JOURNAL OF SYSTEMS AND INDUSTRIAL PROJECT ENGINEERING
JSIPE

Vol. 1, N° 2, November 2015
pp. 47-58
ISSN: 2411-7226

Improving the Performance of JIRAMA using the TRIZ Approach: Analysis of Total System Losses, Sales Losses and Treasury

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ABSTRACT

This paper investigates the impacts of total system losses and sales losses on the JIRAMA treasury. After evaluating the current losses, the impacts on the treasury were assessed considering two scenarios:(i) 50% reduction of total system losses and annual sales losses; (ii) elimination of total system losses and annual sales losses. The results showed that, under scenarios, the total system losses and the losses on sales negatively impacted the JIRAMA treasury. Afterwards, these results were scrutinized under various financial analysis theories in order to obtain a first series of short-term recommendations. The TRIZ approach, which is a problem-solving theory developed in 1946 by the Russian engineer Genrich Altshuller,was then used to identify the best ways for the implementation of our first series of recommendations. The results of the TRIZ approach led to a second series of recommendations focusing on innovative changes in the JIRAMA system settings to improve company treasury.

Keywords: *Sales losses, Total system losses, Treasury, TRIZ*

1. INTRODUCTION

The performance of the Malagasy Energy sector during the last decade is generally perceived as unsatisfactory. In the case of JIRAMA, the national company which provides water and electricity, recurrent blackouts repeatedly trigger complaints from the customers. Moreover, rate increases practiced from 2005 to 2012, following increases in oil prices, have failed to bring any significant improvement in the access rate or in the quality of service. Currently, the JIRAMA treasury exhibits clear deteriorations in all indicators considered. This situation severely hinders the maintenance and development of the production park. In particular, new connections to the national grid are rationed out since 2004, thereby crippling the development of new economic activities throughout the country. In other words, the crisis in the energy sector constitutes an impediment for economic and social development [14].

Latest researches have not particularly highlighted any major difficulties in the JIRAMA treasury. However, these difficulties are detrimental to the JIRAMA quality of service and performances. A preliminary analysis of the problem indicates that several causes could lead to this situation [14]: they can be political, economic, social, technical (including system losses) or commercial (in particular sales losses). The identification of the main causes will facilitate the adoption of remedial measures.

The objective of our research is to confirm the nature of the relationships between treasury and total system losses and sales losses.

Hence the research question: To which extent do existing data illustrate the impact of total system losses and sales losses impact on the JIRAMA treasury?

2. LITERATURE REVIEW

In an electrical system, there are different types of loss, including:

- the total system losses, which is the energy unsold due to technical lost during the production, transport and distribution processes;
- the sales losses, which is the difference between sales prices and production costs.

2.1. Total system losses

The total system losses include both technical and non-technical losses.

Technical losses are divided into:

- the technical production losses caused by failures in the production process and auxiliaries;
- the technical transport and distribution losses during the transit on the electricity network.

These technical losses are linked to poor network performance due to load imbalance, active and reactive losses, wrong power factor, etc. These losses are measured from the difference between the energy injected and the energy consumed.

Non-technical losses result from energy theft, counting errors and/or profiling, as well as from the non-payment of bills by consumers [9, 13].While it seems easy to estimate the level of non-technical losses from the difference between the energy injected and the energy actually charged, the origin of the losses are actually hard to pinpoint and to measure with accuracy. It is estimated that, in some developing countries, non-technical losses can reach up to 50% of the total amount of electricity fed into the grid [7]. In particular, theft can amount to 10 to 40% of the total production [16].

According to the Institute of Energy and Environment of the French Speaking World [7], only total system losses, from production to distribution, between 15 to 16% are considered acceptable.

2.2. Sales losses

Sales losses occur when, for a given period, the average selling price is below the average production cost [3].

Theoretically, selling prices depend on the application of the marginal production cost. This application itself depends on factors that may be considered seasonal and stationary such as temperature and economic activity.

The production cost may vary greatly from one power plant to another; it is possible to observe phenomena on the market for very large temporary price variation [8].

2.3. Difficulty of treasury

In general, difficulties arise in treasury following deficiencies of Working Capital (WC) or excessive Working Capital Requirement (WCR).The deficiency of WC is the main cause of difficulty of treasury. It results from the combination of several short and medium-term factors such as weak social capital, financial losses, excessive withdrawals, and poorly studied investment financing.

The excessive WCR is directly related to the economic environment in which the company operates. It can either be the result of surplus stocks or uncollected receivables or a poor recovery system.

The crisis scenarios and the ideal situation

There are various possible difficulties in treasury, in particular the crisis of profitability scenario (Figure 1) and the ideal situation scenario (Figure 2).In both figures, the cash is represented in terms of turnovers (CA), working capital (WC) and working capital requirement (WCR). The emergency actions to overcome these situations of difficulty are given in each figure. T+ shows positive treasury and T- : negative treasury

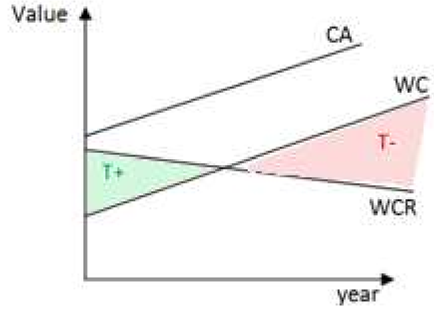

Figure 1 : The crisis of profitability scenario

Under the Crisis of profitability scenario, the losses accumulate, thereby causing the fall of WC. It quickly changes from a positive to a negative cash flow. In case of emergency, a fund supply is necessary and causes of declining profitability must be sought to find a solution.

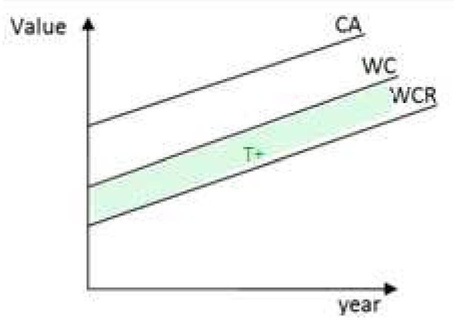

Figure 2: The ideal situation scenario

Under the ideal situation scenario, WC also increases regularly and as quickly as CA. Consequently, profitability is preserved. WCR is boosted by the activity grows but at a rate not faster than that of CA.

3. METHODOLOGY

The following steps were taken during the first phase of our research. Using existing data provided by JIRAMA, we started by estimating the annual total system losses. We also valued the annual total system losses. Then, we conducted a trend analysis for the annual total system losses over a period of ten years. After that, we compared the average sales prices with the average production costs. Finally, we analyzed the total system losses and the sales losses and compared them with the JIRAMA treasury.

In the second phase of our research, we applied the TRIZ approach to identify the best ways for the implementation of the recommendations during the fisrt phase.

3.1 Estimated annual total system losses

According to MC Anumaka [4], an overall estimate of the losses can be performed using the formula below:

Total system losses= Energy injected into the network – Energy billed

The energy fed into the grid can be assimilated with the energy produced by JIRAMA during a given period. The energy billed is equivalent to the energy sold to customers during the same period. The overall performance of the network is given by the following equation:

Overall efficiency = (energy sold) / (energy produced)

This performance is used as an indicator to assess the overall state of a power system.

3.2 Value of annual total system losses

To allow Malagasy companies to recover from losses, Decree n°2001-849 of 26 September 2001 lays down the conditions and methods to calculate the electricity price in Madagascar. It stipulates that the value of losses can be estimated by using the average cost of production [12]. In fact, prices vary according to the technology used for the energy production: diesel thermal, hydraulics and fuel.

Therefore, the annual cost of losses can be calculated by the following formula:

Annual cost of losses = annual losses × average production cost

The average cost (Cm) is given by the following formula [3]:

$$C_m = \frac{\Delta C}{\Delta x}$$

∆C being the variation in total cost

∆x being the variation in total quantities produced

3.3 Trend analysis of annual total system losses over a period of 10 years

Trend analysis using time series has been conducted in order to forecast the annual losses at the JIRAMA. In particular, a linear least squares fit trend was adopted. This method assesses existing trend from the ordinary least squares method using the linear function:

$Z_t = a_t + b$

where the couple (a, b) is given by:

$$a = \frac{cov(t, X_t)}{var(t)}$$

$$b = \overline{X} - a\overline{t}$$

with $\overline{t} = \frac{1}{n}\sum_{t=1}^{n} t$

and $\overline{X} = \frac{1}{n}\sum_{t=1}^{n} X_t$

$$cov(t, X_t) = \frac{1}{n}\sum_{t=1}^{n}\left(t - \overline{t}\right)\left(X_t - \overline{X}\right)$$

$$var(t) = \frac{1}{n}\sum_{t=1}^{n}\left(t - \overline{t}\right)^2$$

The value of the series at time t + h when h ≥1 was determined from the estimates of the trend. However, various scenarios can be considered during the preparation steps. These scenarios are based on the results from previous forecast:

- Scenario 1: losses will follow the current trend and the average production’s cost
- Scenario 2: 20% reduction in annual losses and maintaining the average production’s cost
- Scenario 3: 50% reduction in annual losses and maintaining the average production’s cost

3.4 Comparative analysis between average sales price and average production cost

This is another analysis of the data provided by JIRAMA. The following formula was applied:

Unit profit of sale = Average price – Average Production Cost

3.5 Analysis of total system losses costs and sales losses costs compared to treasury

This is to assess the total system losses sand sales losses in order to ascertain their relationship with the treasury of the company. For this, it is necessary to consider various difficulties of treasury as discussed in the literature review above. Simulations were therefore conducted according to the two following situations:

- Scenario 4: 50% reduction of total system losses and annual sales losses;
- Scenario 5: elimination of total system losses and annual sales losses.

3.6. The TRIZ approach

Designed in 1946 by the Russian engineer Genrich Altshuller, TRIZ is an inventive problem solving theory which is combined with an exploration method for the generation of new concepts [1, 2, 5, 6, 15]. This method is used for inventive problems, or for problems with at least one contradiction (improving a characteristic result in the deterioration of other characteristic) and having no solution, and where we can use similar solutions applied in other areas to find a solution. The aim is to capitalize existing industrial knowledge and to broaden the spectrum of investigation, particularly in the creative phases of a project. It allows the elimination of contradictions and the identification of concrete solutions to a given problem instead of just finding compromises.

In the TRIZ process (Figure 3), problem solving starts from the transformation of the original problem into a specific standard model problem. Then, standard solutions are proposed using specific TRIZ tools before any of them can be implemented to the specific problem.

The use of the TRIZ approach is further explored in the discussion section of the current paper.

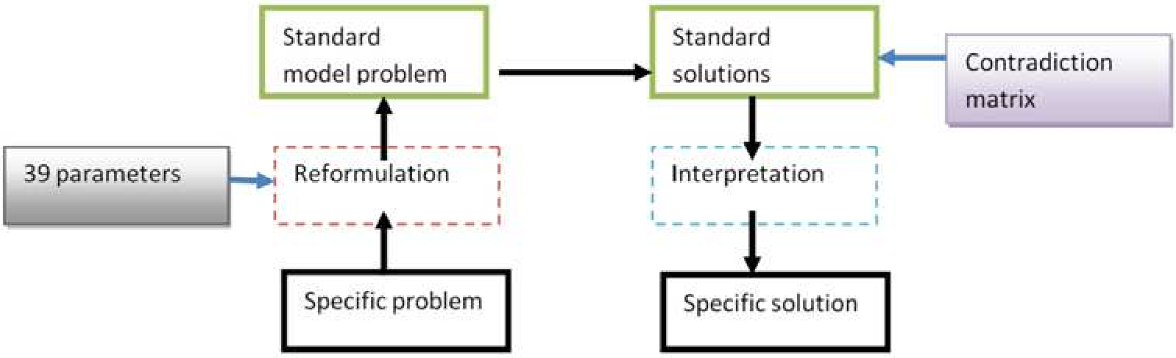

Figure 3: The TRIZ process

4. RESULTS

Based on the average production costs of electricity since 2008, the following table summarizes annual total system losses.

Years	2008	2009	2010	2011	2012	2013
Total system losses (kWh)	251508964	312048558	345854630	384697747	412300000	463650000
Marginal cost (MGA/KWh)	311,000	320	464	548	619	600
Annual cost of total system losses (MGA)	78 219 287 804	99 855 538 560	160 476 548 320	210 814 365 356	255 213 700 000	278 190 000 000
Sum (MGA)	78 219 287 804	178 074 826 364	338 551 374 684	549 365 740 040	804 579 440 040	1 082 769 440 040

Table 1.Annual total system losses since 2008 to 2013

The results of the trend analysis are given in the Figure 4 below. It should be remembered that the trend analysis is based on the following three scenarios:

- Scenario 1: losses according to the current trend and the average production cost;
- Scenario 2: 20% reduction in annual losses but no change in the average production cost;
- Scenario 3: 50% reduction in annual losses but no change in the average production cost.

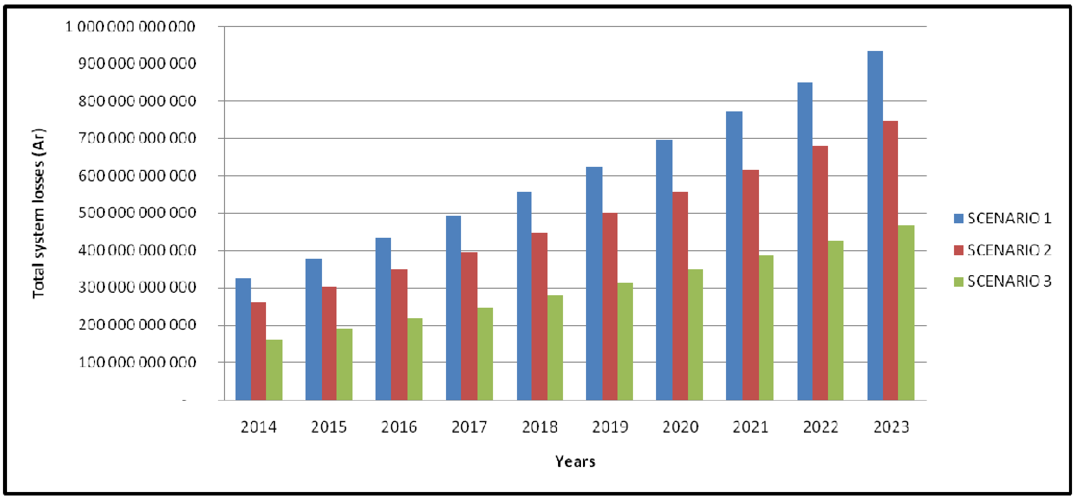

Figure 2: Trend analysis for the annual total system losses

The unit profit of sale per kWh since 2008 is given by the green curve in the Figure 5 below.

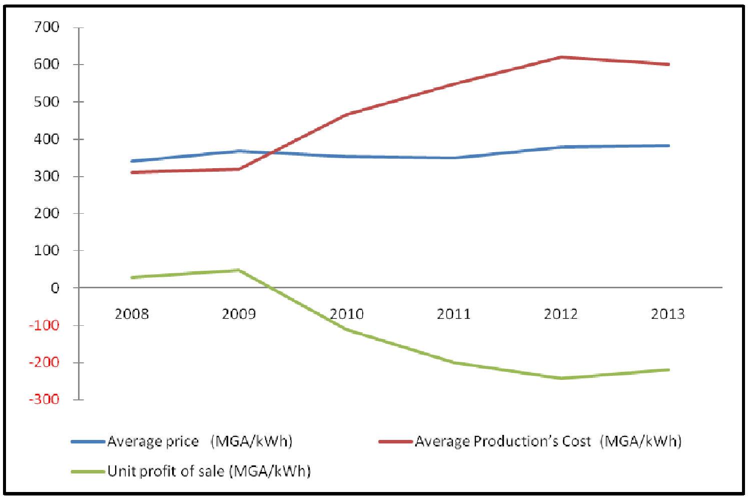

Figure 3: Profit unit sales since 2008

The analysis of total system losses costs and sales losses costs compared to treasury is provided in the figures below. In particular, Figure 6 shows the situation of the treasury since 2010; thereby highlighting the fact that the JIRAMA treasury is definitely in profitability crisis.

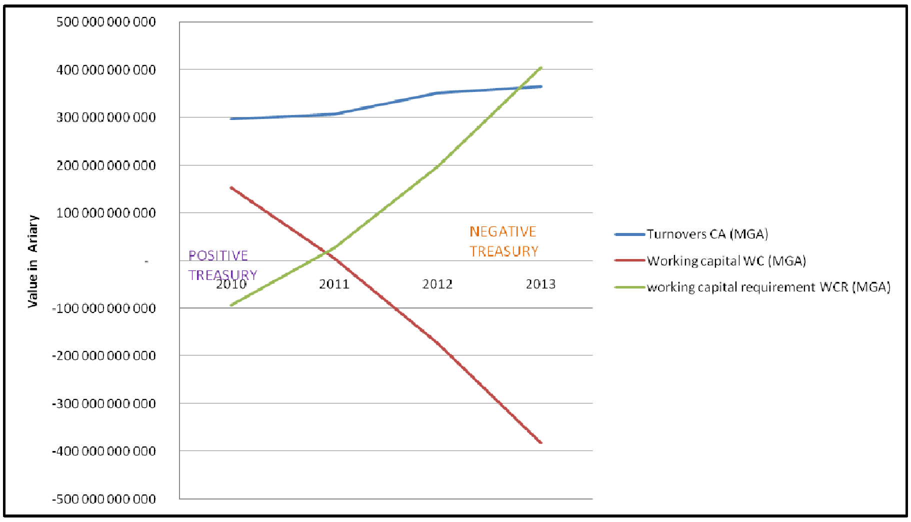

Figure 6: Situation of the JIRAMA's treasury since 2010

The figure 7 below is the result of a simulation of treasury according to Scenario 4 "50% reduction of total system losses and annual sales losses."

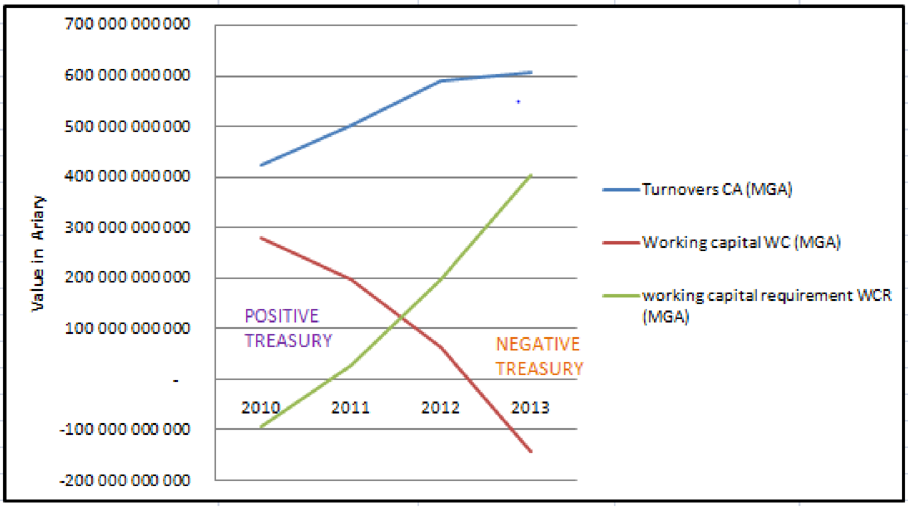

Figure 4 : Scenario 4 with 50% reduction of total system losses and annual sales losses

The figure 8 below is the result of a simulation of treasury according to Scenario 5 "Elimination of total system losses and annual sales losses."

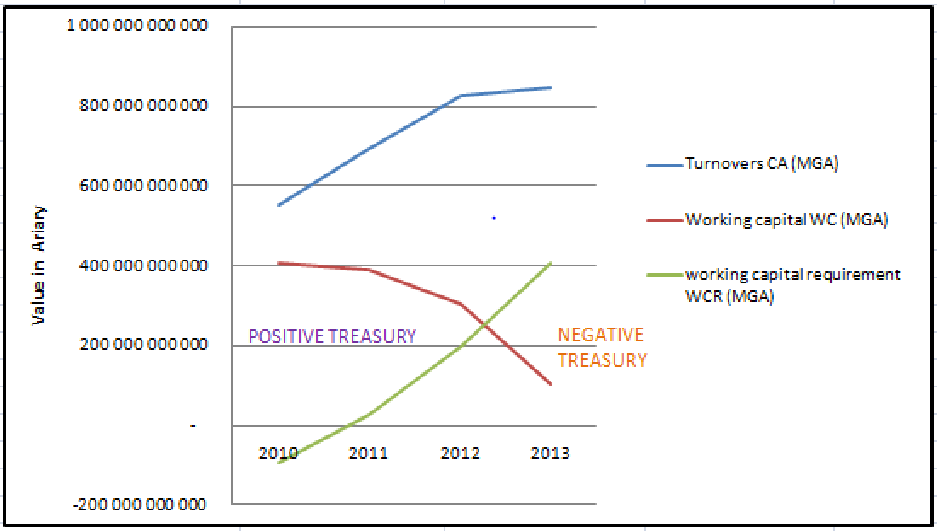

Figure 5 : Scenario 5 with elimination of total system losses and annual sales losses

5. DISCUSSION

Results from our research showed that, in the case of JIRAMA, the total system losses have continually grown since 2000. Starting from 163,337 MWh in 2000, a value which represent 21% of the total production, the annual total system losses reached 463,650MWh in 2013, which is the equivalent of about 33% of the total production. It can thus be concluded that the total system losses of the company had tripled in 14 years. In fact, JIRAMA recorded its highest percentage of total system losses in 2013.

In the meantime, the performance of the company has steadily declined. The rate went from 79% in 2000 to 67% in 2013, which is the lowest level observed since the inception of the company.

The JIRAMA total system losses were higher than the standard accepted by the Institute of

Energy and Environment of the French Speaking World international experts, which is 15 to 16% [7].These losses were distributed throughout the entire value chain of electricity supply, from the production, the transport and the distribution process. The JIRAMA total system losses however fell within the average values of other developing countries which is between 30 and 50% of total production.

The JIRAMA annual total system losses were relatively important. Taking into consideration the annual average prices of the company sales since 2008, the total system losses could be estimated at 78 billion MGA in 2008 (so about 40 million USD) to 278 billion MGA (or about 126 million USD) in 2013. The overlapping of these losses was estimated to reach up to 1082 billion MGA (or 490 million USD) in 2013. This estimation clearly exceeds the accumulated turnover of 2011-2013 which was equivalent to1,024 billion MGA (or 463 Million USD).Considering that the cost of installing a (01) KW hydroelectric power plant is about 7,000 USD[11], the JIRAMA total system losses since 2008 could have made possible the building of an hydroelectric plant with an installed capacity of 70MW. Such a hydroelectric plant would have been equivalent of Andekaleka with turbine N°1, 2 and 3, which is the biggest hydroelectric power plant in Madagascar installed on 1982.

The trend analysis of the JIRAMA total system losses conducted during our research showed that, under Scenario 1, which correspond to the current situation with no decision to reduce total system losses being taken within the next 10 years, the losses would reach 6060 billion MGA by2023 (2745Millions USD in 10 years). This amount would have been enough for the construction of a 392 MW power plant, such as Sahofika (300MW) or Mahavola (300MW), some of biggest hydroelectric site identified in Madagascar.

The comparative analysis between the sale price and the annual production costs within JIRAMA (Figure 5) indicated that the electricity sector was loss-making since 2010. The unit result was estimated to be about -112 MGA per KWh in 2010 to -218 MGA per KWh in 2013, despite the gradual rate increase implemented by the company in 2012. These values confirm the study conducted by Fabrice BERTHOLET and Vonjy RAKOTONDRAMANANA on the smallest effects of tariff increases applied on the treasury of JIRAMA [14].

There was no significant correlation between the selling prices and the production costs in the case of JIRAMA since 2008. However, in theory, there should have been some correlations between the two parameters in order to ensure a profit on each sale transaction [8]. There were probably other parameters considered in the process of setting sales prices instead of just relying on the production cost. The intervention of the Malagasy State in the management of JIRAMA could also explain the current situation. Indeed, the State remains the major shareholder of JIRAMA and, although tariff adjustments might have been necessary for the survival of the company, it regularly decided against making such adjustments since 2009. It is true that official texts allow operators to implement tariff adjustments following the rise of fuel prices, the inflation rate and the depreciation of the MGA. The State’s decision could be justified by the need to avoid social crises; the purchasing power of the population being considered too limited to cope with significant increases in the energy prices. No wonder that the true prices remain a recurring problem within JIRAMA.

The JIRAMA sales losses were evaluated to reach up to 94 billion MGA (about 45 million USD) in 2010 and 205 billion MGA (about 92 million USD) in 2013. These losses doubled in this four year period. These values were a little below the annual total system losses of the Company. One of the reasons could be that the fact that JIRAMA purchases power from private power producers. As the central buyer, JIRAMA has to limit gaps in its power generation and buys from several private operators of electrical energy production (The group Henri Fraise et Fils, AGRECO, ENELEC, Hydelec). Their systems are mainly diesel thermal. JIRAMA purchases about 22% of his total production in 2011, so about 288,586 MWh, from these private operators.

When the JIRAMA total system losses are combined with the sales losses, the situation becomes alarming. In 2010, the total losses was estimated at 255 billion MGA (122 million USD), which represents about 86% of the company turnover whereas, in 2013, it reached 483 billion MGA (219 million USD), which represents about 132% of the turnover. In terms of losses, JIRAMA was losing 21 billion MGA per month in 2010 and up to 40 billion MGA per in 2013. These results confirm the recent test carried out by the Ministry of Finance. Over time, this situation could clearly worsen the financial fragility of the JIRAMA.

Worse, our research indicates that JIRAMA is definitely in profitability crisis (Figure 6). The working capital is continually falling, probably as a result of the accumulation of losses. Which one is no longer able to support the working capital requirement, which is continuously growing. Moreover, every year, the corporate expenses are constantly increasing while resources are shrinking. This growth is parallel to the increase in the marginal cost of production. A close look at the JIRAMA production system, a net growth can be observed in the production of diesel power plant, which raised from 404GWh in 2008 to 578GWh in 2011. By contrast, the production of hydroelectric energy was stagnating at around 700GWhper year during the same period. This trend would certainly impact the company expenses because of the high production costs of thermal power plants, a situation which could lead to a significant increase in the working capital requirement.

Scenario 4 conducted during our research highlighted the fact thata50% reduction of the total losses in sales and total system losses can have a positive impact on the cash flow. Compared to the current situation within JIRAMA is presented (Figure 6), the decrease in the working capital would have been slightly more abrupt in Scenario 4(Figure 7). Indeed, a negative treasury and a negative cash flow would have been observed with a delay of six months compared to the actual situation. In other words, in the current situation, a negative treasury and a negative cash flow can already be observed at the beginning of 2011 whereas, in Scenario 4,they would have started only towards the middle of 2011.

Scenario 5 with the elimination of the total losses in sales and total system losses can have a better impact on the cash flow than Scenario 4. Indeed, a negative treasury would have appeared only towards the middle of 2012; so a delay of two years compared to the current situation within JIRAMA. So, both reducing and eliminating the annual losses within JIRAMA would give a positive impact on cash flow of the company, at least for a brief period, and as long as the working capital requirement maintains the same trend.

It then seems obvious that according to financial analysis theories outlined above (in the figure 1), in the short term, a potential alternative to restore the JIRAMA treasury would be the input of new fund, which could be done through loans or grants. Logically, this approach will unfortunately impact the volume or debt threshold of JIRAMA, whose value is currently at a very high level. In the TRIZ model, such a situation is recognized as a technical contradiction: increasing a company treasury through external borrowing ends up degrading the company debt threshold.

After the transposition of these two parameters from the field of financial management to the TRIZ matrix, the following model adopted in our search for solutions (Table 2):

- Parameters that improve: volume moving object (07), productivity (39), duration of action of the moving object (15), reliability (27);
- Parameters that degrade: power usage by a mobile object (19), effect or harmful factor affecting the object (30).

The choice of these parameters can be explained as follow. Firstly, cash can be assimilated to a moving object because its value changes over time. The addition of other parameters such as productivity, moving object duration of action and reliability mean the management and use of cash to achieve the company's activities. Secondly, the debt threshold is a parameter generating not only the borrowing and the repayment thresholds but also their interests. Interests may be assimilated to the energy needed to use the loans injected into the treasury, which will accordingly impact the cash flow.

The use of the technical contradictions resolution matrix gives the results depicted in Table 2.

Parameters that degrade / Parameters that improve		energy use by a moving object	effect or harmful factor affecting the object
		19	30
07	volume of moving object	35	22, 21, 27, 35
15	duration of action of the moving object	28, 06, 35, 18	22, 15, 33, 28
27	reliability	21, 11, 27, 19	27, 35, 02, 40
39	productivity	35, 10, 18, 19	22, 35, 13, 24

Table 2 : Extract of TRIZ matrix

The matrix shows 16 solutionsto40 possible principles. A number of principles appear only once but Principle 35 "change of state or changing a setting" appears five times; Principle 22 "transformation of a more and less" and Principle 27 "ancillary cheap ephemeral life" each appear three times; whereas Principles 18, 19, 21 and 28 each appear twice. The fact that Principle 35 appears five times indicates that many ideas surely may ensue from this principle. However, this does not mean that it will generate the final solution.

Some specific constraints of the JIRAMA have not been taken into account at this stage, which may render many of the solution paths outlined here unusable.

From the generic solution "change of state or changing a setting", we would make the following recommendations to increase the treasury of the JIRAMA while maintaining its current debt threshold:

- The JIRAMA should undertake activities with opportunities to reduce or erase taxes;
- It should review the ideal currency for potential trade with the other countries(convertibility);
- It should change the levels of risk taken for each activity in order to ensure cost effectiveness;
- For very short-term activities, it should promote rentals and sales locations rather than new purchases;
- It should change its payment program (debts, bills, interest ...)
- It should promote variable rate loans and/or minimal rates;
- It should sell properties that are not anymore used for the realization of the company activities;
- It should ensuring the gains of each activity by promoting the long term;
- It should invest in other more income-generating activities in the long term.

6. CONCLUSION

The objective of our research was to analyze the relationships between the treasury and the total system losses and sales losses within JIRAMA. Our approach allowed us to see the relationship between these parameters. We recommended that JIRAMA should input new fund to improve its treasury. Yet, our research also demonstrated that bringing in new fund could cause other problems, including the deterioration of the JIRAMA debt threshold. According to the TRIZ approach, This situation represents a real contradiction, an innovative problem worth exploration. The application of the TRIZ method led us to generic solutions from which we derived specific solutions focusing on changing the settings of JIRAMA activities. Our second set of recommendations could be considered as innovative solutions. These solutions were difficult to identify by the first methodological basis. As an example: investing in other more income-generating activities, the elimination of hazards or the use of activities that reduce taxes.

ACKNOWLEDGMENTS

Thanks to Taiichi Ohno Laboratory for Innovation and Strategy for the various exchanges of ideas that have allowed us to conduct this study.

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