BASIS OF A COMPUTER GAME THAT CONSISTS OF CHOOSING SOURCES FOR THE EXPANSION OF ELECTRIC CAPACITY

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ABSTRACT

An interactive computer game can show to the average citizen concepts that make the electric power planning unique. There are so many variables, relations and constrains in this planning that it is impossible for the non-technical citizen to answer with rationality. Interested in winning the game, players allocate generation sources to meet the expanding electric market in order to achieve economic goals as well as minimize social and environmental damages. At the beginning of the game, the players must choose exactly what objectives are to be accomplished, for example, the cheapest electrical energy or the lowest investment of the electric sector or the minimum rate of CO2 emissions or any other output. Obviously, the player that makes the better choices is the champion. At the end of the game, the players will understand all the consequences of their choices. As a collateral effect, they will also realize that electrical planning have not the same characteristics of other planning activities. The objective of expanding capacity with minimum economic, social and environmental impacts, the information about the main generating sources and the demand requirements represent the basis for the development of this planning model. Many of them are shown throughout this work. So, this work describes conceptually the game, which is, in deed, a consequence of the defined planning model. After the definition stage, a computer technician can develop the appropriate program for the game. With the use of this game, the choice of the sources is taken more rationally and the subjective aspects have less influence in the decision process. As added benefit, the players will also learn that each generation source has its positive and negative aspects.

1. INTRODUCTION

Untrained people in the subject of available technologies for electricity generation often adopt a position favorable for one of the options, based on superficial information about them. Usually, they do not consider a full analysis of the impacts of possible alternatives.

Unfortunately, there is not a single conclusion obtained from this decision process, because there is no source whose outputs are better than those of the other sources. However, there are some specific conclusions of this process that escape the comprehension of a non-technical citizen and they are relevant.

An interactive computer game may show to the average citizen concepts such as the lack of attractiveness of the intermittency of wind and solar power generation, as well as the possibility of hydroelectric generation to follow the variation of the demand curve during the day.

In order to understand the consequences of the player’s actions, the game will provide for each decision taken, the variation on the select objectives, achieved by him. For example, each decision will bring impacts on the CO2 emissions, on the averaged cost of electricity, on
the level of investment required, on the area of flooding of lands and on the population displaced from their lands.

The player that better satisfy the objectives will win the game. The inherent competitiveness of human being will push him to play the game and, as a consequence, will help him to understand more about the electrical planning.

2. DEVELOPMENT OF THE GAME

The game begins with the players loading into the program, the additional demand for electric generation that Brazil will need every year between 2016 and 2045 [1] [2]. However, the players may accept a conservative value that is already in the program, which can be, for example, 30 terawatt hours per year (TWh/year). If they do so, there is no need of the loading. The decisions for additional generation constructions from now to 2015 have already been taken and the constructions must be in course at this moment. Also, in the model, this additional generation capacity of hydroelectric plants in construction is already allocated, beginning in the year when the generation starts.

At this right moment, the intensity of use of electricity in Brazilian society and economy is being decided. Notice that the population estimative for the period 2016-2045 exists and, so, the consumption of the population for this period can be estimated. More difficult to choose is the desired degree of electrification of the economy. For example, if Brazil is a major exporter of electrical intensive products, like aluminum, the consumption per capita will be high, while the society itself may not be a great consumer. On the other hand, if the electric car is introduced in the period, it will bring benefits to society, when compared with other transportation options, and electricity consumption will grow dramatically [3].

Each player chooses a mix of electricity sources, following his own understanding of the problem, in order to increase generation and to meet the additional electricity demands of the period. The sources or forms of energy available in Brazil to supply reasonable amounts of electricity are hydraulic, nuclear, natural gas, fuel oil, diesel oil, coal, crushed sugarcane and wind power. We want that solar energy, tidal energy, the one obtained from nuclear fusion and others become technical and economic viable before 2045. Unfortunately, at the present moment, we are not sure that these sources will provide large amounts of electricity before this year.

Obviously, each of these alternative sources will become viable in different years. Today, solar energy is already technically feasible, missing only new developments that will reduce the cost of the electricity. But, we cannot say today, with certainty, that nuclear fusion will be some day technically feasible.

Each mix of electric power sources allocated to satisfy the demand expansion brings different result, for instance, for the additional investment required, the average cost of additional electricity generated and the additional emissions of greenhouse gases released into the atmosphere. These three outputs may be selected, for example, to measure the performance of each mix of sources chosen by the players. But, they, in the beginning of the game, must define the list of outputs that will be considered in order to rank the players’ choices.

Notice that the players will choose the additional capacity of each source to be expanded, which will provide increases in the electricity supply to the country, and these increases must satisfy the additional demand required. We have to be aware for the fact that the same increase of installed capacity, obtained with two different mixes of sources, does not necessarily generate, for technical reasons, equal addition of electricity.
The developer of the game must show the outputs obtained with the mix of sources chosen by a player to meet the additional need of electricity for the Brazilian market in the period. Nevertheless, he must show also a grade related to the mix chosen by this player. Using the example given previously, there will be three tables inside the program that will permit to get grades related to the three outputs of each choice.

In the first table, ranges of variation of the investment required will permit to determine the first grade. In the second table, ranges of variation of the average cost of additional electricity will help to determine the second grade. Finally, in the third table, ranges of variation of additional emissions of CO2 due to the mix of sources chosen will determine the third grade.

Before the game starts, the players must agree also about the weight or the importance level of each one of the grades to be obtained. The players may also follow the recommendation of the developer about these weights, which is in the default on the computer. Thus, the program may calculate the weighted average grade of a player, using the above-described weights of each output, obtaining the final grade. Obviously, the player with the highest final grade wins the game. He is the one who has electrified the country with the best choice for the mix of generating sources, under the established criteria. So, one possible name for this game can be “Electrifying Brazil”.

The players will learn, with this trial and error process, how each one of their choices contributes to the output and to the final grade. This game will serve as an educative tool for the common citizen, who is not a technician. The decision of the electricity sources to satisfy the demand and to bring maximum benefit to the society cannot be taken emotionally, after a simple analysis. Acquiring this knowledge with the game, the citizen may also stop the work of lobbyists, because he identifies their effort to convince with wrong and tendentious arguments.

The improvement of electrical efficiency is not a source, but it frees generation that is already committed. So, the effort to increase efficiency decreases the need for expansion in the immediate future. However, since the efficiency increase is limited, the need to expand the generation in a medium horizon is not eliminated. Therefore, it is possible to program the game so that it contemplates the efficiency increase of the electricity sector as a source of limited resource. Information can be obtained from technical literature to show how difficult is to improve substantially the efficiency of the electricity sector. Some Non Governmental Organizations state fabulous figures for the results of electricity efficiency. Many of these figures can only be obtained if we change some habits of our way of living. For instance, to replace 10% of the actual electric showers by solar collectors is necessary a reasonable effort of propaganda to encourage people to accept the change. The cost of an effective campaign to advice people to use less warm water will be huge and will have a limited result. Thus, it is not so easy to obtain great electricity consumption economy.

Some program information and data to be used by the game developer are listed below. These information and data make the planning of the electricity sector expansion unique.

The size and the investment of industrial modules for each generating source are reported to the program [1] [2] [4] [5]. In the case of hydraulic power, since it is not possible to have module, the investment of each remaining hydraulic generating capacity is reported.

When the generating unit must be constructed far from consumption centers, transmission lines investment must have influence on the generation cost in the program. This is the case of hydraulic and wind power sources. When the source chosen is the hydraulic, the payments to displace people from the area of the dam should be added to the investment generation. When the source chosen is the nuclear, the contribution to a fund for the final disposal of radioactive
waste should be included in the cost of this energy. All these observations can be resumed with the following statement. The costs related to specific energy characteristics, like an expected environmental damage, should be allocated to the investment or the cost of this energy.

The electricity costs obtained from different sources should incorporate all existing distinctions between these sources [6]. In that conception, all source differentiations will be considered and a fair comparison will be obtained. For example, the need for transportation and storage of fuel to operate a generation unit of 1,000 MW during a year is quite different for some possible sources [7]. The nuclear thermal unit requires 30 t of uranium; natural gas thermal unit needs 1.1 million t of gas; diesel oil thermal unit, 1.4 million t of oil; and coal thermal unit, 2.2 million t of coal. The corresponding transportation and storage costs must be contained in the respective electricity generation costs.

Other interesting information that helps to establish a comparative model is the following. The area required to place a nuclear or a fossil thermal unit with installed capacity of 1,000 MW varies from 1 to 4 km² [7]; the corresponding area for solar panels is 20 to 50 km²; the same area necessary for eolic generators is 50 to 150 km²; and, finally, the unit that uses crashed cane as the source needs an area of 4,000 to 6,000 km².

The availability factor of each source, which influences the cost of generated energy, should be introduced in the model [2] [5]. For example, this factor for nuclear plants is around 85% and for hydropower is 55%. However, since the country is now building hydroelectric units with very small accumulation areas, the hydroelectric lakes, in order to contain the flooded area, the number of projected turbines is smaller, which reduces the generation capacity. Thus, all the turbines of these new units will be used to generate steady electricity and they will not follow the demand curve during the day. In these new conditions, the availability factor will increase. For wind power, this factor is close to 30%, since there are moments when the wind is not blowing.

The transformation efficiency of each energy source to electricity should also be informed. For example, the transformation efficiency of thermal energy obtained from coal burning to electricity is around 35%. It is obvious that this efficiency influences the cost of electricity generated from coal.

The model of power sector expansion, described in this game, should positively consider the capability of some sources, which related technologies follow the daily demand curve. As an example, nuclear power cannot follow this curve. However, the introduction in the model of the possibility of some sources to satisfy the daily demand curve increases the complexity of the model, what requires greater ability from the programmer.

Beside all costs related to investment, the operational and maintenance cost, and the fuel cost, if there is any, should be also introduced. The cost of generated electricity is calculated with all mentioned information and following the traditional methodology [6].

The emission of greenhouse gases in the atmosphere of each generation technology option will be featured, including the amount related to the fuel cycle, if it is the case [8].

Brazilian government agencies have even more sophisticated models for this purpose, but none was specifically developed to be an interactive model with non-technical people, seeking for their understanding of the planning difficulties in the electricity sector.

3. CONCLUSIONS AND RECOMMENDATION
This game consists of a step-by-step learning process that will look forward the rational choice of electricity sources. It should help the common citizen to increase his understanding of the problem. After playing this game, he will become less vulnerable to the attacks from biased interest groups in the existing war of information. The Brazilian Government or some non-profitable entity has to assume the task of giving precise, not biased and complete information about these sources to the population.

The economic interest groups gain a lot of money if the common citizen remains without understanding this issue. Any decision taken by Government will satisfy the common citizen, no matter how bad it is, if he is in an unskilled condition. This explains the existence of strong economic lobbies acting near the Government’s decision makers and why the media try so much to form people’s opinion in some direction. A model of this kind can be classified at the same category of a transparence effort of the Government.

No great promotion effort needs to be made for the acceptance of the game by the population, since it is a fun diversion. Thus, while the players are enjoying the game and start to understand the positive and negative aspects of each generation source, it will happen an awareness process.

Any student of engineering, economics, information technology and other areas related to this theme, that needs a challenging thesis subject, may develop this game, if he finds it interesting.

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