Reduction of Capital Cost and Opex Cost in Geothermal Wells

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SUMMARY

The use of Electrical Submersible Pumps (ESPs) in combination with inflatable packers will eliminate the need for tubing and reduce initial equipment cost. More importantly, it will reduce the electrical energy required during every production day for the life of the well.

The installation and pulling of this system takes less time, is easier, less costly and will reduce the downtime of the well.

This all results in a reliable and highly economical production solution that has already been proven in hundreds of wells in Australia.

INTRODUCTION

Heat from geothermal wells is an excellent way of heating houses, offices, schools, factories and public buildings. The earth is a very constant and reliable source of energy. Under most areas in the world significant heat resources can be found at depths of 2000 meter and greater. Temperatures of 80 degrees Celsius and higher are common.

Geothermal energy has been used since people started living in the vicinity of volcanic areas many centuries ago. It was not only the Romans who made clever use of this energy source. Iceland, Japan and Korea also have a strong geothermal history.

Geothermal energy produces no CO2 emissions. It is a very good resource to replace the burning of coal, oil and natural gas for heating purposes. It is also an almost inexhaustible supply with geothermal energy from our inner earth expected to be around for much longer than mankind.

Since the first oil crisis in 1973, countries in Europe have been looking at using geothermal energy as an alternative to reduce dependence on politically unstable oil producing regimes. Geothermal heat is available close to where it is needed. It is only 2000 to 3000 meters away from consumers.

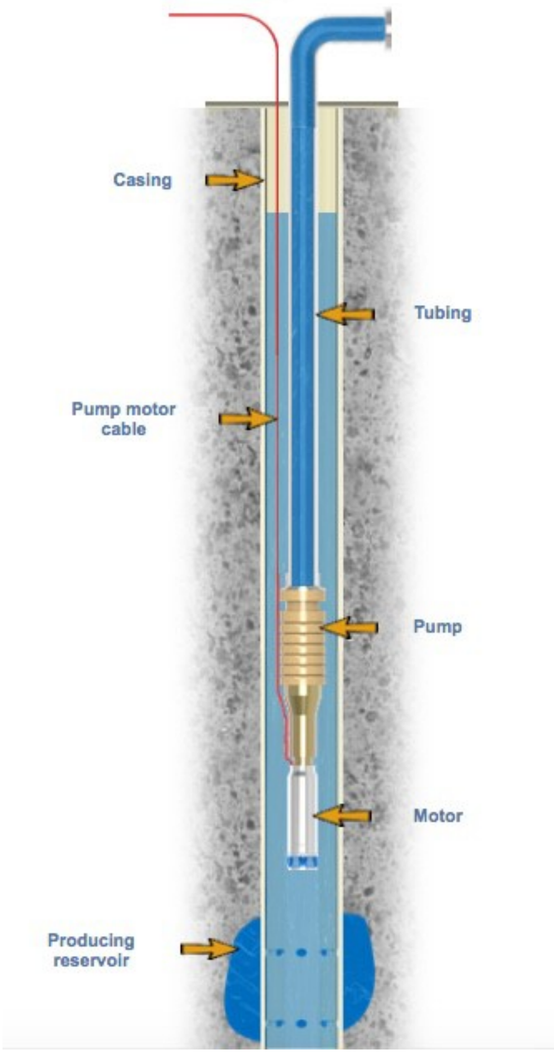
The process of getting this heat to surface requires the drilling of a production well and an injection well. Technically neither of these are difficult. Since the 1970's, thousands of wells have been drilled in Europe alone. The initial learning curve involved in choosing the right materials on the surface to ensure a long lifetime and trouble-free operation of the equipment has been completed.

However, the low cost of burning fossil fuels and political choices at that time made geothermal energy marginal and it was not always recognized as the preferred solution. With a changed political climate and the pressure to reduce their CO2 footprint, countries in Europe are now looking at using geothermal heat as one of their main sources of heating.

Producing water from geothermal wells requires submersible pumps when the wells are not artesian (artesian means free flowing from the well without the need of a mechanical pump). Even if wells are free flowing the production capacity of such wells may not be sufficient for economic purposes.

Electrical Submersible Pumping (ESP) systems are used for lifting geothermal water to the surface. Considering the high temperature of the water the ESPs used tend to be of the oilfield type and quality. See figure 1 for a typical installation.

Figure 1



As the required volume from geothermal applications is significant the flow capacity of the ESPs needs to be high. As is the motor size required to produce the hot water to the surface. Typical casing size is 13 3/8”. Typical tubing or riser size is 7” or 8 5/8”. Moreover, with a setting depth of anywhere between 200 and 500 meter the completion is significant.

The pump and tubing are installed in the wellbore. The completions is critical item when it comes to reliable production. A failed pump means no production and no production means no heat from the well. No production for longer periods of time becomes costly. Especially in winter when production is needed 24/7. The time to change out a pumping system is dependent of the ease of pulling and re- installing the completion. In addition, flow through the tubing (or riser column) creates friction when pumping that translates into greater electrical power requirements and larger motor sizes.

GOAL

This article looks at ways to:

- Eliminate the need for a workover rig
- Reduce the downtime of the well
- Reduce the cost to install and pull an ESP from the production well
- Reduce the power cost due to reducing friction loss.

DESCRIPTION

ESPs have mainly been installed as shown in figure 1. The ESP is suspended from a large size tubing. The tubing has a large diameter as the volumes produced from geothermal wells tend to be high. With these larger flow rates the friction loss in 200 to 500 meters of tubing will be significant.

The ESP system has the following main components:

- Pump
- Seal Section
- Motor
- Cable
- Variable Speed Drive
- Tubing or a riser column.

Pump
The pump is a standard multi-stage centrifugal pump. Most of the larger volume pumps are of a bolted bowl type. The pump typically runs in down thrust, loading the thrust bearing in the seal section. Material for the impellers and bowl varies from nickel aluminum bronze (NAB) or Ni-Resist cast iron and, more recently, super duplex stainless steel. The pump shaft is coupled to the seal section. Pumps in geothermal applications tend to produce from 60 to 200 liters per second.

Seal Section
The seal section is located between the pump and the motor. The seal section houses a number of mechanical seals in series and a thrust bearing. The mechanical seals protect the motor internals from well fluids entering the motor. The thrust bearing carries any thrust from the pump. The seal section housing is made from a corrosion resistant material. The shaft couples to the pump above and the motor below the seal section.

Motor
The motor is asynchronous motor that is designed to be used with variable speed drives to vary the speed of the pumping system. The speed variation allows changing the capacity and the discharge pressure of the pump. The motor has an electrical cable running to the surface power supply to provide power to the motor. Most geothermal applications use motors in the range of 200-500 Kilowatt.

Cable
The cable is a 3-phase cable. This cable is suitable for the high voltage that the motor will need. The cable can have a metal armour around the cable.

Tubing
The tubing's main function is to allow the flow of warm water to reach the surface and to support the ESP hanging underneath the tubing. (See figure 1)

The large size tubing comes in threaded lengths each around 10 meters which require pickup handling and torqueing tools suitable for the installation. Oilfield style work-over rigs are often used to install the ESP and tubing. Work-over rigs are not readily available and come with a crew and need rig up and rig down time. In general, these complications mean that it's time consuming to install or pull an ESP and tubing system. Of course, this also comes at a significant expense in both time and money.

During the workover time the geothermal well will not produce any energy for heating purposes. Every day of downtime means loss of revenue.

Tubing has friction loss when water is flowing through the tubing. This translates in additional power requirements for the ESP motor. The actual extra power is dependent on the tubing size and the quantity of flow through the tubing. It can be anywhere from 10 to 20% of the total power required.
Tubing increases power requirements and increases the time it takes running in and out of the well. The question is how to avoid tubing?

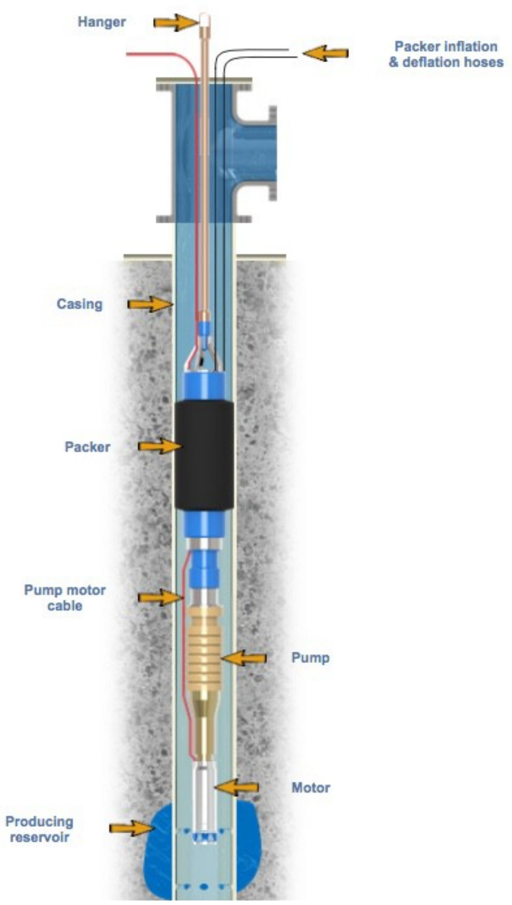
ALTERNATIVE TO TUBING
Removing the tubing altogether and producing the water through the annulus itself would greatly reduce the friction loss. However, an alternative is needed to support the ESP when running in and out of the well. This can be done by hanging the ESP on a smaller size pipe or rods such

as those used with sucker rod pumps in the oil industry. This smaller pipe or rods is just to support the ESP and not to produce through.

The smaller size rods will allow for faster handling and will therefore require less time to land the ESP at its setting depth. Being smaller and lighter they can also be installed without the need for an expensive workover rig and crew.

To direct the flow into the casing, a seal is needed between the pump suction and discharge side. This can be done by locating an inflatable packer just above the pump. The pump suction is then below the packer and the pump discharge above the packer. See picture 2.

Figure 2



INFLATABLE PACKER

The inflatable packer is run together with the ESP. The ESP and packer assembly is hanging on the smaller pipe. A hydraulic or similar crane can be used to lower the assembly into the well. The power cable will be connected to the pipe while running in. When at setting depth the packer will be inflated and become the main anchor point for the ESP. The small pipe will remain in place and can be used to pull the ESP and packer combination at a later stage. The pipe is also the support member for the electrical cable and the inflate and deflate lines. The electrical cable will pass through the packer using glands or a penetrator for sealing purposes.

The time needed to install an ESP and packer combination is significantly less than running an ESP on tubing, especially when rig setup and rig-down times are considered. The pump will use the annulus between the casing and the small diameter pipe to flow water to the surface. This equivalent diameter is much larger than the diameter of tubing which will lead to much lower friction losses.

The alternative ESP and inflatable packer system meets the following goals:

- Equipment handling is easier making use of a crane versus a workover rig
- Better availability of cranes allows immediate action resulting in less production downtime
- Fewer people are needed overall due to the easier installation method both of which further reduce costs in time and materials

- Lower friction losses will save 10-20% in power requirements during operation of the ESP

How much difference does this all make? The use of a hydraulic crane means less rig up and rig down time translating into savings in hours needed and the number of people. Cost will reduce significantly.

Hydraulic cranes can be organized quickly as they tend to be available in most industrial and urban areas. The cost for hydraulic cranes is much less than the typical work-over rig. However, the real saving is in getting the well back in production sooner. Organizing a hydraulic crane to come out requires less time and there is less time needed on the well. Revenues from heat production will therefore (re)start sooner.

A large saving is also gained from the reduced friction loss when pumping up the annulus. This means a smaller pumping system at a lower cost and there will be 10 to 20% less energy consumption. This translates in serious savings over time.

Example: A system requiring a 500 kW motor with tubing can be down-sized to 400 kW due to less friction loss using the alternative system. The gain is:

- Motor consuming 400 kW rather than 500 kW when using a tubing/riser
- Less energy due to less friction is 20%
- Energy cost: € 0,10/kWh
- Operational time: 200 days a year
- Life of well: 30 years
- 100 kw * 24 hrs * 200 days * € 0,10 = **€ 48.000 per year** or a massive **€1.440.000 over 30 years**

APPLICATION

Where can the ESP and inflatable packer combination be used?

ESP's and inflatable packers can be used in almost any application in which a standard ESP is used. Most ESPs are used on tubing. As long as replacing the tubing with rods or smaller pipe and producing up the annulus makes the ESP installation and pulling time shorter there is an advantage in this type of system. Typical applications are:

Water wells

The ESP and packer combination are typically very suitable for water wells. ESPs in water wells are normally not installed deeper than 600 meters, although deeper setting depths are possible. In Australia, this type of inflatable packer system is used in close to a thousand water wells according to one of the inflatable packer manufacturers.

Geothermal wells

Water wells and geothermal wells tend to produce large volumes of water. The ESP and packer combination offers a very efficient, convenient and extremely economical solution..

Oil wells

In some cases, even in oil wells the combination of ESP and inflatable packer can be a solution. Sometimes, offshore platforms can only accommodate work-over rigs at a high cost. In comparison, this ESP inflatable packer combination can be installed using the platform crane.

The ESP and inflatable packer solution can also be used as a redundancy solution. For example, an ESP that produces significant oil fails for some reason. The oil production stops when the pump fails. A workover will need to be organized. This can take

anywhere from a week to months. After failure a smaller size, high-speed ESP with an inflatable packer can be run inside the tubing. Production can be restarted within a short period of time after the main ESP failure.
A high-speed ESP and packer can also be installed in marginal oil wells skimming the surface in non-producing wells. The low cost of installation tends to make this an attractive way of producing.

REFERENCES
RISERLESS BORE PUMPING SYSTEM – NEW GENERATION OF GROUND WATER BORES. *Author:* Jason Ip, *Operations Engineer,* Riverina Water County Council
6th Annual WIOA NSW Water Industry Engineers & Operators Conference, Tamworth Regional Entertainment & Conference Centre, 27 to 29 March, 2012

WATER CORPORATION OF WESTERN AUSTRALIA. Using in 7 wells the combination of inflatable packers and high volume and high Horsepower ESP's since 1998 in multiple bores in Perth.

ROCKWATER, PERTH, AUSTRALIA. Using the combination of inflatable packers and high volume and high Horsepower ESP's in a mining dewatering environment.

Well name		1	2
Capacity	m3/hr	180	108
Head	meters	700	650
Pump type	brand	Schlumberger	Schlumberger
Motor size	kW	894	410
Setting depth	meters	665	659
Casing size	mm ID	254	238

VERMILLION, PERTH, AUSTRALIA. Used a combination of inflatable packer and ESP in an offshore oil well. This was driven by lack of a work over rig.

AGE DEVELOPMENTS, PERTH, AUSTRALIA
Supplier of riserless systems to different mining and dewatering companies in Australia. See attachment for partial reference list.

Partial Reference list for Riserless Electrical Submersible Pumping system

Well name	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Enduser or location	Pilbara, WA	Eaton, WA	Perth, WA	Woorabinda, QLD	Barwon, VIC	Toowoomba, QLD	Perth, WA	Perth, WA	Perth, WA
Install date	1991	1996	1999	2000	2002	2003	2003	2008	2014
Packer size (OD)	168mm	219mm	323mm	219mm	356mm	219mm	323mm	323mm	323mm
Capacity l/sec	10	25	260	8	35	35	280	250	245
Setting depth meters	120	85	200	550	120	200	200	235	200
Casing size	8" Steel Casing	10" Steel Casing	14" FRP Casing	9 5/8" Steel Casing	16" FRP Casing	10" FRP Casing	14" FRP Casing	14" FRP Casing	14" FRP Casing
			5 units				3 units	6 units	

Attachment to: Reduction of Capital Cost and Opex Cost in Geothermal Wells

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