INTEGRATED OPTIMIZATION OF ELECTRICITY PRODUCTION AND MULTIPLE USE OF WATER

1. Motivation

The recent controversy between Rio and São Paulo governments, the national operator of the system (ONS) and the national agency of water (ANA) on the use of water reservoirs for the supply of cities against energetic safety was the first of many conflicts on the prioritary use of water that made news in 2014. Similar events of this kind, with financial impacts of hundreds of millions of reais and on the activity of various municipal and regional sectors include:

(i) the interruption of Tietê waterway (according to São Paulo government, the service on the waterway could be partially restored emptying upstream reservoirs but ONS argues that this would affect electric supply safety);
(ii) the emptying of Três Marias dam which was constructed for irrigation but which is today used for electricity production;
(iii) the interruption of turistic activities of various cities at the water’s edge whose water resources have been used intensively.

We observe that these conflicts are not a Brazilian specificity. On the contrary, they appear worldwide. An example of what is called water-energy nexus is a report published in June 2014 of the North American Department of Energy (DOE) with that title and whose second title is Challenges and Opportunities.

2. Objective

The objective of this project is to contribute to the improvement of the integrated management of water resources in Brazil, putting emphasis on the interaction between multiple use of water and electricity production. This problem is quite complex because it involves technical and institutional challenges.

The technical challenge is, essentially, to represent in ONS management methodology the priorities of irrigation, water supply, navigation, flood control, tourism, and others. At first sight, the modelling of this problem can seem simple: each week, establish a priority order (for instance human supply, flood control, navigation, electricity production, irrigation, etc.) and manage the reservoirs attending successively each priority. However, the existence of reservoirs makes it possible to store water in advance to guarantee water supply. The situation is similar to a family in which the parents work and one of them was fired. Must the family cut immediately expenses such as forecast trips and foreign language classes, to preserve savings in the case when the familiar reconstruction takes longer than expected; or must she keep on spending these expenses for some time, being confident in the probability of a recruitment in the short term? This kind of modelling corresponds mathematically to decisions to be taken under uncertainty, in a multistage context, with probabilistic constraints, whose solution is at the border of actual knowledge.
FGV and PSR have qualified professors and engineers to solve these technical challenges, since one of the research areas at FGV is stochastic and robust optimization and PSR developed advanced methodologies for the management of the electric system which are now applied in more than 60 countries in all continents, including by ONS.

The institutional challenge is as or even more complex than the technical one. The first barrier is the legislation ambiguity which determines that ANA and ONS will agree and solve together the problem of multiple use of water. The problem is that, with the exception of human supply, there is no mechanism to solve disagreements between these agencies.

A second barrier is the asymmetry between the technical abilities of ANA and ONS teams, the first one being less trained than the second.

The third barrier is the relative institutional weakness of the committees in charge of basin management compared to ONS and the Ministry of Mines and Energy. As a consequence of this asymmetry, the energetic sector in recent years, decided without the participation of the boards, for example, to impose reductions in minimum flow targets, as is the case of Sobradinho in 2012; 2013; and now in 2014. Obviously this pressure of ONS and MME has an important reason, which is the security of energy supply; however, this "authoritative" behavior of the electricity sector has caused resentment and prevented the adoption of structural solutions that benefit everyone. A concrete example of this type of structural solution is precisely the minimum flow in Sobradinho, which is 1 300 $m^3/s$. PSR analyzed the technical documentation of ANA and IBAMA which resulted in this value (which basically is due to a combination of supply, navigation, and prevent the entrance of sea water (salty) during tide) and showed that with a set of operational measures and very low investment (of the order of thousands of dollars, against potential losses in the hundreds of millions) this minimum flow could be permanently reduced to 800 $m^3/s$, without any damage to the multiple uses of water and obvious benefits for the electricity sector. However, the reaction of the watershed committee to this proposal was negative, claiming, during the first energetic crisis, that this new limit would be violated by the electric sector. In other words, the authoritative behavior of the electric sector (again, for important reasons) created a profound crisis of confidence that prevents the implantation of solutions "win-win". From the technical side, FGV and PSR have unique qualifications to contribute to this issue by combining the training and experience of FGV on institutional questions and the experience of PSR in the energy sector. Indeed, PSR contributed actively to the management of rationing, proposed models for the electric sector, advised the government, the presidency of the republic, was part of the team that drafted solutions to supply water to São Paulo, and frequently does consulting for IBAMA, ANA, and ONS.

3. Products

The main products of this work are solution methods to tackle the optimization problem at hand, a software implementing the methodology and a position paper analyzing the institutional and technical issues, and proposing detailed solutions covering the regulatory, institutional and legal issues. On the technical side, the
proposed solutions will be illustrated through detailed simulations of system operation using both the software that ONS applies in the actual operation of the system (whose methodology was developed by PSR) as well as new software modules that will be developed during this research. The methodology and software that will be developed will allow us to represent the relative importance of each use as well as the need for preventive decisions (somewhat reduce water usage months in advance to ensure, with high probability, that there will be no more severe disruptions). This problem can be represented by a model of multistage stochastic optimization and probabilistic constraints. This work will result in articles on the theory, solution methods, case studies, and workshops and seminars with agents of the electricity sector and water resources for presenting the results.

4. Added value

- Impact of the model on company management; impact on public policy. The potential economy of an integrated management of water resources is substantial. For instance, the financial losses due to the interruption of Tietê waterway was estimated to 200 millions of reais. On top of that, the low reservoir levels in 2014 resulted in an intensive use of thermal plants, summing as much as 30 billions of reais.
- Impacts on the image. The problem of integrated management of energy and water resources has received a high attention in the media recently. FGV is in a privileged position to contribute to the solution of this problem for possessing specialists both on the mathematical aspects and on public policies.

5. Members

- Vincent Guigues (FGV),
- Moacyr Alvim Horta Barbosa da Silva (FGV),
- Alexandre Esvukoff (FGV),
- Paulo Cezar Pinto Carvalho (FGV),
- Yunier Bello Cruz (UFG).