Geothermal Heat Sources from Oil Wells Using Binary Cycles*

Silvia P. Barredo[1], Hans-Joachim Wiemer[2], Dietmar Kuhn[3], and Luis Stinco[4]

Search and Discovery Article #42358 (2019)**
Posted February 25, 2019

*Adapted from oral presentation given at 2018 AAPG Annual Convention & Exhibition, Salt Lake City, Utah, May 20-23, 2018
 DOI:10.1306/42358Barredo2019

[1]Departamento de Postgrado, Instituto Tecnológico de Buenos Aires, Ciudad Autónoma de Buenos Aires, Buenos Aires, Argentina (sbarredo@itba.edu.ar)
[2]Institute for Nuclear- and Energy Technologies (IKET), Karlsruhe Institute of Technology (KIT), Eggenstein-Leopoldshafen, Karlsruhe, Germany
[3]Institut für Kern- und Energietechnik (IKET), Karlsruher Institut für Technologie (KIT), Eggenstein-Leopoldshafen, Karlsruhe, Germany
[4]Instituto del Gas y Petróleo, Universidad de Buenos Aires, Ciudad Autónoma de Buenos Aires, Buenos Aires, Argentina

Abstract

The growing demand for energy challenges the development and utilization of renewable sources. Among them, the geothermal energy represents the natural and internal heat of the Earth that is stored within the rock and its fluids. In the special case of hydrocarbon bearing basins the heat is conductively transferred to the surface through its fluids, offering the possibility to provide energy for the field itself and even to power generation. This latter is known as coproduced fluids, since oil/gas is pumped from wells along with hot water. The energy required for operations in oil fields is obtained from the produced hydrocarbons representing an important high cost for companies. It is suggested here that the energy consumed in these procedures could be supplied from the hot waters produced during hydrocarbon extraction, considerably reducing the present high expenses and extending the oilfield's life. Additionally, direct uses can also be achieved for cooling or heating of individual buildings of the field or heating for pipe tubes in cold regions. Spent fluids can also be collected and used again for other industrial applications in a "cascading" process.

A geothermal power generation project is expensive, specially if it is necessary to drill wells, but in the case of oil fields the existing infrastructures, mature production technologies and rich reservoir data assure lowering the inversion cost. The Golfo San Jorge Basin located in Argentina exhibits normal geothermal gradients from 2 to 5 degrees C for each 100 meters of depth. Considering that some wells reach 6 km deep, it is possible to ensure a low to medium enthalpy reservoir. In all cases, and given the diversity of depths to which the wells are drilled (from 300 to 4500 mah), fluids (280 bbl/d water) produced are at temperatures between 100-150 degrees C, such as the South Flank of the Basin. This hot brine is not usable for the direct generation of electricity in classical steam power plants, but instead it is proposed here that this thermal energy could be transferred to a "binary cycle", the Organic Rankine Cycle (ORC), and converted into electrical energy to be delivered in the field. This article analyzes the technical feasibility of generating electricity from those wells using this technology and the new test facility Monika.

Selected References

Sylwan, C., C. Droeven, J. Iñigo, F. Mussel, and D. Padva, 2011, Cuenca del Golfo San Jorge: VIII Congreso de Exploración y Desarrollo de Hidrocarburos. Simposio Cuencas Argentinas: visión actual, Instituto Argentino de Petróleo y Gas (IAPG), Mar del Plata, p. 139-183.

William, Colin F., Marshall J. Reed, and Arlene F. Anderson, 2011, Updating the classification of geothermal resources: Thirty-Sixth Workshop on Geothermal Reservoir Engineering Stanford University, Stanford, California, January 31 - February 2, 2011, SGP-TR-191.

GEOTHERMAL HEAT SOURCES FROM OIL WELLS USING BINARY CYCLES

Silvia Barredo[1], Hans-Joachim Wiemer[2], Dietmar Kuhn[2] and Luis Stinco[3]

[1] ITBA, Dpto. de Postgrado, Buenos Aires. E-mail: sbarredo@itba.edu.ar
[2] KIT, Karlsruhe Institute of Technology, Germany
[3] Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires

20-23 May 2018 • Salt Lake City, Utah
ACE 2018 ANNUAL CONVENTION & EXHIBITION
ACE 101: Bridging Fundamentals and Innovation

AGENDA

- Introduction
- Technical Approach
- Geological Setting and Drilling Activity
- Conceptual Application of GE in Oil Wells
- Theoretical Exercise
- Conclusions

INTRODUCTION

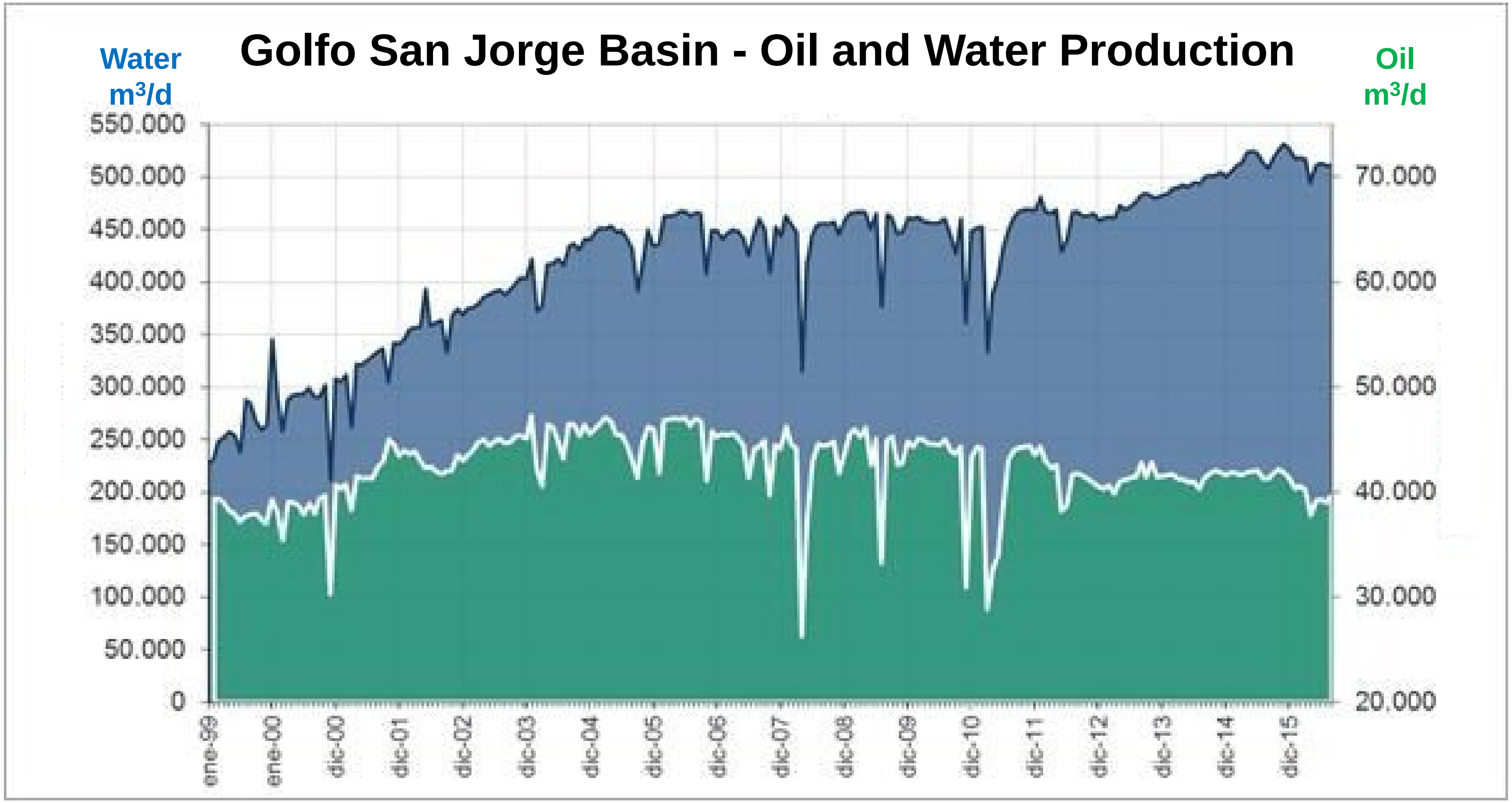
The energy consumptions in the oil and/or gas fields associated with the operation of them represent between 5 to 10% of the equivalent hydrocarbon´s production.

This equivalent energy includes:

- Pumping
- Injection
- Fluid movement
- Heating
- Treatment plant
- Facilities
- Offices
- Lighting

INTRODUCTION

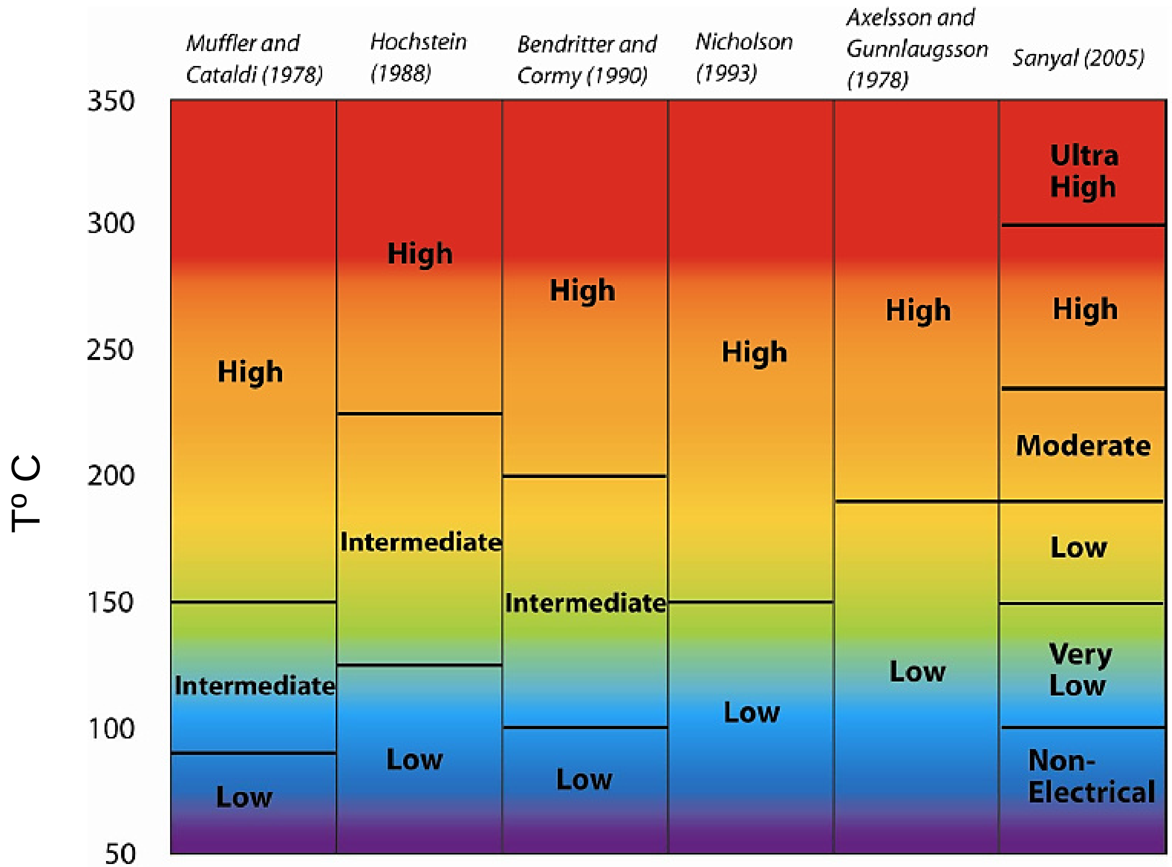
One characteristic of the production of oil fields is that in addition to the hydrocarbon, associated water is produced, and in some cases this volume represents more than 97%.



Hirtschfield, 2016

TECHNICAL APPROACH

Geothermal energy, understood as the energy of the earth stored in the form of heat by rocks and fluids that can be used by man, compared with other renewable has greater reliability, does not depend on seasonal conditions and its carbon footprint is smaller.



Williams *et al.*, 2011

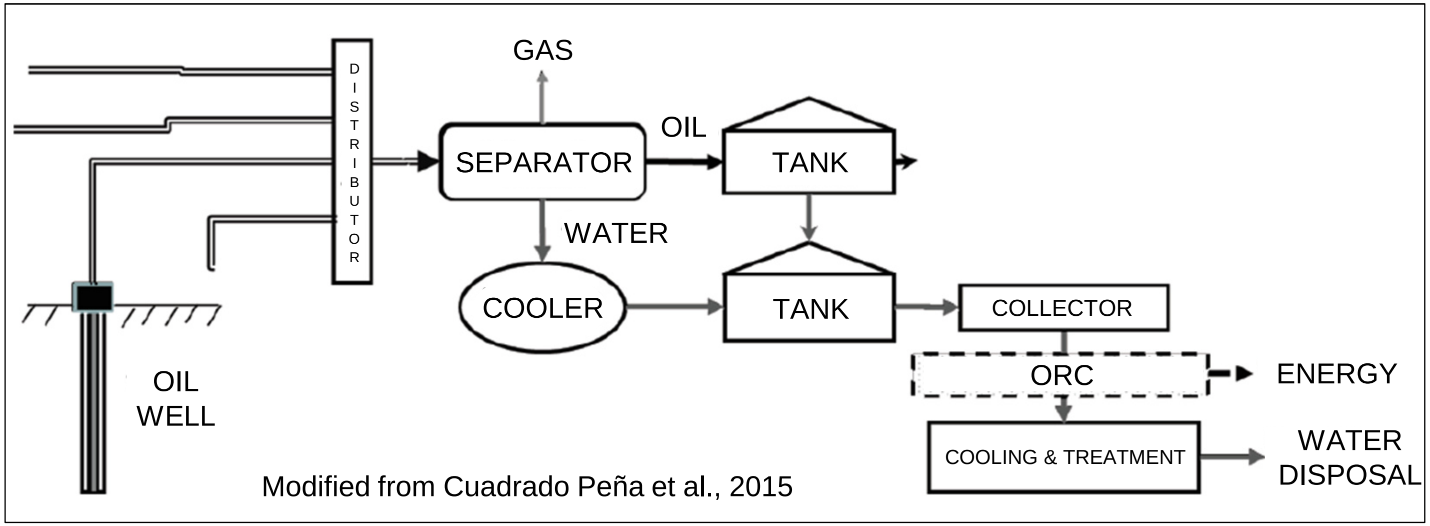
TECHNICAL APPROACH

The main feature in oil wells is that, in most cases, the fluids produced have temperatures within the range of 50º C up to 260º C that can be considered quasi-constant throughout the life of the field.

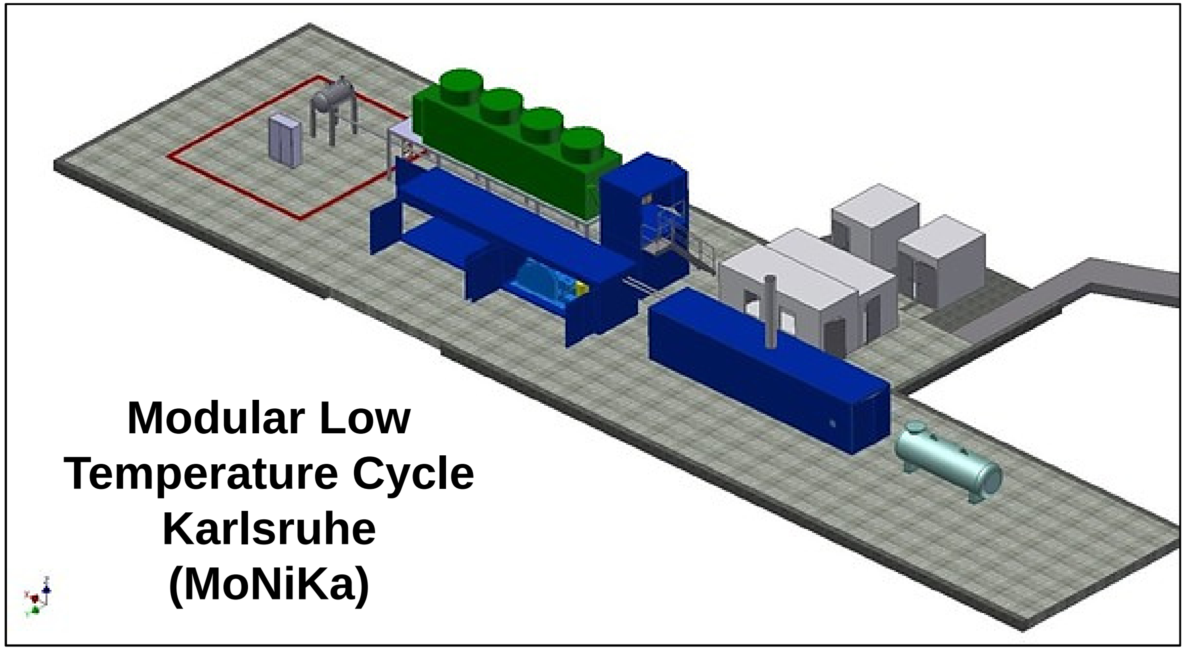
Among other geological environments, non-volcanic conductive or convective hydrothermal reservoirs are well developed in Argentina. The warm water stored in most of them can display temperatures of about 100º C up to 150º C.

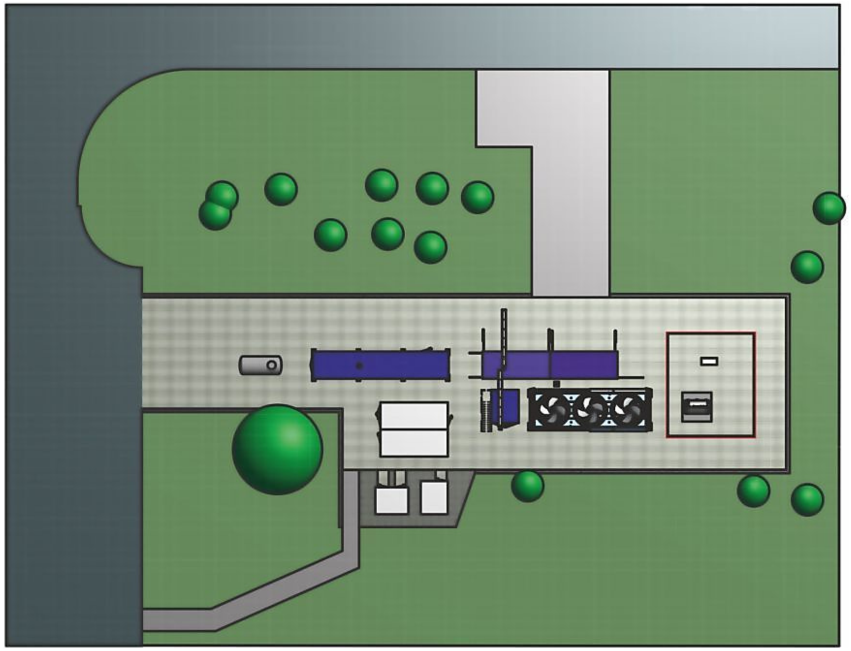
This thermal energy could be transferred to a “binary cycle” the Organic Rankine Cycle (ORC), and converted into electrical energy.

TECHNICAL APPROACH



Modified from Cuadrado Peña et al., 2015





http://www.monika.kit.edu/english/59.php

GEOLOGICAL SETTING & DRILLING

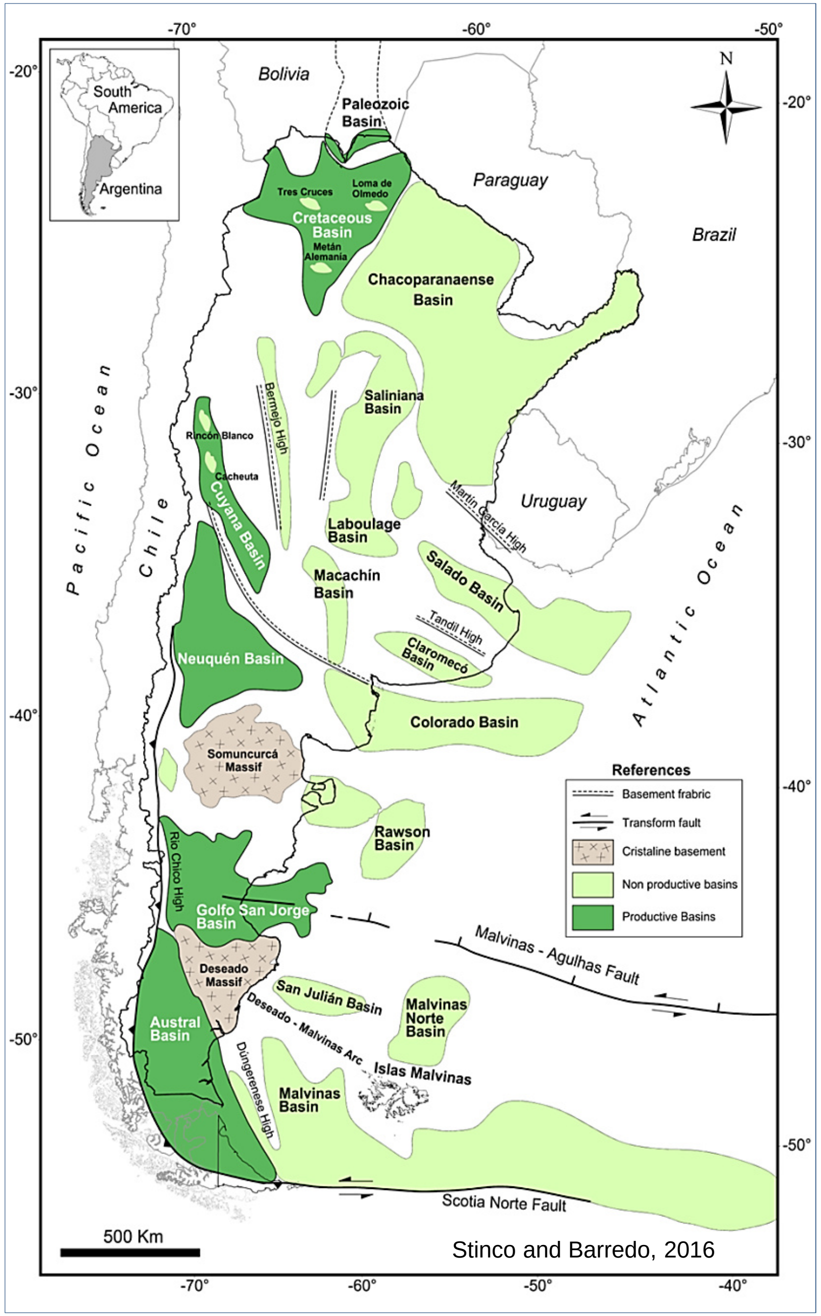
There are six economically productive hydrocarbon basins: Paleozoic, Cretaceous, Cuyana, Neuquén, Golfo San Jorge and Austral.

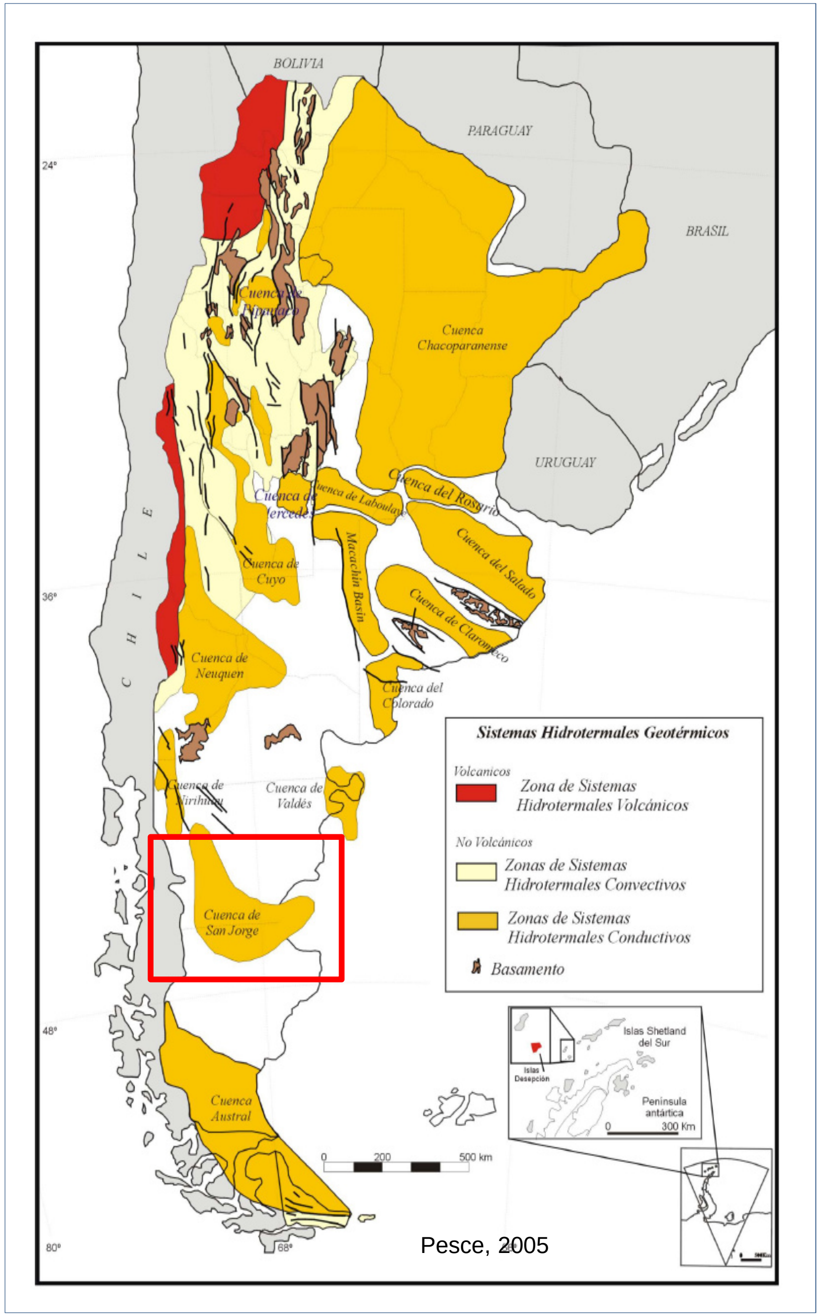
A wide diversity of depths to which wells are drilled (from 300 to 6000 mah), frequently with fluids produced at temperatures close to 100º C or higher.

As per December 2017, there are more than 70,000 wells drilled in Argentina. Of them, more than 22,400 are oil producers and more than 3,000 are currently producing gas.

Every year, as an average, the drilling activity comprises 1,100 development wells and 60 exploration ones.

GEOLOGICAL SETTING & DRILLING





CONCEPTUAL APPLICATION

A geothermal energy generation project where it would be necessary to drill wells purely and exclusively for these purposes would be extremely onerous and therefore uneconomical.

However, the great advantage is that the wells have already been drilled in order to produce hydrocarbons.

Viability of this type of project depends on:

- geothermal energy replacing the volume of hydrocarbons not consumed and sold
- availability of wells with required temperatures
- integration of the energy distribution system
- environmental issues

CONCEPTUAL APPLICATION

Worldwide (Wyoming, Alaska and China) there are examples of pilot projects where technologies are being adapted for the optimal use of this type of energy source in oil fields.

The ranges of temperatures are between 70º C up to 150º C and energy generated varies from 40 kW/h to 320 kW/h.

The geothermal energy could be used for:

- keeping the proper heat in the pipelines
- heating buildings and facilities
- modifying the API gravity of the oil
- generating electricity for field consumption/selling

THEORETICAL EXERCISE

Simulation over (x) years

- Production
- Water cut (%)
- Average Tº C of the reservoir
- Wellhead temperature losses

↓

- Flow (n) years and at T(x) (ºC)
- Determine efficiency and kW

↓

Economic analysis over (x) years including maintenance, well curve types, annual development plan and field decline over time.

THEORETICAL EXERCISE

Economic Analysis

$$\text{NPV} = \sum_{n=0}^{N} \frac{C_n}{(1+r)^n}$$

Net Present Value
n years
Cn time of cash flow (n)
r discount rate

Initial costs include: pipelines, pumps, transmission lines, environmental impact studies and facilities

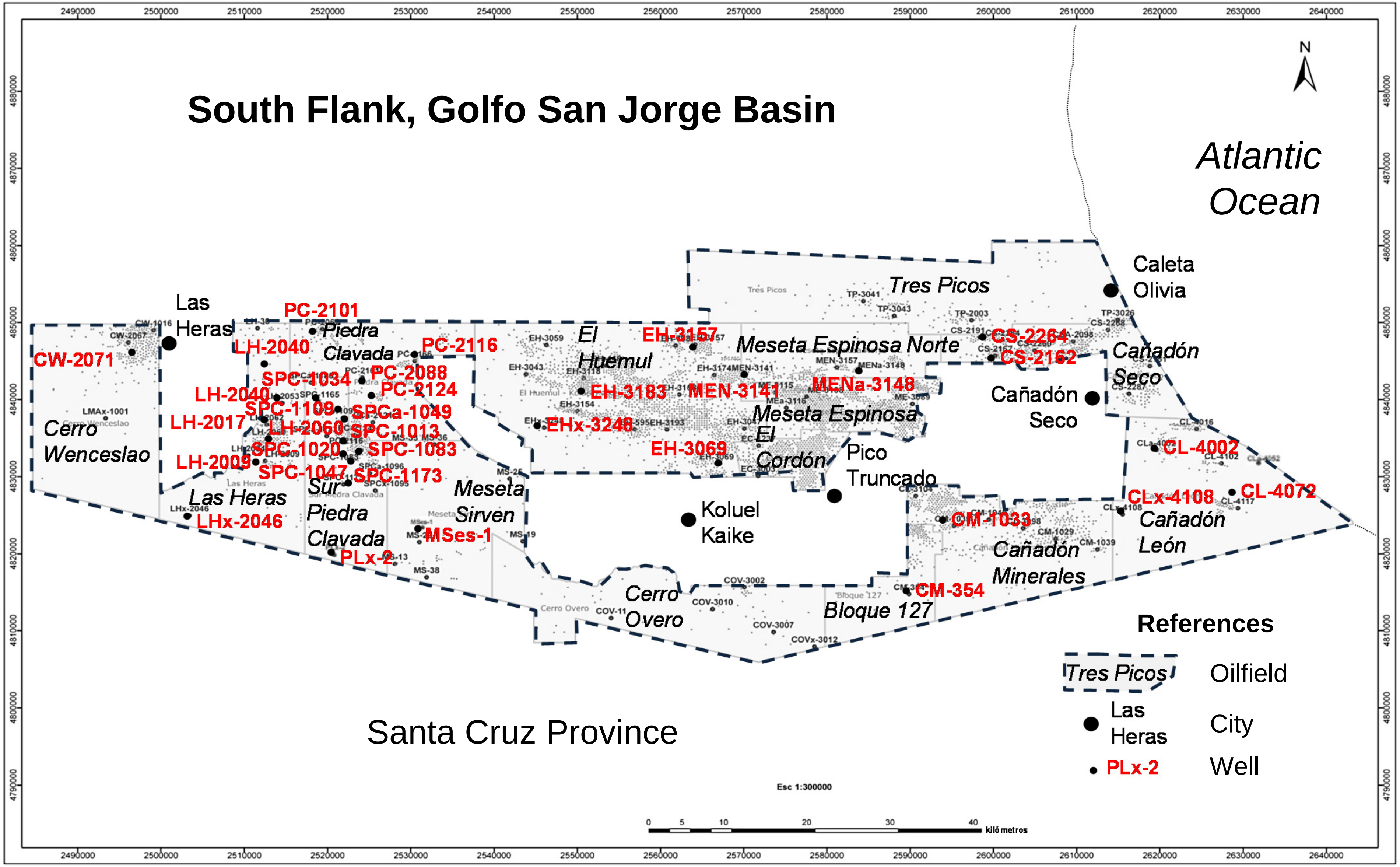
In this approach are not considered exploration and development of the reservoirs, nor the electric distribution and taxes. A 70% in cost reduction could be assumed compared to a regular geothermal project.

THEORETICAL EXERCISE

A theoretical exercise was performed in the Southern Flank of Golfo San Jorge basin over 15 oilfields with 2150 active wells and 50 water flooding projects ongoing.

Modified from Sylwan *et al.*, 2011

THEORETICAL EXERCISE



Stinco, 2015

THEORETICAL EXERCISE

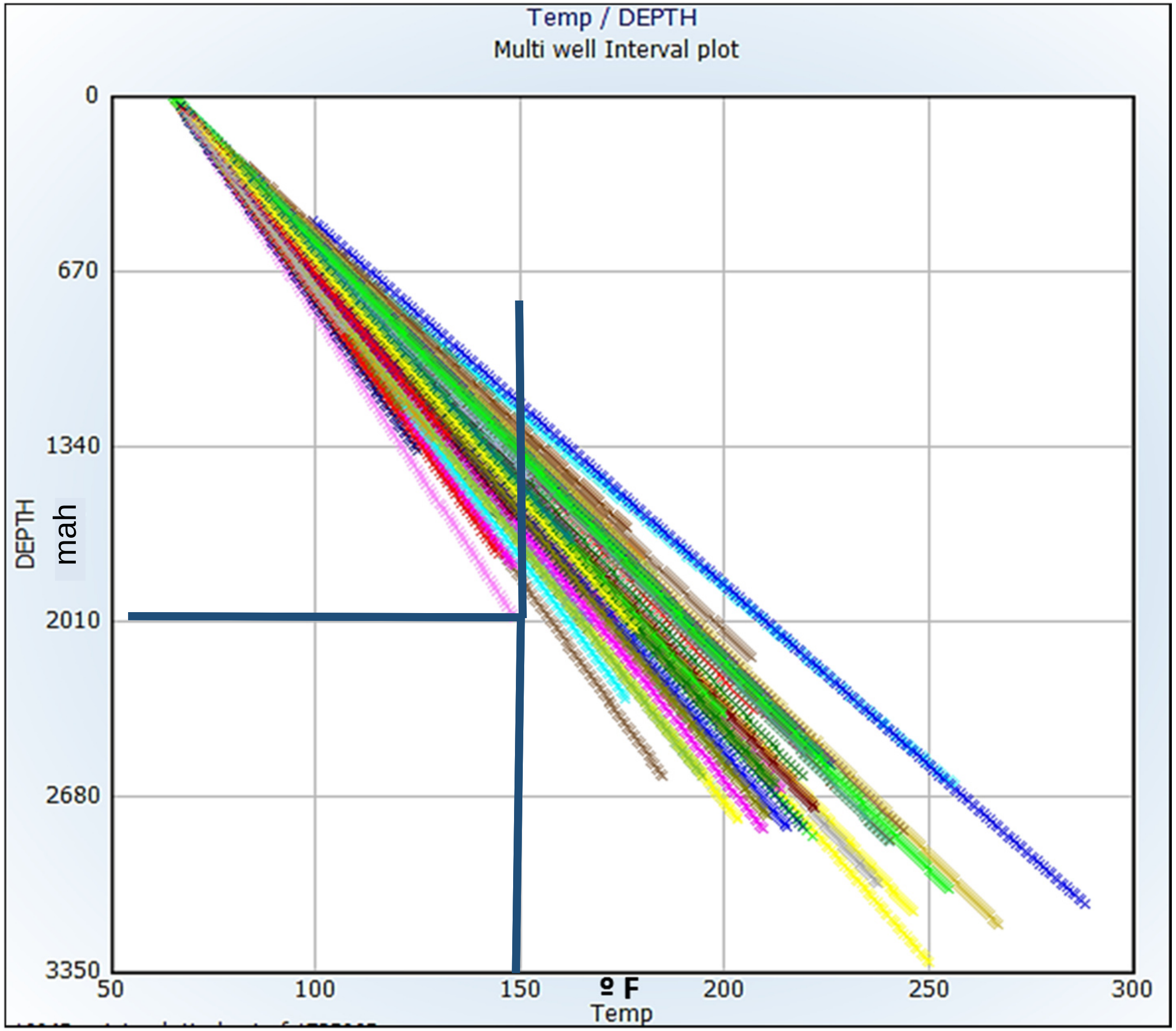
Several studies have established that for producing 1 kW it is required a volume of 16 barrels per day of a fluid at temperature ranges between 70º C and 150º C.

As an average, a well can produce 120 barrels of oil per day and 280 barrels of water per day for a period greater than 20 years.

Consequently, it has potential for producing 17.5 kW per day.

On the other hand, a 20 hp pumpjack has an energy consumption of 15 kW per day.

THEORETICAL EXERCISE



Stinco, 2015

After analyzing 90 wells the mean estimated geothermal gradient was 3.59º C every 100 m

70ºC – 149ºC

THEORETICAL EXERCISE

Therefore, the big question is:

What about considering a full field development with 50 water flooding projects and a huge amount of fluids being transport from 2150 active producing wells from 15 different oilfields?

The energy consumption in this case arises to 56 MW per day, with a cost of 15 MM U$D per annum (6/7 development wells).

In this particular case, overall water production reaches 340,000 barrels per day that have a potential generation of energy of 21 MW per day. Represents almost 38% of the energy consumption of the 15 fields that could have been provided by a geothermal technology with the corresponding cost savings.

CONCLUSIONS

- A theoretical model for using geothermal energy was presented based on real data with promising results considering the existing oilfield infrastructures, mature production technologies and rich reservoir data.

- Modern technology is capable of generating electricity at low and intermediate enthalpy.

- There is a crucial benefit in taking advantage of the oilfield facilities as it provides a cost reduction in the geothermal energy production project of around 70 % when compared to one that starts from the very beginning.

- The development and utilization of geothermal energy has the potential to extend the oilfield's life, increase its ultimate oil recovery and effectively reduce operating costs.