FEASIBILITY OF USING PUMPS WORKING AS TURBINES (BFT) TO MICROGENERATE ELECTRICITY IN IRRIGATION SYSTEMS

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ABSTRACT

Distributed Electricity Micro- and Mini-Generation have been financial and socio-environmental innovations, meeting the demands of places not covered by the electricity grid and allowing the surplus to be shared with neighboring regions. Several studies have been carried out to improve aspects of this project, one of which is the use of turbine pumps, since hydraulic pumps are more cost-effective and deliver similar results to turbines. This study therefore aimed to assess the feasibility of applying the BFT project receiving water from a dam in a rural area of Colatina (ES), as well as showing the values of the investment made and projecting the time it would take to start seeing a return on investment.

Keywords: *hydraulic pumps, micro hydro systems, electric energy.*

1 INTRODUCTION

Brazilian consumers can generate their own electricity from renewable sources or qualified cogeneration and even supply the surplus to their local distribution network. These are distributed micro- and mini-generation of electricity, innovations that combine financial savings, socio-environmental awareness and self-sustainability (ANEEL RN No. 482/2012).

With the aim of complying with law 14.300/2021, known as the legal framework for distributed generation, reducing the costs and time for connecting microgeneration and minigeneration, making the Electric Energy Compensation System (SCEE) compatible with the general conditions of energy supply (Normative Resolution No.

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1.000/2021), increasing the target audience and improving the information on the bill, ANEEL published Normative Resolution No. 1.059/2023, revoking the old Normative Resolution No. 482/2012.

The use of any renewable source, apart from qualified cogeneration, is permitted. Distributed microgeneration is the name given to generating plants with an installed capacity of up to 75 kilowatts (kW), and distributed mini-generation is that with a capacity of more than 75 kW and less than or equal to 5 MW, connected to the distribution network via consumer unit installations. (ANEEL RN no. 482/2012).

According to Ferreira (2021), even though they have numerous advantages from an environmental perspective, economic viability is essential if systems that take advantage of distributed energy are to be widely applied and sustainable alternatives. As a result, the energy compensation system, created by Normative Resolution 482/2012 (ANEEL, 2012), has become the biggest driver of microgeneration growth in the country.

According to Macintyre (1983), the choice of location for a micro-plant would be at a high point on the hillside, where a small dam to take water from a pipe would descend as directly as possible to the plant located at the lowest level possible.

Due to the huge market for pumps in a wide power range, they present themselves as an easily found, cheap and reliable alternative, especially when it comes to maintenance, presenting many advantages when compared to turbines, which are manufactured to order (Alves, 2010).

Also according to Alves (2010), the hydraulic pump working as a turbine is economically viable for applications in small systems, limited to around 150 kW of power. This technology is already used in some parts of the world and has characteristics that justify its use.

The advantage of using this method for micro-generation of electricity is that it takes advantage of the local hydraulic potential and uses a pump working as a turbine (BFT) to generate electricity. The hydraulic potential ranges from the sanitary flow of dams to the dry boxes used in irrigation systems.

For the pump to work as a turbine, the direction of the water flow will be reversed and there will be a reversal in the direction of rotation, as shown in figure 1.

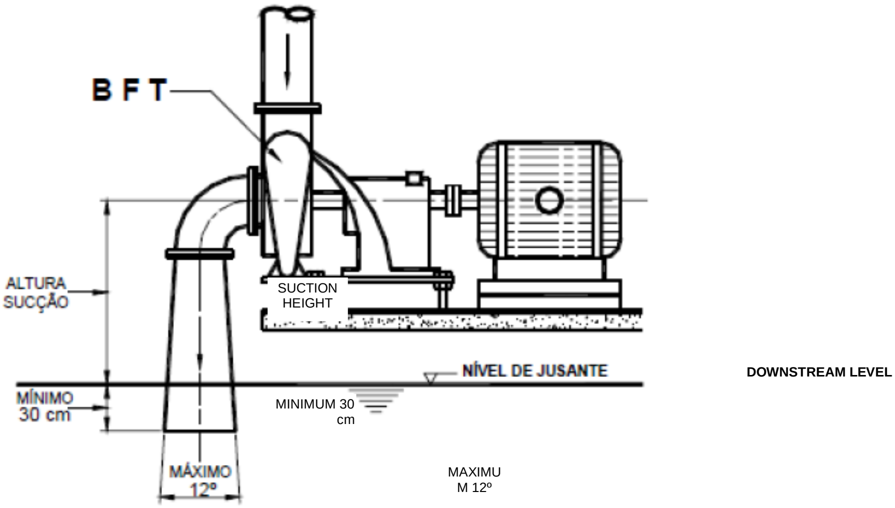


Figure 1: Pump working as a turbine
Source: Souza *et al*. (1983)

Driving machines transform hydraulic energy into mechanical work, taking advantage of the difference between two levels of water, which, by means of the turbine's rotor shaft, drives the rotor of a generator (Santos, 2007).

According to Beluco (1994), a proposed method for providing performance curves for pumps used as turbines, drawn up by the manufacturers, these curves would be available for all pump models and composed into a selection chart.

Centrifugal pumps have good performance and require few modifications for their adoption in reverse operation, as well as being cheaper than the traditional hydraulic turbines used by Beluco (1994).

According to Beluco (1994), figure 2 shows the availability on the market of centrifugal pumps that can operate as turbines, where there is a relationship between head and flow.

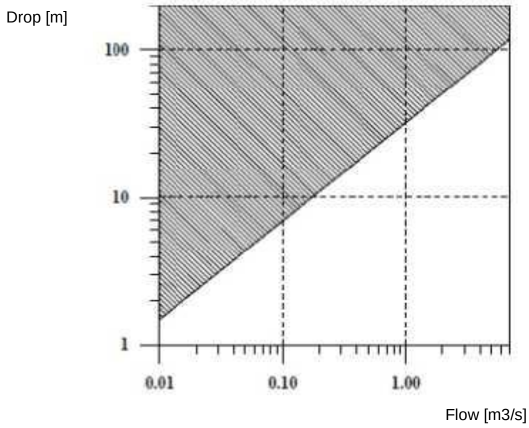


Figure 2: Preferred region for application of centrifugal pumps used in reverse mode.
Source: Beluco (1994)

According to Beluco (1994), the idea of using pumps as turbines is therefore viable, offering facilities that are difficult to find for using water as a source of motive power.

The aim of this article is to assess the feasibility of using pumps working as turbines (BFT) to microgenerate electricity in small irrigation systems. The research aims to analyze the efficiency and financial costs of this method, with a view to contributing to the use of pumps and the optimization of water resources in agriculture.

2 MATERIALS AND METHODS

For the test, the pump installed on a rural property in Colatina (ES) was used to operate in reverse, i.e. the pump working as a turbine (BFB)**,** which consists of an induction motor working as an electricity generator. To obtain the data, a Schneider Bc- 21 R 2 1/2 5 Cv Three-Phase Pump was used as a model, and the data on the use of the pump working as a turbine to generate electricity was collected.

The pump running as a turbine (BFB) has the following installation characteristics according to table 1 below.

Features	Values
Pump flow	14.00 m³/h
Rotation	1600 rpm
Power	5cv
Piping	230 m
Manometric head	50 m
Suction (Output)	75 mm
Discharge (Inlet)	75 mm

Table 1: Pump characteristics
Source: Authors (2023).

To obtain a power output of 954.02 W, using a generation efficiency of 50%, we used the following equation:

$$P_{EL} = (g\ x\ Q_T\ x\ H_T\ x\ \eta_T\ x\ \eta_g\ x\ \eta_{ac})\quad \text{(eq. 1)}$$

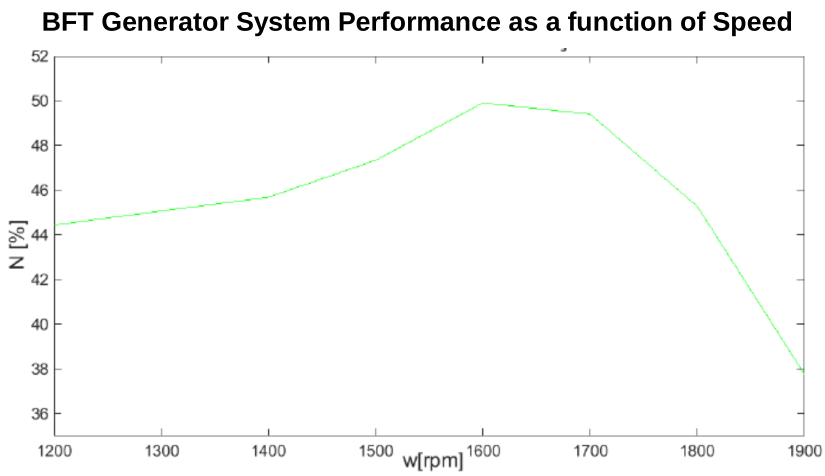
in which:

	g (m/s^2)	Qt(1/s^2)	H_T(mca)	η
P_{EL}(W)=	9.81	3.89	50	0.50

Table 2: Obtaining Power
Source: Authors (2023).

P_{EL} (W)= Electrical power of the generator;
g (m/s²)= acceleration due to gravity;
QT(1/s²)= nominal flow rate;
H_T(mca)= useful pressure;
ηt= BFT yield;
ηg= generator efficiency;
ηac= coupling performance;

According to Custódio *et al.* (2018), in studies carried out with a pump working as a turbine (BFB), the result is shown by the system performance versus speed curve, as shown in graph 1.



Graph 1: BFT system yields
Source: Custódio *et al.* (2018)

3 RESULTS AND DISCUSSION

Regarding the use of the BFT system as an electricity generator, after collecting and analyzing the data to obtain the power to generate electricity, we used an efficiency of 50% of the pump and a calculated power of 954.02 W, verifying the feasibility of using this system on the rural property in Colatina (ES).

In order to analyze the viability of the system, it was considered that the concessionaire, Empresa de Luz e Força Santa Maria S.A., charges R$0.70 per kWh for rural installations.

The investment required to install the pump is described in Table 3.

Equipment	Investment (R$)
Schneider Bc-21 R 2 1/2 5 Cv Three-Phase Centrifugal Pump	5,000.00
1600 rpm three-phase induction motor	900.00
Weg CFW500 Three-phase Frequency Inverter 5CV 220V 16A	3,500.00
Total	**9,400.00**

Table 3: BFT cost
Source: Authors (2023).

Given that the value generated of 954.02 W would be equal to that consumed, according to the value of the tariff modality of Empresa de Luz e Força Santa Maria (ELFSM), R$ 480.82 would have to be paid per month [(0.95402 kWh) x (0.70R$/kWh) x (24 h) x (30d)].

Considering that the owner financed the amount of R$ 9,400.00 at a financial institution with a compound interest rate of 3.5% per month, within 12 months, he would pay a total amount of R$ 14,204.05 with installments of R$ 972.75.

Considering the consumption of all the energy produced by the BFT system, applied on the basis of the rural tariff of 0.70 R$/kWh, the final amount paid for the financing will generate a financial return 30 months after the installation of the BFT system.

4 CONCLUSION

Therefore, it can be concluded that the use of the BFT system saves energy and that the materials are easy to find, both for installation and for future maintenance.

Considering that the installation site has a constant and abundant watercourse, energy will be generated 24 hours a day, guaranteeing safety and quality in the generation of electricity.

If there is economic viability, the next step in the study will be to look at the technical feasibility of using pumps working as turbines (BFT) to microgenerate electricity in irrigation systems.

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