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HYDRO POWER PLANT FOR A MINE



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# Summary executive

In small vein mines one of its main consumptions is the electricity, which is used to operate pumps to draw water used within the mine, electric motors to generate rotational motion to granulators that crush the rock to extract the gold and also the lighting of the mine. In this project will be analyzed a mine in Cisneros, Antioquia, which has a water resource that is a stream. The mine contains only an electric motor generating rotational motion to 10 granulators, which generates great consumption of electricity, because it is used around of 232.5 hours per month in a place where the kWh’s price is $ 409.51. Also the motor produces the 59% of the expenses of electricity It is therefore important to reduce this energy consumption to decrease costs, and moreover, reduce the environmental impact caused by such consumes.

The objective of this project is to design a Pelton turbine and assess if it can replace a 5HP electric motor and generate the same rotational movement at 10 granulators, for reducing expenses for electricity. For this design will be performed using the hydraulic turbine theory.

The turbine will be made for a net height (H) of 14m and a flow rate (Q) of 30l / s, therefore it has a hydraulic power of 4.12 kW. With an average theoretical cost taking the kW turbine installed in US$ 2000, the cost to implement the turbomachine is $ 15'520 616,8. This investment gets out approximately 3.67 years. But this value is somewhat approximate, so must make a financial study taking into account all factors that involve costs such as materials for manufacturing and turbine construction, erection, civil works, etc., and determine the NPV of turbine.

# Description

## Problem proposal

Implementation of a Pelton turbine type in a mine of Cisneros (Antioquia) to generate mechanical energy, and therefore reduce electricity consumption.

## Hypothesis

Using a Pelton turbine could replace a 5 HP electric motor to generate rotational motion to 10 granulators in a mine in Cisneros, Antioquia.

## Justification

Cisneros is a town in Antioquia, which has been studied its mining potential by the Canadian company Antioquia Gold and the multinational company Logan Drilling Colombia SAS, where they found four exploration areas with significant potential for gold mining **[1].** This has recently generated increased gold mining on a small scale.

Spoke with several partners in the township mines and commented that one of the major costs in mining vein in Cisneros is the consumption of electricity. Where this energy is used for the operation of electric motors and pumps, which generate rotational motion granulators and extract the water used inside the mine respectively.

On the other hand, Cisneros has a lot of hydric resources, therefore, some mines are near to rivers and exactly for that reason, the rivers are used for generating hydro power and decrease consumption but also the environmental impact. The mine that is assessed in this project is La Manuela´s and it is localized in Cisneros (Antioquia) in the Lemon village.

Theoretically the cost per kW installed on a small hydro power is 1500US $ / kW to 2500 U.S. $ / kW **[2].** The energy potential of the turbine in La Manuela is 4.12 kW; analyzing theoretically the approximate cost of the Pelton turbine, taking an average value of $ 2000US Kw installed, the cost is approximately $ 15’.520.616,8.

In La Manuela mine as one of its partners said that has an average power consumption of $ 600,000 / monthly. Where 5HP electric motor has a working of 15 to 16 hours a day for 15 days per month. Where monthly uses 232.5 h / month (taking an average working of 15.5 hours per day) and the Kwh value is $ 409.51 / Kwh, it must be the annual consumption of the electric motor is $4'227.371,76.

Replacing the electric motor by the turbine would generate an economic benefit in the medium term, because after 3.67 years approximately the initial investment is recovered and start to generate free and clean mechanical energy, also reduces energy consumption approximately 59%.

## Theoretical framework.

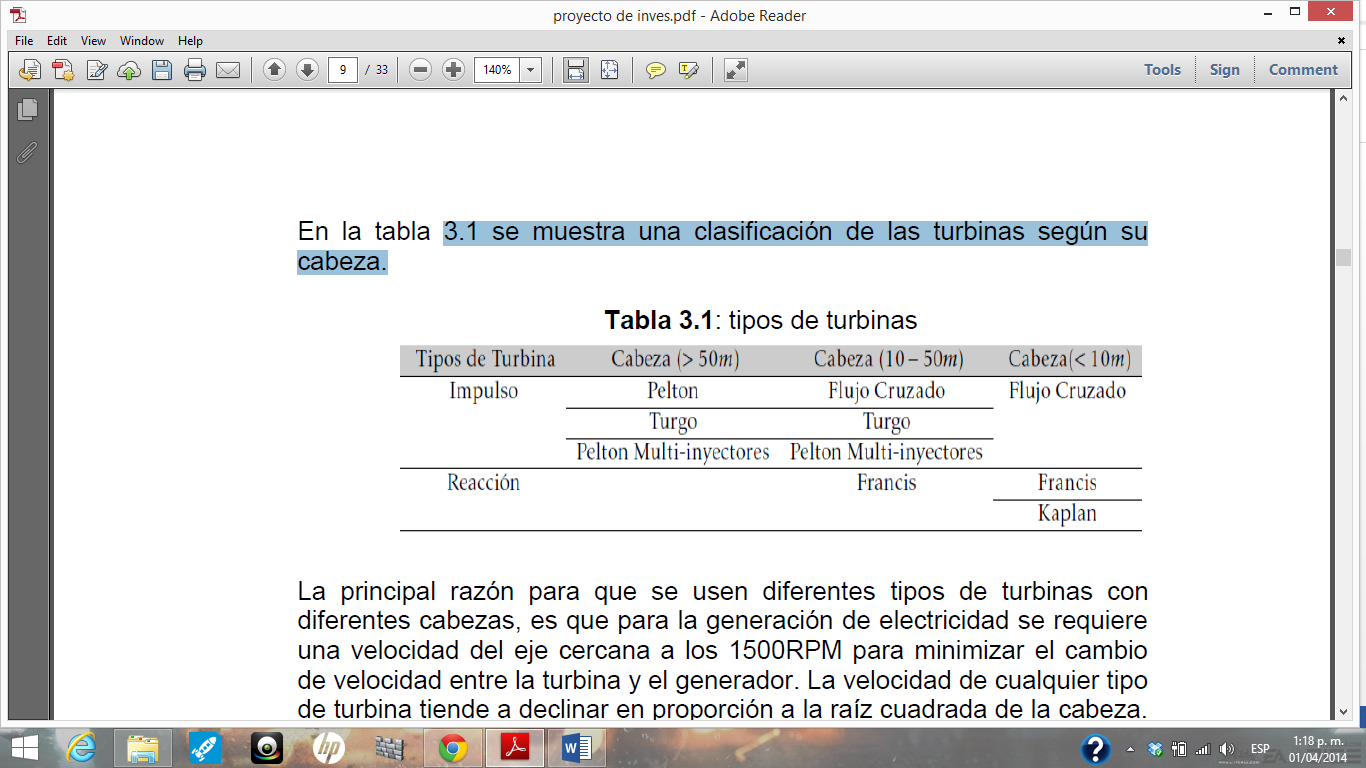
### Hydropower Generation

Hydropower has like source the potential energy of water. This is converted into mechanical energy passing through a turbine. Where to couple the turbine to a generator that produces electricity.

Hydropower has been used for many years in mills and “Trapiches” to generate mechanical energy to grind wheat or sugar cane respectively. Today, hydropower is used for electricity generation through hydropower.

In any scheme of hydropower generation, the turbine plays an essential role, because it is the component that converts the hydraulic energy into the water in mechanical energy of rotation. The selection of the best turbine for any particular site depends on the characteristics of the site, being the head and the flow are predominant. All turbines have a power and a characteristic efficiency, they tend to operate more efficiently at a speed, head and flow specifics **[3].** Main mountings for generating electrical energy around the world is primarily on the Francis, Kaplan and Pelton turbines; and to a lesser extent Turgo and Michell Banki turbines. Owing to the feature of head and flow of projects implemented in the country, Pelton and Francis turbines are the most commonly used; in large plants (over 10 MW) and small (1 to 10 MW). For small hydro power, the Pelton usage is predominant.

Table 3.1 shows a classification of turbines by their head:



### Selecting the type of turbine

Turbines can be classified by their principle of operation; may be of action or reaction. Action turbines only exploit water flow rate to produce a rotational motion; In contrast the reaction turbines use the pressure loss that occurs in its interior. **[4]** The impulse turbines are several types: Pelton, the Turgo, crossflow.

The selection of type of turbine can be done with the use of graphics that depend on the jump (head) and flow rate. Figure 3.1 shows a graph that defines the ranges of use of different types of turbines depending on the type of head and flow for smaller powers to 15000 kW.

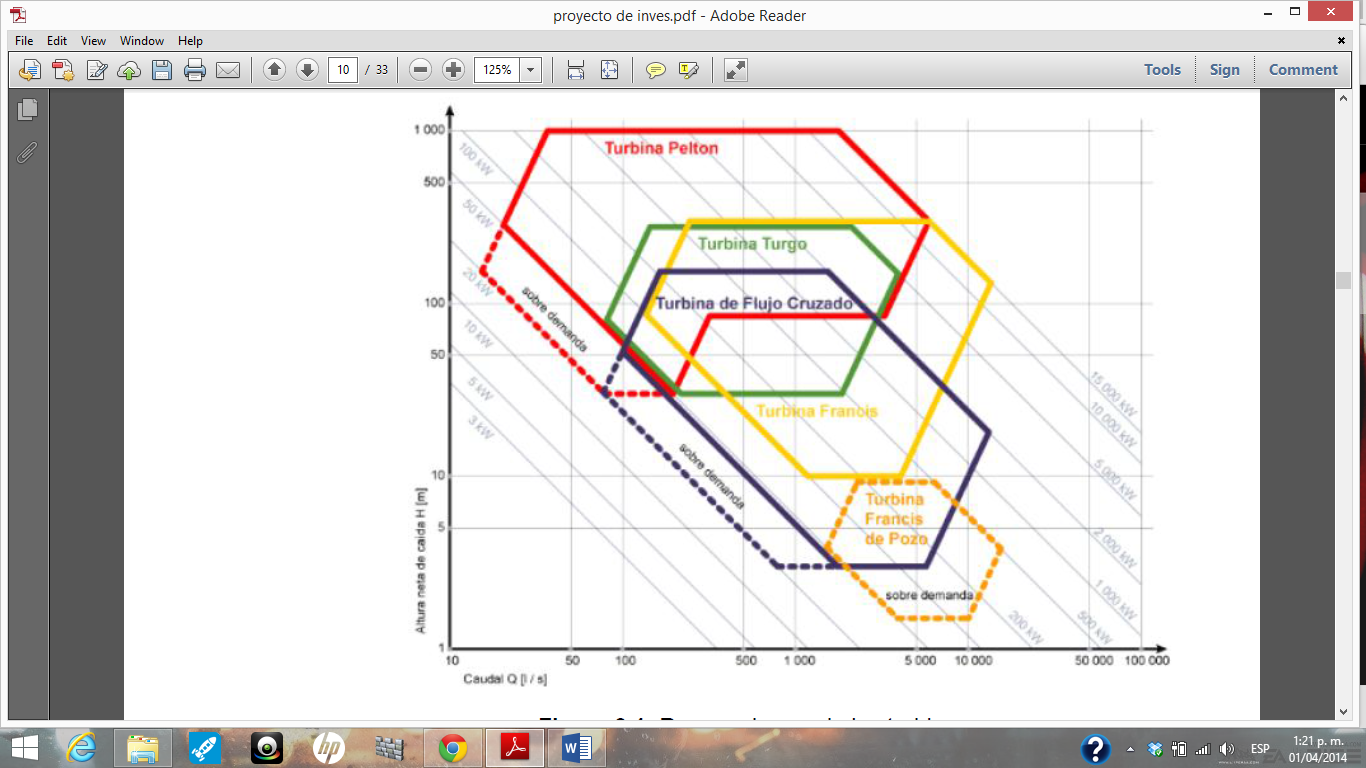
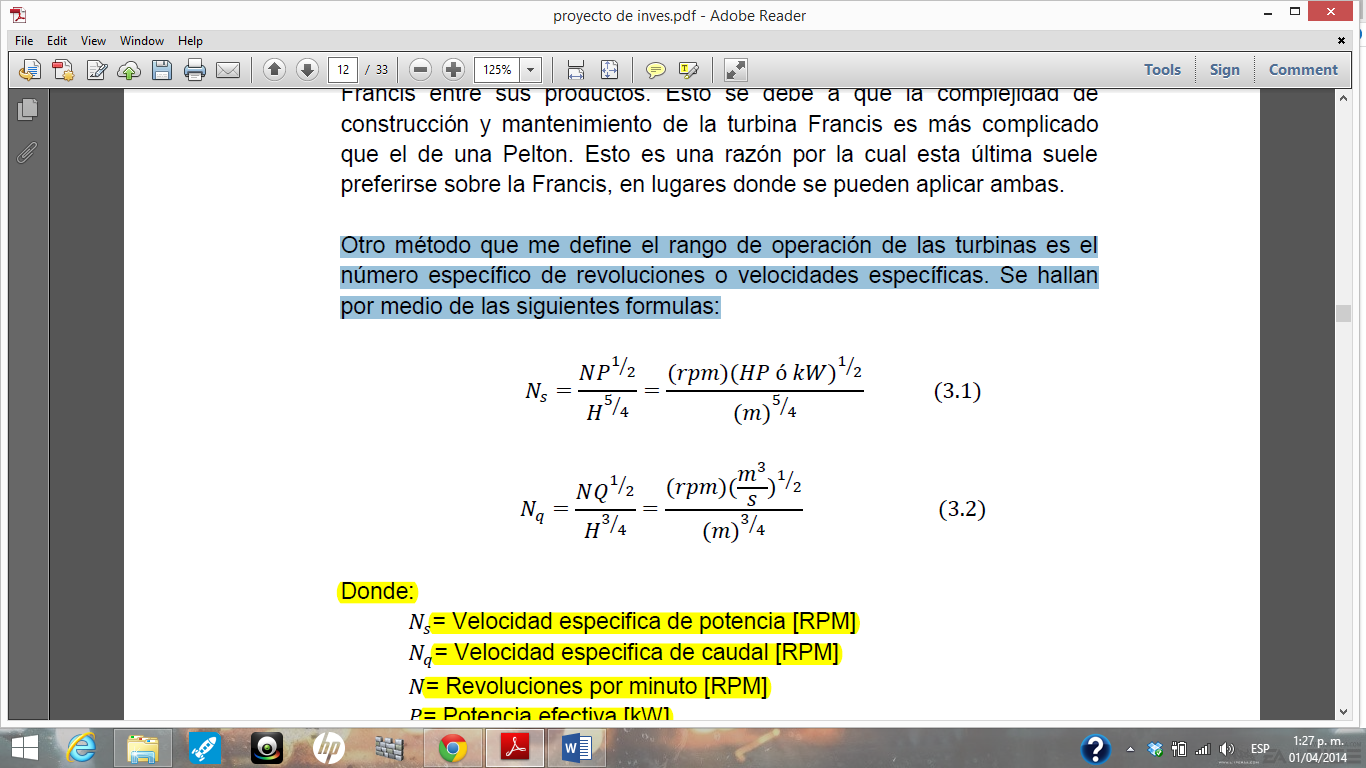


Figure 3.1: Ranges using turbines [5]

Figure 3.1 used as Y axis net fall height [m] and X flow Q [l / s], entering these values ​​to graphic the most appropriate type of turbine installation is obtained.

Another method that defines the operating range of the turbine is the specific speed or specific speeds. They are found by the following formulas:



Where:

Ns= Power specific speed [RPM]

Nq= Flow specific speed [RPM]

N= revolution per minute [RPM]

P= effective Power [KW]

Q= Flow [m3/s]

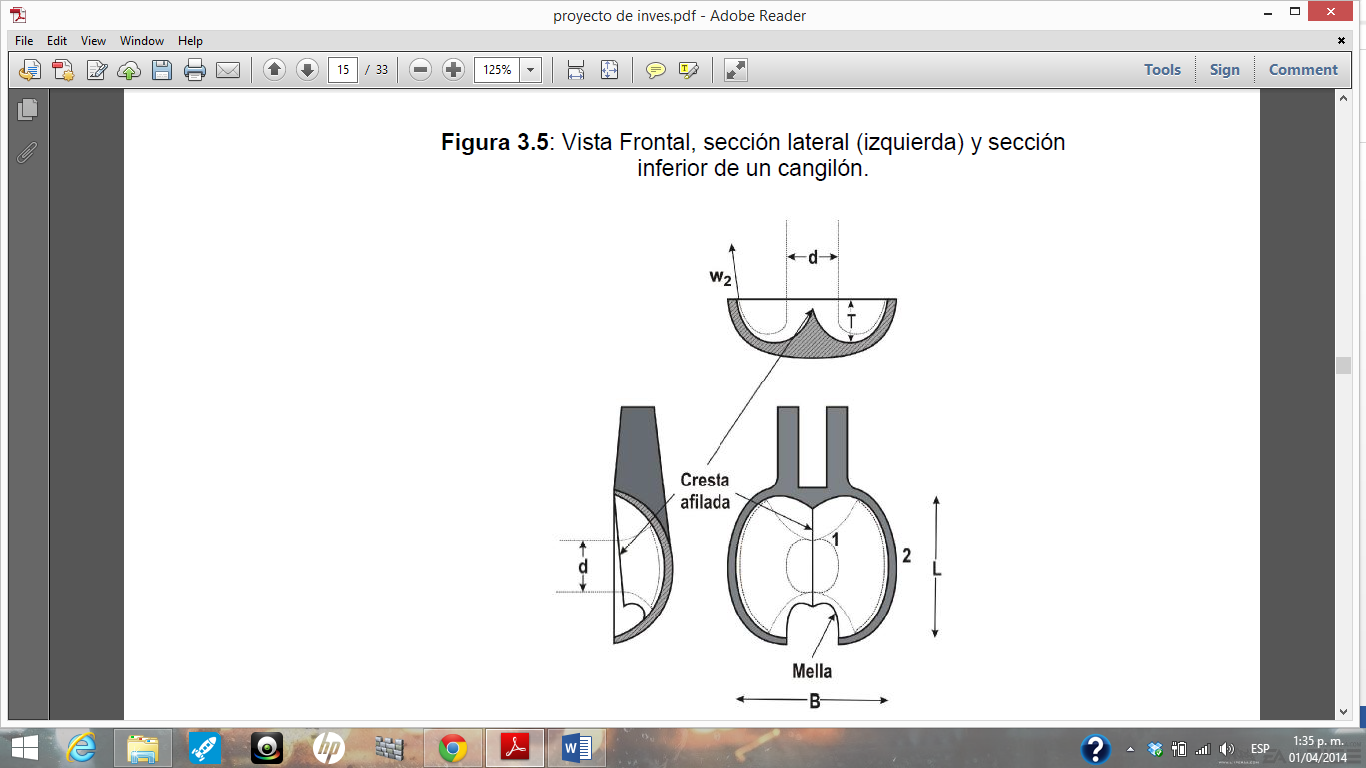
H= net height [m]

### Pelton turbine

Hydraulic turbines are machines that developing torque and shaft power resulting from the variation of the amount of movement of the fluid passing through them, so the potential energy of the fluid passing through, it is converted into rotational mechanical energy in its shaft. This energy can be used directly to make working (such as water mills) or to produce electrical energy, connecting the turbine shaft to an electrical generator. Pelton turbine, known as pressure turbine, as the constant pressure in the region of the impeller; likewise enter the classification of tangential turbine or action. Its main elements are: the rotor, distributor, injector or nozzle that regulate and guide the water entering the turbine. The impeller, which aims to transform the kinetic energy of fluid in mechanical energy more efficiently, optimally exploiting all the kinetic energy of the fluid obtained from the potential energy of the jump.

Pelton turbines are the oldest turbine model and one of the most used in the world. It is a machine design and robust construction, high reliability and allows higher efficiencies. In contrast to some other patterns, it is also characterized by high efficiency when operating at partial flows. **[5]**

Pelton turbines are commonly used in small exploitation by simplicity of manufacture, easy installation and high yields; especially in the case the turbines witch a single injector or maximum of two. ***[5]***



### Design of a Pelton turbine

For the design of a Pelton turbine, must take into account the design of the distributor, rotor and blades. The distributor is a nozzle or injector with needle valve, where a Pelton turbine can have between 1 and 6 injectors. The number of injectors gives them the specific number of revolutions Ns (Eq. 3.1).

# Objectives

## General objective.

* To design a Pelton turbine for the generation of mechanical energy and evaluate if can replace an electric motor of 5HP, which generates rotational movement to 10 granulators; and therefore reduce the paid costs by electricity in the mine La Manuela in Cisneros, Antioquia.

## Specific Objectives

* To carry out a hydrological study to determine the flow and energy head, and  establish if the hydric resources that has the mine reaches or exceeds 5HP that has the electric motor.
* To establish engine speed and torque needed for a turbine to move 10 granulators, and therefore, determine the dimensions of the turbine.
* To design Pelton turbine in a CAD software for obtaining drawings for manufacturing or melting of the turbine.
* To establish what type of material will melt the turbine.
* To determine the type of pipeline that will be used to transport fluid to the turbine.
* To make a financial study to establish the VPN of the turbine.

# Scopes.

In this project a hydraulic turbine to generate mechanical energy and replace an electric motor located in a mine will be designed, while decreases the electricity consumption. Where is taken into account a financial analysis to determine the true value of the turbo-machinery and establish in how long the initial investment is repaid.

# Commitment.

The main commitment of this project is to establish if with the hydric resource and turbine to implement, can be done a better job comparing it with the electric motor of 5 HP.

After establishing that the turbine can replace the electric motor and evaluate its feasibility, would proceed to manufacture the turbine and make the necessary civil works in order to leave the turbo-machine running smoothly. Also train people to make good use and maintenance of the turbine.

# Methodology.

## Calculation of the necessary variables for the turbine design.

For the design of any turbine the most important is to have a flow and energy head, because without it could neither design nor fabricate the turbine. These data are determined by a hydrological study in which is performed an analysis of the flow passing through the river and the required flow to generate the desired power, the flow is determined by the method of dump thin wall.

To determine the energy head, a GPS will be used, this is an instrument of global positioning giving the exact location of a place on earth be means of triangulation form satellites.

The variables that are needed apart from the flow and energy head for turbine design, are the engine speed and turbine torque. The torque needed to move the ten granulators present in the mine is determined by the specifications of the electric motor of 5 HP, since the torque that should generate the turbine must be equal to or greater than the form of the motor and to have the necessary torque is obtained revolutions to which are moving the turbine.

When determining the revolutions of the turbine, could settle down the dimensions of the turbine impeller, since this depends on its specific speed.

## Design and drawing of the turbine.

When the dimensions of the turbine and angles of entry and exit of the fluid are determined, will be performed the design of the turbo-machine through a software Computer Aided Design (CAD), for example Autodesk Inventor, Solid Edge, Solid Works, and others. After designing by means of any of these programs will be made the drawings and subsequently the turbine will be manufactured.

## Material and turbine manufacture.

To determine if the material must be abrasion resistant is necessary take into account the type of particles that go with the fluid passing through the turbine. Considering this must be set the type of material to melt the turbine, where the most used elements to manufacture of Peltorn turbines are stainless steel or copper alloy. The manufacture of the turbomachine (Pelton turbine) can be more economic if is local manufacture and not imported from another country, so when the import is done there is an extra spend of money due to all taxes that this operation costs.

## Financial analysis and economic evaluation.

After designing, having the correct pipeline and knowing the necessary constructions to put the turbine into operation, a financial study will be conducted to establish the true value of turbine or pico-generator.

The analysis is done to know the exact prices of the turbine, civil works, pipelines, staff costs, contractor, etc, since only we have the theoretical cost of turbo-machine that was found based in the standard value in Colombia which is approximately 2000 USD$/KW .

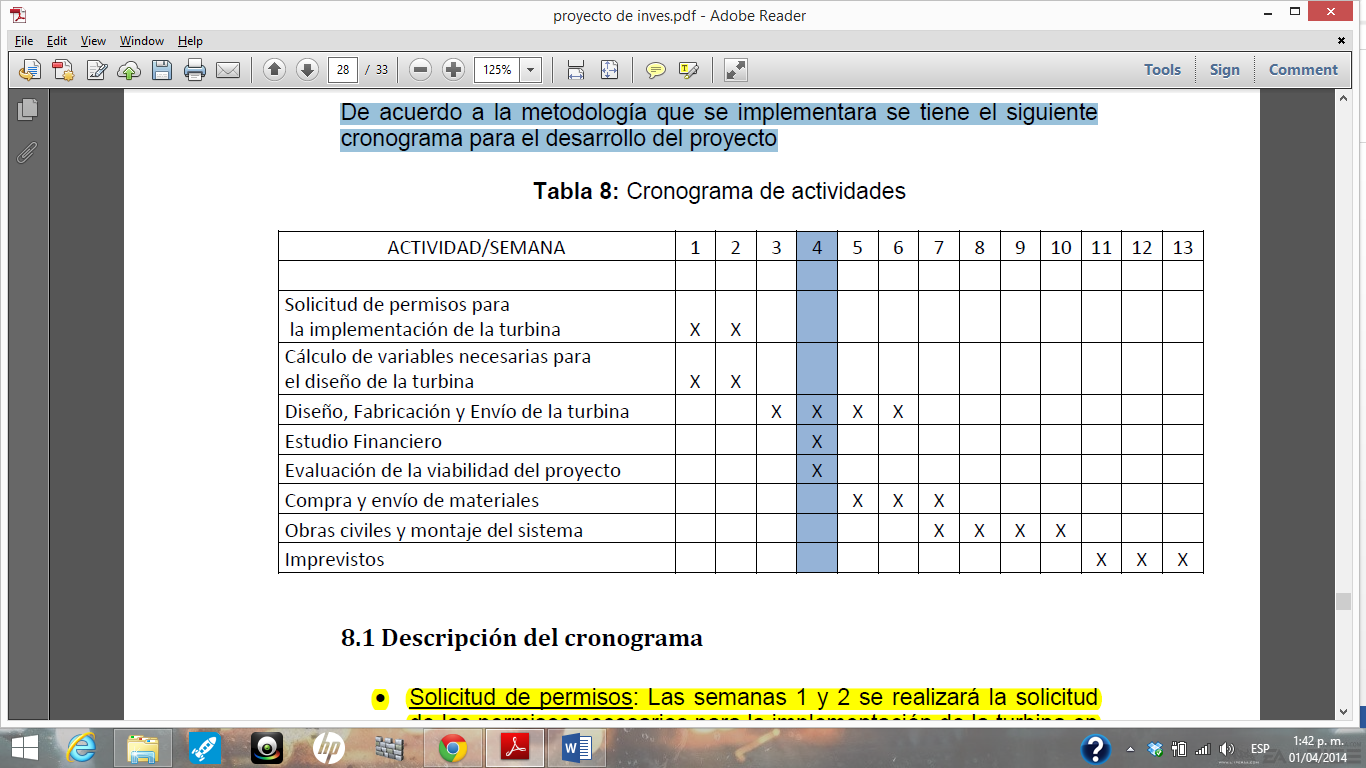
## Evaluation of project viability.

The viability of the project is determined by the economic benefits that will generate the implementation of the turbine in the mine La Manuela in the municipality of Cisneros, Antioquia. In the first place if turbine cam perform the same work as electric motor will be assessed, that is, generate rotational motion needed for the 10 granulators operate optimally.

In second place how long the turbine begins to generate profit and in so far as percentage reduces the electricity consumption to determine economic viability will be assessed.

# Timeline.

In accordance to the methodology that will be implemented we have the following timeline for the project;



# Expected Results and potential beneficiaries.

With the realization of this project the replacement of an electric motor by a Pelton turbine to produce mechanical energy and generate rotational movement to 10 granulators is expected, which would reduce electric energy consumption in medium term by 59% approximately. Where the main beneficiaries would be the mine owners because medium term (approximately 3, 67 years) the mine starts to produce almost free mechanical energy.

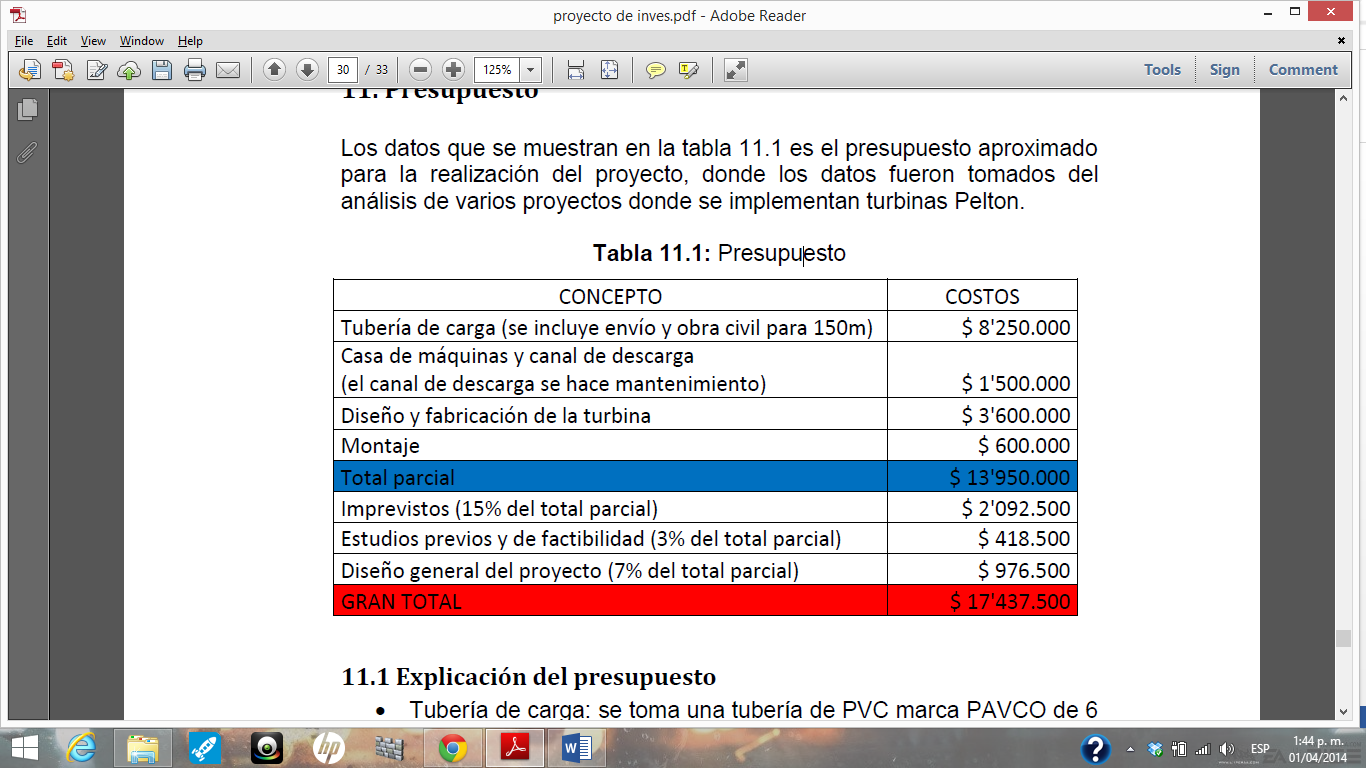
# Expected impacts from the expected results.

Economic impact is expected because the electricity consumption will be reduced by 59%, which generate less cost for the mine.

Also occurs an environmental impact, since by reducing electricity consumption generates less pollution because the pico-generator hydraulic is considered a renewable energy that causes no damage to the environment.

# Budget.

The data that shown in *table 11.1* is the estimated budget for the project, where data were taken from the analysis of various project In which are implemented Pelton turbines.



# Glossary

**Turbine**: Any of various types of machine in which the kinetic energy of a moving fluid is converted into mechanical energy by causing a bladed rotor to rotate. The moving fluid may be water, steam, air, or combustion products of a fuel.

**Electric motor:** A device that converts electrical energy to mechanical torque.

**Design:** To work out the structure or form of (something), as by making a sketch, outline, pattern, or plans

**Potential energy:** Is the energy of a body as a result of its position in an electric, magnetic, or gravitational field. It is measured in joules ( SI units ), electronvolts, ergs, etc. Symbol: Ep.

**Kinetic energy:** Is the energy of motion of a body, equal to the work it would do if it were brought to rest The translational kinetic energy depends on motion through space, and for a rigid body of constant mass is equal to the product of half the mass times the square of the speed. The rotational kinetic energy depends on rotation about an axis, and for a body of constant moment of inertia is equal to the product of half the moment of inertia times the square of the angular velocity.

**Hydraulic:** Operated by pressure transmitted through a pipe by a liquid, such as water or oil.

**Mechanical energy:** Is the energy that is due to the position and movement of a body, therefore, is the sum of the potential and kinetic energy of a system.

**Flow:** (of liquids) to move or be conveyed as in stream.

**Energy head:** Is the height at which the fluid will pass through the turbine.

**Mine:** A system of excavations made for the extraction of minerals, esp coal, ores, or precious stones.

**Granulator:** Apparatus or machine that serves to grind coarse material and reduce it to fine grains.

**NPV:** Net present value.

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