Modeling and Optimization of The Energy Bill

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Abstract
In our shaken world of energy crisis and inadequate supply in relation to the increased demand of our country, it is important that all companies have a good control of their energy consumption which is synonymous with gain of profit for the country, and on the other hand to relieve demand. The objective of this work is to find the correlations between the sulfur consumed and the thermal energy produced (high pressure steam) of a Moroccan company which is one of the five largest fertilizer companies in the world and the leader in the field of phosphate industry. These correlations will then make it possible to realize a simulator which will be used to optimize the energy bill on the basis of linear programming.

Keywords: Thermal energy; Modeling; High pressure; Sulfur

Methods
The Principal Component Analysis (PCA) is part of the data analysis, which is to reduce the number of descriptive characters and seeking the most faithful projection plane by distorting the least possible reality. The characters obtained through this analysis are new characters ‘principal’ [2]. Predicting the future is all about optimizing decisions must be based on an increasing number of data [3]. It is not easy to handle this data in hand it is the reason for which data processing software is used. In our study we used the SPSS statistical analysis software.

Discussion of Results
Modelling of the principal component’s analysis

The principal component analysis (PCA) is part of the data analysis, which is to reduce the number of descriptive characters and seeking the most faithful projection plane by distorting the least possible reality. The characters obtained through this analysis are new characters ‘principal’ [2]. Predicting the future is all about optimizing decisions must be based on an increasing number of data [3]. It is not easy to handle this data in hand it is the reason for which data processing software is used. In our study we used the SPSS statistical analysis software.
616,090.61 and a standard deviation of 58,755.744 shows that the values are dispersed around the average.

**Correlations table:** We then study the correlation between the different variables. The table 2 represents the correlations between the various input-output sulfuric plants. This is the correlation matrix that gives an insight into the relationship between pairwise variables. Note that all correlations are positive (all variables vary in the same direction) which means that characters are considered correlated. There are strong positive correlations around 0.987 and 0.828 respectively between HP steam, MP steam and sulfuric acid production, which explain the influence of $\text{H}_2\text{SO}_4$ production on HP and PM steam production and thus the power generation platform. A strong positive correlation in the order of 0.816 between steam extraction and steam HP production which explains why it has less losses in steam extraction.

| Table 1: Descriptive statistics. |
|---------------------------------|
| **N** | The Cadence | Seawater (m$^3$) | Consumed Sulfur | HP Steam (T) | MP Steam (T) | $\text{H}_2\text{SO}_4$ (T) | E.E (MWH) |
|------|--------------|------------------|-----------------|--------------|--------------|-----------------|------------|
| Valid | 184 | 184 | 184 | 184 | 184 | 184 | 184 |
| Missing | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Average | 616,090.61 | 4790.02 | 10,605,819 | 62,401,115 | 145,692,25 | 87,584 |
| Standard-deviation | 58,755.744 | 449,078 | 91,867,748 | 94,796,687 | 1,364,457 | 80,781 |
| Variance | 3,452,237,416,796 | 20167,019 | 843968,32 | 898,641,179 | 1861742,8 | 65,255 |
| Minimum | 458300 | 2266 | 5527,00 | 2636,00 | 6892 | 66,4 |
| Maximum | 724900 | 5628 | 12278,00 | 8557,00 | 17119 | 100,9 |
| Percentiles | 25 | 566250,00 | 4462,50 | 99,550,00 | 13578,25 | 79,625 |
| | 50 | 618252,00 | 4759,00 | 10,450,00 | 14471,00 | 90,650 |
| | 75 | 662194,00 | 5265,50 | 11,498,250 | 16007,75 | 94,400 |

**Table 2: The correlation between the different variables.**

| **The Cadence** | Seawater (m$^3$) | Consumed Sulfur | HP Steam (T) | MP Steam (T) | $\text{H}_2\text{SO}_4$ (T) |
|-----------------|-----------------|-----------------|--------------|--------------|-----------------|
| Pearson correlation | 1 | 0.620** | 1.000** | 0.987** | 0.828** |
| Sig. (Bilatérale) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **N** | 184 | 184 | 184 | 184 | 184 |
| Seawater (m$^3$) | Pearson correlation | 0.620** | 1 | 0.618** | 0.605** | 0.482** |
| Sig. (Bilatérale) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **N** | 184 | 184 | 184 | 184 | 184 |
| Consumed sulfur | Pearson correlation | 1.000** | 0.618** | 1 | 0.986** | 0.829** |
| Sig. (Bilateral) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **N** | 184 | 184 | 184 | 184 | 184 |
| HP steam (T) | Pearson correlation | 0.987** | 0.605** | 0.986** | 1 | 0.816** |
| Sig. (Bilateral) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **N** | 184 | 184 | 184 | 184 | 184 |
| MP steam (T) | Pearson correlation | 0.828** | 0.482** | 0.829** | 0.816** | 1 |
| Sig. (Bilateral) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **N** | 184 | 184 | 184 | 184 | 184 |
| $\text{H}_2\text{SO}_4$ (T) | Pearson correlation | 1.000** | 0.620** | 1.000** | 0.987** | 0.828** |
| Sig. (Bilateral) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **N** | 184 | 184 | 184 | 184 | 184 |
| EE (MWH) | Pearson correlation | 0.674** | 0.717** | 0.673** | 0.675** | 1 |
| Sig. (Bilateral) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **N** | 184 | 184 | 184 | 184 | 184 |

**Note:** Correlation is significant at 0.01 (bilateral).

It is also noted that there is a very high correlation between the consumed sulfur and sulfuric acid product it indicates that, for a good combustion and conversion absorption generates good production of sulfuric acid and vice versa. On the other hand, we cannot estimate a correlation between the production of MP steam and the seawater consumption since our correlation coefficient is not sufficiently determinative which is of the order of 0.482.

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Factorial analysis: The projection of variables on a plane gives the distribution shown in the following diagram.

**Linear regression**

A regression problem is to find a function $f$ such that for all $i$, $Y_i$ is approximately equal to $f(X_i)$. The simplest case is that of simple linear regression. In simple linear regression, it is to estimate the parameters and test the validity of the model $[4,5]$.

$$Y_i = \beta_0 + \beta_1 X_i + \epsilon_i \quad (1)$$

With:
- $\beta_0$ is the intercept: The value of $Y$ when $X = 0$. 
- $\beta_1$ is the slope: Variation caused by the variation of one unit of $X$. 
- $\epsilon_i$ is a random variable reflecting the inadequacy of the model.

We will estimate the $\beta$ vector by a vector $b$. There will therefore be a straight:

$$Y_i^\wedge = b_0 + b_1 x_i \quad (2)$$

To estimate $\beta_0$ and $\beta_1$, we use the famous method of least squares $[6]$, which is to choose $b_0$ and $b_1$ so that the sum of the squares differences $e_i$ between the observed values and calculated values is minimum.

The term that minimizes, $\sum_i (Y_i - Y_i^\wedge)^2$, named the sum of squared residuals (SCRes).  

Where:
- $e_i = Y_i - (b_0 + b_1 x_i) \quad (3)$
- $b_0 = \bar{y} - b_1 \bar{x}$
- $b_1 = \frac{\sum_i (x_i - \bar{x})(y_i - \bar{y})}{\sum_i (x_i - \bar{x})^2} \quad (4)$

We find:

We measure the adequacy of the estimated regression equation to the observed values $y_i$ by $R^2$ “coefficient of determination” $[7]$:

$$R^2 = \frac{SC \text{Re} g}{SC \text{Re} g + SC \text{Re} s} = \frac{SC \text{Re} g}{SC \text{Tot}}; 0 \leq R^2 \leq 1 \quad (5)$$

$R^2$ expresses the percentage of the sum of total 1 square explained by the estimated regression equation.

With:
- $SC \text{Re} s = \sum_i (y_i - Y_i^\wedge)^2 \quad (6)$
- $SC \text{Re} g = \sum_i (Y_i^\wedge - Y)^2 \quad (7)$

**Table 4:** The model parameters and their degrees of significance.

| Model                  | Non-Standardise Coefficients | Standardise Coefficients | $t$    | sig   |
|------------------------|------------------------------|--------------------------|-------|-------|
| Constant Consumed Sulf | 942,77,3,2017                | 121,064,025              | .986  | 778,780,166 | .000  |

**Conclusion**

The maximum energy efficiency, a fundamental challenge for sustainability of production, suggests solutions for the mastery of electricity consumption. In our case, modeling and optimization of the energy bill was necessary. Indeed, thanks to the ACP method, synthesized and summarized data, we could highlight trends combinations or contrasts between individuals or between
variables. Information obtained via the graphical representations and correlations table allowed us to choose the model of simple linear regression to study the connections of the energy cycle of the workshop between the sulfur consumed and HP steam produced to address the problem of energy modeling, first step towards optimizing energy bills. This modeling allowed HP steam management and thereafter, developing the energy performance of the thermal station used for the production of electrical energy.

Figure 1: Diagrams components.

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Conflict of Interest
No conflict of interest.

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