (www.enogia.com)

Created in 2009 in Marseille (France), Enogia is specialised in small scale ORC systems (5-100 kW). At the core of its performance is a highly innovative micro-turbine that serves as a power plant, internally designed and manufactured. Enogia's technology allows its machines to work with temperatures not lower than 85°C. Its main geothermal installation is in San Nicolas de Hidalgo, Mexico, where their ORC installation produces 40 kW_e (gross) from a 110°C geothermal water.

Figure 12: Enogia 10 kW ORC unit, 2015

Zuccato (www.zuccatoenergia.it)

Zuccato Energia is an Italian company based in Verona that started operating in 2011. It is specialized in design, development, manufacture and distribution of systems from 30 up to 500 kW_e based on the ORC cycle that can exploit geothermal water starting from 95°C. Zuccato has already opened a commercial office in Cordoba, which counts on a local engineering firm for the technical support.

Figure 13: The ULH and ULH+ ORC systems, as advertised on the Zuccato website (www.zuccatoenergia.it/en)

3.2 Scenario A: hot source at 75°C

3.2.1 Electratherm – POWER+Generator

The only plant in the world that could be found as reference using a source colder than 80°C is the Chena plant in Alaska that was described in Chapter 1.4.1. The 200 kW ORC system exploits hot water at 73°C with a flow rate of 34 l/s, but has a very cold and abundant source that allows it to make use of a vast temperature range increasing its efficiency consistently. The plant was realised as one-off product also for research purposes.

The only company in the market that offers a solution for such low temperatures is Electratherm, with its product POWER+Generator 4200, an ORC system that uses a twin screw expander with characteristics shown in Table 3.

Table 3: Characteristics of the POWER+Generator by ElectraTherm

Hot water input parameters	Hot water input temp range	°C	77-116
	Thermal input range	kW_{th}	300-650
	Flow rate range	l/s	3.2-12.6
Water cooled condensing parameters	Cooling water input temp range	°C	4-65
	Heat rejected to cooling water range	kW_{th}	300-600
	Cooling water flow rate	l/s	13.9
Performance characteristics			
Nominal rating	Up to 35 kWe* at 380-500V / 3 phase / 50 and 60 Hz		
Output depends on hot and cold resources			
Ambient operation	0-38°C		
Power factor correction	Load and site dependent – from 0.9 to 1		
Total Harmonic Distortion	2% for voltage, 10% for current		
Design attributes			
Refrigerant plumbing	Built to ASME and CE Standards		
Energy Block	Twin Screw Expander		

Generator	Grid-tied induction (Brushless construction, asynchronous)
Heat exchangers	Compact, brazed plate construction
Design life	20 years
Lubrication	Process lubrication
Transient voltage/Surge suppression	Basic protection are standard
Grid protective relay	External additional interface included
Installation	Indoor or outdoor installation
System description	
Working fluid	R245fa* (Pentafluoropropane)
R245fa is non-flammable, non-toxic and non-ozone depleting working fluid	
Controls	Custom controls software using standard programmable logic controller
Remote monitoring	Will support internet protocol, 3G cellular, satellite communications, wireless
Operation	Designed for unattended operation
Cabinet	NEMA 3R outdoor rated / IP 54 compliant
Shipping	Ships from Flowery Branch, GA, USA
Dimensions	2.4 x 2.0 x 2.3 m
Weight	3.2 t
Sound pressure	80 db at 1 m. Sound attenuated option: < 72 db at 1 m

In Figure 14 it is interesting to observe the working conditions of the products POWER+Generator 4200 and 4400, where the latter works with hot source temperatures above 92°C.

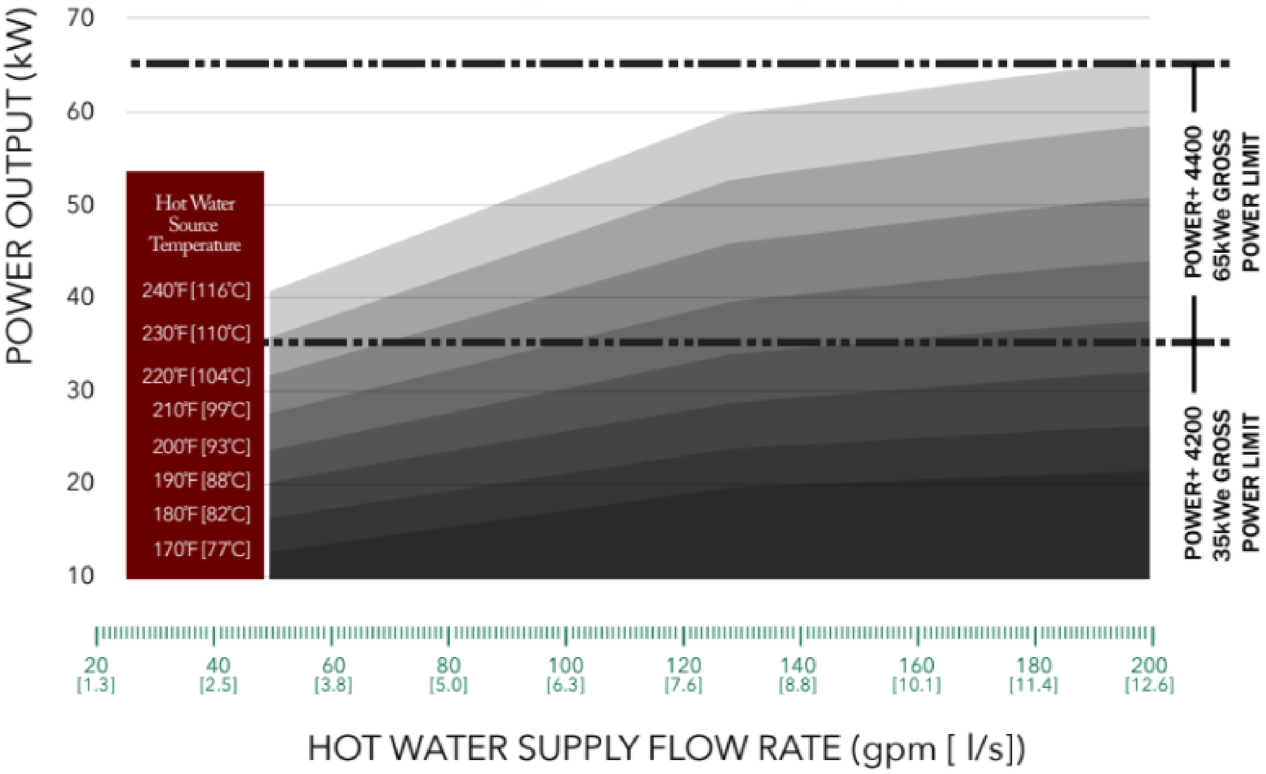
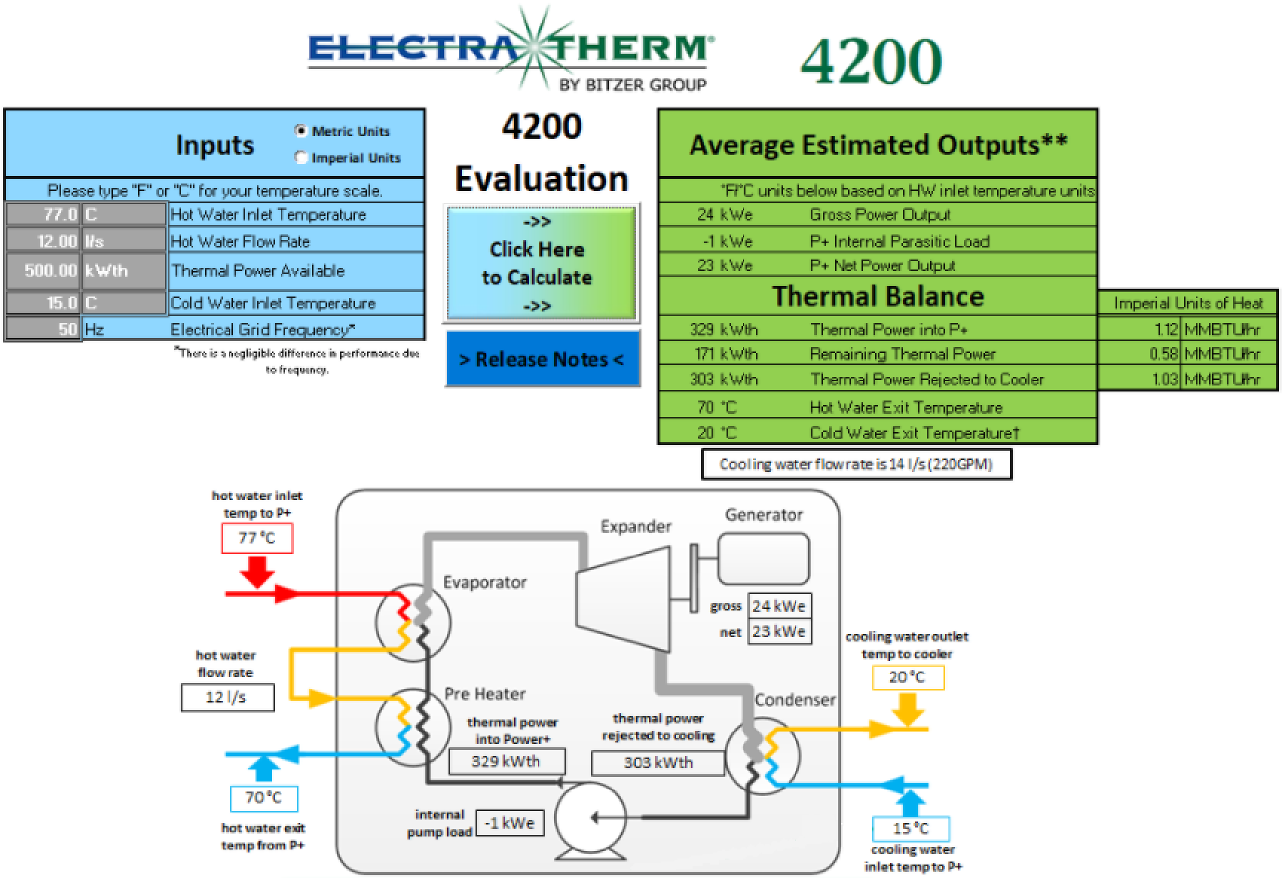


Figure 14: Power output with respect to temperature and flow-rate that can be expected from the POWER+Generator 4200 and 4400

It can observed how, with a hot source at 77°C, the power output that can be expected goes from around 12 kWe in case of a flow rate of about 3 l/s to around 22 kWe in case of a flow rate of 12.6 l/s. This also means that the for the POWER+Generator the low source flow-rate and the power output are not linked with a linear relation: as it is also shown in Figure 14, there is an inflexion point when the flow-rate reaches a value of about 8 l/s. Interestingly, there is a very low difference in power output between a flow-rate of 8 and 12 l/s, respectively equal to 20 and 22 kWe. This means that it is probably more convenient to take advantage of low flow-rate wells and produce slightly less energy, rather than enhance the production of a well to reach the 12 l/s. The Electratherm simulation tool (accessed through personal communication) shows the following working conditions:



ELECTRATHERM BY BITZER GROUP **4200**

Inputs ● Metric Units ○ Imperial Units

Please type "F" or "C" for your temperature scale.

77.0	C	Hot Water Inlet Temperature
12.00	l/s	Hot Water Flow Rate
500.00	kWth	Thermal Power Available
15.0	C	Cold Water Inlet Temperature
50	Hz	Electrical Grid Frequency*

*There is a negligible difference in performance due to frequency.

4200 Evaluation

Average Estimated Outputs**

*F/°C units below based on HW inlet temperature units

24	kWe	Gross Power Output
-1	kWe	P+ Internal Parasitic Load
23	kWe	P+ Net Power Output

Thermal Balance

			Imperial Units of Heat	
329	kWth	Thermal Power into P+	1.12	MMBTU/hr
171	kWth	Remaining Thermal Power	0.58	MMBTU/hr
303	kWth	Thermal Power Rejected to Cooler	1.03	MMBTU/hr
70	°C	Hot Water Exit Temperature		
20	°C	Cold Water Exit Temperature†		

Cooling water flow rate is 14 l/s (220GPM)

Figure 15: Simulation of the POWER+Generator 4200 with a hot source of 77°C and 12 l/s flow rate

Figure 15 shows a simulation of what the system would work like with hot source conditions equal to 77°C and 12 l/s, and cold source temperature of 15°C. The simulation shows that the expected net power output is 23 kWe.

Working with the same initial conditions, a model has been run on the software GeSi, provided by the Karlsruhe Institute of Technology, to verify the working conditions (Figure 16).

Eingabe
● Frischdampfdruck, Frischdampftemperatur
○ Frischdampfdruck, gesättigter Dampf
○ Frischdampftemperatur, gesättigter Dampf
○ Frischdampfdruck, Dampfgehalt nach Turbine
○ Frischdampftemperatur, Dampfgehalt nach Turbine

Eingabe Wärmetauscher
● Massenstrom Thermalwasser (Kg/s)
○ Übertragene Wärme (KW)

Kondensator
● Wasserkühlung
○ Luftkühlung

Fluid
R141b
R142b
R143a
R152a
R218
R227ea
R236ea
R236fa
R245ca
R245fa

Aktuell ausgewähltes Fluid:
R245fa

Kritische Temperatur(°C)
154.01

Kritischer Druck(MPa)
3.651

☐ Beschränkung der Thermalwasseraustritstemperatur
☐ Kleiner Bildschirm
☐ Bilder
☐ Design

Referenzzustandsdruck(MPa 0.01
Referenzzustandstemperatur(°C) 30

Pumpenwirkungsgrad 0.75
Turbinenwirkungsgrad 0.55

Organic Rankine Cycle
Frischdampftemperatur(°C) 73
Frischdampfdruck(MPa) 0.55
Kondensatortemperatur(°C 20
Netto Leistung(KW) 23.2671
Brutto Leistung(KW) 24.0331
Realer Wirkungsgrad 5.7321
Isentroper Wirkungsgrad 10.6235
Rankinemassenstrom(Kg/s) 1.7371

Thermalwasser
Druck(MPa) 1
Eintrittstemperatur(°C) 77
Massenstrom (Kg/s) 12
Zugeführte Wärme (KW) 405.9104
Austrittstemperatur(°C) 68.9271

Wärmetauscher
Grädigkeit 4
Druckverlust(MPa) 0.02
Eintrittstemperaturdifferenz 48.6965
Austrittstemperaturdifferenz 4

Kondensator
Grädigkeit 4
Druckverlust(MPa) 0.02
Eintrittstemperaturdifferenz 29.2371
Austrittstemperaturdifferenz 5

Kühlwasser
Druck(MPa) 1
Eintrittstemperatur(°C) 15
Abgeführte Wärme(KW) 382.6433
Austrittstemperatur(°C) 20.1304
Massenstrom(Kg/s) 17.8288

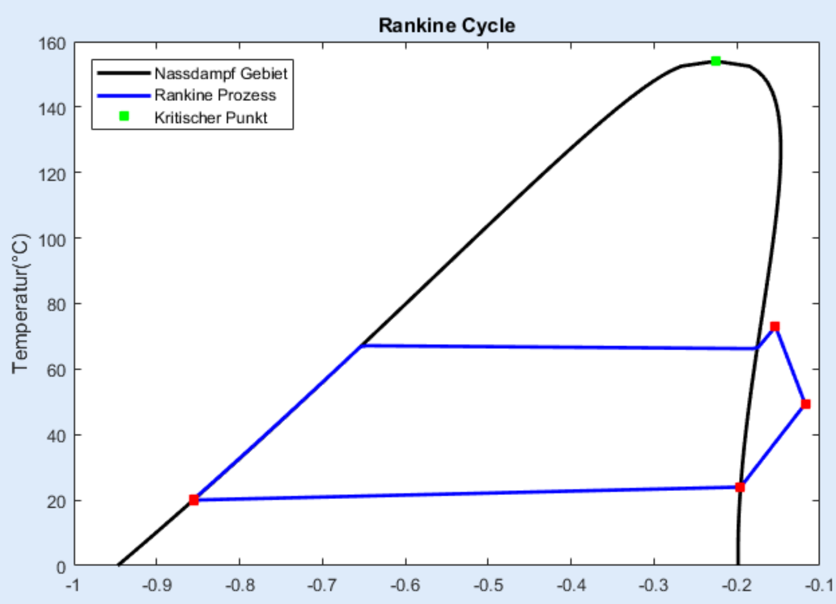


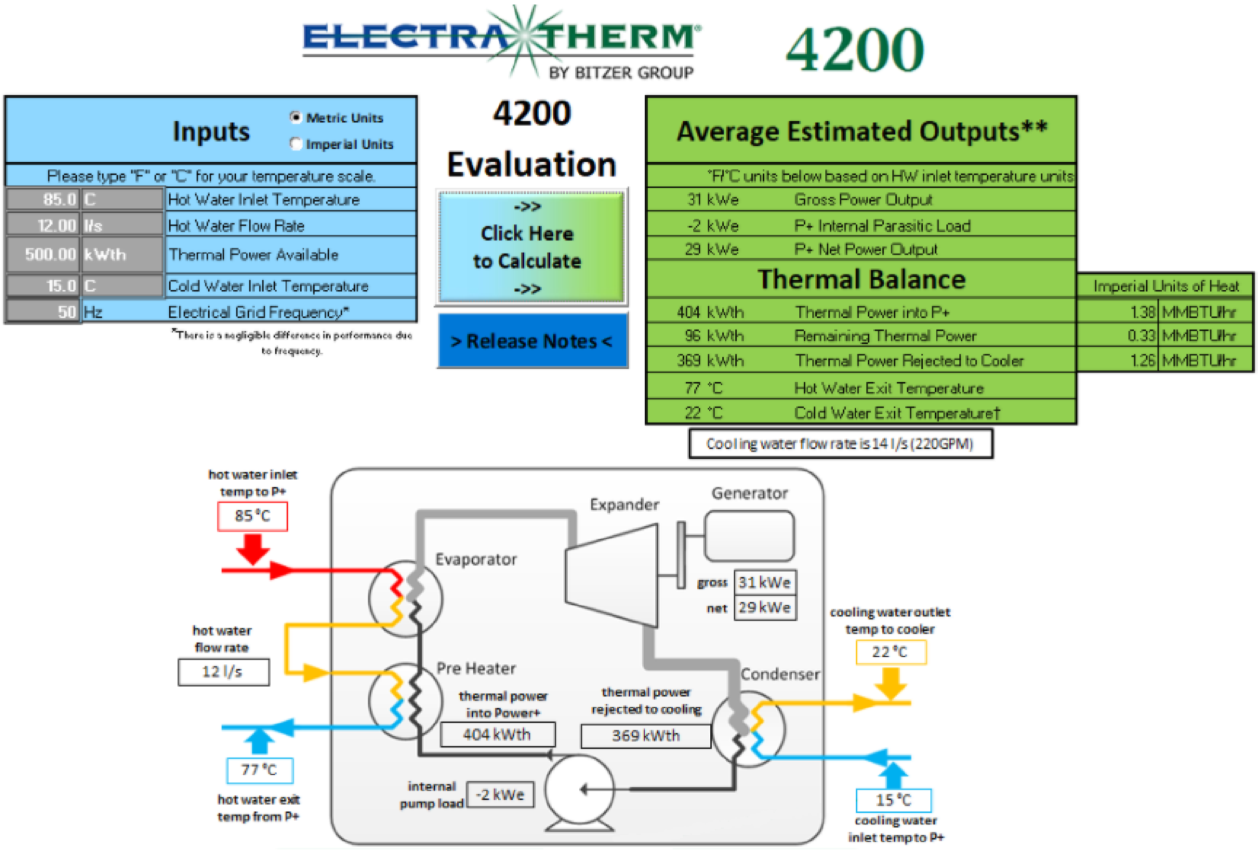
Figure 16: Electratherm's POWER+Generator 4200 possible working conditions as simulated by GeSi with hot source at 77°C

3.3 Scenario B: hot source at 85°C

A temperature of 85°C is still a temperature that is hardly used in the world to produce energy via ORC systems. There have been a couple of projects (of those that could found in literature) using this temperature level, where one is using the Electratherm product previously described (Chapter 1.4.5), another was closed due to economic reasons (see Chapter 1.4.2) and one was just a study case (Chapter 1.4.7).

3.3.1 Electratherm – POWER+Generator

The same Electratherm POWER+Generator 4200 previously presented can be simulated another time with this more favourable temperature condition:



Inputs ● Metric Units ○ Imperial Units

Please type "F" or "C" for your temperature scale.

85.0	C	Hot Water Inlet Temperature
12.00	l/s	Hot Water Flow Rate
500.00	kWth	Thermal Power Available
15.0	C	Cold Water Inlet Temperature
50	Hz	Electrical Grid Frequency*

*There is a negligible difference in performance due to frequency.

Average Estimated Outputs**

"F/"C units below based on HW inlet temperature units

31 kWe	Gross Power Output
-2 kWe	P+ Internal Parasitic Load
29 kWe	P+ Net Power Output

Thermal Balance

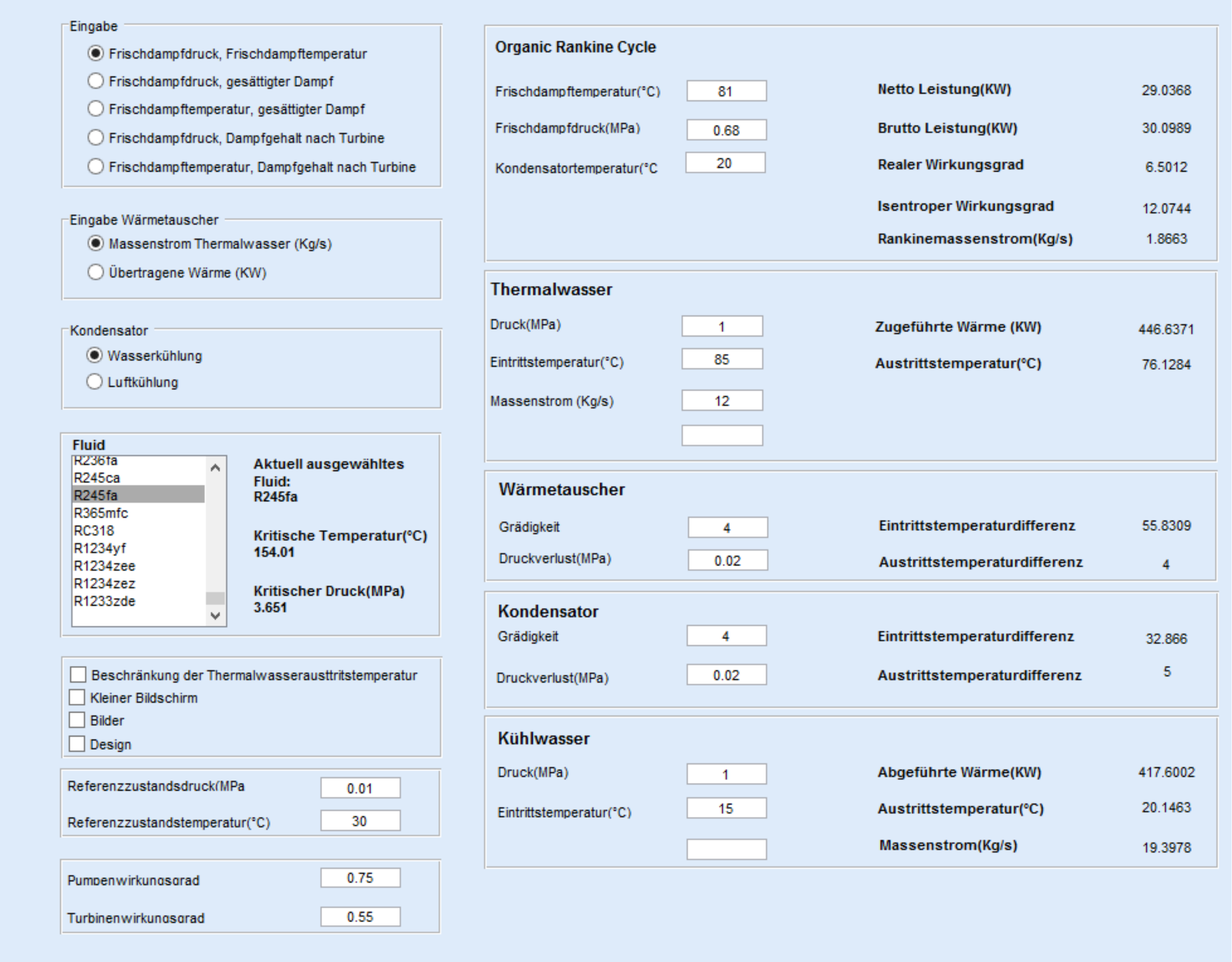
		Imperial Units of Heat
404 kWth	Thermal Power into P+	1.38 MMBTU/hr
96 kWth	Remaining Thermal Power	0.33 MMBTU/hr
369 kWth	Thermal Power Rejected to Cooler	1.26 MMBTU/hr
77 °C	Hot Water Exit Temperature	
22 °C	Cold Water Exit Temperature†	

Cooling water flow rate is 14 l/s (220GPM)

Figure 17: Simulation of the POWER+Generator 4200 with a hot source of 85°C and 12 l/s flow rate

Figure 17 shows the simulation of what the system would work like with hot source conditions equal to 85°C and 12 l/s, and cold source temperature of 15°C. The simulation shows that the expected gross power output is 31 kW$_e$. This can also be confirmed by the graph in Figure 14.

Reproducing the cycle in GeSi, the working conditions are shown in Figure 18.



Eingabe
● Frischdampfdruck, Frischdampftemperatur
○ Frischdampfdruck, gesättigter Dampf
○ Frischdampftemperatur, gesättigter Dampf
○ Frischdampfdruck, Dampfgehalt nach Turbine
○ Frischdampftemperatur, Dampfgehalt nach Turbine

Eingabe Wärmetauscher
● Massenstrom Thermalwasser (Kg/s)
○ Übertragene Wärme (KW)

Kondensator
● Wasserkühlung
○ Luftkühlung

Fluid
R236fa
R245ca
R245fa
R365mfc
RC318
R1234yf
R1234zee
R1234zez
R1233zde

Aktuell ausgewähltes Fluid:
R245fa

Kritische Temperatur(°C)
154.01

Kritischer Druck(MPa)
3.651

☐ Beschränkung der Thermalwasserausttritstemperatur
☐ Kleiner Bildschirm
☐ Bilder
☐ Design

Referenzzustandsdruck(MPa 0.01
Referenzzustandstemperatur(°C) 30

Pumpenwirkungsgrad 0.75
Turbinenwirkungsgrad 0.55

Organic Rankine Cycle

Frischdampftemperatur(°C)	81	**Netto Leistung(KW)**	29.0368
Frischdampfdruck(MPa)	0.68	**Brutto Leistung(KW)**	30.0989
Kondensatortemperatur(°C	20	**Realer Wirkungsgrad**	6.5012
		Isentroper Wirkungsgrad	12.0744
		Rankinemassenstrom(Kg/s)	1.8663

Thermalwasser

Druck(MPa)	1	**Zugeführte Wärme (KW)**	446.6371
Eintrittstemperatur(°C)	85	**Austrittstemperatur(°C)**	76.1284
Massenstrom (Kg/s)	12		

Wärmetauscher

Grädigkeit	4	**Eintrittstemperaturdifferenz**	55.8309
Druckverlust(MPa)	0.02	**Austrittstemperaturdifferenz**	4

Kondensator

Grädigkeit	4	**Eintrittstemperaturdifferenz**	32.866
Druckverlust(MPa)	0.02	**Austrittstemperaturdifferenz**	5

Kühlwasser

Druck(MPa)	1	**Abgeführte Wärme(KW)**	417.6002
Eintrittstemperatur(°C)	15	**Austrittstemperatur(°C)**	20.1463
		Massenstrom(Kg/s)	19.3978

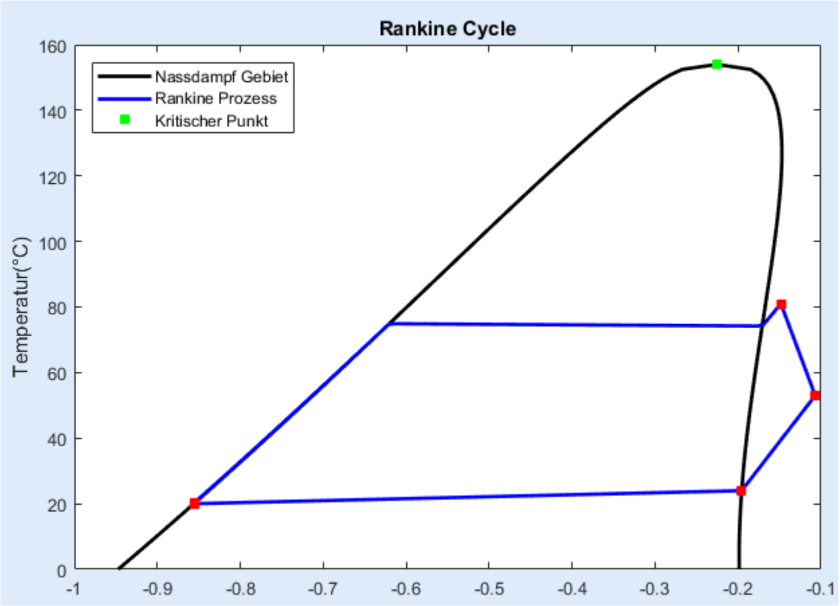


Figure 18: Electratherm's POWER+Generator 4200 possible working conditions as simulated by GeSi with hot source at 85°C

3.3.2 Enogia – ENO-LT

The French company Enogia also provides a solutions for when the hot source has a temperature as low as 85°C: this is the “ENO-LT” series, that ranges from 10 to 180 kW$_e$ gross power production. Up to 100 kW the unit is composed by a single system or circuit, whereas larger installations are composed of two circuits in the same unit. The unit is always complete and packaged, including all the components needed for a reliable and efficient heat to power conversion.

The installation is also quite simple: hot loop and cold loop are connected to the ORC with standard ISO PN16 flanges, electrical output is connected to the grid directly with the grid feed inverter, and communication with the fully automated control system is made via Ethernet. The dimensions of the 100 kW unit are shown in Figure 19 and Table 4.

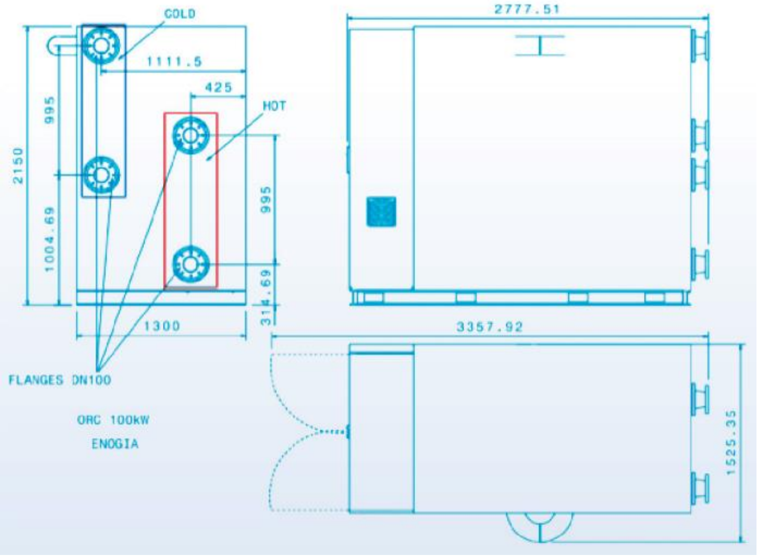


Figure 19: Typical dimension of the 100 kW ENO-LT unit

Table 4: Characteristics of the ENO-LT series by Enogia

Hot source temperature	80-100°C
Cold source temperature	10-30°C
Single-circuit gross power production	10-100 kW$_e$
Double-circuit gross power production	100-180 kW$_e$
Working fluid	R1233zd
Heat flux	Up to 1.4 MW at 90°C
Efficency	From 6 to 10%
Weight	About 2.6 tons
Inlet fluid conditions	Water/glycol
Low temperature startup	60°C
Max temperature	100°C
Main dimensions	
Length	2.80 m
Width	1.50 m
Height	2.16 m

Connections	
Hot loop	2 ISO flanges DN100 PN16
Cold loop	2 ISO flanges DN100 PN16
Electrical output	400V 50Hz 3ph
Data	Ethernet RJ45

According to a model internally run by Enogia, their 100 kW single-circuit product should run as detailed in Figure 20 and Table 5

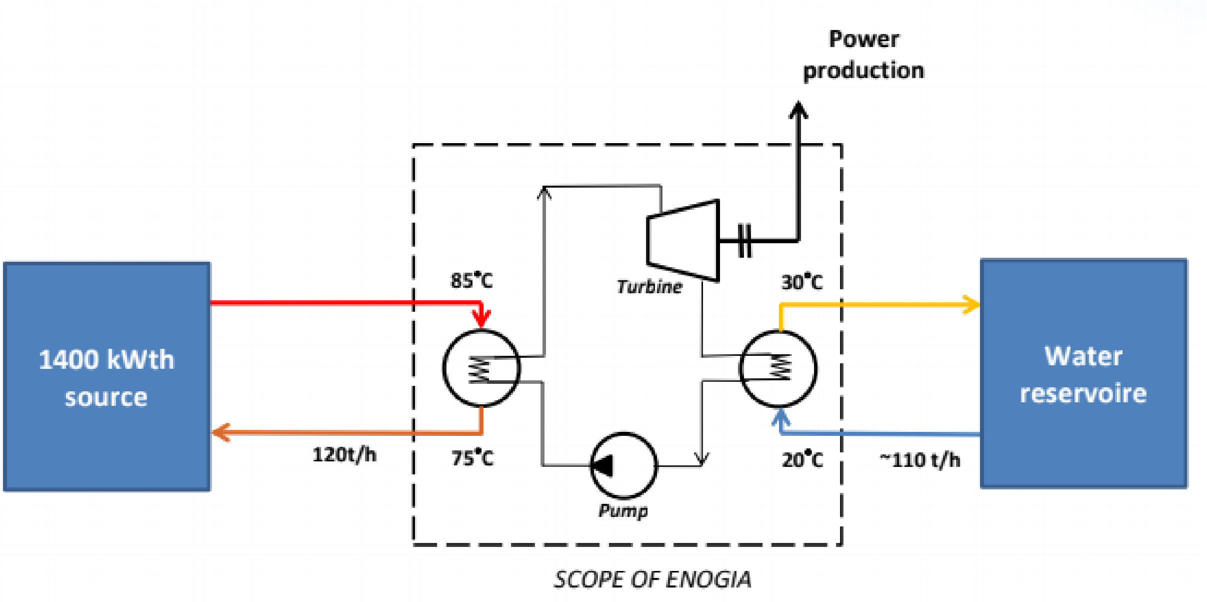
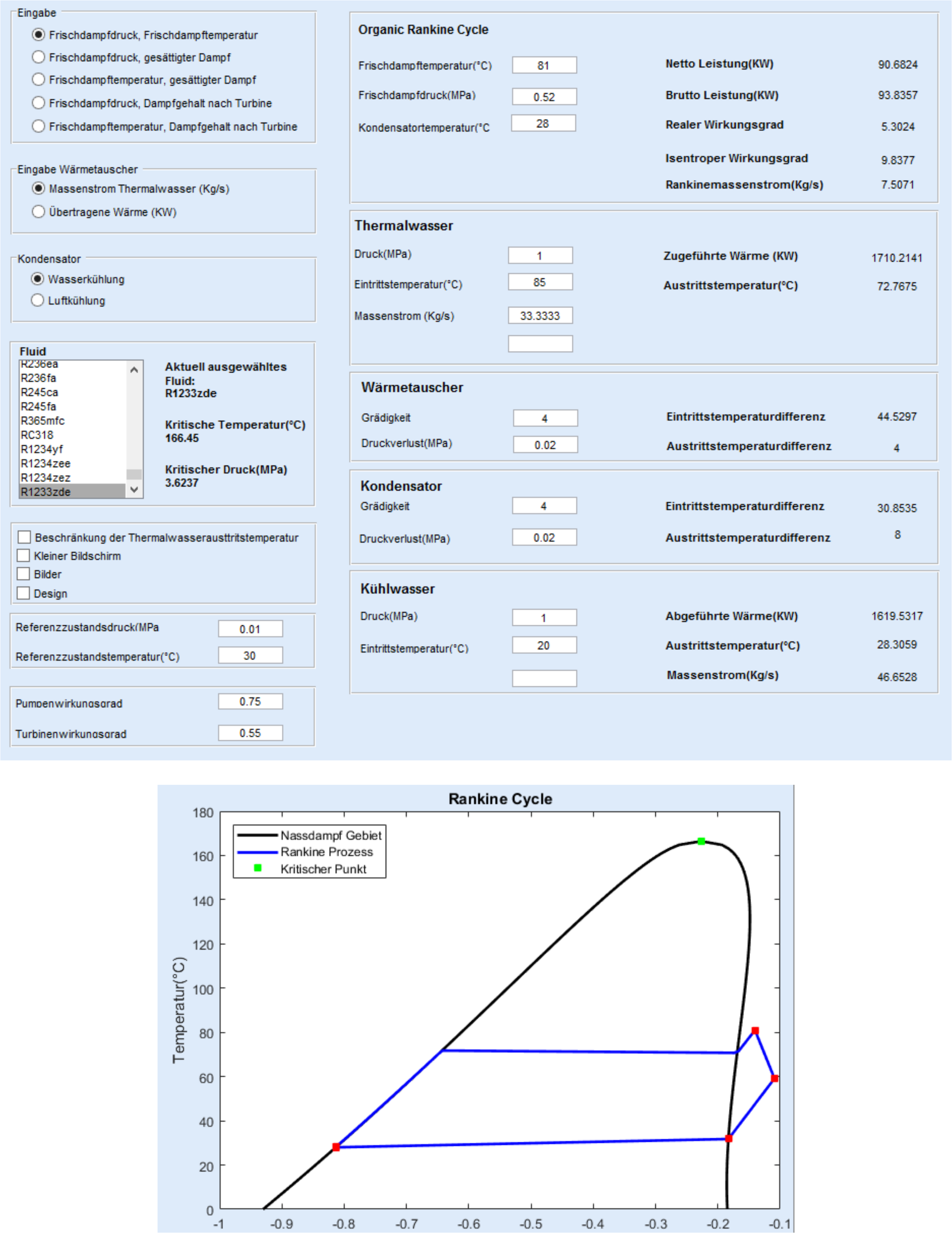


Figure 20: Running conditions of the 100 kW configuration of the ENO-LT product with 85°C inlet

Table 5: Running conditions of the 100 kW configuration of the ENO-LT product with 85°C inlet

Hot side	
Thermal power	1400 kW_{th}
Fluid:	Water
Inlet temperature	85°C
Outlet temperature	75°C
Flow rate	120 m^3/h (33.33 l/s)
Cold side	
Fluid	Water
Inlet temperature	20°C
Outlet temperature	30°C
Flow rate	About 110 m^3/h (30.56 l/s)
Performance	
Gross production	96 kW_e
Net production	89 kW_e

The same conditions are simulated with the software GeSi to analyse the working conditions (Figure 21)



Eingabe

- ● Frischdampfdruck, Frischdampftemperatur
- ○ Frischdampfdruck, gesättigter Dampf
- ○ Frischdampftemperatur, gesättigter Dampf
- ○ Frischdampfdruck, Dampfgehalt nach Turbine
- ○ Frischdampftemperatur, Dampfgehalt nach Turbine

Eingabe Wärmetauscher

- ● Massenstrom Thermalwasser (Kg/s)
- ○ Übertragene Wärme (KW)

Kondensator

- ● Wasserkühlung
- ○ Luftkühlung

Fluid

R236ea
R236fa
R245ca
R245fa
R365mfc
RC318
R1234yf
R1234zee
R1234zez
R1233zde

Aktuell ausgewähltes Fluid:
R1233zde

Kritische Temperatur(°C)
166.45

Kritischer Druck(MPa)
3.6237

- ☐ Beschränkung der Thermalwasseraustritstemperatur
- ☐ Kleiner Bildschirm
- ☐ Bilder
- ☐ Design

Referenzzustandsdruck(MPa	0.01
Referenzzustandstemperatur(°C)	30
Pumpenwirkungsgrad	0.75
Turbinenwirkungsgrad	0.55

Organic Rankine Cycle

Frischdampftemperatur(°C)	81	**Netto Leistung(KW)**	90.6824
Frischdampfdruck(MPa)	0.52	**Brutto Leistung(KW)**	93.8357
Kondensatortemperatur(°C	28	**Realer Wirkungsgrad**	5.3024
		Isentroper Wirkungsgrad	9.8377
		Rankinemassenstrom(Kg/s)	7.5071

Thermalwasser

Druck(MPa)	1	**Zugeführte Wärme (KW)**	1710.2141
Eintrittstemperatur(°C)	85	**Austrittstemperatur(°C)**	72.7675
Massenstrom (Kg/s)	33.3333		

Wärmetauscher

Grädigkeit	4	**Eintrittstemperaturdifferenz**	44.5297
Druckverlust(MPa)	0.02	**Austrittstemperaturdifferenz**	4

Kondensator

Grädigkeit	4	**Eintrittstemperaturdifferenz**	30.8535
Druckverlust(MPa)	0.02	**Austrittstemperaturdifferenz**	8

Kühlwasser

Druck(MPa)	1	**Abgeführte Wärme(KW)**	1619.5317
Eintrittstemperatur(°C)	20	**Austrittstemperatur(°C)**	28.3059
		Massenstrom(Kg/s)	46.6528

Figure 21: Enogia's ENO-LT 100 kW possible working conditions as simulated by GeSi with hot source at 85°C

Their highest capacity product (180 kW) can also run with a hot source of 85°C, as simulated in Figure 22 and Table 6.

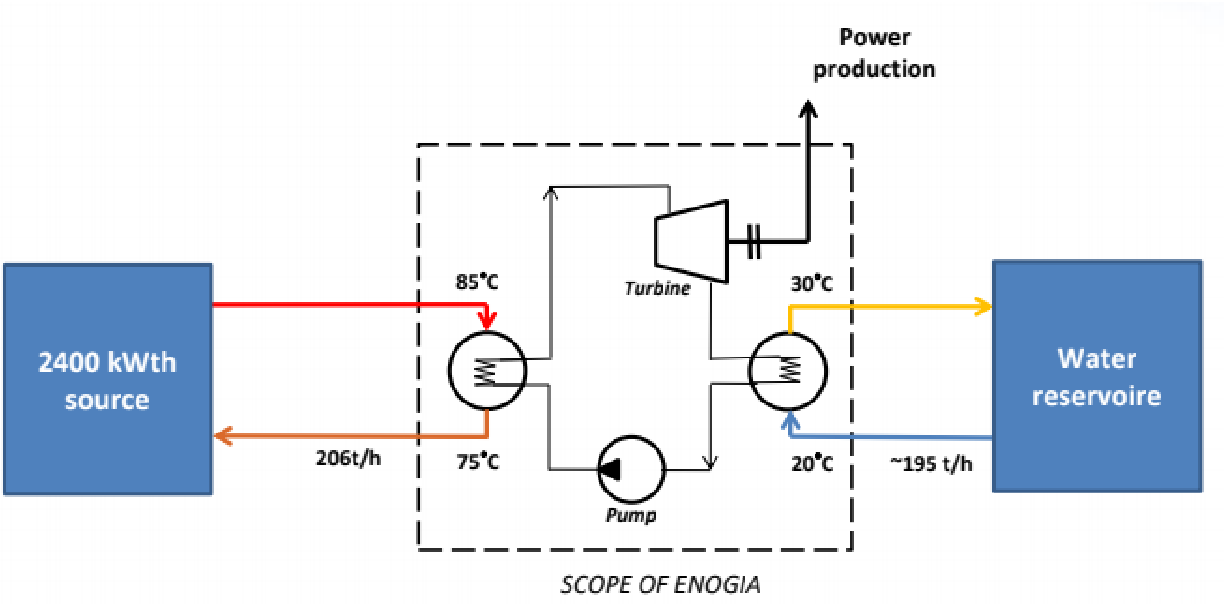
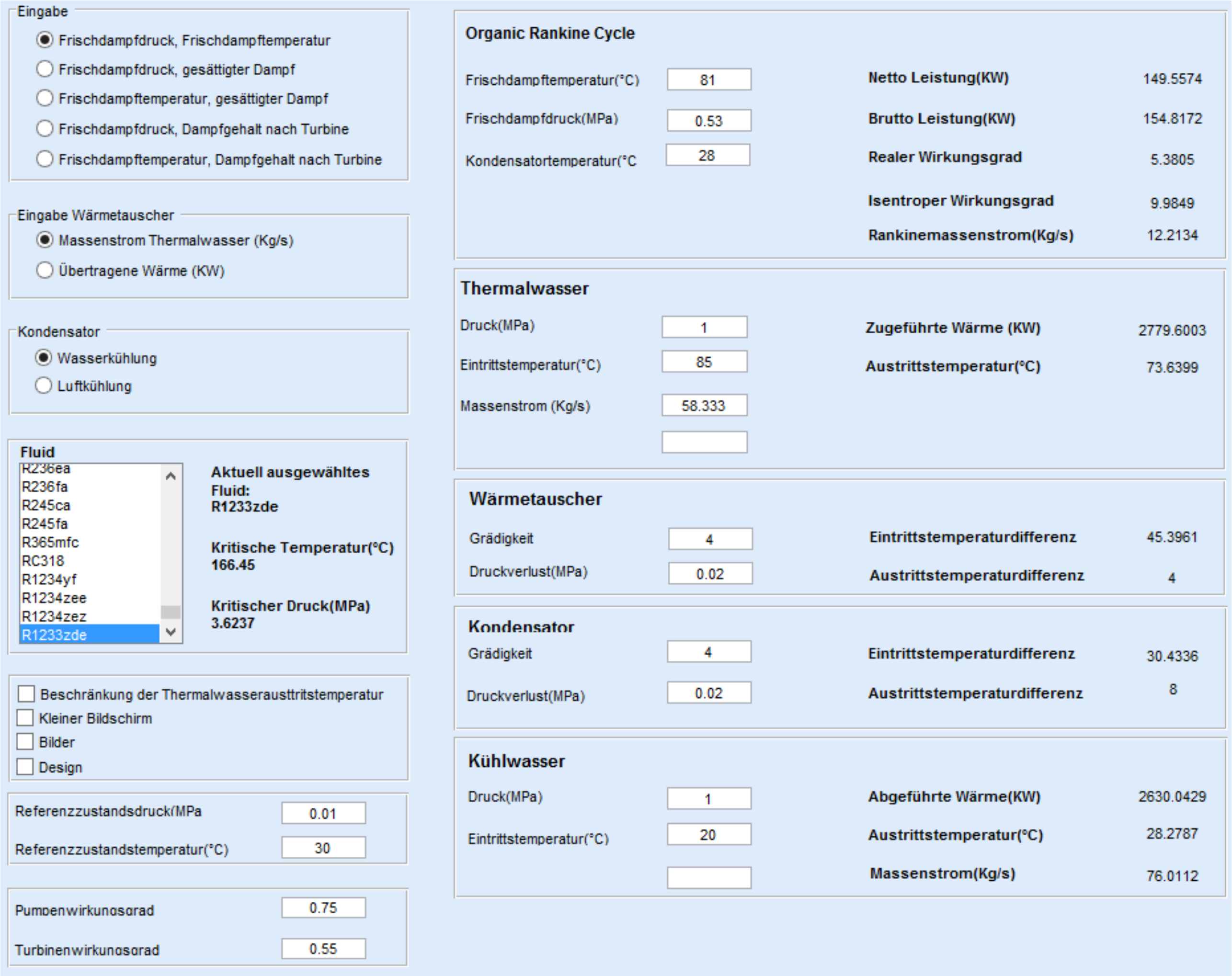


Figure 22: Running conditions of the 180 kW configuration of the ENO-LT product with 85°C inlet

Table 6: Running conditions of the 180 kW configuration of the ENO-LT product with 85°C inlet

Hot side	
Thermal power	2400 kW_{th}
Fluid:	Water
Inlet temperature	85°C
Outlet temperature	75°C
Flow rate	206 m^3/h (58.33 l/s)
Cold side	
Fluid	Water
Inlet temperature	20°C
Outlet temperature	30°C
Flow rate	About 196 m^3/h (54.44 l/s)
Performance	
Gross production	156 kW_e
Net production	144 kW_e

The GeSi simulation is shown in Figure 23.



Eingabe
● Frischdampfdruck, Frischdampftemperatur
○ Frischdampfdruck, gesättigter Dampf
○ Frischdampftemperatur, gesättigter Dampf
○ Frischdampfdruck, Dampfgehalt nach Turbine
○ Frischdampftemperatur, Dampfgehalt nach Turbine

Eingabe Wärmetauscher
● Massenstrom Thermalwasser (Kg/s)
○ Übertragene Wärme (KW)

Kondensator
● Wasserkühlung
○ Luftkühlung

Fluid
R236ea
R236fa
R245ca
R245fa
R365mfc
RC318
R1234yf
R1234zee
R1234zez
R1233zde

Aktuell ausgewähltes Fluid:
R1233zde

Kritische Temperatur(°C)
166.45

Kritischer Druck(MPa)
3.6237

☐ Beschränkung der Thermalwasseraustrittstemperatur
☐ Kleiner Bildschirm
☐ Bilder
☐ Design

Referenzzustandsdruck(MPa: 0.01
Referenzzustandstemperatur(°C): 30

Pumpenwirkungsgrad: 0.75
Turbinenwirkungsgrad: 0.55

Organic Rankine Cycle

Frischdampftemperatur(°C)	81	**Netto Leistung(KW)**	149.5574
Frischdampfdruck(MPa)	0.53	**Brutto Leistung(KW)**	154.8172
Kondensatortemperatur(°C	28	**Realer Wirkungsgrad**	5.3805
		Isentroper Wirkungsgrad	9.9849
		Rankinemassenstrom(Kg/s)	12.2134

Thermalwasser

Druck(MPa)	1	**Zugeführte Wärme (KW)**	2779.6003
Eintrittstemperatur(°C)	85	**Austrittstemperatur(°C)**	73.6399
Massenstrom (Kg/s)	58.333		

Wärmetauscher

Grädigkeit	4	**Eintrittstemperaturdifferenz**	45.3961
Druckverlust(MPa)	0.02	**Austrittstemperaturdifferenz**	4

Kondensator

Grädigkeit	4	**Eintrittstemperaturdifferenz**	30.4336
Druckverlust(MPa)	0.02	**Austrittstemperaturdifferenz**	8

Kühlwasser

Druck(MPa)	1	**Abgeführte Wärme(KW)**	2630.0429
Eintrittstemperatur(°C)	20	**Austrittstemperatur(°C)**	28.2787
		Massenstrom(Kg/s)	76.0112

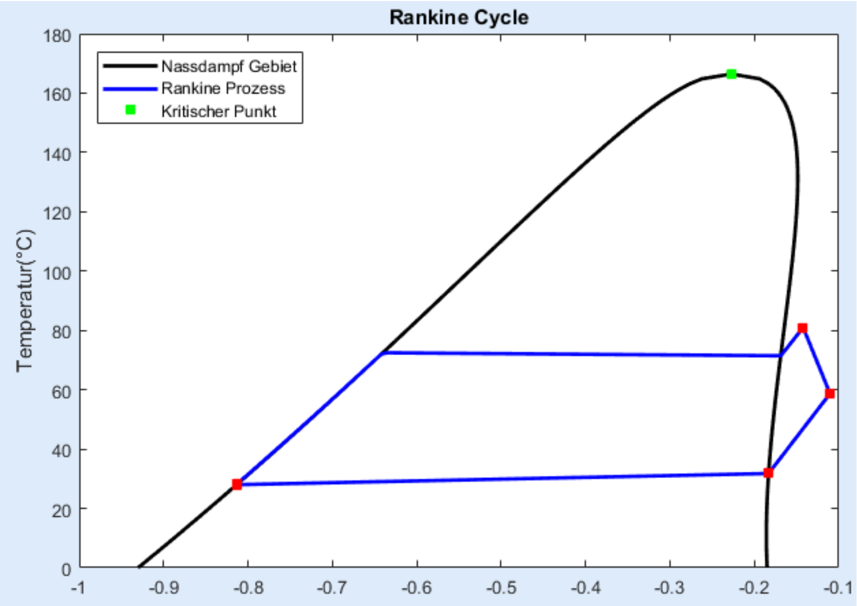


Figure 23: Enogia's ENO-LT 180 kW possible working conditions as simulated by GeSi with hot source at 85°C

3.3.3 Review of the 75°C and 85°C scenarios working conditions

To sum up the 75°C and 85°C scenarios, the working conditions of the considered ORC systems are shown in Figure 24. It is interesting to observe that when large power capacities are involved, the cold water flow rate becomes much higher than the hot water flow rate. The first data of the Power+Gen. 4200 is referred to the 75°C hot-source scenario.

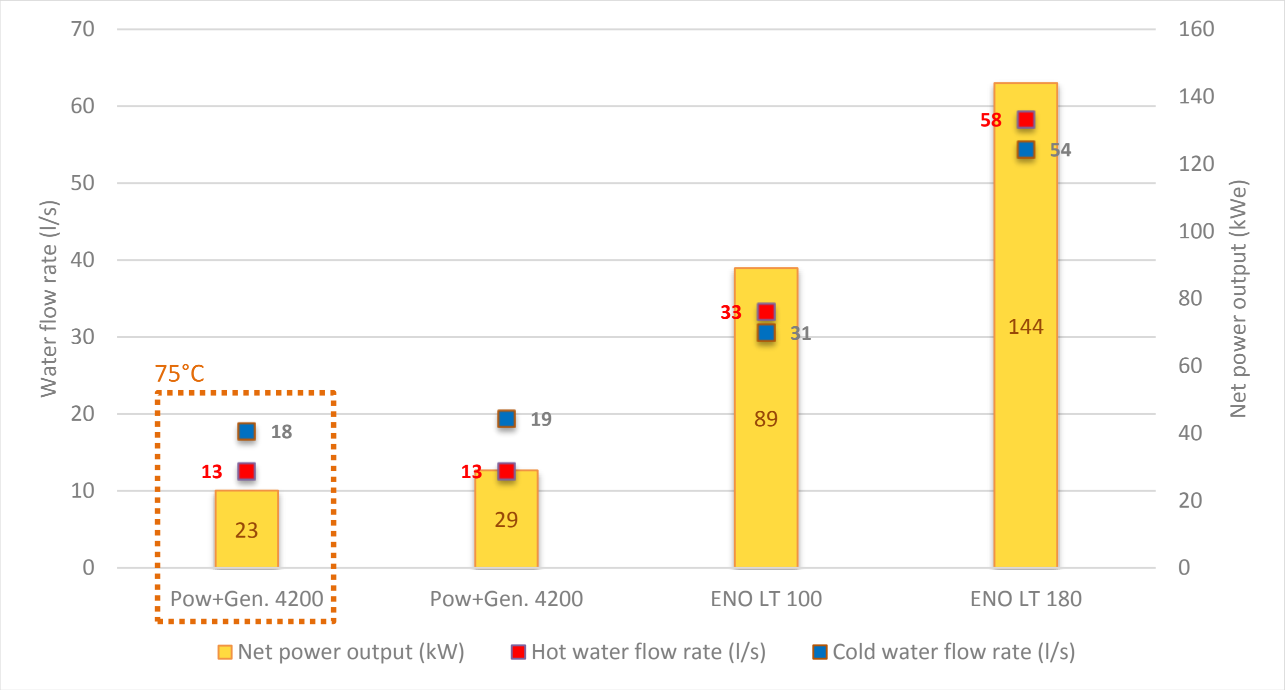


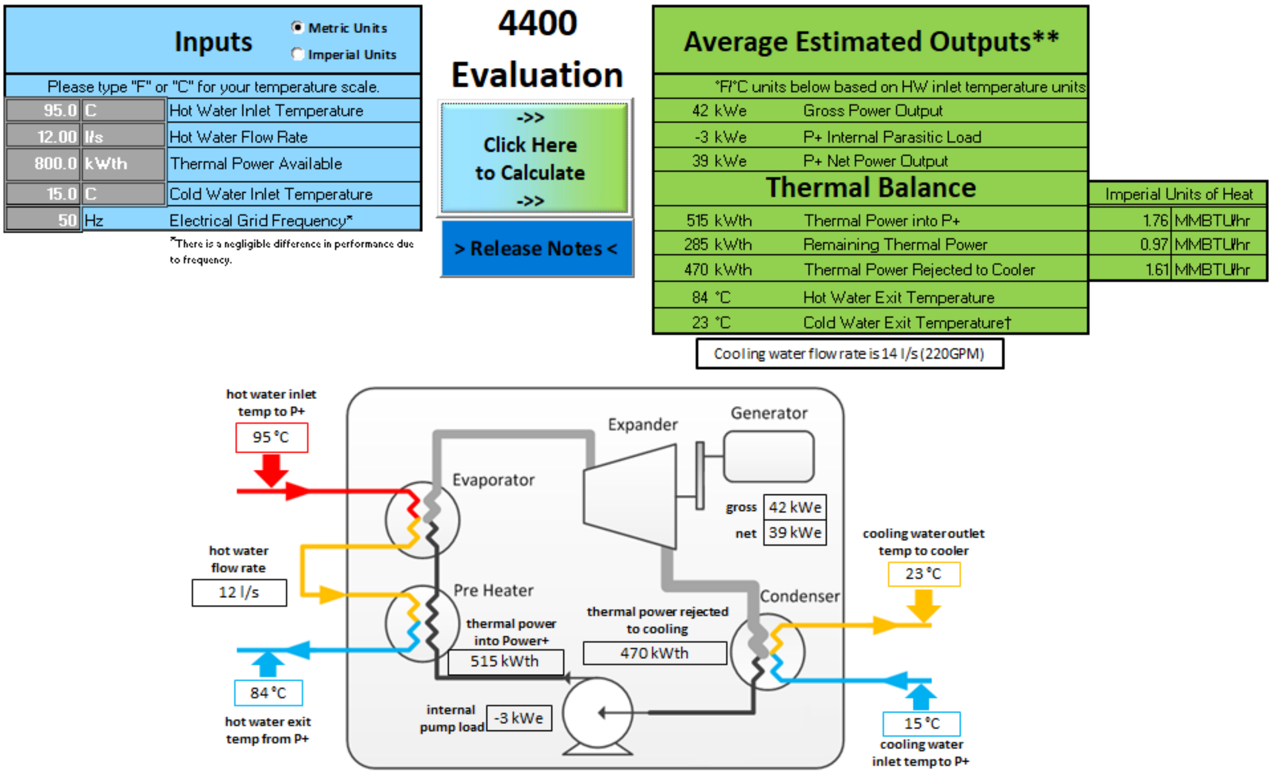
Figure 24: Working conditions of the evaluated ORC systems at 85°C hot-source temperature

3.4 Scenario C: hot source at 95°C

95°C is a temperature where ORC really start making an impact in power production, with quite a few installations already present in the world (similar to the one described in Chapter 1.4.6). Above 90°C, an interesting production can be achieved at satisfying efficiencies.

3.4.1 Electratherm – POWER+Generator

The Electratherm POWER+Generator 4400, a unit size larger than the previously presented 4200 version, is simulated to be working with the conditions shown in Figure 25



Inputs ● Metric Units ○ Imperial Units

Please type "F" or "C" for your temperature scale.

95.0	C	Hot Water Inlet Temperature
12.00	l/s	Hot Water Flow Rate
800.0	kWth	Thermal Power Available
15.0	C	Cold Water Inlet Temperature
50	Hz	Electrical Grid Frequency*

*There is a negligible difference in performance due to frequency.

Average Estimated Outputs**

*F/°C units below based on HW inlet temperature units

42	kWe	Gross Power Output
-3	kWe	P+ Internal Parasitic Load
39	kWe	P+ Net Power Output

Thermal Balance

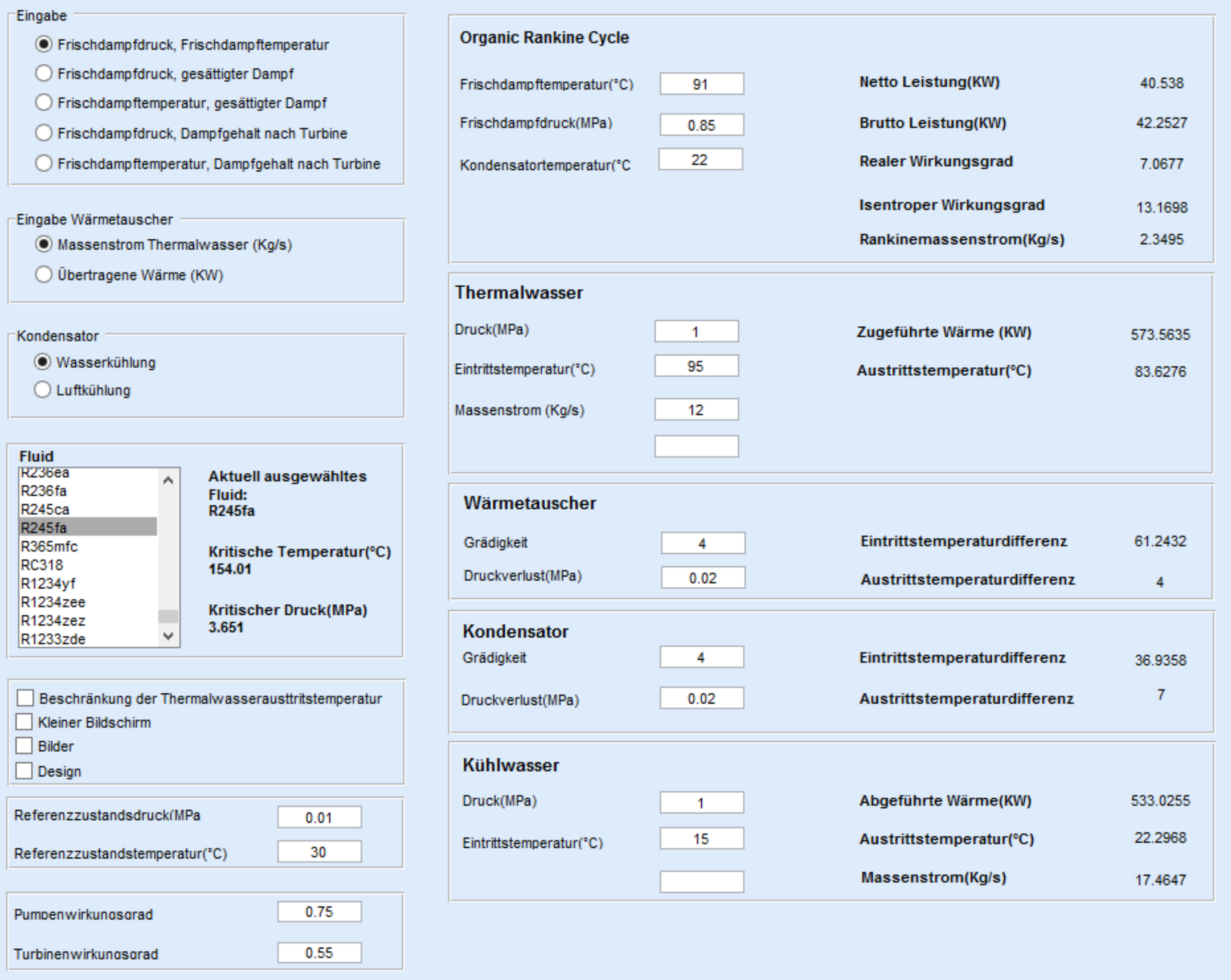
			Imperial Units of Heat	
515	kWth	Thermal Power into P+	1.76	MMBTU/hr
285	kWth	Remaining Thermal Power	0.97	MMBTU/hr
470	kWth	Thermal Power Rejected to Cooler	1.61	MMBTU/hr
84	°C	Hot Water Exit Temperature		
23	°C	Cold Water Exit Temperature†		

Cooling water flow rate is 14 l/s (220GPM)

Figure 25: Simulation of the POWER+Generator 4400 with a hot source of 95°C and 12 l/s flow rate

Figure 25Figure 17 shows the simulation of what the system would work like with hot source conditions equal to 95°C and 12 l/s, and cold source temperature of 15°C. The simulation shows that the expected gross power output is 42 kW_e. This can also be confirmed by the graph in Figure 14.

Reproducing the cycle in GeSi, the working conditions are shown in Figure 26Figure 18.



Eingabe
- ● Frischdampfdruck, Frischdampftemperatur
- ○ Frischdampfdruck, gesättigter Dampf
- ○ Frischdampftemperatur, gesättigter Dampf
- ○ Frischdampfdruck, Dampfgehalt nach Turbine
- ○ Frischdampftemperatur, Dampfgehalt nach Turbine

Eingabe Wärmetauscher
- ● Massenstrom Thermalwasser (Kg/s)
- ○ Übertragene Wärme (KW)

Kondensator
- ● Wasserkühlung
- ○ Luftkühlung

Aktuell ausgewähltes Fluid:
R245fa

Kritische Temperatur(°C)
154.01

Kritischer Druck(MPa)
3.651

- ☐ Beschränkung der Thermalwasserausttritstemperatur
- ☐ Kleiner Bildschirm
- ☐ Bilder
- ☐ Design

Referenzzustandsdruck(MPa 0.01
Referenzzustandstemperatur(°C) 30

Pumpenwirkungsgrad 0.75
Turbinenwirkungsgrad 0.55

Organic Rankine Cycle

Frischdampftemperatur(°C)	91	**Netto Leistung(KW)**	40.538
Frischdampfdruck(MPa)	0.85	**Brutto Leistung(KW)**	42.2527
Kondensatortemperatur(°C	22	**Realer Wirkungsgrad**	7.0677
		Isentroper Wirkungsgrad	13.1698
		Rankinemassenstrom(Kg/s)	2.3495

Thermalwasser

Druck(MPa)	1	**Zugeführte Wärme (KW)**	573.5635
Eintrittstemperatur(°C)	95	**Austrittstemperatur(°C)**	83.6276
Massenstrom (Kg/s)	12		

Wärmetauscher

Grädigkeit	4	**Eintrittstemperaturdifferenz**	61.2432
Druckverlust(MPa)	0.02	**Austrittstemperaturdifferenz**	4

Kondensator

Grädigkeit	4	**Eintrittstemperaturdifferenz**	36.9358
Druckverlust(MPa)	0.02	**Austrittstemperaturdifferenz**	7

Kühlwasser

Druck(MPa)	1	**Abgeführte Wärme(KW)**	533.0255
Eintrittstemperatur(°C)	15	**Austrittstemperatur(°C)**	22.2968
		Massenstrom(Kg/s)	17.4647

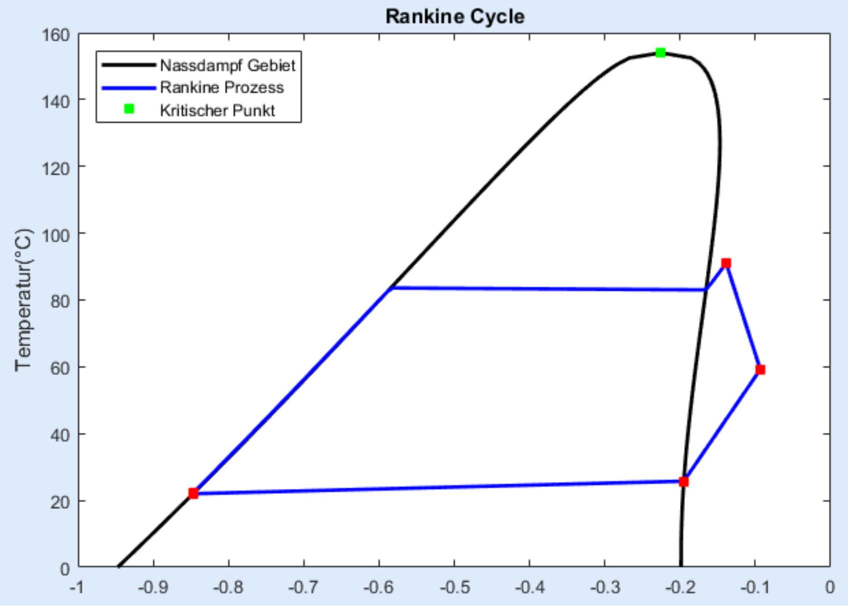


Figure 26: Electratherm's POWER+Generator 4400 possible working conditions as simulated by GeSi with hot source at 95°C

3.4.2 Enogia – ENO-LT

The same ENO-LT product can be run at the temperature of 95°C. However the flow rate in this case must decrease from 33.33 to 30 l/s for the 100 kW case (Figure 27 , and from 58.33 to 55.56 l/s for the 180 kW case.

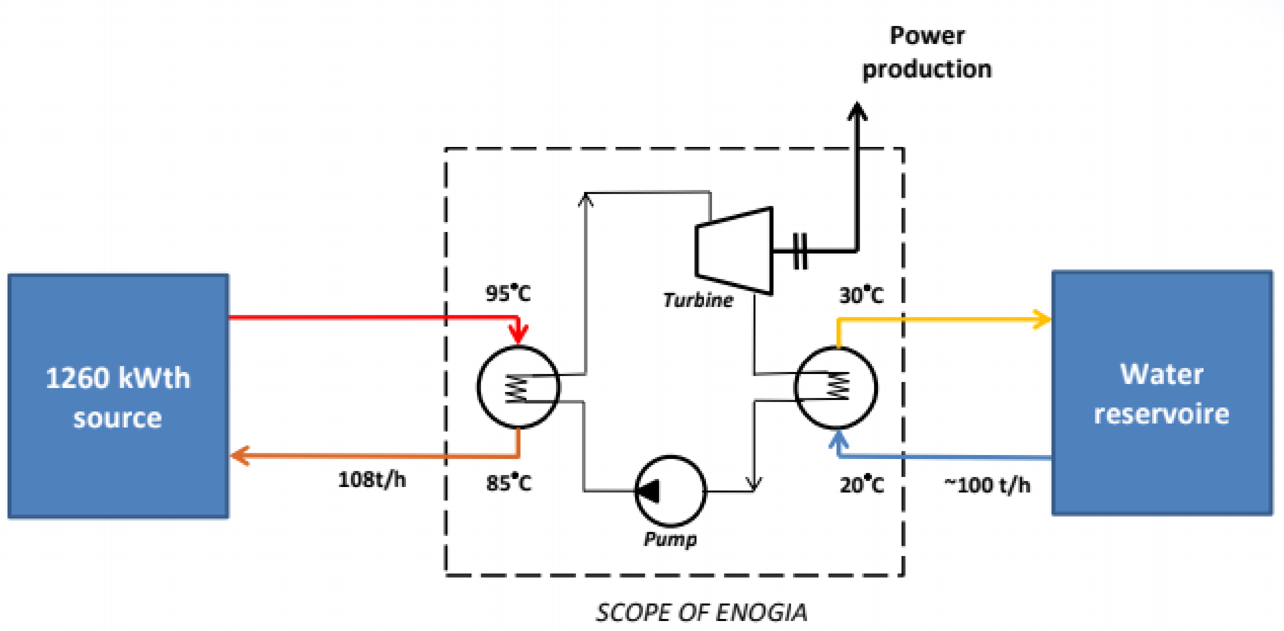
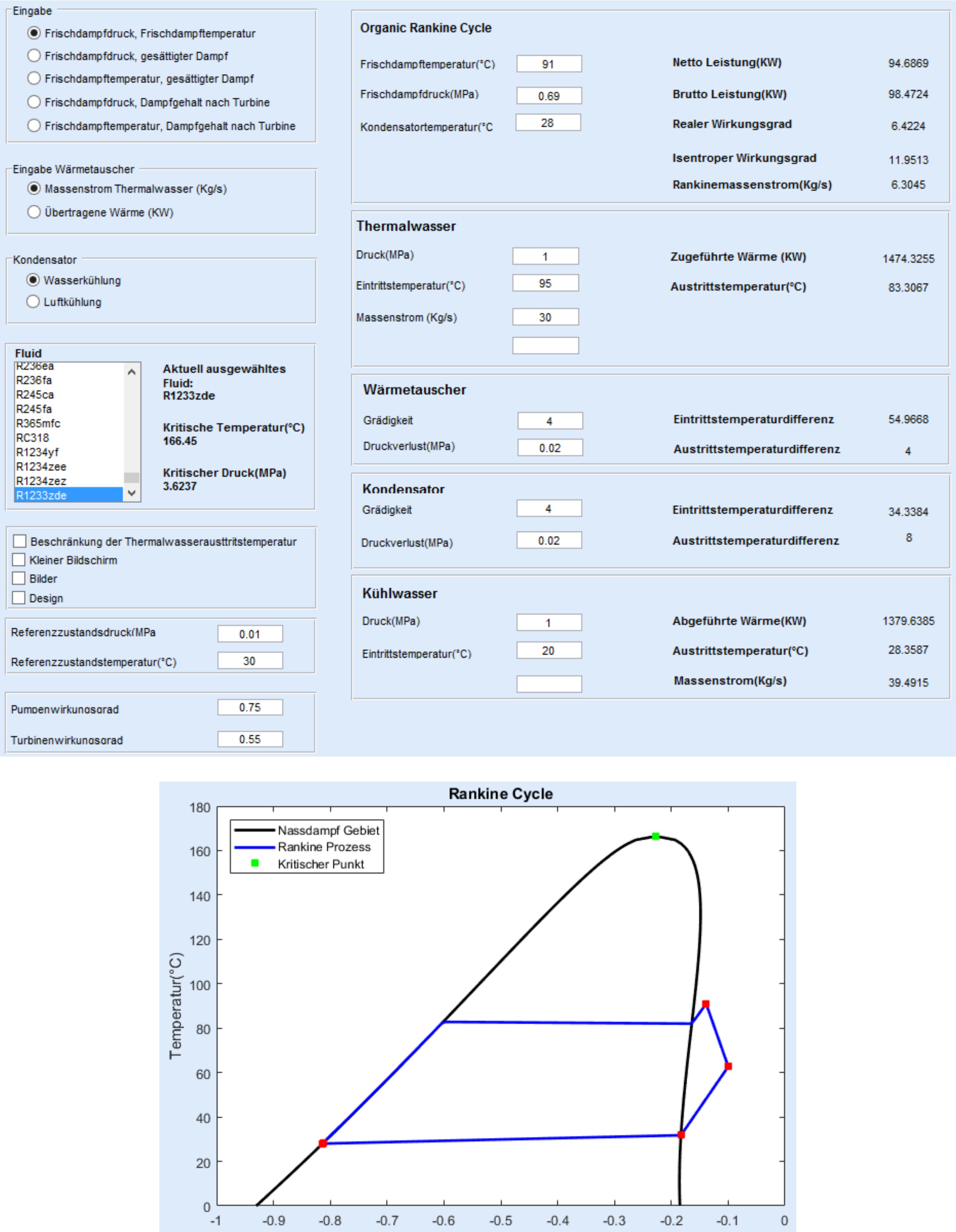


Figure 27: Running conditions of the 100 kW configuration of the ENO-LT product with 95°C inlet

Table 7: Running conditions of the 100 kW configuration of the ENO-LT product with 95°C inlet

Hot side	
Thermal power	1260 kW_{th}
Fluid:	Water
Inlet temperature	95°C
Outlet temperature	85°C
Flow rate	108 m^3/h (30 l/s)
Cold side	
Fluid	Water
Inlet temperature	20°C
Outlet temperature	30°C
Flow rate	About 100 m^3/h (27.78 l/s)
Performance	
Gross production	100 kW_e
Net production	92 kW_e



Eingabe
- ● Frischdampfdruck, Frischdampftemperatur
- ○ Frischdampfdruck, gesättigter Dampf
- ○ Frischdampftemperatur, gesättigter Dampf
- ○ Frischdampfdruck, Dampfgehalt nach Turbine
- ○ Frischdampftemperatur, Dampfgehalt nach Turbine

Eingabe Wärmetauscher
- ● Massenstrom Thermalwasser (Kg/s)
- ○ Übertragene Wärme (KW)

Kondensator
- ● Wasserkühlung
- ○ Luftkühlung

Fluid

R236ea
R236fa
R245ca
R245fa
R365mfc
RC318
R1234yf
R1234zee
R1234zez
R1233zde

Aktuell ausgewähltes Fluid:
R1233zde

Kritische Temperatur(°C)
166.45

Kritischer Druck(MPa)
3.6237

- ☐ Beschränkung der Thermalwasserausttritstemperatur
- ☐ Kleiner Bildschirm
- ☐ Bilder
- ☐ Design

Referenzzustandsdruck(MPa	0.01
Referenzzustandstemperatur(°C)	30
Pumpenwirkungsgrad	0.75
Turbinenwirkungsgrad	0.55

Organic Rankine Cycle

Frischdampftemperatur(°C)	91	**Netto Leistung(KW)**	94.6869
Frischdampfdruck(MPa)	0.69	**Brutto Leistung(KW)**	98.4724
Kondensatortemperatur(°C	28	**Realer Wirkungsgrad**	6.4224
		Isentroper Wirkungsgrad	11.9513
		Rankinemassenstrom(Kg/s)	6.3045

Thermalwasser

Druck(MPa)	1	**Zugeführte Wärme (KW)**	1474.3255
Eintrittstemperatur(°C)	95	**Austrittstemperatur(°C)**	83.3067
Massenstrom (Kg/s)	30		

Wärmetauscher

Grädigkeit	4	**Eintrittstemperaturdifferenz**	54.9668
Druckverlust(MPa)	0.02	**Austrittstemperaturdifferenz**	4

Kondensator

Grädigkeit	4	**Eintrittstemperaturdifferenz**	34.3384
Druckverlust(MPa)	0.02	**Austrittstemperaturdifferenz**	8

Kühlwasser

Druck(MPa)	1	**Abgeführte Wärme(KW)**	1379.6385
Eintrittstemperatur(°C)	20	**Austrittstemperatur(°C)**	28.3587
		Massenstrom(Kg/s)	39.4915

Figure 28: Enogia's ENO-LT 100 kW possible working conditions as simulated by GeSi with hot source at 95°C

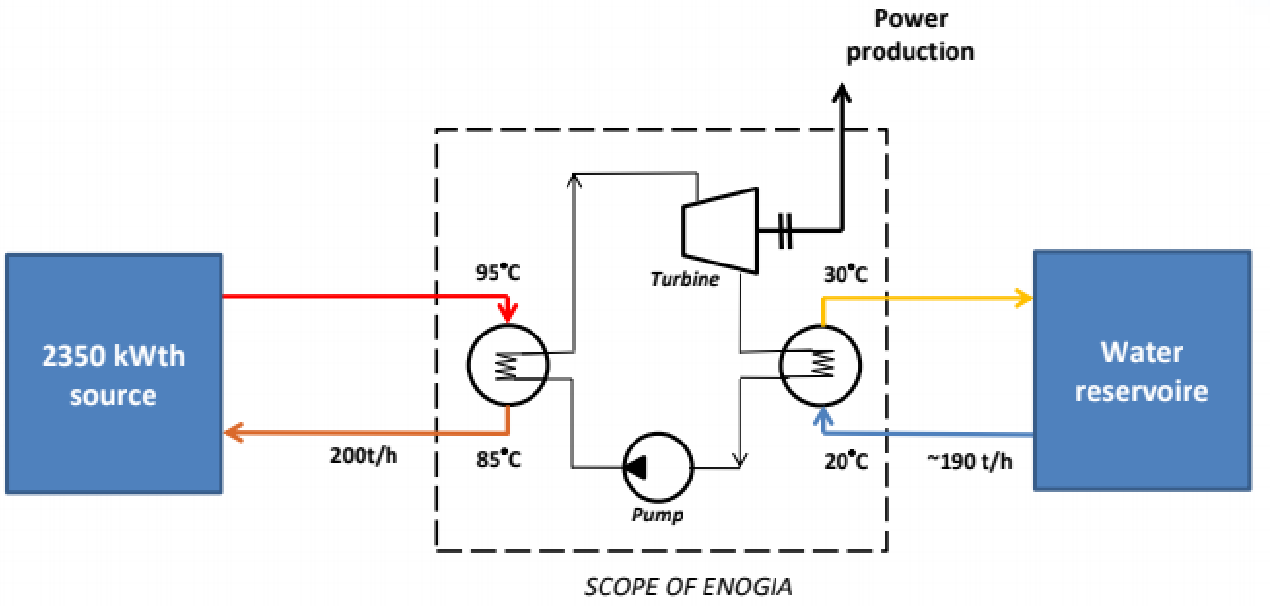


Figure 29: Running conditions of the 180 kW configuration of the ENO-LT product with 95°C inlet

Table 8: Running conditions of the 180 kW configuration of the ENO-LT product with 95°C inlet

Hot side	
Thermal power	2350 kW_{th}
Fluid:	Water
Inlet temperature	95°C
Outlet temperature	85°C
Flow rate	200 m^3/h (55.56 l/s)
Cold side	
Fluid	Water
Inlet temperature	20°C
Outlet temperature	30°C
Flow rate	About 190 m^3/h (52.78 l/s)
Performance	
Gross production	180 kW_e
Net production	162 kW_e

Eingabe
● Frischdampfdruck, Frischdampftemperatur
○ Frischdampfdruck, gesättigter Dampf
○ Frischdampftemperatur, gesättigter Dampf
○ Frischdampfdruck, Dampfgehalt nach Turbine
○ Frischdampftemperatur, Dampfgehalt nach Turbine

Eingabe Wärmetauscher
● Massenstrom Thermalwasser (Kg/s)
○ Übertragene Wärme (KW)

Kondensator
● Wasserkühlung
○ Luftkühlung

Fluid
R236ea
R236fa
R245ca
R245fa
R365mfc
RC318
R1234yf
R1234zee
R1234zez
R1233zde

Aktuell ausgewähltes Fluid:
R1233zde

Kritische Temperatur(°C)
166.45

Kritischer Druck(MPa)
3.6237

☐ Beschränkung der Thermalwasserausttritstemperatur
☐ Kleiner Bildschirm
☐ Bilder
☐ Design

Referenzzustandsdruck(MPa 0.01
Referenzzustandstemperatur(°C) 30

Pumpenwirkungsgrad 0.75
Turbinenwirkungsgrad 0.55

Organic Rankine Cycle
Frischdampftemperatur(°C) 91
Frischdampfdruck(MPa) 0.69
Kondensatortemperatur(°C 28
Netto Leistung(KW) 175.3602
Brutto Leistung(KW) 182.3708
Realer Wirkungsgrad 6.4224
Isentroper Wirkungsgrad 11.9513
Rankinemassenstrom(Kg/s) 11.6759

Thermalwasser
Druck(MPa) 1
Eintrittstemperatur(°C) 95
Massenstrom (Kg/s) 55.56
Zugeführte Wärme (KW) 2730.4508
Austrittstemperatur(°C) 83.3067

Wärmetauscher
Grädigkeit 4
Druckverlust(MPa) 0.02
Eintrittstemperaturdifferenz 54.9668
Austrittstemperaturdifferenz 4

Kondensator
Grädigkeit 4
Druckverlust(MPa) 0.02
Eintrittstemperaturdifferenz 34.3384
Austrittstemperaturdifferenz 8

Kühlwasser
Druck(MPa) 1
Eintrittstemperatur(°C) 20
Abgeführte Wärme(KW) 2555.0906
Austrittstemperatur(°C) 28.3587
Massenstrom(Kg/s) 73.1383

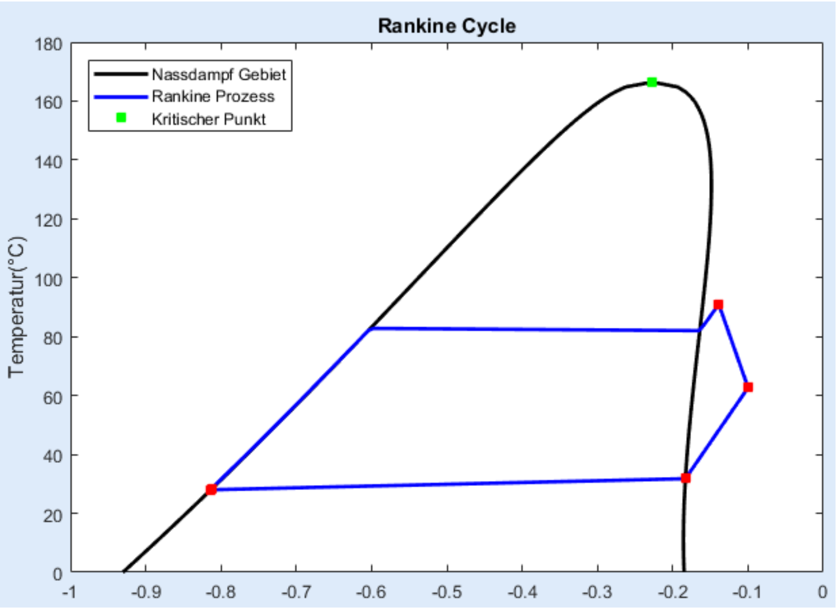


Figure 30: Enogia's ENO-LT 180 kW possible working conditions as simulated by GeSi with hot source at 95°C

3.4.3 Zuccato – ULH and ULH+

Zuccato presents two series of products that can work with temperatures equal or higher than 94°C. These are the ULH and the ULH+ series, where their main difference is their power production, with the ULH series ranging from 30 to 50 kW and the ULH+ ranging from 200 to 300 kW.

The working fluid used by Zuccato is made in-house and its information is not public. Therefore, it becomes impossible to simulate the working conditions of their products. This special working fluid is used in all Zuccato systems. Its working range (60-165°C) and it is non-toxic, non-flammable, 100% biodegradable and ozone-friendly HFC (hydro-fluoro-carbon) mixture.

Table 9: Characteristics of the ULH and ULH+ series by Zuccato

General specifications	**ZE-30-ULH**	**ZE-40-ULH**	**ZE-50-ULH**	**ZE-200-ULH+**	**ZE-250-ULH+**	**ZE-300-ULH+**
Thermal power input (kWt)	350	450	550	2500	3050	3600
Gross Electric power output (kWe)	30	40	50	200	250	300
Net Electric power output (kWe)	25.5	36.4	45.2	184.0	229.5	275.1
System efficiency	8.50%	8.90%	9.60%	8,0 %	8.2 %	8.3 %
Working fluid	Environment-friendly, non-flammable hydrofluorocarbon mixture					
Vector fluid	Hot water					
Vector fluid input temp.	≥94°C			≥95°C		
Vector fluid output temp.	86°C			80°C		
Vector fluid nominal flow rate	10.20 l/s	13.40 l/s	14.90 l/s	39,70 l/s	48,40 l/s	57.10 l/s
Skid dimensions (LxWxH)	3.8 x 1.2 x 2.3 m			6.2 x 2.6 x 3.2m		
Weight	3.1 t			n/a		
Condenser						
Type	Brazed plates heat exchanger in AISI 316 stainless and 99.9% copper					
Dissipated thermal power	310 kWt	390 kWt	470 kWt	2266 kWt	2758 kWt	3249 kWt
Water input temp.	26°C					
Water output temp.	31°C					
Water circuit nominal flowrate	14,81 l/s	18,65 l/s	22,46 l/s	108.27 l/s	131.75 l/s	155.24 l/s
Turbine						
Type	Radial, fixed nozzles, directly coupled to generator					
Working fluid input temp.	85°C			81°C		
Working fluid output temp.	~60°C					
Stage pressure	4,42 bar (tested up to 10 bar)					
Working fluid						
Working temperature range	60°C < T <165 °C					
Condensation Temperature	≤ 33 °C					
Operational pressure	≤ 20 bar					
Toxicity / Biodegradability / Ozone layer impact	Non-toxic / 100% biodegradable / ozone friendly					

3.4.4 Review of the 95°C scenario working conditions

To sum up the 95°C scenario, the working conditions of the considered ORC systems are shown in Figure 31. It is interesting to observe that when large power capacities are involved, the cold water flow rate becomes much higher than the hot water flow rate.

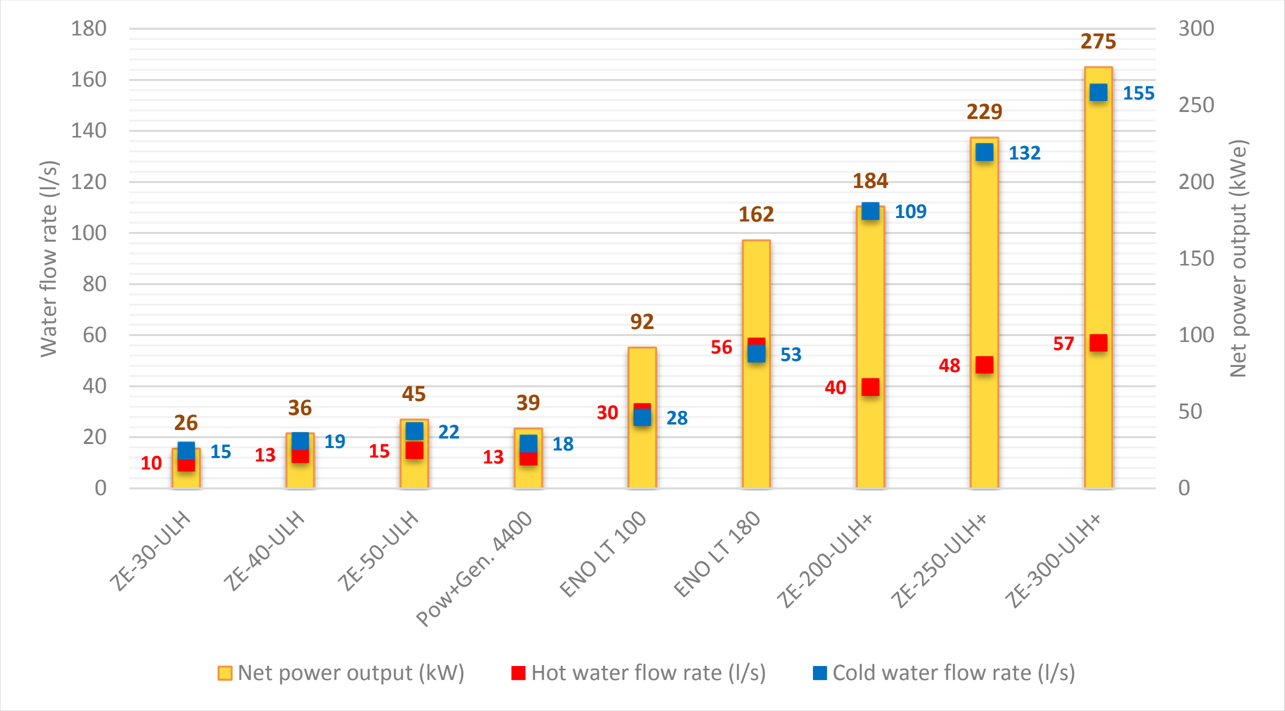


Figure 31: Working conditions of the evaluated ORC systems at 95°C hot-source temperature

3.5 Cost of the considered products

The three companies have been questioned upon their sale costs, and even if not all products have been priced, it has been possible to make an estimation of the price for all of them. In addition, refrigerant cost, commissioning and start-up, shipping and manual labour have also been added and are shown in Table 11 in Chapter 4.5.

4 Economic evaluation

Today, the tendency of ORC plants development is to improve the efficiency of the components to maximize the power production of such power plants, whilst keeping their cost as low as possible. A compromise between these two parameters is essential for the future development of ORCs for decentralized power production. Several ORC architectures have been presented in literature, with added components to the basic thermodynamic processes, with the aim of increasing the performance of the system. However, in small-scale ORCs, a simpler plant schematic is usually preferred, which is mainly driven by its capability of a lower specific cost. The cost of the power plant needs in fact to be low enough to guarantee a decent payback period to the end user (Quoilin and Lemort, 2009).

Generally, an important catalyst for the widespread dissemination of the ORC technology (and any other renewable energy production technology) is the price of electricity, i.e., the price at which industries buy electricity from the grid. In fact, those countries in which the specific price of the electrical energy is higher guarantee a more attractive payback period. Figure 32 displays the cost of non-household electricity in European countries for the period 2014–2016 (Eurostat, 2017).

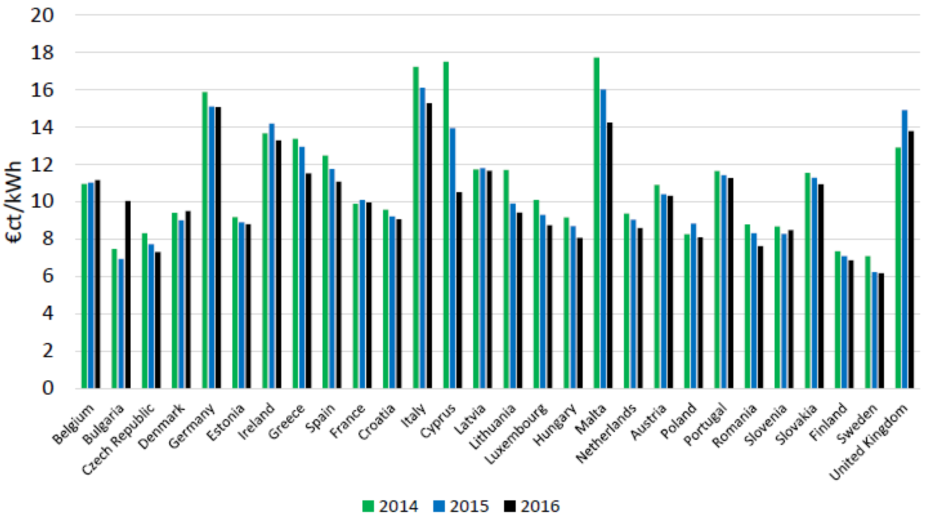


Figure 32: Electricity price for industries in European countries in the years 2014–2016 (Eurostat, 2017)

In Europe, Tocci et al., 2017, carried out an interesting study where they explain how a competitive specific cost for ORC technologies can been estimated from the comparison with the technologies currently available in the market. The specific cost of installed plants that are based on wind, solar PVs, internal combustion engines, gas turbines and hydro are shown in Figure 33.

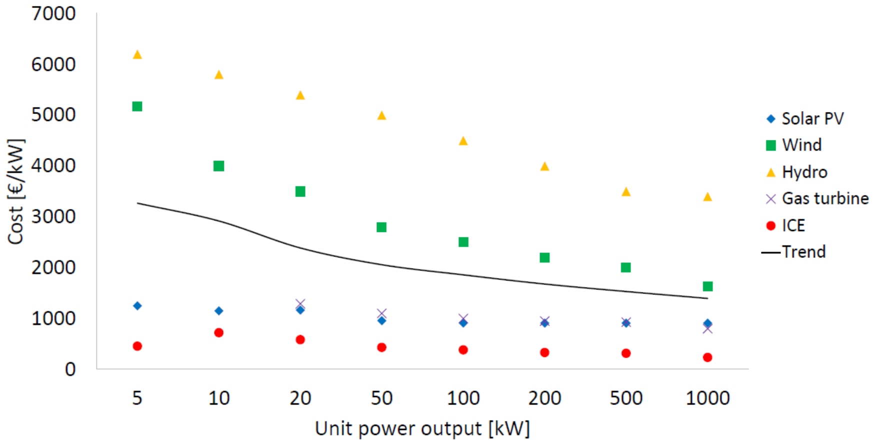


Figure 33: Investment costa s a function of installed capacity (Tocci et al., 2017)

The trend line in Figure 33 is representative of the average specific cost among all of the technologies considered. Tocci et al., 2017, argue that it is a good approximation to consider ORC competitive whenever the specific cost (€/kW) of the plant falls below this trend line. Therefore, based on the results shown in Figure 33, the specific cost of ORC units should not exceed the value of 3500 €/kW (4060 USD/kW) and 2500 €/kW (2900 USD/kW), respectively, in the power range of 5–10 kW and 10–100 kW. As observed in Chapter 4.5, the values offered by the evaluated products are in the suggested order of magnitude, with the higher size systems complying with the suggestion on the specific costs. Notice that the technologies that have a specific cost that is lower than the average value are combustion engines, gas turbines and solar. Arguably, all of them present some weaknesses with respect to the ORC technologies:

- gas turbines and ICEs burn fuel to produce electricity, emitting CO_2. The purchase of the fuel represents an additional cost to operate such plants, while the CO_2 emissions deny access to incentives and increase the emissions of greenhouse gases.
- PVs do not guarantee a continuous production of electricity during the day and throughout the year.

This is where an important mechanism becomes the main issue that can tip the scale in favour of ORC systems: incentive mechanisms. Examples of these are:

- Feed-in Tariffs (FiTs)
- Premium Tariffs (FiP)
- Green certificates/quota obligations
- Investment incentives
- Auctions/tenders
- Net metering

In this case, an investor that realizes an ORC plant covers his expenses through the earnings of selling the energy and the received incentives, therefore resulting in a lower payback period. It has been calculated that usually 4 years is a short enough payback period that guarantees the diffusion of a technology (Tocci et al., 2017).

4.1 The “RenovAr” Program: Argentina’s incentive scheme

In Argentina the Law No. 27191, published in 2015, establishes that renewable energies should reach 20% of the energy matrix by 2025. This is a great challenge, since current renewable energies only account for approximately 2% of total energy consumption.

To achieve this goal, the Government launched the plan “RenovAr”. This includes a regular public bidding processes in which different companies present their investment projects and the price at which they are willing to sell their capacity. CAMMESA (*Compañía Administradora del Mercado Mayorista Eléctrico*) is the body that administers these long-term agreements (PPA), which are stated in US Dollars.

So far, two tenders have been launched, with respective names RenovAr 1 and RenovAr 2, where a specific power amount was allowed divided according to the production source and the geographic location. In RenovAr 2, held last November, 66 projects were awarded, for wind, solar, biomass, biogas, landfill biogas and small-scale hydroelectric plants. With respect to the prices with which energy is sold, these have fallen in each auction, with averages in Round 1, held in July 2016, of $59.70 per MWh, while prices in Round 2 averaged $40.40 per MWh.

This year should see the introduction of geothermal energy for the first time in the RenovAr round 3, with the inclusion of only high-enthalpy projects such as the Copahue geothermal project in the Province of Neuquen. However, it is probable that next year, when RenovAr 4 is launched, even more technologies are introduced including ORC cycles. It is impossible to estimate to-date what their energy selling price will be, but an assumption can be made to carry out some calculations.

This study will evaluate the possibility to enter in the RenovAr program, or to carry out the project in a private way, with the sale of the electricity in the private market or with the self-consumption.

4.2 Description of costs and incomes

To analyse the situation in Santiago del Estero, it is fundamental to know what is the price that is being paid to the owner of the plant for the produced electricity. This will vastly depend on what scheme the ORC plant falls into or if it does not fall into any scheme. The calculations will be carried out including and excluding the participation of this technology to the RenovAr scheme. O&M costs, integration works, operation time, discount rate and inflation rate must also be assumed.

Price of electricity: to-date, there are no functioning geothermal plants on the Argentine territory. It is therefore unknown what is a range of values that could be assigned to energy produced in such way. However, geothermal energy can be compared with hydroelectric energy thanks to two main features they have in common: the high initial cost and the capacity to produce base-load energy (therefore showing many hours of use during the year, i.e. a high “capacity factor”, see later on).

- Self-consumption: this kind of operation falls into the category of “distributed generation projects”. These are in fact small energy production units connected to the grid, where the owner has a meter that counts how much energy is given and taken to/from the grid. His fee will be according to the difference between these two values. In Argentina, the law that rules this kind of projects has still not being regulated, meaning that there is no incentive awarded. The owner of the plant would therefore gain from not buying energy from the grid, consuming its own-created energy from the ORC plant. The energy produced by the ORC plant will allow a certain reduction of this cost, therefore allowing for a gain. In Santiago del Estero, the energy provider, called EDESE, monthly charges a fixed price for capacities between 50 and 300 kW that averages at 10.14 U$D/kW, plus a variable price that averages at 0.047 U$D/kWh. Useful information on how the cost of electricity may change in the future has not been found.

- In RenovAr: the price of the sold electricity can be taken as the price that is being paid to the small hydroelectric projects that won the tenders 1 and 2 of the RenovAr program. Considering both rounds, the maximum price was 105 U$D/MWh while the minimum 89 U$D/MWh (Minem, 2018). Given the fact that geothermal installations include more components and working fluid, the maximum price of 105 U$D/MWh (or 0.105 U$D/kWh) is selected as assumed price for the electricity sold.
- Sale of produced energy to a “big-user”: this type of commercial activity is accepted by the Argentine legislation and actually falls in a framework that is called MATER (*Mercado A Término de Energías Renovables*). A so called “big-user” is any energy consumer that needs a contracted power of >300 kW. There are about 2000 big users in Argentina, who by law are to be consuming 8% of their energy from renewables by the end of 2018. In this case, the consumer and the producer sign a contract where the economic conditions are set that binds legally the two parties. The cost of the electricity in this case is usually calculated using the Levelised Cost of Energy (LCOE) as a reference, where the producer calculated his cost of producing the energy and the profit he wants to make. The MATER also follows a tender process that occurs every 3 months and is typically based on a lowest-price tendering system, where the energy producer “puts” his produced energy in the market and, if accepted by CAMMESA, can agree a sale to any interested big-user. For this project, it is assumed that the electricity is sold to make a 20% profit

To sum up the described considerations, Table 10 shows the assumed electricity prices in the different possible scenarios.

Table 10: Assumed prices of electricity according to various scenarios

	Self-consumption	RenovAr	MATER
Price of electricity	10.14 U$D/kW + 0.047 U$D/kWh	0.105 U$D/kWh	LCOE + 20%

O&M costs: Operation and Maintenance costs are very hard to foresee, especially in an area where no such systems exist. The company Electratherm provides indicative values for their products that range from 15 to 20 USD/MWh produced (Electratherm, 2018). Given the high cost of labour in Argentina, the highest value of the given range is used to make the calculations. The maintenance considered is ordinary maintenance and includes minor items, such as annual belt inspection, filter changes, along with standard pump, generator and dry cooler maintenance. The maintenance of the transformer must also be included, which from personal professional experience can be taken as 5 USD/MWh.

Integration works: once again, installation costs are also difficult to estimate. These include all the equipment that is necessary outside of the ORC system for it to work, such as pipes for hot and cold water, outside pumps, connections of the pipes to the system, earthworks, construction of shed or building to place the system, etc. In the same study mentioned above, Lemmens (2016) notices that in Europe the installation costs can be averaged to about 10% of the ORC system cost.

Electric works: when connecting a power production plant to the electric grid it is fundamental that the voltage, type of current and frequency of the plant are the same as those of the grid. The ORC plants produces electric energy in Alternating Current (AC) at 50 Hz frequency, meaning that there is no need to take action on these two characteristics. However particular attention should be paid to the voltage, which is equal to to 13.2 kV in a standard urban electric grid. Given that the ORC plant’s production is at a range between 380 and 500 V, a transformer is needed to elevate it to 13.2 kV. This component, which is therefore placed between the ORC plant and the grid has a cost of about 10000 USD up to 50 MW, 15000 USD for 100 MW, 20000 USD up to 200 MW, 25000 USD for 250 MW and 30000 for 300 MW. The cables, connections, ground wires, switches and other electric components have a cost of about 5000 USD up to 50 MW, 6000 USD up to 200 MW, and 7000 USD up to 300 MW.

Operation time (capacity factor): the capacity factor is the ratio of how many hours the plant will work over the number of hours in one year. Geothermal plants in general, similarly to hydroelectric plants, show a very high capacity factor, usually in the range 80-90%. This means that, during one year, they run 80 to 90% of the time. Among the various types of geothermal power plants, ORC plants are the ones that run most of the time and can therefore easily reach a capacity factor of 85% (Macchi and Astolfi, 2016).

4.3 Evaluated scenarios

It is now considered that the Government of Santiago del Estero forms a company, most probably a "Specific Purpose Company", to buy, install and operate the plant at the costs previously described. Then, various scenarios are analysed:

I. The produced energy is completely used by the producer, for internal consumption. Calculations are based on the cost of electricity described in Section 4.2, as given by the energy provider of Santiago del Estero.
II. The produced energy is sold at the price previously assumed as if it participated to RenovAr tenders: given the current situation (as of September 2018), it is still not possible to sell electricity to the Grid, and there is no incentive scheme nor economic benefit that can be awarded to a geothermal project that uses an ORC system. The owner of the project could only benefit from the generation of its own electric energy without the need to buy it from the national grid. However, a future possibility is that of small geothermal projects participating in the RenovAr program (described in Chapter 4.1) or in similar programs for smaller projects. The RenovAr program so far does not allow geothermal projects to participate, nor projects smaller to 1 MW. It becomes therefore arduous to assume a possible earning from the sale of electricity, with the best approximation being what has been described in Chapter 4.2 with associating geothermal projects with hydroelectric projects.
III. The LCOE is calculated, to be able to know what is the price of producing energy from the ORC system. This price can be used to reach an agreement with a so called "Big User", who would buy this energy at the agreed price in the MATER market, to be able to reach its legally binding target of 8% of renewable energy consumption by the end of 2018. The LCOE measures the lifetime costs of the ORC project divided by its energy production, calculating the present value of the total cost of building and operating it over an assumed lifetime of 20 years.
IV. The price of the sold energy is calculated to guarantee a payback period of 4 years: another possibility is that of fixing the amount of years during which the pay-back period has to be reached, and from then calculating the price of the energy sold. Given the nature of the owner, it has been assumed that the payback period is equal to 4 years. The price of the produced electricity is then calculated as a fixed amount during this time.

Table 11, **Table 12**, Figure 34 and Figure 35 summarise the costs that have been calculated taking into account the assumptions described so far. Table 13 and Figure 36 show the calculation of the expected produced energy. Table 14 to Table 17 and Figure 38 to Figure 40Figure 39 show the calculations for the evaluated scenarios. The calculations are carried out taking into account the 95°C hot-source scenario, with the exception of Electratherm's Power+Generator 4200 showing its 75°C hot-source operation conditions.

4.4 Calculation of the Internal Rates of Return

The Internal rate of return (IRR) is a value used in capital budgeting to estimate the profitability of potential investments. The IRR is a discount rate that makes the net present value of all cash flows from a particular project equal to zero: the calculated value shows the profit that has to be made from a particular investment in order to recover the invested capital. It gives an idea of what profit needs to be made from the investment in order to make it profitable.

As an example, if the IRR of a hypothetical investment is 10%, it means that if profit from the investment reaches 10%, it will be recovered. To make the investment profitable, its profit needs to be higher than 10%.

To calculate the IRR, all the cashflows from a project need to be considered: Capex, Opex, taxes and incomes.

The formula is the following: $IRR = \sum_{t-1}^{t}(\frac{C_t}{1^t}) - C_o$

Where:

C_t = net cash inflow during the period *t,*
t = number of time periods, in years,
C_o = total initial investment cost.

The calculation of the value C_t takes into account the *business tax* and the *income tax*: the former is a tax that is applied to all incomes from a project/investment, whereas the latter is only applied to the net income. In Argentina, these are respectively equal to 3% and 35%. In addition, the Argentinean legislation allows some advantages when the investment is made on renewable energy projects:

- the importation of components is exempt of VAT,
- the initial investment can be divided up to a maximum 10 years. Each year, if the net income is lower than the yearly amortization amount, no taxes are to be paid. If the income is higher, the tax is paid only on the difference between the net income and the amortization amount (see Appendix 2).

The calculation of the IRRs can be seen in Appendix 2, with a summary shown in Figure 40.

4.5 Results

Table 11: Calculation of estimated CAPEX (USD)

	ElectraTherm		Zuccato			Enogia		Zuccato		
	(Pow+Gen. 4200)	**Pow+Gen. 4400**	**ZE-30-ULH**	**ZE-40-ULH**	**ZE-50-ULH**	**ENO LT 100**	**ENO LT 180**	**ZE-200-ULH+**	**ZE-250-ULH+**	**ZE-300-ULH+**
ORC Module	130.000	150.000	160.000	170.000	180.000	230.000	350.000	350.000	400.000	450.000
Refrigerant	6.000	6.000	7.000	8.000	9.000	10.000	12.000	20.000	25.000	30.000
Commissioning and start-up	5.000	5.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000
Shipping	8.000	8.000	10.000	10.000	10.000	11.000	11.000	15.000	15.000	15.000
Manual labour	2.000	2.000	2.000	2.000	2.000	3.000	3.000	5.000	5.000	5.000
Total ORC	151.000	171.000	185.000	196.000	207.000	260.000	382.000	396.000	451.000	506.000
Specific cost (USD/kW)	4.194	3.571	5.333	4.250	3.600	2.300	1.944	1.750	1.600	1.500
Integration costs	13.000	15.000	16.000	17.000	18.000	23.000	35.000	35.000	40.000	45.000
Electric works	5.000	5.000	5.000	5.000	5.000	6.000	6.000	7.000	7.000	7.000
Tranformer	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000
Total initial investment	**179.000**	**201.000**	**216.000**	**228.000**	**240.000**	**299.000**	**433.000**	**448.000**	**508.000**	**568.000**

Table 12: Calculation of estimated OPEX (USD/year)

ORC O&M costs	3425	5808	3872	5361	6701	13701	24125	27401	34103	40953
Tranformer O&M costs	856	1452	968	1340	1675	3425	6031	6850	8526	10238
Total O&M costs	**4281**	**7260**	**4840**	**6701**	**8377**	**17126**	**30156**	**34252**	**42628**	**51191**

Table 13: Calculation of estimated energy production

	ElectraTherm		**Zuccato**			**Enogia**		**Zuccato**		
	(Pow+Gen. 4200)	**Pow+Gen. 4400**	**ZE-30-ULH**	**ZE-40-ULH**	**ZE-50-ULH**	**ENO LT 100**	**ENO LT 180**	**ZE-200-ULH+**	**ZE-250-ULH+**	**ZE-300-ULH+**
Gross power output (kW)	31	42	30	40	50	100	180	200	250	300
Net power output (kW)	23	39	26	36	45	92	162	184	229	275
Hours in one year (h)	8760	8760	8760	8760	8760	8760	8760	8760	8760	8760
Potential produced electricity (kWh/year)	201480	341640	227760	315360	394200	805920	1419120	1611840	2006040	2409000
Capacity factor	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%
Actual produced electricity (kWh/year)	**171258**	**290394**	**193596**	**268056**	**335070**	**685032**	**1206252**	**1370064**	**1705134**	**2047650**
Number of dwellings' consumption equivalent	21	36	24	34	42	86	151	172	214	256

Table 14: Scenario 1 – Self-consumption of the produced energy

	ElectraTherm		**Zuccato**			**Enogia**		**Zuccato**		
	(Pow+Gen. 4200)	**Pow+Gen. 4400**	**ZE-30-ULH**	**ZE-40-ULH**	**ZE-50-ULH**	**ENO LT 100**	**ENO LT 180**	**ZE-200-ULH+**	**ZE-250-ULH+**	**ZE-300-ULH+**
Fixed savings (USD/year) - bi-monthly fee	1399	2373	1582	2190	2738	5597	9856	11195	13932	16731
Variable savings (USD/year)	8049	13649	9099	12599	15748	32197	56694	64393	80141	96240
Partial savings (USD/year)	9448	16021	10681	14789	18486	37794	66550	75588	94074	112971
O&M costs	4281	7260	4840	6701	8377	17126	30156	34252	42628	51191
Total saving	5167	8761	5841	8087	10109	20668	36394	41336	51445	61779
Total initial investment	179.000	201.000	216.000	228.000	240.000	304.000	443.000	458.000	523.000	588.000
Simple payback (years)	**34.6**	**22.9**	**37.0**	**28.2**	**23.7**	**14.7**	**12.2**	**11.1**	**10.2**	**9.5**

Table 15: Scenario 2 – Energy produced is completely sold to the National Grid according to the RenovAr program

	ElectraTherm		**Zuccato**			**Enogia**		**Zuccato**		
	(Pow+Gen. 4200)	**Pow+Gen. 4400**	**ZE-30-ULH**	**ZE-40-ULH**	**ZE-50-ULH**	**ENO LT 100**	**ENO LT 180**	**ZE-200-ULH+**	**ZE-250-ULH+**	**ZE-300-ULH+**
Gross income (USD/year)	17982	30491	20328	28146	35182	71928	126656	143857	179039	215003
O&M costs	4281	7260	4840	6701	8377	17126	30156	34252	42628	51191
Net income (USD/year)	13701	23232	15488	21444	26806	54803	96500	109605	136411	163812
Simple payback (years)	**13.1**	**8.7**	**13.9**	**10.6**	**9.0**	**5.5**	**4.6**	**4.2**	**3.8**	**3.6**

Table 16: Scenario 3 – The LCOE is calculated as a way to participate in the MATER program

	ElectraTherm		**Zuccato**			**Enogia**		**Zuccato**		
	(Pow+Gen. 4200)	**Pow+Gen. 4400**	**ZE-30-ULH**	**ZE-40-ULH**	**ZE-50-ULH**	**ENO LT 100**	**ENO LT 180**	**ZE-200-ULH+**	**ZE-250-ULH+**	**ZE-300-ULH+**
Actual produced electricity in total (kWh)	3425160	5807880	3871920	5361120	6701400	13700640	24125040	27401280	34102680	40953000
Total Cost of Ownership (USD)	264629	346197	312798	362028	407535	646516	1046126	1143032	1375567	1611825
LCOE (USD/kWh)	**0.077**	**0.060**	**0.081**	**0.068**	**0.061**	**0.047**	**0.043**	**0.042**	**0.040**	**0.039**
Price of sale (USD/kWh)	0.093	0.072	0.097	0.081	0.073	0.057	0.052	0.050	0.048	0.047
Gross income (USD/year)	15878	20772	18768	21722	24452	38791	62768	68582	82534	96710
Net income (USD/year)	11596	13512	13928	15020	16075	21665	32611	34330	39906	45518
Simple payback (years)	**15.4**	**14.9**	**15.5**	**15.2**	**14.9**	**14.0**	**13.6**	**13.3**	**13.1**	**12.9**

Table 17: Scenario 4 – The price of the sold energy is calculated to guarantee a payback period of 4 years

	ElectraTherm		**Zuccato**			**Enogia**		**Zuccato**		
	(Pow+Gen. 4200)	**Pow+Gen. 4400**	**ZE-30-ULH**	**ZE-40-ULH**	**ZE-50-ULH**	**ENO LT 100**	**ENO LT 180**	**ZE-200-ULH+**	**ZE-250-ULH+**	**ZE-300-ULH+**
Total electricity produced (kWh)	685032	1161576	774384	1072224	1340280	2740128	4825008	5480256	6820536	8190600
Price of sold electricity (USD/kWh)	**0.286**	**0.198**	**0.304**	**0.238**	**0.204**	**0.136**	**0.117**	**0.109**	**0.102**	**0.097**
% on LCOE	271%	232%	276%	252%	236%	188%	169%	160%	152%	146%

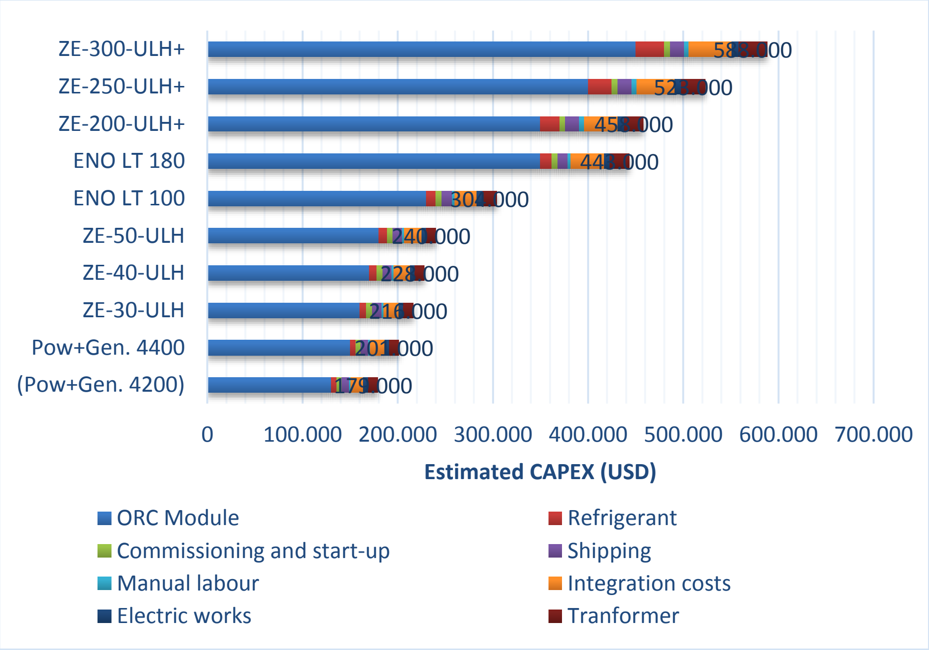


Figure 34: Calculation of estimated CAPEX (USD)

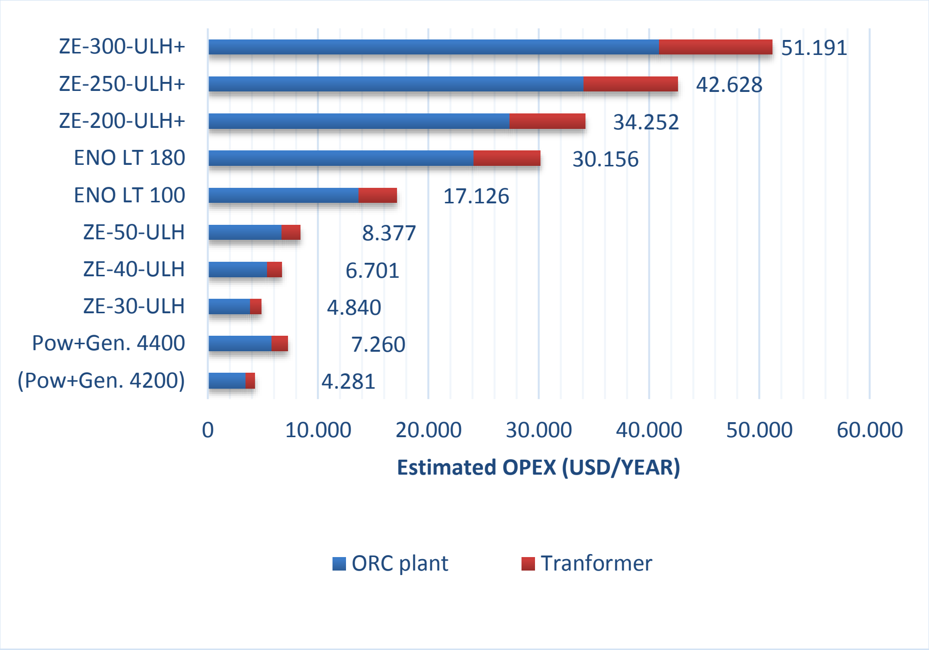


Figure 35: Calculation of estimated OPEX (USD/year)

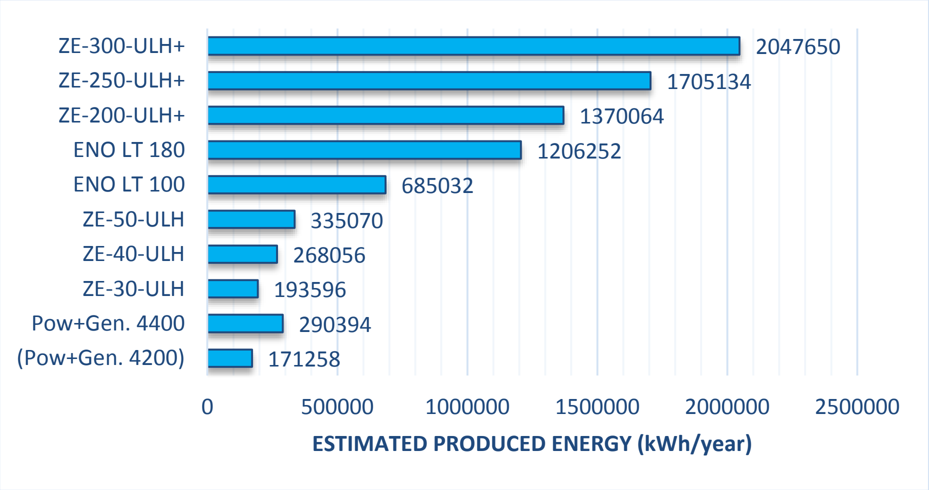


Figure 36: Estimated produced energy (kWh/year)

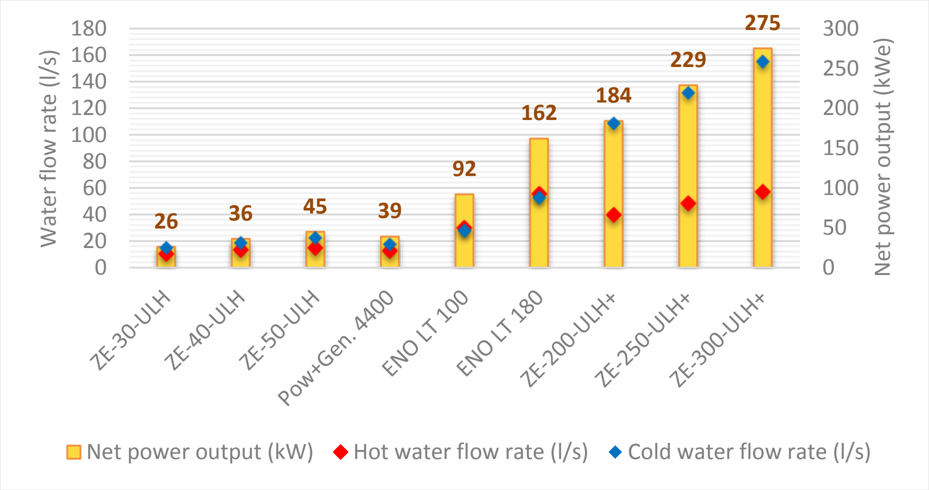


Figure 37: Working conditions of the evaluated ORC systems at 95°C hot-source temperature (Duplicate from Chapter 3.4.4)

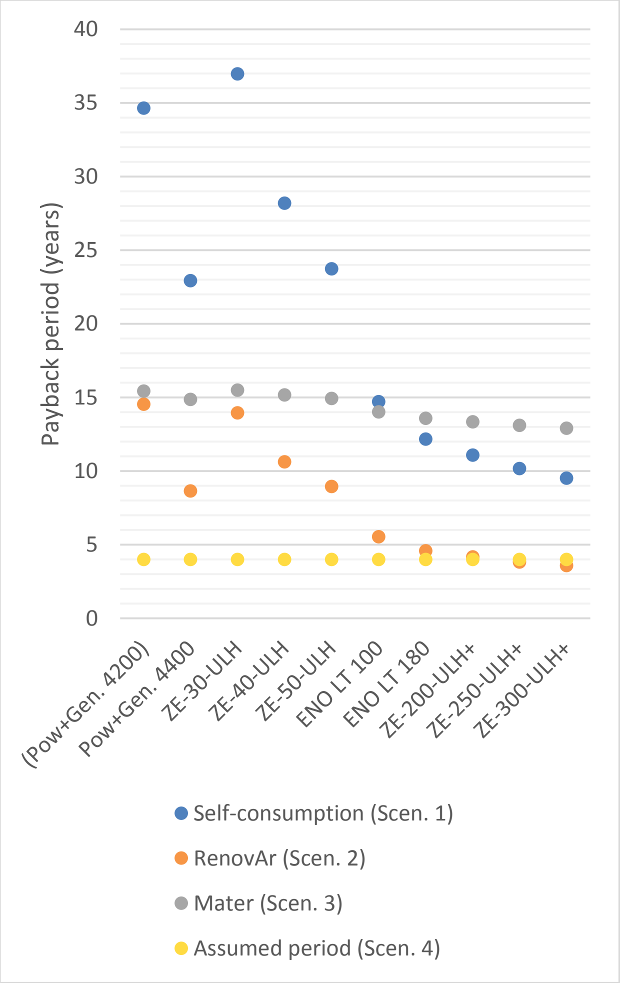


Figure 38: Payback time of each ORC system for each scenario

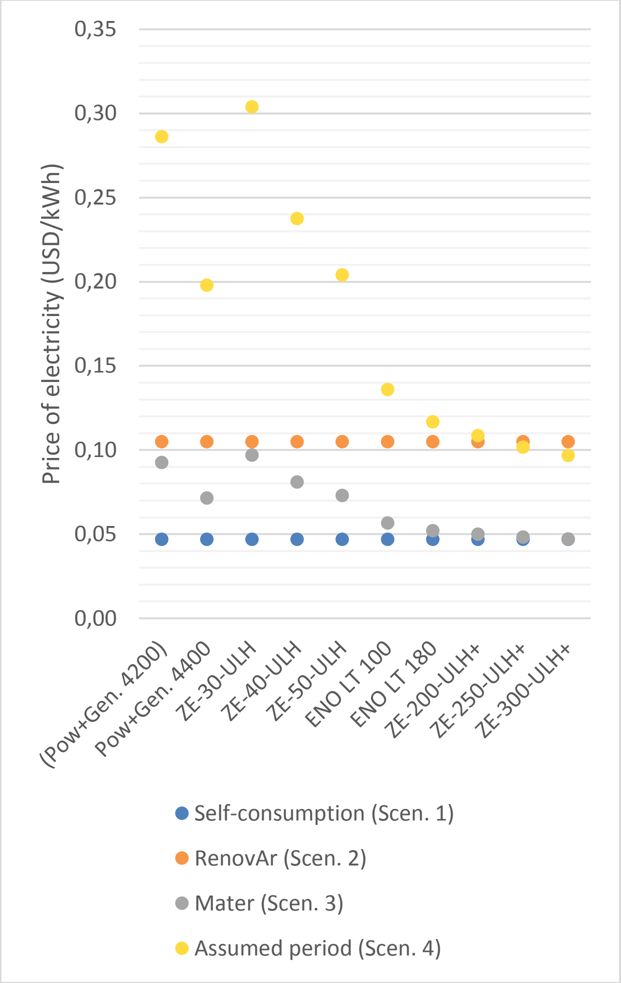


Figure 39: Price of sold electricity of each ORC system for each scenario

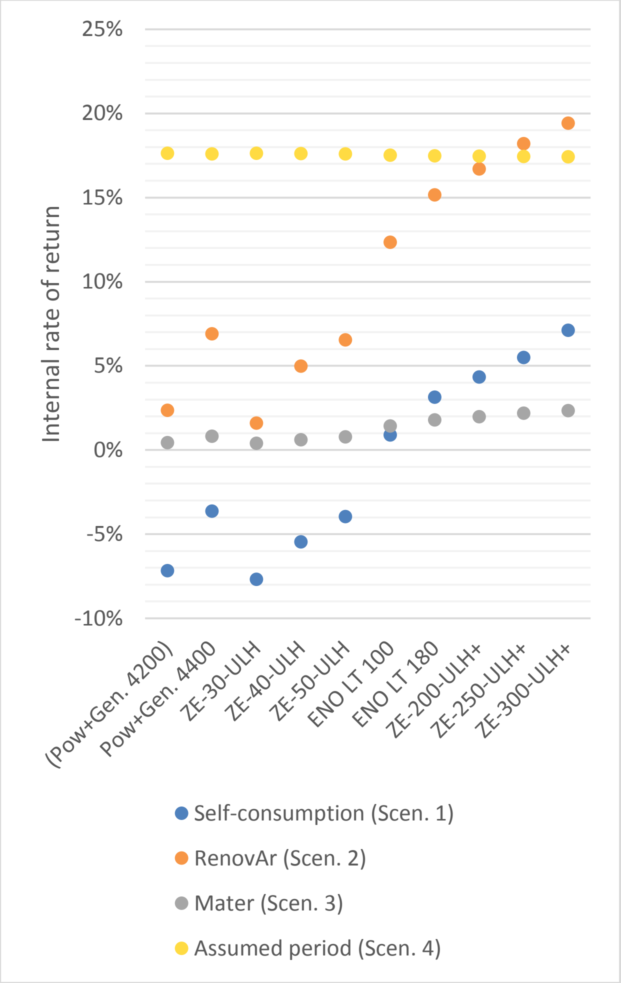


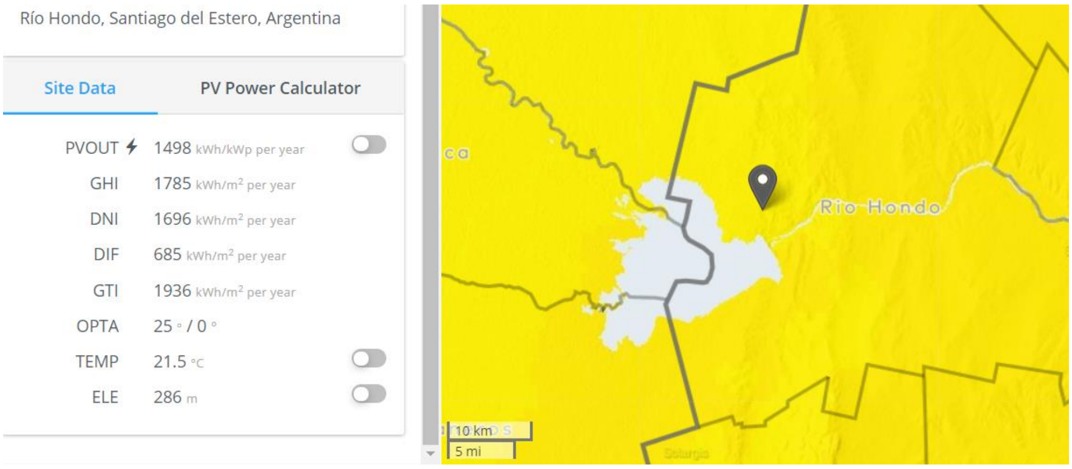
Figure 40: Internal Rate of Return of each ORC system for each scenario

Relevant facts:

- The number of dwellings' consumption equivalent in Table 13 shows the number of dwellings that can be supplied for one year with the energy produced by each unit. The calculation is based on 2016 data that is made available from the Ministry of Energy, that states that in that year Termas de Ríio Hondo had a population of 44100 inhabitants, who consumed 88013.53 MWh, equivalent to a specific consumption of 1996 kWh/person. Assuming a dwelling of 4 people, each dwelling would require 7983 kWh/year (Minem, 2018).
- The scenarios do not take into account the realization of the geothermal wells, which in a geothermal project usually account for the highest part of the required investment. It is considered that wells have already been drilled and can be exploited for the ORC systems. Their flow rate needs to be assessed in order to decide which of the suggested units to implement.
- Increase in electricity prices and inflation rates have not been taken into consideration, for the impossibility of assuming possible reasonable future scenarios on these topics. For this reason, the results of the calculations show the worst-possible scenario conditions, where there is no growth of the electricity price (giving a disadvantage to the self-consumption scenario) nor inflation rate (giving a disadvantage to the electricity-sale scenarios).
- In general, the larger the unit the more profitable it is.
- The 100 kW value seems to be the lower limit to make the investment interesting, even though, with only 0.9%, the IRR of the ENO LT 100 loses interest with respect to many other possible investments with interest rates of >1%.
- Negative IRRs occur when the payback period is higher than the life expectancy of the project. Having assumed a life-expectancy of 20 years, it can be seen how if the payback period is higher than 20 years the IRR is negative. A negative IRR is a sign that, considering the whole life expectancy, the revenues from the project never balance the initial investment.
- For almost all units, the decision of a fixed and short payback period is the scenario that provides the most favourable conditions. The critical aspect is the possibility of selling the produced energy with the calculated price. The two larger units however are more advantageous when participating in the RenovAr program, for their large amount of produced energy.
- When establishing a fixed payback period, the IRR is similar for all units. This is because the calculated price of the sold electricity is a function of their power output, with a ratio that therefore keeps almost constant for all of them. The higher the fixed payback period, the lower the price of the electricity, and therefore the lower the IRR.
- Considering the Power+Generator 4400 and the ZE40ULH, which show a similar power output of respectively 36 and 39 kWe, it can be observed how more economic convenient the former is despite the higher energy production from the latter. This is because of the high initial cost of Zuccato's product.
- Considering the largest unit, Zuccato's ZE300ULH+, it is interesting to observe that the price of the electricity sold in a MATER scenario (scenario 3) coincides with the present value of the electricity's price in the self-consumption scenario (scenario 1). However, the payback period differs (from 13 to 9.5 years) as in the self-consumption scenario there is an additional saving given by avoiding the fixed tariff that is paid for the contracted kW, which instead has to be paid in the MATER scenario.
- When calculating the price of electricity in scenario 3, only a 20% profit has been assumed. This is in order to keep a low price in order to have a higher possibility of winning the tender. However, these is still a high margin that can be added to the profit if it is considered that big-users usually buy electricity from the national grid at a much higher price, usually around 0.70 USD/kWh. All units have

however resulted with an electricity's price that is lower than 0.10 USD/kWh, meaning that a margin of more than 0.60 USD/kWh can still be added. This would however play against in the MATER tendering process.

- A quick comparison can be made with an alternative solar or wind project, in order to get an idea of other ways in which the same amount of renewable energy could be produced:
    - Sun irradiation is relatively high in Termas de Río Hondo, that allows a PV output in optimal conditions of just less than 1500 kWh/kWp per year (Figure 41).



Río Hondo, Santiago del Estero, Argentina

Site Data | PV Power Calculator

PVOUT 1498 kWh/kWp per year
GHI 1785 kWh/m² per year
DNI 1696 kWh/m² per year
DIF 685 kWh/m² per year
GTI 1936 kWh/m² per year
OPTA 25 ° / 0 °
TEMP 21.5 °C
ELE 286 m

Figure 41: Irradiation in Termas de Río Hondo

However, the heat and the high cloudiness level only generally allow a capacity factor of about 25%. This means that each ORC unit is able to produce the same amount of energy as a photovoltaic plant of the capacity and surface area shown in Table 18.

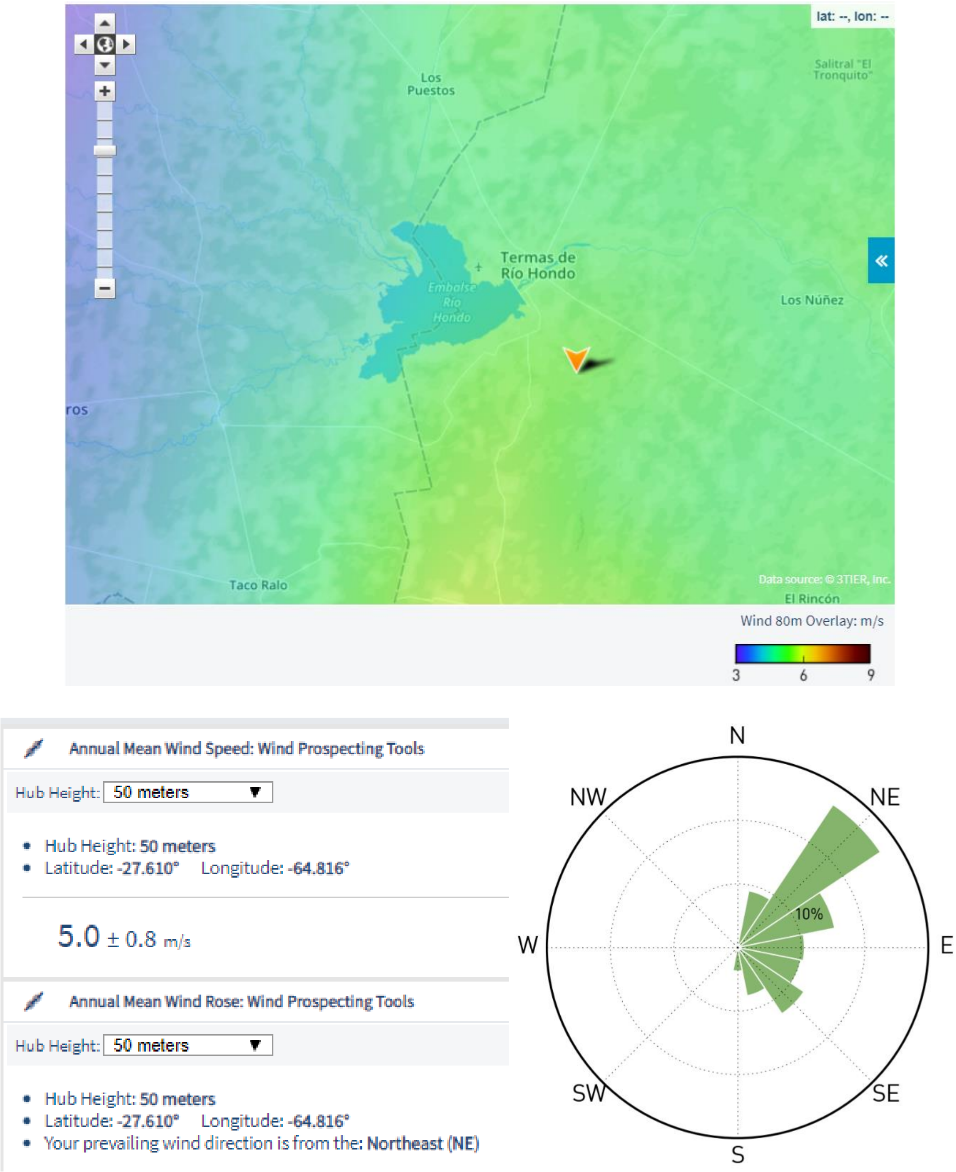
Table 18: Comparison with a photovoltaic plant

	(Pow+ Gen. 4200)	Pow+ Gen. 4400	ZE-30-ULH	ZE-40-ULH	ZE-50-ULH	ENO LT 100	ENO LT 180	ZE-200-ULH+	ZE-250-ULH+	ZE-300-ULH+
Equivalent power (kW)	78	133	88	122	153	313	551	626	779	935
Surface area (m^2)	2346	3978	2652	3672	4590	9384	16524	18768	23358	28050
Surface area (has)	0.2	0.4	0.3	0.4	0.5	0.9	1.7	1.9	2.3	2.8

    - Wind velocity is rather low in Termas de Río Hondo, with an yearly average velocity around 5 m/s (Figure 42). Here, a capacity factor of 30% can be expected. At these speed, only low power (<100 kW) wind turbines offer some degree of efficiency. For example, a typical 50 kW nominal capacity wind turbine only produces 10 kW at 5 m/s (Figure 43).

Table 19: Comparison with a wind plant

	(Pow+ Gen. 4200)	Pow+ Gen. 4400	ZE-30-ULH	ZE-40-ULH	ZE-50-ULH	ENO LT 100	ENO LT 180	ZE-200-ULH+	ZE-250-ULH+	ZE-300-ULH+
Equivalent power (kW)	65	111	74	102	128	261	459	521	649	779
Number of turbines	7	11	7	10	13	26	46	52	65	78



Annual Mean Wind Speed: Wind Prospecting Tools

Hub Height: 50 meters

- Hub Height: **50 meters**
- Latitude: **-27.610°** Longitude: **-64.816°**

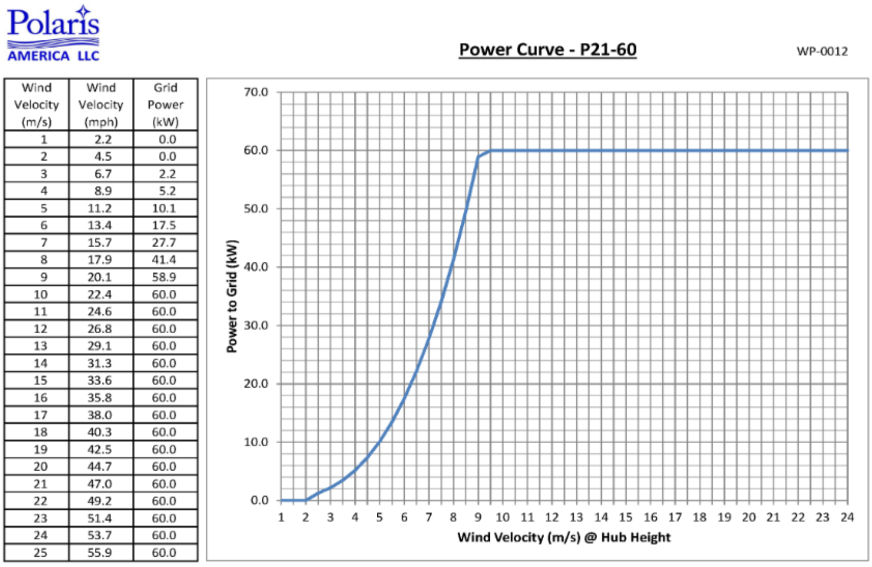
5.0 ± 0.8 m/s

Annual Mean Wind Rose: Wind Prospecting Tools

Hub Height: 50 meters

- Hub Height: **50 meters**
- Latitude: **-27.610°** Longitude: **-64.816°**
- Your prevailing wind direction is from the: **Northeast (NE)**

Figure 42: Yearly wind conditions in Termas de Río Hondo



Wind Velocity (m/s)	Wind Velocity (mph)	Grid Power (kW)
1	2.2	0.0
2	4.5	0.0
3	6.7	2.2
4	8.9	5.2
5	11.2	10.1
6	13.4	17.5
7	15.7	27.7
8	17.9	41.4
9	20.1	58.9
10	22.4	60.0
11	24.6	60.0
12	26.8	60.0
13	29.1	60.0
14	31.3	60.0
15	33.6	60.0
16	35.8	60.0
17	38.0	60.0
18	40.3	60.0
19	42.5	60.0
20	44.7	60.0
21	47.0	60.0
22	49.2	60.0
23	51.4	60.0
24	53.7	60.0
25	55.9	60.0

Figure 43: Standard operating conditions of a 50 kW nominal power wind turbine

5 Conclusions

The proposed study has evaluated the possibility of installing an Organic Rankine Cycle geothermal system in Termas de Río Hondo, Santiago del Estero mainly from a commercial and economic point of view.

ORC systems are units that take advantage of low temperature geothermal sources (typically in the range 80-180°C, so called the "medium-enthalpy" temperature range) to produce electric energy. This is achieved thanks to a particular working fluid, commonly called "refrigerant", that absorbs heat from the geothermal source, and through a thermodynamic cycle transforms it into electricity, by boiling at a lower temperature than water and expanding into a turbine that spins. A cold source is also required for the fluid to condense and go back to a pumping phase and an evaporation phase during heat absorption.

Given the relatively low temperatures expected in Termas de Ríio Hondo, only a few of the commercially available refrigerants can be taken into consideration when boiling occurs below 100°C. In addition, their environmental impact must be taken into account as the most common refrigerants have a high impact on greenhouse warming and on the ozone layer depletion. Legislation exist that gradually limit the refrigerants that can be used according to their environmental impact potential.

Three hot source temperature scenarios have been considered: 75°C, 85°C and 95°C. A commercial investigation has been carried out where 8 companies worldwide have been contacted to ask for what products they can provide, and in what conditions, to work in the assumed scenarios. Based on their response, three companies have been selected as the most promising in these scenarios: Electratherm from the USA, Enogia from France and Zuccato from Italy.

No company has been found that offers standard ORC systems that can work with a hot source of 75°C, but Electratherm is the only one that can provide a product that functions with a 77°C hot source. At this temperature, Electratherm's *Power+Generator 4200* accepts a hot source flow rate up to 12.6 l/s, a cold source flow rate of 17.8 l/s, a gross power production of 24 kWe and a net power production of 23 kWe.

At 85°C, the same unit from Electratherm and two units from Enogia can operate.

- Electratherm's *Power+Generator 4200* works with 12.6 l/s hot source flow rate, 19.4 l/s cold source flow rate, a gross power output of 31 kWe and net power output of 29 kWe.
- Enogia's *ENO LT 100* works with 33.3 l/s hot source flow rate, 30.6 l/s cold source flow rate, a gross power output of 100 kWe and net power output of 89 kWe.
- Enogia's *ENO LT 180* works with 58.3 l/s hot source flow rate, 54.4 l/s cold source flow rate, a gross power output of 180 kWe and net power output of 144 kWe.

At 95°C, Zuccato too can provide operating ORC systems, in a vast range of possible power outputs.

- Electratherm's *Power+Generator 4400* works with 12.6 l/s hot source flow rate, 17.6 l/s cold source flow rate, a gross power output of 44 kWe and net power output of 39 kWe.
- Enogia's *ENO LT 100* works with 30.0 l/s hot source flow rate, 27.8 l/s cold source flow rate, a gross power output of 100 kWe and net power output of 92 kWe.
- Enogia's *ENO LT 180* works with 55.6 l/s hot source flow rate, 52.8 l/s cold source flow rate, a gross power output of 180 kWe and net power output of 162 kWe.
- Zuccato's *ZE30ULH* works with 10.2 l/s hot source flow rate, 14.8 l/s cold source flow rate, a gross power output of 30 kWe and net power output of 26 kWe.
- Zuccato's *ZE40ULH* works with 13.4 l/s hot source flow rate, 18.6 l/s cold source flow rate, a gross power output of 40 kWe and net power output of 36 kWe.

- Zuccato's *ZE50ULH* works with 14.9 l/s hot source flow rate, 22.4 l/s cold source flow rate, a gross power output of 50 kWe and net power output of 45 kWe.
- Zuccato's *ZE200ULH+* works with 39.7 l/s hot source flow rate, 108.7 l/s cold source flow rate, a gross power output of 200 kWe and net power output of 184 kWe.
- Zuccato's *ZE250ULH+* works with 48.4 l/s hot source flow rate, 131.7 l/s cold source flow rate, a gross power output of 250 kWe and net power output of 229 kWe.
- Zuccato's *ZE300ULH+* works with 57.1 l/s hot source flow rate, 155.2 l/s cold source flow rate, a gross power output of 300 kWe and net power output of 275 kWe.

The three refrigerants evaluated are Electratherm's R254fa, Enogia's R1233zd and Zuccato's homemade HFC mixture. Unfortunately it is not possible to compare Zuccato's mixture, as its information is not public. However, given the information provided, it can be concluded that R1233zd is the most environmentally friendly because of its low GWP, R245fa is the cheapest as it is the easiest to find, and Zuccato's mixture is probably in the middle with respect to both environment and economic features. The latter is the safest from the toxic, fire and instability hazard point of view, followed by the R1233zd which is slightly toxic, and the R245fa which is slightly toxic and slightly flammable. The R245fa will not be allowed in Europe after 2020 because of its high GWP, and it is expected that other countries will follow the trend.

With respect to the available products from these three companies, their economic evaluation is carried out in 4 possible scenarios:

- Scenario 1: the energy produced is self-consumed, therefore allowing the gain from not buying electricity from the grid.
  Payback periods: from about 35 to about 10 years. Price of electricity: 0.047 USD/kWh.
- Scenario 2: the energy produced is sold to the grid in participation of the RenovAr program at a fixed price.
  Payback periods: from about 13 to about 3 years and a half. Price of electricity: 0.105 USD/kWh.
- Scenario 3: the energy produced is sold to a private user, calculating its LCOE and applying an assumed profit.
  Payback periods: from about 15 to about 13 years. Price of electricity: from 0.093 to 0.047 USD/kWh.
- Scenario 4: the payback period is fixed and electricity price is calculated to meet it.
  Payback period: 4 years. Price of electricity: from 0.286 to 0.093 USD/kWh.

From an economic point of view, the most favourable scenario is that of a large unit (>200 kWe) to participate in the RenovAr program (Scenario 2). As a matter of fact, the assumed conditions make the smaller units (<100 kWe) unprofitable, giving negative Internal Rates of Return. Market price can therefore be met only by implementing a minimal size of the plant, in this case about 100 kWe. This can however be modified by expanding their life expectancy, and therefore their expected income, or by increasing the temperature of the thermal source, for example by drilling deeper. With respect to the evaluated companies, it can be summarised that all of them show some advantages:

- Among the small units (<100 kW) Electratherm offers the cheapest products, with the cheapest refrigerant and the most experience, having being commercialised for a longer time.
- Enogia offers the most environmentally friendly products, for their almost no-impact refrigerant. In addition they have shown the highest interest in developing this project.
- Zuccato is the only company that already opened a commercial branch in Argentina. In addition they partnered with an engineering company to be able to respond to the technical issues.

Appendix 1: operation and maintenance procedures

Small power plants are intended to be installed in industrial or civil facilities in which specialized technicians are not available to face system breakdowns. Therefore, low pressure levels, limited turbine rotational speed and non-toxic organic fluids need to be used, thus enforcing the limits to the options generally available in ORC design. The aforementioned limitation on thermodynamic and technical parameters lowers the optimal performance of the cycle. (Tocci et al., 2017)

Corrosion and scaling are the most common problems of geothermal plants, and require special care. These problems can be corrected by condition monitoring and preventive maintenance. Periodic maintenance procedures are recommended by all manufacturing companies, and include (Abisa, 2002):

- Daily inspection (performed by the operators), such as:
    - Check generator, turbines, gearbox, feed pump and oil pumps for vibrations, noise or oil leaks.
    - Check turbine and feed pump for motive fluid leaks.
    - Noise and leaks should be checked by a technician and repaired as necessary.
- Weekly inspection (during operation period), such as:
    - Fill out the ORC test sheet and compare the results to the design point values.
    - Check and compare condenser pressure with the pressure obtained from the P/T diagram at the existing condensing temperature, if higher, release air from condenser.
    - Check oil level in the oil tanks, add oil if necessary.
    - Check oil level in the gearbox.
- Monthly inspection (during operation), such as:
    - Check valve shafts and pump seals for leaks.
    - Check the oil ring in the generator bearing housing visually.
    - Check battery.
    - Check for hot spots in the power and control cabinets (connections, switches and contractors).
- First month inspection:
    - Clean motive fluid strainer.
    - Replace line oil filter elements.
    - Check the oil ring in the generator bearing housing visually.
    - Grease all motors according to manufacturer’s instructions.
- Six months inspection:
    - Replace line filters in all systems (lubrication oil, seal oil, and gearbox).
    - Tighten all construction bolts.
    - Check flanges for leaks (use a leak detector).
    - Grease all electrical motors and couplings.
    - Check oil quantity and purity.
- Yearly inspection, which is the most complete, includes:
    - Check feed pumps shut-off pressure by operating the pump against closed valve and reading the delivery pressure.
    - Perform feed pump, generator and gearbox maintenance as required by manufacturer.
    - Check turbine/gearbox coupling as required by manufacturer.
    - Check turbine/gearbox alignment, correct if required.

  - Check gearbox/generator couplings, check alignment and correct if required.
  - Replace oil in the lubrication and oil tanks.
- Two years maintenance procedure:
  - Disassemble the turbine wheel and nozzles ring.
  - Check condition of turbine wheel and nozzles ring.
  - Check turbine mechanical seal, o-rings and bearings.

Appendix 2: calculation of Internal Rates of Return

Power+Generator 4200 – Electratherm

SELF CONSUMPTION																					
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Income		$ 9.448	$ 9.448	$ 9.448	$ 9.448	$ 9.448	$ 9.448	$ 9.448	$ 9.448	$ 9.448	$ 9.448	$ 9.448	$ 9.448	$ 9.448	$ 9.448	$ 9.448	$ 9.448	$ 9.448	$ 9.448	$ 9.448	$ 9.448
Expenses		$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281
Gross Result		**$ 5.167**	**$ 5.167**	**$ 5.167**	**$ 5.167**	**$ 5.167**	**$ 5.167**	**$ 5.167**	**$ 5.167**	**$ 5.167**	**$ 5.167**	**$ 5.167**	**$ 5.167**	**$ 5.167**	**$ 5.167**	**$ 5.167**	**$ 5.167**	**$ 5.167**	**$ 5.167**	**$ 5.167**	**$ 5.167**
Amort		$ -17.900	$ -17.900	$ -17.900	$ -17.900	$ -17.900	$ -17.900	$ -17.900	$ -17.900	$ -17.900	$ -17.900										
Business Tax (IIGG)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -1.808	$ -1.808	$ -1.808	$ -1.808	$ -1.808	$ -1.808	$ -1.808	$ -1.808	$ -1.808	$ -1.808
Income Tax (IIBB)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -283	$ -283	$ -283	$ -283	$ -283	$ -283	$ -283	$ -283	$ -283	$ -283
Net Result	$ -179.000	$ 5.167	$ 5.167	$ 5.167	$ 5.167	$ 5.167	$ 5.167	$ 5.167	$ 5.167	$ 5.167	$ 5.167	$ 3.075	$ 3.075	$ 3.075	$ 3.075	$ 3.075	$ 3.075	$ 3.075	$ 3.075	$ 3.075	$ 3.075
TIR	**-7,2%**																				

RENOVAR		Tariff		0,105	USD/kWh																
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Income		$ 17.982	$ 17.982	$ 17.982	$ 17.982	$ 17.982	$ 17.982	$ 17.982	$ 17.982	$ 17.982	$ 17.982	$ 17.982	$ 17.982	$ 17.982	$ 17.982	$ 17.982	$ 17.982	$ 17.982	$ 17.982	$ 17.982	$ 17.982
Expenses		$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281
Gross Result		**$ 13.701**	**$ 13.701**	**$ 13.701**	**$ 13.701**	**$ 13.701**	**$ 13.701**	**$ 13.701**	**$ 13.701**	**$ 13.701**	**$ 13.701**	**$ 13.701**	**$ 13.701**	**$ 13.701**	**$ 13.701**	**$ 13.701**	**$ 13.701**	**$ 13.701**	**$ 13.701**	**$ 13.701**	**$ 13.701**
Amort		$ -17.900	$ -17.900	$ -17.900	$ -17.900	$ -17.900	$ -17.900	$ -17.900	$ -17.900	$ -17.900	$ -17.900										
Business Tax (IIGG)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -4.795	$ -4.795	$ -4.795	$ -4.795	$ -4.795	$ -4.795	$ -4.795	$ -4.795	$ -4.795	$ -4.795
Income Tax (IIBB)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -539	$ -539	$ -539	$ -539	$ -539	$ -539	$ -539	$ -539	$ -539	$ -539
Net Result	$ -179.000	$ 13.701	$ 13.701	$ 13.701	$ 13.701	$ 13.701	$ 13.701	$ 13.701	$ 13.701	$ 13.701	$ 13.701	$ 8.366	$ 8.366	$ 8.366	$ 8.366	$ 8.366	$ 8.366	$ 8.366	$ 8.366	$ 8.366	$ 8.366
TIR	**2,4%**																				

MATER																					
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Income		$ 15.878	$ 15.878	$ 15.878	$ 15.878	$ 15.878	$ 15.878	$ 15.878	$ 15.878	$ 15.878	$ 15.878	$ 15.878	$ 15.878	$ 15.878	$ 15.878	$ 15.878	$ 15.878	$ 15.878	$ 15.878	$ 15.878	$ 15.878
Expenses		$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281
Gross Result		**$ 11.596**	**$ 11.596**	**$ 11.596**	**$ 11.596**	**$ 11.596**	**$ 11.596**	**$ 11.596**	**$ 11.596**	**$ 11.596**	**$ 11.596**	**$ 11.596**	**$ 11.596**	**$ 11.596**	**$ 11.596**	**$ 11.596**	**$ 11.596**	**$ 11.596**	**$ 11.596**	**$ 11.596**	**$ 11.596**
Amort		$ -17.900	$ -17.900	$ -17.900	$ -17.900	$ -17.900	$ -17.900	$ -17.900	$ -17.900	$ -17.900	$ -17.900										
Business Tax (IIGG)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -4.059	$ -4.059	$ -4.059	$ -4.059	$ -4.059	$ -4.059	$ -4.059	$ -4.059	$ -4.059	$ -4.059
Income Tax (IIBB)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -476	$ -476	$ -476	$ -476	$ -476	$ -476	$ -476	$ -476	$ -476	$ -476
Net Result	$ -179.000	$ 11.596	$ 11.596	$ 11.596	$ 11.596	$ 11.596	$ 11.596	$ 11.596	$ 11.596	$ 11.596	$ 11.596	$ 7.061	$ 7.061	$ 7.061	$ 7.061	$ 7.061	$ 7.061	$ 7.061	$ 7.061	$ 7.061	$ 7.061
TIR	**0,5%**																				

Assumed payback period																					
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Income		$ 49.031	$ 49.031	$ 49.031	$ 49.031	$ 49.031	$ 49.031	$ 49.031	$ 49.031	$ 49.031	$ 49.031	$ 49.031	$ 49.031	$ 49.031	$ 49.031	$ 49.031	$ 49.031	$ 49.031	$ 49.031	$ 49.031	$ 49.031
Expenses		$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281	$ -4.281
Gross Result		**$ 44.750**	**$ 44.750**	**$ 44.750**	**$ 44.750**	**$ 44.750**	**$ 44.750**	**$ 44.750**	**$ 44.750**	**$ 44.750**	**$ 44.750**	**$ 44.750**	**$ 44.750**	**$ 44.750**	**$ 44.750**	**$ 44.750**	**$ 44.750**	**$ 44.750**	**$ 44.750**	**$ 44.750**	**$ 44.750**
Amort		$ -17.900	$ -17.900	$ -17.900	$ -17.900	$ -17.900	$ -17.900	$ -17.900	$ -17.900	$ -17.900	$ -17.900										
Business Tax (IIGG)		$ -9.398	$ -9.398	$ -9.398	$ -9.398	$ -9.398	$ -9.398	$ -9.398	$ -9.398	$ -9.398	$ -9.398	$ -15.663	$ -15.663	$ -15.663	$ -15.663	$ -15.663	$ -15.663	$ -15.663	$ -15.663	$ -15.663	$ -15.663
Income Tax (IIBB)		$ -1.471	$ -1.471	$ -1.471	$ -1.471	$ -1.471	$ -1.471	$ -1.471	$ -1.471	$ -1.471	$ -1.471	$ -1.471	$ -1.471	$ -1.471	$ -1.471	$ -1.471	$ -1.471	$ -1.471	$ -1.471	$ -1.471	$ -1.471
Net Result	$ -179.000	$ 33.882	$ 33.882	$ 33.882	$ 33.882	$ 33.882	$ 33.882	$ 33.882	$ 33.882	$ 33.882	$ 33.882	$ 27.617	$ 27.617	$ 27.617	$ 27.617	$ 27.617	$ 27.617	$ 27.617	$ 27.617	$ 27.617	$ 27.617
TIR	**17,6%**																				

Power+Generator 4400 – Electratherm

SELF CONSUMPTION																					
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Income		$ 16.021	$ 16.021	$ 16.021	$ 16.021	$ 16.021	$ 16.021	$ 16.021	$ 16.021	$ 16.021	$ 16.021	$ 16.021	$ 16.021	$ 16.021	$ 16.021	$ 16.021	$ 16.021	$ 16.021	$ 16.021	$ 16.021	$ 16.021
Expenses		$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260
Gross Result		**$ 8.761**	**$ 8.761**	**$ 8.761**	**$ 8.761**	**$ 8.761**	**$ 8.761**	**$ 8.761**	**$ 8.761**	**$ 8.761**	**$ 8.761**	**$ 8.761**	**$ 8.761**	**$ 8.761**	**$ 8.761**	**$ 8.761**	**$ 8.761**	**$ 8.761**	**$ 8.761**	**$ 8.761**	**$ 8.761**
Amort		$ -20.100	$ -20.100	$ -20.100	$ -20.100	$ -20.100	$ -20.100	$ -20.100	$ -20.100	$ -20.100	$ -20.100										
Business Tax (IIGG)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -3.066	$ -3.066	$ -3.066	$ -3.066	$ -3.066	$ -3.066	$ -3.066	$ -3.066	$ -3.066	$ -3.066
Income Tax (IIBB)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -481	$ -481	$ -481	$ -481	$ -481	$ -481	$ -481	$ -481	$ -481	$ -481
Net Result	$ -201.000	$ 8.761	$ 8.761	$ 8.761	$ 8.761	$ 8.761	$ 8.761	$ 8.761	$ 8.761	$ 8.761	$ 8.761	$ 5.214	$ 5.214	$ 5.214	$ 5.214	$ 5.214	$ 5.214	$ 5.214	$ 5.214	$ 5.214	$ 5.214
TIR	**-3,6%**																				

RENOVAR		Tariff		0,105	USD/kWh																
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Income		$ 30.491	$ 30.491	$ 30.491	$ 30.491	$ 30.491	$ 30.491	$ 30.491	$ 30.491	$ 30.491	$ 30.491	$ 30.491	$ 30.491	$ 30.491	$ 30.491	$ 30.491	$ 30.491	$ 30.491	$ 30.491	$ 30.491	$ 30.491
Expenses		$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260
Gross Result		**$ 23.232**	**$ 23.232**	**$ 23.232**	**$ 23.232**	**$ 23.232**	**$ 23.232**	**$ 23.232**	**$ 23.232**	**$ 23.232**	**$ 23.232**	**$ 23.232**	**$ 23.232**	**$ 23.232**	**$ 23.232**	**$ 23.232**	**$ 23.232**	**$ 23.232**	**$ 23.232**	**$ 23.232**	**$ 23.232**
Amort		$ -20.100	$ -20.100	$ -20.100	$ -20.100	$ -20.100	$ -20.100	$ -20.100	$ -20.100	$ -20.100	$ -20.100										
Business Tax (IIGG)		$ -1.096	$ -1.096	$ -1.096	$ -1.096	$ -1.096	$ -1.096	$ -1.096	$ -1.096	$ -1.096	$ -1.096	$ -8.131	$ -8.131	$ -8.131	$ -8.131	$ -8.131	$ -8.131	$ -8.131	$ -8.131	$ -8.131	$ -8.131
Income Tax (IIBB)		$ -915	$ -915	$ -915	$ -915	$ -915	$ -915	$ -915	$ -915	$ -915	$ -915	$ -915	$ -915	$ -915	$ -915	$ -915	$ -915	$ -915	$ -915	$ -915	$ -915
Net Result	$ -201.000	$ 21.221	$ 21.221	$ 21.221	$ 21.221	$ 21.221	$ 21.221	$ 21.221	$ 21.221	$ 21.221	$ 21.221	$ 14.186	$ 14.186	$ 14.186	$ 14.186	$ 14.186	$ 14.186	$ 14.186	$ 14.186	$ 14.186	$ 14.186
TIR	**6,9%**																				

MATER																					
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Income		$ 20.772	$ 20.772	$ 20.772	$ 20.772	$ 20.772	$ 20.772	$ 20.772	$ 20.772	$ 20.772	$ 20.772	$ 20.772	$ 20.772	$ 20.772	$ 20.772	$ 20.772	$ 20.772	$ 20.772	$ 20.772	$ 20.772	$ 20.772
Expenses		$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260
Gross Result		**$ 13.512**	**$ 13.512**	**$ 13.512**	**$ 13.512**	**$ 13.512**	**$ 13.512**	**$ 13.512**	**$ 13.512**	**$ 13.512**	**$ 13.512**	**$ 13.512**	**$ 13.512**	**$ 13.512**	**$ 13.512**	**$ 13.512**	**$ 13.512**	**$ 13.512**	**$ 13.512**	**$ 13.512**	**$ 13.512**
Amort		$ -20.100	$ -20.100	$ -20.100	$ -20.100	$ -20.100	$ -20.100	$ -20.100	$ -20.100	$ -20.100	$ -20.100										
Business Tax (IIGG)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -4.729	$ -4.729	$ -4.729	$ -4.729	$ -4.729	$ -4.729	$ -4.729	$ -4.729	$ -4.729	$ -4.729
Income Tax (IIBB)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -623	$ -623	$ -623	$ -623	$ -623	$ -623	$ -623	$ -623	$ -623	$ -623
Net Result	$ -201.000	$ 13.512	$ 13.512	$ 13.512	$ 13.512	$ 13.512	$ 13.512	$ 13.512	$ 13.512	$ 13.512	$ 13.512	$ 8.160	$ 8.160	$ 8.160	$ 8.160	$ 8.160	$ 8.160	$ 8.160	$ 8.160	$ 8.160	$ 8.160
TIR	**0,8%**																				

Assumed payback period																					
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Income		$ 57.510	$ 57.510	$ 57.510	$ 57.510	$ 57.510	$ 57.510	$ 57.510	$ 57.510	$ 57.510	$ 57.510	$ 57.510	$ 57.510	$ 57.510	$ 57.510	$ 57.510	$ 57.510	$ 57.510	$ 57.510	$ 57.510	$ 57.510
Expenses		$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260	$ -7.260
Gross Result		**$ 50.250**	**$ 50.250**	**$ 50.250**	**$ 50.250**	**$ 50.250**	**$ 50.250**	**$ 50.250**	**$ 50.250**	**$ 50.250**	**$ 50.250**	**$ 50.250**	**$ 50.250**	**$ 50.250**	**$ 50.250**	**$ 50.250**	**$ 50.250**	**$ 50.250**	**$ 50.250**	**$ 50.250**	**$ 50.250**
Amort		$ -20.100	$ -20.100	$ -20.100	$ -20.100	$ -20.100	$ -20.100	$ -20.100	$ -20.100	$ -20.100	$ -20.100										
Business Tax (IIGG)		$ -10.553	$ -10.553	$ -10.553	$ -10.553	$ -10.553	$ -10.553	$ -10.553	$ -10.553	$ -10.553	$ -10.553	$ -17.588	$ -17.588	$ -17.588	$ -17.588	$ -17.588	$ -17.588	$ -17.588	$ -17.588	$ -17.588	$ -17.588
Income Tax (IIBB)		$ -1.725	$ -1.725	$ -1.725	$ -1.725	$ -1.725	$ -1.725	$ -1.725	$ -1.725	$ -1.725	$ -1.725	$ -1.725	$ -1.725	$ -1.725	$ -1.725	$ -1.725	$ -1.725	$ -1.725	$ -1.725	$ -1.725	$ -1.725
Net Result	$ -201.000	$ 37.972	$ 37.972	$ 37.972	$ 37.972	$ 37.972	$ 37.972	$ 37.972	$ 37.972	$ 37.972	$ 37.972	$ 30.937	$ 30.937	$ 30.937	$ 30.937	$ 30.937	$ 30.937	$ 30.937	$ 30.937	$ 30.937	$ 30.937
TIR	**17,6%**																				

ZE30ULH – Zuccato

SELF CONSUMPTION																					
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Income		$ 10.681	$ 10.681	$ 10.681	$ 10.681	$ 10.681	$ 10.681	$ 10.681	$ 10.681	$ 10.681	$ 10.681	$ 10.681	$ 10.681	$ 10.681	$ 10.681	$ 10.681	$ 10.681	$ 10.681	$ 10.681	$ 10.681	$ 10.681
Expenses		$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840
Gross Result		**$ 5.841**	**$ 5.841**	**$ 5.841**	**$ 5.841**	**$ 5.841**	**$ 5.841**	**$ 5.841**	**$ 5.841**	**$ 5.841**	**$ 5.841**	**$ 5.841**	**$ 5.841**	**$ 5.841**	**$ 5.841**	**$ 5.841**	**$ 5.841**	**$ 5.841**	**$ 5.841**	**$ 5.841**	**$ 5.841**
Amort		$ -21.600	$ -21.600	$ -21.600	$ -21.600	$ -21.600	$ -21.600	$ -21.600	$ -21.600	$ -21.600	$ -21.600										
Business Tax (IIGG)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -2.044	$ -2.044	$ -2.044	$ -2.044	$ -2.044	$ -2.044	$ -2.044	$ -2.044	$ -2.044	$ -2.044
Income Tax (IIBB)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -320	$ -320	$ -320	$ -320	$ -320	$ -320	$ -320	$ -320	$ -320	$ -320
Net Result	$ -216.000	$ 5.841	$ 5.841	$ 5.841	$ 5.841	$ 5.841	$ 5.841	$ 5.841	$ 5.841	$ 5.841	$ 5.841	$ 3.476	$ 3.476	$ 3.476	$ 3.476	$ 3.476	$ 3.476	$ 3.476	$ 3.476	$ 3.476	$ 3.476
TIR	**-7,7%**																				

RENOVAR		Tariff		0,105	USD/kWh																
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Income		$ 20.328	$ 20.328	$ 20.328	$ 20.328	$ 20.328	$ 20.328	$ 20.328	$ 20.328	$ 20.328	$ 20.328	$ 20.328	$ 20.328	$ 20.328	$ 20.328	$ 20.328	$ 20.328	$ 20.328	$ 20.328	$ 20.328	$ 20.328
Expenses		$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840
Gross Result		**$ 15.488**	**$ 15.488**	**$ 15.488**	**$ 15.488**	**$ 15.488**	**$ 15.488**	**$ 15.488**	**$ 15.488**	**$ 15.488**	**$ 15.488**	**$ 15.488**	**$ 15.488**	**$ 15.488**	**$ 15.488**	**$ 15.488**	**$ 15.488**	**$ 15.488**	**$ 15.488**	**$ 15.488**	**$ 15.488**
Amort		$ -21.600	$ -21.600	$ -21.600	$ -21.600	$ -21.600	$ -21.600	$ -21.600	$ -21.600	$ -21.600	$ -21.600										
Business Tax (IIGG)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -5.421	$ -5.421	$ -5.421	$ -5.421	$ -5.421	$ -5.421	$ -5.421	$ -5.421	$ -5.421	$ -5.421
Income Tax (IIBB)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -610	$ -610	$ -610	$ -610	$ -610	$ -610	$ -610	$ -610	$ -610	$ -610
Net Result	$ -216.000	$ 15.488	$ 15.488	$ 15.488	$ 15.488	$ 15.488	$ 15.488	$ 15.488	$ 15.488	$ 15.488	$ 15.488	$ 9.457	$ 9.457	$ 9.457	$ 9.457	$ 9.457	$ 9.457	$ 9.457	$ 9.457	$ 9.457	$ 9.457
TIR	**1,6%**																				

MATER																					
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Income		$ 18.768	$ 18.768	$ 18.768	$ 18.768	$ 18.768	$ 18.768	$ 18.768	$ 18.768	$ 18.768	$ 18.768	$ 18.768	$ 18.768	$ 18.768	$ 18.768	$ 18.768	$ 18.768	$ 18.768	$ 18.768	$ 18.768	$ 18.768
Expenses		$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840
Gross Result		**$ 13.928**	**$ 13.928**	**$ 13.928**	**$ 13.928**	**$ 13.928**	**$ 13.928**	**$ 13.928**	**$ 13.928**	**$ 13.928**	**$ 13.928**	**$ 13.928**	**$ 13.928**	**$ 13.928**	**$ 13.928**	**$ 13.928**	**$ 13.928**	**$ 13.928**	**$ 13.928**	**$ 13.928**	**$ 13.928**
Amort		$ -21.600	$ -21.600	$ -21.600	$ -21.600	$ -21.600	$ -21.600	$ -21.600	$ -21.600	$ -21.600	$ -21.600										
Business Tax (IIGG)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -4.875	$ -4.875	$ -4.875	$ -4.875	$ -4.875	$ -4.875	$ -4.875	$ -4.875	$ -4.875	$ -4.875
Income Tax (IIBB)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -563	$ -563	$ -563	$ -563	$ -563	$ -563	$ -563	$ -563	$ -563	$ -563
Net Result	$ -216.000	$ 13.928	$ 13.928	$ 13.928	$ 13.928	$ 13.928	$ 13.928	$ 13.928	$ 13.928	$ 13.928	$ 13.928	$ 8.490	$ 8.490	$ 8.490	$ 8.490	$ 8.490	$ 8.490	$ 8.490	$ 8.490	$ 8.490	$ 8.490
TIR	**0,4%**																				

Assumed payback period																					
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Income		$ 58.840	$ 58.840	$ 58.840	$ 58.840	$ 58.840	$ 58.840	$ 58.840	$ 58.840	$ 58.840	$ 58.840	$ 58.840	$ 58.840	$ 58.840	$ 58.840	$ 58.840	$ 58.840	$ 58.840	$ 58.840	$ 58.840	$ 58.840
Expenses		$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840	$ -4.840
Gross Result		**$ 54.000**	**$ 54.000**	**$ 54.000**	**$ 54.000**	**$ 54.000**	**$ 54.000**	**$ 54.000**	**$ 54.000**	**$ 54.000**	**$ 54.000**	**$ 54.000**	**$ 54.000**	**$ 54.000**	**$ 54.000**	**$ 54.000**	**$ 54.000**	**$ 54.000**	**$ 54.000**	**$ 54.000**	**$ 54.000**
Amort		$ -21.600	$ -21.600	$ -21.600	$ -21.600	$ -21.600	$ -21.600	$ -21.600	$ -21.600	$ -21.600	$ -21.600										
Business Tax (IIGG)		$ -11.340	$ -11.340	$ -11.340	$ -11.340	$ -11.340	$ -11.340	$ -11.340	$ -11.340	$ -11.340	$ -11.340	$ -18.900	$ -18.900	$ -18.900	$ -18.900	$ -18.900	$ -18.900	$ -18.900	$ -18.900	$ -18.900	$ -18.900
Income Tax (IIBB)		$ -1.765	$ -1.765	$ -1.765	$ -1.765	$ -1.765	$ -1.765	$ -1.765	$ -1.765	$ -1.765	$ -1.765	$ -1.765	$ -1.765	$ -1.765	$ -1.765	$ -1.765	$ -1.765	$ -1.765	$ -1.765	$ -1.765	$ -1.765
Net Result	$ -216.000	$ 40.895	$ 40.895	$ 40.895	$ 40.895	$ 40.895	$ 40.895	$ 40.895	$ 40.895	$ 40.895	$ 40.895	$ 33.335	$ 33.335	$ 33.335	$ 33.335	$ 33.335	$ 33.335	$ 33.335	$ 33.335	$ 33.335	$ 33.335
TIR	**17,6%**																				

ZE40ULH – Zuccato

SELF CONSUMPTION

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Income		$ 14.789	$ 14.789	$ 14.789	$ 14.789	$ 14.789	$ 14.789	$ 14.789	$ 14.789	$ 14.789	$ 14.789	$ 14.789	$ 14.789	$ 14.789	$ 14.789	$ 14.789	$ 14.789	$ 14.789	$ 14.789	$ 14.789	$ 14.789
Expenses		$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701
Gross Result		**$ 8.087**	**$ 8.087**	**$ 8.087**	**$ 8.087**	**$ 8.087**	**$ 8.087**	**$ 8.087**	**$ 8.087**	**$ 8.087**	**$ 8.087**	**$ 8.087**	**$ 8.087**	**$ 8.087**	**$ 8.087**	**$ 8.087**	**$ 8.087**	**$ 8.087**	**$ 8.087**	**$ 8.087**	**$ 8.087**
Amort		$ -22.800	$ -22.800	$ -22.800	$ -22.800	$ -22.800	$ -22.800	$ -22.800	$ -22.800	$ -22.800	$ -22.800										
Business Tax (IIGG)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -2.831	$ -2.831	$ -2.831	$ -2.831	$ -2.831	$ -2.831	$ -2.831	$ -2.831	$ -2.831	$ -2.831
Income Tax (IIBB)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -444	$ -444	$ -444	$ -444	$ -444	$ -444	$ -444	$ -444	$ -444	$ -444
Net Result	$ -228.000	$ 8.087	$ 8.087	$ 8.087	$ 8.087	$ 8.087	$ 8.087	$ 8.087	$ 8.087	$ 8.087	$ 8.087	$ 4.813	$ 4.813	$ 4.813	$ 4.813	$ 4.813	$ 4.813	$ 4.813	$ 4.813	$ 4.813	$ 4.813
TIR	**-5,5%**																				

RENOVAR Tariff 0,105 USD/kWh

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Income		$ 28.146	$ 28.146	$ 28.146	$ 28.146	$ 28.146	$ 28.146	$ 28.146	$ 28.146	$ 28.146	$ 28.146	$ 28.146	$ 28.146	$ 28.146	$ 28.146	$ 28.146	$ 28.146	$ 28.146	$ 28.146	$ 28.146	$ 28.146
Expenses		$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701
Gross Result		**$ 21.444**	**$ 21.444**	**$ 21.444**	**$ 21.444**	**$ 21.444**	**$ 21.444**	**$ 21.444**	**$ 21.444**	**$ 21.444**	**$ 21.444**	**$ 21.444**	**$ 21.444**	**$ 21.444**	**$ 21.444**	**$ 21.444**	**$ 21.444**	**$ 21.444**	**$ 21.444**	**$ 21.444**	**$ 21.444**
Amort		$ -22.800	$ -22.800	$ -22.800	$ -22.800	$ -22.800	$ -22.800	$ -22.800	$ -22.800	$ -22.800	$ -22.800										
Business Tax (IIGG)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -7.506	$ -7.506	$ -7.506	$ -7.506	$ -7.506	$ -7.506	$ -7.506	$ -7.506	$ -7.506	$ -7.506
Income Tax (IIBB)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -844	$ -844	$ -844	$ -844	$ -844	$ -844	$ -844	$ -844	$ -844	$ -844
Net Result	$ -228.000	$ 21.444	$ 21.444	$ 21.444	$ 21.444	$ 21.444	$ 21.444	$ 21.444	$ 21.444	$ 21.444	$ 21.444	$ 13.095	$ 13.095	$ 13.095	$ 13.095	$ 13.095	$ 13.095	$ 13.095	$ 13.095	$ 13.095	$ 13.095
TIR	**5,0%**																				

MATER

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Income		$ 21.722	$ 21.722	$ 21.722	$ 21.722	$ 21.722	$ 21.722	$ 21.722	$ 21.722	$ 21.722	$ 21.722	$ 21.722	$ 21.722	$ 21.722	$ 21.722	$ 21.722	$ 21.722	$ 21.722	$ 21.722	$ 21.722	$ 21.722
Expenses		$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701
Gross Result		**$ 15.020**	**$ 15.020**	**$ 15.020**	**$ 15.020**	**$ 15.020**	**$ 15.020**	**$ 15.020**	**$ 15.020**	**$ 15.020**	**$ 15.020**	**$ 15.020**	**$ 15.020**	**$ 15.020**	**$ 15.020**	**$ 15.020**	**$ 15.020**	**$ 15.020**	**$ 15.020**	**$ 15.020**	**$ 15.020**
Amort		$ -22.800	$ -22.800	$ -22.800	$ -22.800	$ -22.800	$ -22.800	$ -22.800	$ -22.800	$ -22.800	$ -22.800										
Business Tax (IIGG)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -5.257	$ -5.257	$ -5.257	$ -5.257	$ -5.257	$ -5.257	$ -5.257	$ -5.257	$ -5.257	$ -5.257
Income Tax (IIBB)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -652	$ -652	$ -652	$ -652	$ -652	$ -652	$ -652	$ -652	$ -652	$ -652
Net Result	$ -228.000	$ 15.020	$ 15.020	$ 15.020	$ 15.020	$ 15.020	$ 15.020	$ 15.020	$ 15.020	$ 15.020	$ 15.020	$ 9.112	$ 9.112	$ 9.112	$ 9.112	$ 9.112	$ 9.112	$ 9.112	$ 9.112	$ 9.112	$ 9.112
TIR	**0,6%**																				

Assumed payback period

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Income		$ 63.701	$ 63.701	$ 63.701	$ 63.701	$ 63.701	$ 63.701	$ 63.701	$ 63.701	$ 63.701	$ 63.701	$ 63.701	$ 63.701	$ 63.701	$ 63.701	$ 63.701	$ 63.701	$ 63.701	$ 63.701	$ 63.701	$ 63.701
Expenses		$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701	$ -6.701
Gross Result		**$ 57.000**	**$ 57.000**	**$ 57.000**	**$ 57.000**	**$ 57.000**	**$ 57.000**	**$ 57.000**	**$ 57.000**	**$ 57.000**	**$ 57.000**	**$ 57.000**	**$ 57.000**	**$ 57.000**	**$ 57.000**	**$ 57.000**	**$ 57.000**	**$ 57.000**	**$ 57.000**	**$ 57.000**	**$ 57.000**
Amort		$ -22.800	$ -22.800	$ -22.800	$ -22.800	$ -22.800	$ -22.800	$ -22.800	$ -22.800	$ -22.800	$ -22.800										
Business Tax (IIGG)		$ -11.970	$ -11.970	$ -11.970	$ -11.970	$ -11.970	$ -11.970	$ -11.970	$ -11.970	$ -11.970	$ -11.970	$ -19.950	$ -19.950	$ -19.950	$ -19.950	$ -19.950	$ -19.950	$ -19.950	$ -19.950	$ -19.950	$ -19.950
Income Tax (IIBB)		$ -1.911	$ -1.911	$ -1.911	$ -1.911	$ -1.911	$ -1.911	$ -1.911	$ -1.911	$ -1.911	$ -1.911	$ -1.911	$ -1.911	$ -1.911	$ -1.911	$ -1.911	$ -1.911	$ -1.911	$ -1.911	$ -1.911	$ -1.911
Net Result	$ -228.000	$ 43.119	$ 43.119	$ 43.119	$ 43.119	$ 43.119	$ 43.119	$ 43.119	$ 43.119	$ 43.119	$ 43.119	$ 35.139	$ 35.139	$ 35.139	$ 35.139	$ 35.139	$ 35.139	$ 35.139	$ 35.139	$ 35.139	$ 35.139
TIR	**17,6%**																				

ZE50ULH – Zuccato

SELF CONSUMPTION

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Income		$ 18.486	$ 18.486	$ 18.486	$ 18.486	$ 18.486	$ 18.486	$ 18.486	$ 18.486	$ 18.486	$ 18.486	$ 18.486	$ 18.486	$ 18.486	$ 18.486	$ 18.486	$ 18.486	$ 18.486	$ 18.486	$ 18.486	$ 18.486
Expenses		$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377
Gross Result		**$ 10.109**	**$ 10.109**	**$ 10.109**	**$ 10.109**	**$ 10.109**	**$ 10.109**	**$ 10.109**	**$ 10.109**	**$ 10.109**	**$ 10.109**	**$ 10.109**	**$ 10.109**	**$ 10.109**	**$ 10.109**	**$ 10.109**	**$ 10.109**	**$ 10.109**	**$ 10.109**	**$ 10.109**	**$ 10.109**
Amort		$ -24.000	$ -24.000	$ -24.000	$ -24.000	$ -24.000	$ -24.000	$ -24.000	$ -24.000	$ -24.000	$ -24.000										
Business Tax (IIGG)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -3.538	$ -3.538	$ -3.538	$ -3.538	$ -3.538	$ -3.538	$ -3.538	$ -3.538	$ -3.538	$ -3.538
Income Tax (IIBB)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -555	$ -555	$ -555	$ -555	$ -555	$ -555	$ -555	$ -555	$ -555	$ -555
Net Result	$ -240.000	$ 10.109	$ 10.109	$ 10.109	$ 10.109	$ 10.109	$ 10.109	$ 10.109	$ 10.109	$ 10.109	$ 10.109	$ 6.016	$ 6.016	$ 6.016	$ 6.016	$ 6.016	$ 6.016	$ 6.016	$ 6.016	$ 6.016	$ 6.016
TIR	**-3,9%**																				

RENOVAR Tariff 0,105 USD/kWh

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Income		$ 35.182	$ 35.182	$ 35.182	$ 35.182	$ 35.182	$ 35.182	$ 35.182	$ 35.182	$ 35.182	$ 35.182	$ 35.182	$ 35.182	$ 35.182	$ 35.182	$ 35.182	$ 35.182	$ 35.182	$ 35.182	$ 35.182	$ 35.182
Expenses		$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377
Gross Result		**$ 26.806**	**$ 26.806**	**$ 26.806**	**$ 26.806**	**$ 26.806**	**$ 26.806**	**$ 26.806**	**$ 26.806**	**$ 26.806**	**$ 26.806**	**$ 26.806**	**$ 26.806**	**$ 26.806**	**$ 26.806**	**$ 26.806**	**$ 26.806**	**$ 26.806**	**$ 26.806**	**$ 26.806**	**$ 26.806**
Amort		$ -24.000	$ -24.000	$ -24.000	$ -24.000	$ -24.000	$ -24.000	$ -24.000	$ -24.000	$ -24.000	$ -24.000										
Business Tax (IIGG)		$ -982	$ -982	$ -982	$ -982	$ -982	$ -982	$ -982	$ -982	$ -982	$ -982	$ -9.382	$ -9.382	$ -9.382	$ -9.382	$ -9.382	$ -9.382	$ -9.382	$ -9.382	$ -9.382	$ -9.382
Income Tax (IIBB)		$ -1.055	$ -1.055	$ -1.055	$ -1.055	$ -1.055	$ -1.055	$ -1.055	$ -1.055	$ -1.055	$ -1.055	$ -1.055	$ -1.055	$ -1.055	$ -1.055	$ -1.055	$ -1.055	$ -1.055	$ -1.055	$ -1.055	$ -1.055
Net Result	$ -240.000	$ 24.768	$ 24.768	$ 24.768	$ 24.768	$ 24.768	$ 24.768	$ 24.768	$ 24.768	$ 24.768	$ 24.768	$ 16.368	$ 16.368	$ 16.368	$ 16.368	$ 16.368	$ 16.368	$ 16.368	$ 16.368	$ 16.368	$ 16.368
TIR	**6,5%**																				

MATER

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Income		$ 24.452	$ 24.452	$ 24.452	$ 24.452	$ 24.452	$ 24.452	$ 24.452	$ 24.452	$ 24.452	$ 24.452	$ 24.452	$ 24.452	$ 24.452	$ 24.452	$ 24.452	$ 24.452	$ 24.452	$ 24.452	$ 24.452	$ 24.452
Expenses		$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377
Gross Result		**$ 16.075**	**$ 16.075**	**$ 16.075**	**$ 16.075**	**$ 16.075**	**$ 16.075**	**$ 16.075**	**$ 16.075**	**$ 16.075**	**$ 16.075**	**$ 16.075**	**$ 16.075**	**$ 16.075**	**$ 16.075**	**$ 16.075**	**$ 16.075**	**$ 16.075**	**$ 16.075**	**$ 16.075**	**$ 16.075**
Amort		$ -24.000	$ -24.000	$ -24.000	$ -24.000	$ -24.000	$ -24.000	$ -24.000	$ -24.000	$ -24.000	$ -24.000										
Business Tax (IIGG)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -5.626	$ -5.626	$ -5.626	$ -5.626	$ -5.626	$ -5.626	$ -5.626	$ -5.626	$ -5.626	$ -5.626
Income Tax (IIBB)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -734	$ -734	$ -734	$ -734	$ -734	$ -734	$ -734	$ -734	$ -734	$ -734
Net Result	$ -240.000	$ 16.075	$ 16.075	$ 16.075	$ 16.075	$ 16.075	$ 16.075	$ 16.075	$ 16.075	$ 16.075	$ 16.075	$ 9.715	$ 9.715	$ 9.715	$ 9.715	$ 9.715	$ 9.715	$ 9.715	$ 9.715	$ 9.715	$ 9.715
TIR	**0,8%**																				

Assumed payback period

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Income		$ 68.377	$ 68.377	$ 68.377	$ 68.377	$ 68.377	$ 68.377	$ 68.377	$ 68.377	$ 68.377	$ 68.377	$ 68.377	$ 68.377	$ 68.377	$ 68.377	$ 68.377	$ 68.377	$ 68.377	$ 68.377	$ 68.377	$ 68.377
Expenses		$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377	$ -8.377
Gross Result		**$ 60.000**	**$ 60.000**	**$ 60.000**	**$ 60.000**	**$ 60.000**	**$ 60.000**	**$ 60.000**	**$ 60.000**	**$ 60.000**	**$ 60.000**	**$ 60.000**	**$ 60.000**	**$ 60.000**	**$ 60.000**	**$ 60.000**	**$ 60.000**	**$ 60.000**	**$ 60.000**	**$ 60.000**	**$ 60.000**
Amort		$ -24.000	$ -24.000	$ -24.000	$ -24.000	$ -24.000	$ -24.000	$ -24.000	$ -24.000	$ -24.000	$ -24.000										
Business Tax (IIGG)		$ -12.600	$ -12.600	$ -12.600	$ -12.600	$ -12.600	$ -12.600	$ -12.600	$ -12.600	$ -12.600	$ -12.600	$ -21.000	$ -21.000	$ -21.000	$ -21.000	$ -21.000	$ -21.000	$ -21.000	$ -21.000	$ -21.000	$ -21.000
Income Tax (IIBB)		$ -2.051	$ -2.051	$ -2.051	$ -2.051	$ -2.051	$ -2.051	$ -2.051	$ -2.051	$ -2.051	$ -2.051	$ -2.051	$ -2.051	$ -2.051	$ -2.051	$ -2.051	$ -2.051	$ -2.051	$ -2.051	$ -2.051	$ -2.051
Net Result	$ -240.000	$ 45.349	$ 45.349	$ 45.349	$ 45.349	$ 45.349	$ 45.349	$ 45.349	$ 45.349	$ 45.349	$ 45.349	$ 36.949	$ 36.949	$ 36.949	$ 36.949	$ 36.949	$ 36.949	$ 36.949	$ 36.949	$ 36.949	$ 36.949
TIR	**17,6%**																				

ENO LT 100 – Enogia

SELF CONSUMPTION

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Income		$ 37.794	$ 37.794	$ 37.794	$ 37.794	$ 37.794	$ 37.794	$ 37.794	$ 37.794	$ 37.794	$ 37.794	$ 37.794	$ 37.794	$ 37.794	$ 37.794	$ 37.794	$ 37.794	$ 37.794	$ 37.794	$ 37.794	$ 37.794
Expenses		$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126
Gross Result		**$ 20.668**	**$ 20.668**	**$ 20.668**	**$ 20.668**	**$ 20.668**	**$ 20.668**	**$ 20.668**	**$ 20.668**	**$ 20.668**	**$ 20.668**	**$ 20.668**	**$ 20.668**	**$ 20.668**	**$ 20.668**	**$ 20.668**	**$ 20.668**	**$ 20.668**	**$ 20.668**	**$ 20.668**	**$ 20.668**
Amort		$ -30.400	$ -30.400	$ -30.400	$ -30.400	$ -30.400	$ -30.400	$ -30.400	$ -30.400	$ -30.400	$ -30.400										
Business Tax (IIGG)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -7.234	$ -7.234	$ -7.234	$ -7.234	$ -7.234	$ -7.234	$ -7.234	$ -7.234	$ -7.234	$ -7.234
Income Tax (IIBB)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -1.134	$ -1.134	$ -1.134	$ -1.134	$ -1.134	$ -1.134	$ -1.134	$ -1.134	$ -1.134	$ -1.134
Net Result	$ -304.000	$ 20.668	$ 20.668	$ 20.668	$ 20.668	$ 20.668	$ 20.668	$ 20.668	$ 20.668	$ 20.668	$ 20.668	$ 12.300	$ 12.300	$ 12.300	$ 12.300	$ 12.300	$ 12.300	$ 12.300	$ 12.300	$ 12.300	$ 12.300
TIR	**0,9%**																				

RENOVAR Tariff 0,105 USD/kWh

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Income		$ 71.928	$ 71.928	$ 71.928	$ 71.928	$ 71.928	$ 71.928	$ 71.928	$ 71.928	$ 71.928	$ 71.928	$ 71.928	$ 71.928	$ 71.928	$ 71.928	$ 71.928	$ 71.928	$ 71.928	$ 71.928	$ 71.928	$ 71.928
Expenses		$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126
Gross Result		**$ 54.803**	**$ 54.803**	**$ 54.803**	**$ 54.803**	**$ 54.803**	**$ 54.803**	**$ 54.803**	**$ 54.803**	**$ 54.803**	**$ 54.803**	**$ 54.803**	**$ 54.803**	**$ 54.803**	**$ 54.803**	**$ 54.803**	**$ 54.803**	**$ 54.803**	**$ 54.803**	**$ 54.803**	**$ 54.803**
Amort		$ -30.400	$ -30.400	$ -30.400	$ -30.400	$ -30.400	$ -30.400	$ -30.400	$ -30.400	$ -30.400	$ -30.400										
Business Tax (IIGG)		$ -8.541	$ -8.541	$ -8.541	$ -8.541	$ -8.541	$ -8.541	$ -8.541	$ -8.541	$ -8.541	$ -8.541	$ -19.181	$ -19.181	$ -19.181	$ -19.181	$ -19.181	$ -19.181	$ -19.181	$ -19.181	$ -19.181	$ -19.181
Income Tax (IIBB)		$ -2.158	$ -2.158	$ -2.158	$ -2.158	$ -2.158	$ -2.158	$ -2.158	$ -2.158	$ -2.158	$ -2.158	$ -2.158	$ -2.158	$ -2.158	$ -2.158	$ -2.158	$ -2.158	$ -2.158	$ -2.158	$ -2.158	$ -2.158
Net Result	$ -304.000	$ 44.104	$ 44.104	$ 44.104	$ 44.104	$ 44.104	$ 44.104	$ 44.104	$ 44.104	$ 44.104	$ 44.104	$ 33.464	$ 33.464	$ 33.464	$ 33.464	$ 33.464	$ 33.464	$ 33.464	$ 33.464	$ 33.464	$ 33.464
TIR	**12,3%**																				

MATER

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Income		$ 38.791	$ 38.791	$ 38.791	$ 38.791	$ 38.791	$ 38.791	$ 38.791	$ 38.791	$ 38.791	$ 38.791	$ 38.791	$ 38.791	$ 38.791	$ 38.791	$ 38.791	$ 38.791	$ 38.791	$ 38.791	$ 38.791	$ 38.791
Expenses		$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126
Gross Result		**$ 21.665**	**$ 21.665**	**$ 21.665**	**$ 21.665**	**$ 21.665**	**$ 21.665**	**$ 21.665**	**$ 21.665**	**$ 21.665**	**$ 21.665**	**$ 21.665**	**$ 21.665**	**$ 21.665**	**$ 21.665**	**$ 21.665**	**$ 21.665**	**$ 21.665**	**$ 21.665**	**$ 21.665**	**$ 21.665**
Amort		$ -30.400	$ -30.400	$ -30.400	$ -30.400	$ -30.400	$ -30.400	$ -30.400	$ -30.400	$ -30.400	$ -30.400										
Business Tax (IIGG)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -7.583	$ -7.583	$ -7.583	$ -7.583	$ -7.583	$ -7.583	$ -7.583	$ -7.583	$ -7.583	$ -7.583
Income Tax (IIBB)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -1.164	$ -1.164	$ -1.164	$ -1.164	$ -1.164	$ -1.164	$ -1.164	$ -1.164	$ -1.164	$ -1.164
Net Result	$ -304.000	$ 21.665	$ 21.665	$ 21.665	$ 21.665	$ 21.665	$ 21.665	$ 21.665	$ 21.665	$ 21.665	$ 21.665	$ 12.919	$ 12.919	$ 12.919	$ 12.919	$ 12.919	$ 12.919	$ 12.919	$ 12.919	$ 12.919	$ 12.919
TIR	**1,4%**																				

Assumed payback period

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Income		$ 93.126	$ 93.126	$ 93.126	$ 93.126	$ 93.126	$ 93.126	$ 93.126	$ 93.126	$ 93.126	$ 93.126	$ 93.126	$ 93.126	$ 93.126	$ 93.126	$ 93.126	$ 93.126	$ 93.126	$ 93.126	$ 93.126	$ 93.126
Expenses		$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126	$ -17.126
Gross Result		**$ 76.000**	**$ 76.000**	**$ 76.000**	**$ 76.000**	**$ 76.000**	**$ 76.000**	**$ 76.000**	**$ 76.000**	**$ 76.000**	**$ 76.000**	**$ 76.000**	**$ 76.000**	**$ 76.000**	**$ 76.000**	**$ 76.000**	**$ 76.000**	**$ 76.000**	**$ 76.000**	**$ 76.000**	**$ 76.000**
Amort		$ -30.400	$ -30.400	$ -30.400	$ -30.400	$ -30.400	$ -30.400	$ -30.400	$ -30.400	$ -30.400	$ -30.400										
Business Tax (IIGG)		$ -15.960	$ -15.960	$ -15.960	$ -15.960	$ -15.960	$ -15.960	$ -15.960	$ -15.960	$ -15.960	$ -15.960	$ -26.600	$ -26.600	$ -26.600	$ -26.600	$ -26.600	$ -26.600	$ -26.600	$ -26.600	$ -26.600	$ -26.600
Income Tax (IIBB)		$ -2.794	$ -2.794	$ -2.794	$ -2.794	$ -2.794	$ -2.794	$ -2.794	$ -2.794	$ -2.794	$ -2.794	$ -2.794	$ -2.794	$ -2.794	$ -2.794	$ -2.794	$ -2.794	$ -2.794	$ -2.794	$ -2.794	$ -2.794
Net Result	$ -304.000	$ 57.246	$ 57.246	$ 57.246	$ 57.246	$ 57.246	$ 57.246	$ 57.246	$ 57.246	$ 57.246	$ 57.246	$ 46.606	$ 46.606	$ 46.606	$ 46.606	$ 46.606	$ 46.606	$ 46.606	$ 46.606	$ 46.606	$ 46.606
TIR	**17,5%**																				

ENO LT 180 – Enogia

SELF CONSUMPTION																					
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Income		$ 66.550	$ 66.550	$ 66.550	$ 66.550	$ 66.550	$ 66.550	$ 66.550	$ 66.550	$ 66.550	$ 66.550	$ 66.550	$ 66.550	$ 66.550	$ 66.550	$ 66.550	$ 66.550	$ 66.550	$ 66.550	$ 66.550	$ 66.550
Expenses		$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156
Gross Result		**$ 36.394**	**$ 36.394**	**$ 36.394**	**$ 36.394**	**$ 36.394**	**$ 36.394**	**$ 36.394**	**$ 36.394**	**$ 36.394**	**$ 36.394**	**$ 36.394**	**$ 36.394**	**$ 36.394**	**$ 36.394**	**$ 36.394**	**$ 36.394**	**$ 36.394**	**$ 36.394**	**$ 36.394**	**$ 36.394**
Amort		$ -44.300	$ -44.300	$ -44.300	$ -44.300	$ -44.300	$ -44.300	$ -44.300	$ -44.300	$ -44.300	$ -44.300										
Business Tax (IIGG)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -12.738	$ -12.738	$ -12.738	$ -12.738	$ -12.738	$ -12.738	$ -12.738	$ -12.738	$ -12.738	$ -12.738
Income Tax (IIBB)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -1.996	$ -1.996	$ -1.996	$ -1.996	$ -1.996	$ -1.996	$ -1.996	$ -1.996	$ -1.996	$ -1.996
Net Result	$ -443.000	$ 36.394	$ 36.394	$ 36.394	$ 36.394	$ 36.394	$ 36.394	$ 36.394	$ 36.394	$ 36.394	$ 36.394	$ 21.659	$ 21.659	$ 21.659	$ 21.659	$ 21.659	$ 21.659	$ 21.659	$ 21.659	$ 21.659	$ 21.659
TIR	**3,1%**																				

RENOVAR		Tariff		0,105	USD/kWh																
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Income		$ 126.656	$ 126.656	$ 126.656	$ 126.656	$ 126.656	$ 126.656	$ 126.656	$ 126.656	$ 126.656	$ 126.656	$ 126.656	$ 126.656	$ 126.656	$ 126.656	$ 126.656	$ 126.656	$ 126.656	$ 126.656	$ 126.656	$ 126.656
Expenses		$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156
Gross Result		**$ 96.500**	**$ 96.500**	**$ 96.500**	**$ 96.500**	**$ 96.500**	**$ 96.500**	**$ 96.500**	**$ 96.500**	**$ 96.500**	**$ 96.500**	**$ 96.500**	**$ 96.500**	**$ 96.500**	**$ 96.500**	**$ 96.500**	**$ 96.500**	**$ 96.500**	**$ 96.500**	**$ 96.500**	**$ 96.500**
Amort		$ -44.300	$ -44.300	$ -44.300	$ -44.300	$ -44.300	$ -44.300	$ -44.300	$ -44.300	$ -44.300	$ -44.300										
Business Tax (IIGG)		$ -18.270	$ -18.270	$ -18.270	$ -18.270	$ -18.270	$ -18.270	$ -18.270	$ -18.270	$ -18.270	$ -18.270	$ -33.775	$ -33.775	$ -33.775	$ -33.775	$ -33.775	$ -33.775	$ -33.775	$ -33.775	$ -33.775	$ -33.775
Income Tax (IIBB)		$ -3.800	$ -3.800	$ -3.800	$ -3.800	$ -3.800	$ -3.800	$ -3.800	$ -3.800	$ -3.800	$ -3.800	$ -3.800	$ -3.800	$ -3.800	$ -3.800	$ -3.800	$ -3.800	$ -3.800	$ -3.800	$ -3.800	$ -3.800
Net Result	$ -443.000	$ 74.430	$ 74.430	$ 74.430	$ 74.430	$ 74.430	$ 74.430	$ 74.430	$ 74.430	$ 74.430	$ 74.430	$ 58.925	$ 58.925	$ 58.925	$ 58.925	$ 58.925	$ 58.925	$ 58.925	$ 58.925	$ 58.925	$ 58.925
TIR	**15,2%**																				

MATER																					
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Income		$ 62.768	$ 62.768	$ 62.768	$ 62.768	$ 62.768	$ 62.768	$ 62.768	$ 62.768	$ 62.768	$ 62.768	$ 62.768	$ 62.768	$ 62.768	$ 62.768	$ 62.768	$ 62.768	$ 62.768	$ 62.768	$ 62.768	$ 62.768
Expenses		$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156
Gross Result		**$ 32.611**	**$ 32.611**	**$ 32.611**	**$ 32.611**	**$ 32.611**	**$ 32.611**	**$ 32.611**	**$ 32.611**	**$ 32.611**	**$ 32.611**	**$ 32.611**	**$ 32.611**	**$ 32.611**	**$ 32.611**	**$ 32.611**	**$ 32.611**	**$ 32.611**	**$ 32.611**	**$ 32.611**	**$ 32.611**
Amort		$ -44.300	$ -44.300	$ -44.300	$ -44.300	$ -44.300	$ -44.300	$ -44.300	$ -44.300	$ -44.300	$ -44.300										
Business Tax (IIGG)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -11.414	$ -11.414	$ -11.414	$ -11.414	$ -11.414	$ -11.414	$ -11.414	$ -11.414	$ -11.414	$ -11.414
Income Tax (IIBB)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -1.883	$ -1.883	$ -1.883	$ -1.883	$ -1.883	$ -1.883	$ -1.883	$ -1.883	$ -1.883	$ -1.883
Net Result	$ -443.000	$ 32.611	$ 32.611	$ 32.611	$ 32.611	$ 32.611	$ 32.611	$ 32.611	$ 32.611	$ 32.611	$ 32.611	$ 19.314	$ 19.314	$ 19.314	$ 19.314	$ 19.314	$ 19.314	$ 19.314	$ 19.314	$ 19.314	$ 19.314
TIR	**1,8%**																				

Assumed payback period																					
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Income		$ 140.906	$ 140.906	$ 140.906	$ 140.906	$ 140.906	$ 140.906	$ 140.906	$ 140.906	$ 140.906	$ 140.906	$ 140.906	$ 140.906	$ 140.906	$ 140.906	$ 140.906	$ 140.906	$ 140.906	$ 140.906	$ 140.906	$ 140.906
Expenses		$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156	$ -30.156
Gross Result		**$ 110.750**	**$ 110.750**	**$ 110.750**	**$ 110.750**	**$ 110.750**	**$ 110.750**	**$ 110.750**	**$ 110.750**	**$ 110.750**	**$ 110.750**	**$ 110.750**	**$ 110.750**	**$ 110.750**	**$ 110.750**	**$ 110.750**	**$ 110.750**	**$ 110.750**	**$ 110.750**	**$ 110.750**	**$ 110.750**
Amort		$ -44.300	$ -44.300	$ -44.300	$ -44.300	$ -44.300	$ -44.300	$ -44.300	$ -44.300	$ -44.300	$ -44.300										
Business Tax (IIGG)		$ -23.258	$ -23.258	$ -23.258	$ -23.258	$ -23.258	$ -23.258	$ -23.258	$ -23.258	$ -23.258	$ -23.258	$ -38.763	$ -38.763	$ -38.763	$ -38.763	$ -38.763	$ -38.763	$ -38.763	$ -38.763	$ -38.763	$ -38.763
Income Tax (IIBB)		$ -4.227	$ -4.227	$ -4.227	$ -4.227	$ -4.227	$ -4.227	$ -4.227	$ -4.227	$ -4.227	$ -4.227	$ -4.227	$ -4.227	$ -4.227	$ -4.227	$ -4.227	$ -4.227	$ -4.227	$ -4.227	$ -4.227	$ -4.227
Net Result	$ -443.000	$ 83.265	$ 83.265	$ 83.265	$ 83.265	$ 83.265	$ 83.265	$ 83.265	$ 83.265	$ 83.265	$ 83.265	$ 67.760	$ 67.760	$ 67.760	$ 67.760	$ 67.760	$ 67.760	$ 67.760	$ 67.760	$ 67.760	$ 67.760
TIR	**17,5%**																				

ZE200ULH+ – Zuccato

SELF CONSUMPTION

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Income		$ 75.588	$ 75.588	$ 75.588	$ 75.588	$ 75.588	$ 75.588	$ 75.588	$ 75.588	$ 75.588	$ 75.588	$ 75.588	$ 75.588	$ 75.588	$ 75.588	$ 75.588	$ 75.588	$ 75.588	$ 75.588	$ 75.588	$ 75.588
Expenses		$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252
Gross Result		**$ 41.336**	**$ 41.336**	**$ 41.336**	**$ 41.336**	**$ 41.336**	**$ 41.336**	**$ 41.336**	**$ 41.336**	**$ 41.336**	**$ 41.336**	**$ 41.336**	**$ 41.336**	**$ 41.336**	**$ 41.336**	**$ 41.336**	**$ 41.336**	**$ 41.336**	**$ 41.336**	**$ 41.336**	**$ 41.336**
Amort		$ -45.800	$ -45.800	$ -45.800	$ -45.800	$ -45.800	$ -45.800	$ -45.800	$ -45.800	$ -45.800	$ -45.800										
Business Tax (IIGG)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -14.468	$ -14.468	$ -14.468	$ -14.468	$ -14.468	$ -14.468	$ -14.468	$ -14.468	$ -14.468	$ -14.468
Income Tax (IIBB)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -2.268	$ -2.268	$ -2.268	$ -2.268	$ -2.268	$ -2.268	$ -2.268	$ -2.268	$ -2.268	$ -2.268
Net Result	$ -458.000	$ 41.336	$ 41.336	$ 41.336	$ 41.336	$ 41.336	$ 41.336	$ 41.336	$ 41.336	$ 41.336	$ 41.336	$ 24.601	$ 24.601	$ 24.601	$ 24.601	$ 24.601	$ 24.601	$ 24.601	$ 24.601	$ 24.601	$ 24.601
TIR	**4,3%**																				

RENOVAR Tariff 0,105 USD/kWh

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Income		$ 143.857	$ 143.857	$ 143.857	$ 143.857	$ 143.857	$ 143.857	$ 143.857	$ 143.857	$ 143.857	$ 143.857	$ 143.857	$ 143.857	$ 143.857	$ 143.857	$ 143.857	$ 143.857	$ 143.857	$ 143.857	$ 143.857	$ 143.857
Expenses		$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252
Gross Result		**$ 109.605**	**$ 109.605**	**$ 109.605**	**$ 109.605**	**$ 109.605**	**$ 109.605**	**$ 109.605**	**$ 109.605**	**$ 109.605**	**$ 109.605**	**$ 109.605**	**$ 109.605**	**$ 109.605**	**$ 109.605**	**$ 109.605**	**$ 109.605**	**$ 109.605**	**$ 109.605**	**$ 109.605**	**$ 109.605**
Amort		$ -45.800	$ -45.800	$ -45.800	$ -45.800	$ -45.800	$ -45.800	$ -45.800	$ -45.800	$ -45.800	$ -45.800										
Business Tax (IIGG)		$ -22.332	$ -22.332	$ -22.332	$ -22.332	$ -22.332	$ -22.332	$ -22.332	$ -22.332	$ -22.332	$ -22.332	$ -38.362	$ -38.362	$ -38.362	$ -38.362	$ -38.362	$ -38.362	$ -38.362	$ -38.362	$ -38.362	$ -38.362
Income Tax (IIBB)		$ -4.316	$ -4.316	$ -4.316	$ -4.316	$ -4.316	$ -4.316	$ -4.316	$ -4.316	$ -4.316	$ -4.316	$ -4.316	$ -4.316	$ -4.316	$ -4.316	$ -4.316	$ -4.316	$ -4.316	$ -4.316	$ -4.316	$ -4.316
Net Result	$ -458.000	$ 82.958	$ 82.958	$ 82.958	$ 82.958	$ 82.958	$ 82.958	$ 82.958	$ 82.958	$ 82.958	$ 82.958	$ 66.928	$ 66.928	$ 66.928	$ 66.928	$ 66.928	$ 66.928	$ 66.928	$ 66.928	$ 66.928	$ 66.928
TIR	**16,7%**																				

MATER

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Income		$ 68.582	$ 68.582	$ 68.582	$ 68.582	$ 68.582	$ 68.582	$ 68.582	$ 68.582	$ 68.582	$ 68.582	$ 68.582	$ 68.582	$ 68.582	$ 68.582	$ 68.582	$ 68.582	$ 68.582	$ 68.582	$ 68.582	$ 68.582
Expenses		$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252
Gross Result		**$ 34.330**	**$ 34.330**	**$ 34.330**	**$ 34.330**	**$ 34.330**	**$ 34.330**	**$ 34.330**	**$ 34.330**	**$ 34.330**	**$ 34.330**	**$ 34.330**	**$ 34.330**	**$ 34.330**	**$ 34.330**	**$ 34.330**	**$ 34.330**	**$ 34.330**	**$ 34.330**	**$ 34.330**	**$ 34.330**
Amort		$ -45.800	$ -45.800	$ -45.800	$ -45.800	$ -45.800	$ -45.800	$ -45.800	$ -45.800	$ -45.800	$ -45.800										
Business Tax (IIGG)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -12.016	$ -12.016	$ -12.016	$ -12.016	$ -12.016	$ -12.016	$ -12.016	$ -12.016	$ -12.016	$ -12.016
Income Tax (IIBB)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -2.057	$ -2.057	$ -2.057	$ -2.057	$ -2.057	$ -2.057	$ -2.057	$ -2.057	$ -2.057	$ -2.057
Net Result	$ -458.000	$ 34.330	$ 34.330	$ 34.330	$ 34.330	$ 34.330	$ 34.330	$ 34.330	$ 34.330	$ 34.330	$ 34.330	$ 20.257	$ 20.257	$ 20.257	$ 20.257	$ 20.257	$ 20.257	$ 20.257	$ 20.257	$ 20.257	$ 20.257
TIR	**2,0%**																				

Assumed payback period

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Income		$ 148.752	$ 148.752	$ 148.752	$ 148.752	$ 148.752	$ 148.752	$ 148.752	$ 148.752	$ 148.752	$ 148.752	$ 148.752	$ 148.752	$ 148.752	$ 148.752	$ 148.752	$ 148.752	$ 148.752	$ 148.752	$ 148.752	$ 148.752
Expenses		$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252	$ -34.252
Gross Result		**$ 114.500**	**$ 114.500**	**$ 114.500**	**$ 114.500**	**$ 114.500**	**$ 114.500**	**$ 114.500**	**$ 114.500**	**$ 114.500**	**$ 114.500**	**$ 114.500**	**$ 114.500**	**$ 114.500**	**$ 114.500**	**$ 114.500**	**$ 114.500**	**$ 114.500**	**$ 114.500**	**$ 114.500**	**$ 114.500**
Amort		$ -45.800	$ -45.800	$ -45.800	$ -45.800	$ -45.800	$ -45.800	$ -45.800	$ -45.800	$ -45.800	$ -45.800										
Business Tax (IIGG)		$ -24.045	$ -24.045	$ -24.045	$ -24.045	$ -24.045	$ -24.045	$ -24.045	$ -24.045	$ -24.045	$ -24.045	$ -40.075	$ -40.075	$ -40.075	$ -40.075	$ -40.075	$ -40.075	$ -40.075	$ -40.075	$ -40.075	$ -40.075
Income Tax (IIBB)		$ -4.463	$ -4.463	$ -4.463	$ -4.463	$ -4.463	$ -4.463	$ -4.463	$ -4.463	$ -4.463	$ -4.463	$ -4.463	$ -4.463	$ -4.463	$ -4.463	$ -4.463	$ -4.463	$ -4.463	$ -4.463	$ -4.463	$ -4.463
Net Result	$ -458.000	$ 85.992	$ 85.992	$ 85.992	$ 85.992	$ 85.992	$ 85.992	$ 85.992	$ 85.992	$ 85.992	$ 85.992	$ 69.962	$ 69.962	$ 69.962	$ 69.962	$ 69.962	$ 69.962	$ 69.962	$ 69.962	$ 69.962	$ 69.962
TIR	**17,5%**																				

ZE250ULH+ – Zuccato

SELF CONSUMPTION

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Income		$ 94.074	$ 94.074	$ 94.074	$ 94.074	$ 94.074	$ 94.074	$ 94.074	$ 94.074	$ 94.074	$ 94.074	$ 94.074	$ 94.074	$ 94.074	$ 94.074	$ 94.074	$ 94.074	$ 94.074	$ 94.074	$ 94.074	$ 94.074
Expenses		$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628
Gross Result		**$ 51.445**	**$ 51.445**	**$ 51.445**	**$ 51.445**	**$ 51.445**	**$ 51.445**	**$ 51.445**	**$ 51.445**	**$ 51.445**	**$ 51.445**	**$ 51.445**	**$ 51.445**	**$ 51.445**	**$ 51.445**	**$ 51.445**	**$ 51.445**	**$ 51.445**	**$ 51.445**	**$ 51.445**	**$ 51.445**
Amort		$ -52.300	$ -52.300	$ -52.300	$ -52.300	$ -52.300	$ -52.300	$ -52.300	$ -52.300	$ -52.300	$ -52.300										
Business Tax (IIGG)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -18.006	$ -18.006	$ -18.006	$ -18.006	$ -18.006	$ -18.006	$ -18.006	$ -18.006	$ -18.006	$ -18.006
Income Tax (IIBB)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -2.822	$ -2.822	$ -2.822	$ -2.822	$ -2.822	$ -2.822	$ -2.822	$ -2.822	$ -2.822	$ -2.822
Net Result	$ -523.000	$ 51.445	$ 51.445	$ 51.445	$ 51.445	$ 51.445	$ 51.445	$ 51.445	$ 51.445	$ 51.445	$ 51.445	$ 30.617	$ 30.617	$ 30.617	$ 30.617	$ 30.617	$ 30.617	$ 30.617	$ 30.617	$ 30.617	$ 30.617
TIR	**5,5%**																				

RENOVAR Tariff 0,105 USD/kWh

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Income		$ 179.039	$ 179.039	$ 179.039	$ 179.039	$ 179.039	$ 179.039	$ 179.039	$ 179.039	$ 179.039	$ 179.039	$ 179.039	$ 179.039	$ 179.039	$ 179.039	$ 179.039	$ 179.039	$ 179.039	$ 179.039	$ 179.039	$ 179.039
Expenses		$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628
Gross Result		**$ 136.411**	**$ 136.411**	**$ 136.411**	**$ 136.411**	**$ 136.411**	**$ 136.411**	**$ 136.411**	**$ 136.411**	**$ 136.411**	**$ 136.411**	**$ 136.411**	**$ 136.411**	**$ 136.411**	**$ 136.411**	**$ 136.411**	**$ 136.411**	**$ 136.411**	**$ 136.411**	**$ 136.411**	**$ 136.411**
Amort		$ -52.300	$ -52.300	$ -52.300	$ -52.300	$ -52.300	$ -52.300	$ -52.300	$ -52.300	$ -52.300	$ -52.300										
Business Tax (IIGG)		$ -29.439	$ -29.439	$ -29.439	$ -29.439	$ -29.439	$ -29.439	$ -29.439	$ -29.439	$ -29.439	$ -29.439	$ -47.744	$ -47.744	$ -47.744	$ -47.744	$ -47.744	$ -47.744	$ -47.744	$ -47.744	$ -47.744	$ -47.744
Income Tax (IIBB)		$ -5.371	$ -5.371	$ -5.371	$ -5.371	$ -5.371	$ -5.371	$ -5.371	$ -5.371	$ -5.371	$ -5.371	$ -5.371	$ -5.371	$ -5.371	$ -5.371	$ -5.371	$ -5.371	$ -5.371	$ -5.371	$ -5.371	$ -5.371
Net Result	$ -523.000	$ 101.601	$ 101.601	$ 101.601	$ 101.601	$ 101.601	$ 101.601	$ 101.601	$ 101.601	$ 101.601	$ 101.601	$ 83.296	$ 83.296	$ 83.296	$ 83.296	$ 83.296	$ 83.296	$ 83.296	$ 83.296	$ 83.296	$ 83.296
TIR	**18,2%**																				

MATER

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Income		$ 82.534	$ 82.534	$ 82.534	$ 82.534	$ 82.534	$ 82.534	$ 82.534	$ 82.534	$ 82.534	$ 82.534	$ 82.534	$ 82.534	$ 82.534	$ 82.534	$ 82.534	$ 82.534	$ 82.534	$ 82.534	$ 82.534	$ 82.534
Expenses		$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628
Gross Result		**$ 39.906**	**$ 39.906**	**$ 39.906**	**$ 39.906**	**$ 39.906**	**$ 39.906**	**$ 39.906**	**$ 39.906**	**$ 39.906**	**$ 39.906**	**$ 39.906**	**$ 39.906**	**$ 39.906**	**$ 39.906**	**$ 39.906**	**$ 39.906**	**$ 39.906**	**$ 39.906**	**$ 39.906**	**$ 39.906**
Amort		$ -52.300	$ -52.300	$ -52.300	$ -52.300	$ -52.300	$ -52.300	$ -52.300	$ -52.300	$ -52.300	$ -52.300										
Business Tax (IIGG)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -13.967	$ -13.967	$ -13.967	$ -13.967	$ -13.967	$ -13.967	$ -13.967	$ -13.967	$ -13.967	$ -13.967
Income Tax (IIBB)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -2.476	$ -2.476	$ -2.476	$ -2.476	$ -2.476	$ -2.476	$ -2.476	$ -2.476	$ -2.476	$ -2.476
Net Result	$ -523.000	$ 39.906	$ 39.906	$ 39.906	$ 39.906	$ 39.906	$ 39.906	$ 39.906	$ 39.906	$ 39.906	$ 39.906	$ 23.463	$ 23.463	$ 23.463	$ 23.463	$ 23.463	$ 23.463	$ 23.463	$ 23.463	$ 23.463	$ 23.463
TIR	**2,2%**																				

Assumed payback period

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Income		$ 173.378	$ 173.378	$ 173.378	$ 173.378	$ 173.378	$ 173.378	$ 173.378	$ 173.378	$ 173.378	$ 173.378	$ 173.378	$ 173.378	$ 173.378	$ 173.378	$ 173.378	$ 173.378	$ 173.378	$ 173.378	$ 173.378	$ 173.378
Expenses		$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628
Gross Result		**$ 130.750**	**$ 130.750**	**$ 130.750**	**$ 130.750**	**$ 130.750**	**$ 130.750**	**$ 130.750**	**$ 130.750**	**$ 130.750**	**$ 130.750**	**$ 130.750**	**$ 130.750**	**$ 130.750**	**$ 130.750**	**$ 130.750**	**$ 130.750**	**$ 130.750**	**$ 130.750**	**$ 130.750**	**$ 130.750**
Amort		$ -52.300	$ -52.300	$ -52.300	$ -52.300	$ -52.300	$ -52.300	$ -52.300	$ -52.300	$ -52.300	$ -52.300										
Business Tax (IIGG)		$ -27.458	$ -27.458	$ -27.458	$ -27.458	$ -27.458	$ -27.458	$ -27.458	$ -27.458	$ -27.458	$ -27.458	$ -45.763	$ -45.763	$ -45.763	$ -45.763	$ -45.763	$ -45.763	$ -45.763	$ -45.763	$ -45.763	$ -45.763
Income Tax (IIBB)		$ -5.201	$ -5.201	$ -5.201	$ -5.201	$ -5.201	$ -5.201	$ -5.201	$ -5.201	$ -5.201	$ -5.201	$ -5.201	$ -5.201	$ -5.201	$ -5.201	$ -5.201	$ -5.201	$ -5.201	$ -5.201	$ -5.201	$ -5.201
Net Result	$ -523.000	$ 98.091	$ 98.091	$ 98.091	$ 98.091	$ 98.091	$ 98.091	$ 98.091	$ 98.091	$ 98.091	$ 98.091	$ 79.786	$ 79.786	$ 79.786	$ 79.786	$ 79.786	$ 79.786	$ 79.786	$ 79.786	$ 79.786	$ 79.786
TIR	**17,4%**																				

ZE300ULH+ – Zuccato

SELF CONSUMPTION																					
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Income		$ 112.971	$ 112.971	$ 112.971	$ 112.971	$ 112.971	$ 112.971	$ 112.971	$ 112.971	$ 112.971	$ 112.971	$ 112.971	$ 112.971	$ 112.971	$ 112.971	$ 112.971	$ 112.971	$ 112.971	$ 112.971	$ 112.971	$ 112.971
Expenses		$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628	$ -42.628
Gross Result		**$ 70.342**	**$ 70.342**	**$ 70.342**	**$ 70.342**	**$ 70.342**	**$ 70.342**	**$ 70.342**	**$ 70.342**	**$ 70.342**	**$ 70.342**	**$ 70.342**	**$ 70.342**	**$ 70.342**	**$ 70.342**	**$ 70.342**	**$ 70.342**	**$ 70.342**	**$ 70.342**	**$ 70.342**	**$ 70.342**
Amort		$ -58.800	$ -58.800	$ -58.800	$ -58.800	$ -58.800	$ -58.800	$ -58.800	$ -58.800	$ -58.800	$ -58.800										
Business Tax (IIGG)		$ -4.040	$ -4.040	$ -4.040	$ -4.040	$ -4.040	$ -4.040	$ -4.040	$ -4.040	$ -4.040	$ -4.040	$ -24.620	$ -24.620	$ -24.620	$ -24.620	$ -24.620	$ -24.620	$ -24.620	$ -24.620	$ -24.620	$ -24.620
Income Tax (IIBB)		$ -3.389	$ -3.389	$ -3.389	$ -3.389	$ -3.389	$ -3.389	$ -3.389	$ -3.389	$ -3.389	$ -3.389	$ -3.389	$ -3.389	$ -3.389	$ -3.389	$ -3.389	$ -3.389	$ -3.389	$ -3.389	$ -3.389	$ -3.389
Net Result	$ -588.000	$ 62.913	$ 62.913	$ 62.913	$ 62.913	$ 62.913	$ 62.913	$ 62.913	$ 62.913	$ 62.913	$ 62.913	$ 42.333	$ 42.333	$ 42.333	$ 42.333	$ 42.333	$ 42.333	$ 42.333	$ 42.333	$ 42.333	$ 42.333
TIR	**7,1%**																				

RENOVAR		Tariff		0,105	USD/kWh																
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Income		$ 215.003	$ 215.003	$ 215.003	$ 215.003	$ 215.003	$ 215.003	$ 215.003	$ 215.003	$ 215.003	$ 215.003	$ 215.003	$ 215.003	$ 215.003	$ 215.003	$ 215.003	$ 215.003	$ 215.003	$ 215.003	$ 215.003	$ 215.003
Expenses		$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191
Gross Result		**$ 163.812**	**$ 163.812**	**$ 163.812**	**$ 163.812**	**$ 163.812**	**$ 163.812**	**$ 163.812**	**$ 163.812**	**$ 163.812**	**$ 163.812**	**$ 163.812**	**$ 163.812**	**$ 163.812**	**$ 163.812**	**$ 163.812**	**$ 163.812**	**$ 163.812**	**$ 163.812**	**$ 163.812**	**$ 163.812**
Amort		$ -58.800	$ -58.800	$ -58.800	$ -58.800	$ -58.800	$ -58.800	$ -58.800	$ -58.800	$ -58.800	$ -58.800										
Business Tax (IIGG)		$ -36.754	$ -36.754	$ -36.754	$ -36.754	$ -36.754	$ -36.754	$ -36.754	$ -36.754	$ -36.754	$ -36.754	$ -57.334	$ -57.334	$ -57.334	$ -57.334	$ -57.334	$ -57.334	$ -57.334	$ -57.334	$ -57.334	$ -57.334
Income Tax (IIBB)		$ -6.450	$ -6.450	$ -6.450	$ -6.450	$ -6.450	$ -6.450	$ -6.450	$ -6.450	$ -6.450	$ -6.450	$ -6.450	$ -6.450	$ -6.450	$ -6.450	$ -6.450	$ -6.450	$ -6.450	$ -6.450	$ -6.450	$ -6.450
Net Result	$ -588.000	$ 120.608	$ 120.608	$ 120.608	$ 120.608	$ 120.608	$ 120.608	$ 120.608	$ 120.608	$ 120.608	$ 120.608	$ 100.028	$ 100.028	$ 100.028	$ 100.028	$ 100.028	$ 100.028	$ 100.028	$ 100.028	$ 100.028	$ 100.028
TIR	**19,4%**																				

MATER																					
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Income		$ 96.710	$ 96.710	$ 96.710	$ 96.710	$ 96.710	$ 96.710	$ 96.710	$ 96.710	$ 96.710	$ 96.710	$ 96.710	$ 96.710	$ 96.710	$ 96.710	$ 96.710	$ 96.710	$ 96.710	$ 96.710	$ 96.710	$ 96.710
Expenses		$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191
Gross Result		**$ 45.518**	**$ 45.518**	**$ 45.518**	**$ 45.518**	**$ 45.518**	**$ 45.518**	**$ 45.518**	**$ 45.518**	**$ 45.518**	**$ 45.518**	**$ 45.518**	**$ 45.518**	**$ 45.518**	**$ 45.518**	**$ 45.518**	**$ 45.518**	**$ 45.518**	**$ 45.518**	**$ 45.518**	**$ 45.518**
Amort		$ -58.800	$ -58.800	$ -58.800	$ -58.800	$ -58.800	$ -58.800	$ -58.800	$ -58.800	$ -58.800	$ -58.800										
Business Tax (IIGG)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -15.931	$ -15.931	$ -15.931	$ -15.931	$ -15.931	$ -15.931	$ -15.931	$ -15.931	$ -15.931	$ -15.931
Income Tax (IIBB)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -2.901	$ -2.901	$ -2.901	$ -2.901	$ -2.901	$ -2.901	$ -2.901	$ -2.901	$ -2.901	$ -2.901
Net Result	$ -588.000	$ 45.518	$ 45.518	$ 45.518	$ 45.518	$ 45.518	$ 45.518	$ 45.518	$ 45.518	$ 45.518	$ 45.518	$ 26.686	$ 26.686	$ 26.686	$ 26.686	$ 26.686	$ 26.686	$ 26.686	$ 26.686	$ 26.686	$ 26.686
TIR	**2,4%**																				

Assumed payback period																					
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Income		$ 198.191	$ 198.191	$ 198.191	$ 198.191	$ 198.191	$ 198.191	$ 198.191	$ 198.191	$ 198.191	$ 198.191	$ 198.191	$ 198.191	$ 198.191	$ 198.191	$ 198.191	$ 198.191	$ 198.191	$ 198.191	$ 198.191	$ 198.191
Expenses		$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191	$ -51.191
Gross Result		**$ 147.000**	**$ 147.000**	**$ 147.000**	**$ 147.000**	**$ 147.000**	**$ 147.000**	**$ 147.000**	**$ 147.000**	**$ 147.000**	**$ 147.000**	**$ 147.000**	**$ 147.000**	**$ 147.000**	**$ 147.000**	**$ 147.000**	**$ 147.000**	**$ 147.000**	**$ 147.000**	**$ 147.000**	**$ 147.000**
Amort		$ -58.800	$ -58.800	$ -58.800	$ -58.800	$ -58.800	$ -58.800	$ -58.800	$ -58.800	$ -58.800	$ -58.800										
Business Tax (IIGG)		$ -30.870	$ -30.870	$ -30.870	$ -30.870	$ -30.870	$ -30.870	$ -30.870	$ -30.870	$ -30.870	$ -30.870	$ -51.450	$ -51.450	$ -51.450	$ -51.450	$ -51.450	$ -51.450	$ -51.450	$ -51.450	$ -51.450	$ -51.450
Income Tax (IIBB)		$ -5.946	$ -5.946	$ -5.946	$ -5.946	$ -5.946	$ -5.946	$ -5.946	$ -5.946	$ -5.946	$ -5.946	$ -5.946	$ -5.946	$ -5.946	$ -5.946	$ -5.946	$ -5.946	$ -5.946	$ -5.946	$ -5.946	$ -5.946
Net Result	$ -588.000	$ 110.184	$ 110.184	$ 110.184	$ 110.184	$ 110.184	$ 110.184	$ 110.184	$ 110.184	$ 110.184	$ 110.184	$ 89.604	$ 89.604	$ 89.604	$ 89.604	$ 89.604	$ 89.604	$ 89.604	$ 89.604	$ 89.604	$ 89.604
TIR	**17,4%**																				

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