Optimal management policies for the economic optimal dispatch of a hydrothermal power grid

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Introduction

This work focuses on the economic optimization of the short-term (three day time horizon) hydrothermal dispatch problem, while analyzing different scenarios regarding the rivers inflow (increasing/decreasing) and the water usage policy at the reservoirs (using versus storing). Here, five different circumstances are considered for the variation of the river flow rate during the second day: constant steady flow, 1% and 2% per hour increases, and 1% and 2% per hour decreases. Meanwhile, every possible alternative is analyzed when it is decided to store or use the water available at every location.

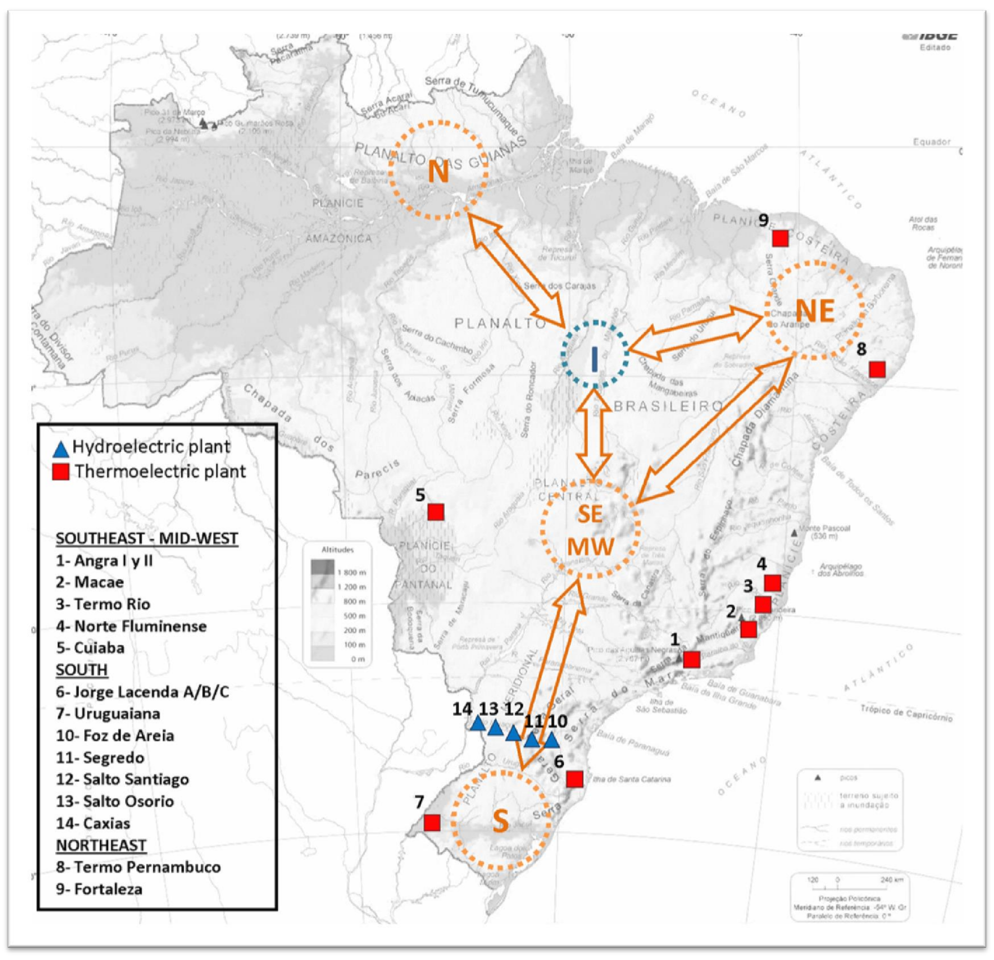
Conclusions

An optimization model for the economic dispatch of a hydrothermal network, including the generation, transport and demand stages, is here proposed and solver by means of software GAMS.

In every case study, the minimum operating cost for the whole system is achieved as more hydric energy is delivered and a lower number of thermal plants are dispatched. Therefore, the comprehensive analysis of the behavior of the system here presented could become a key tool for decision makers, since policies implemented in the day-to-day operation will also impact the future sustainability of the system.

Optimization Model

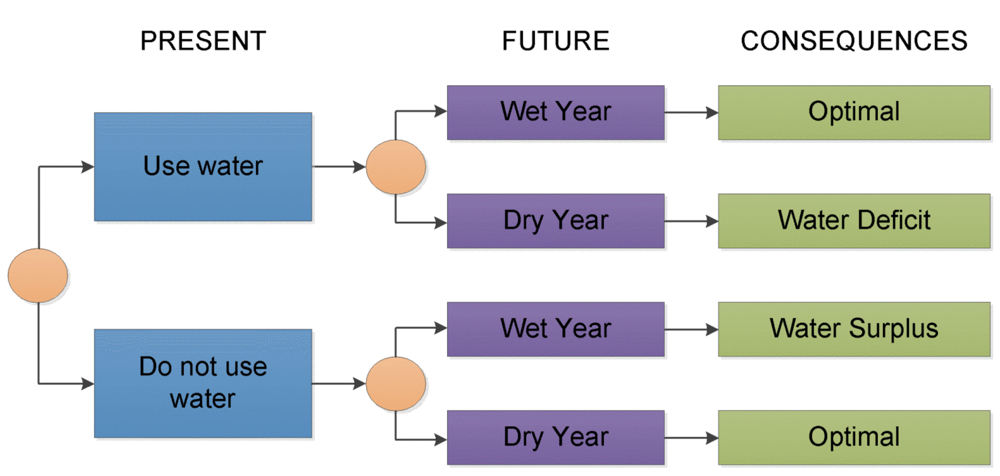
The proposed model for the power grid includes the demand profile at each node and transport capacity between them, the design and operating characteristics of the hydric and thermal power plants, as well as the economic evaluation of each mayor part of the system.

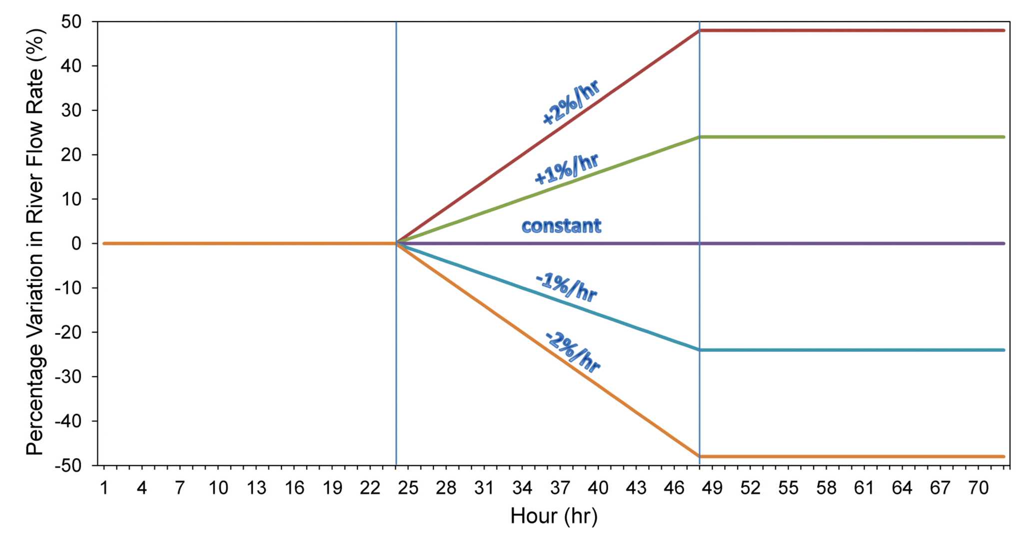


The resultant set of equations constitutes a mixed integer non-linear programming (MINLP) model, with 17000 equality and inequality constraints and 13000 variables of which 1300 are integer ones, and is implemented in the optimization software GAMS.

$$\min f = \min C_{opt}$$
$$h(x,y) = 0$$
$$g(x,y) \leq 0$$
$$x \in \mathcal{R}^n \,, y \in \{0,1\}^m$$

Case Studies



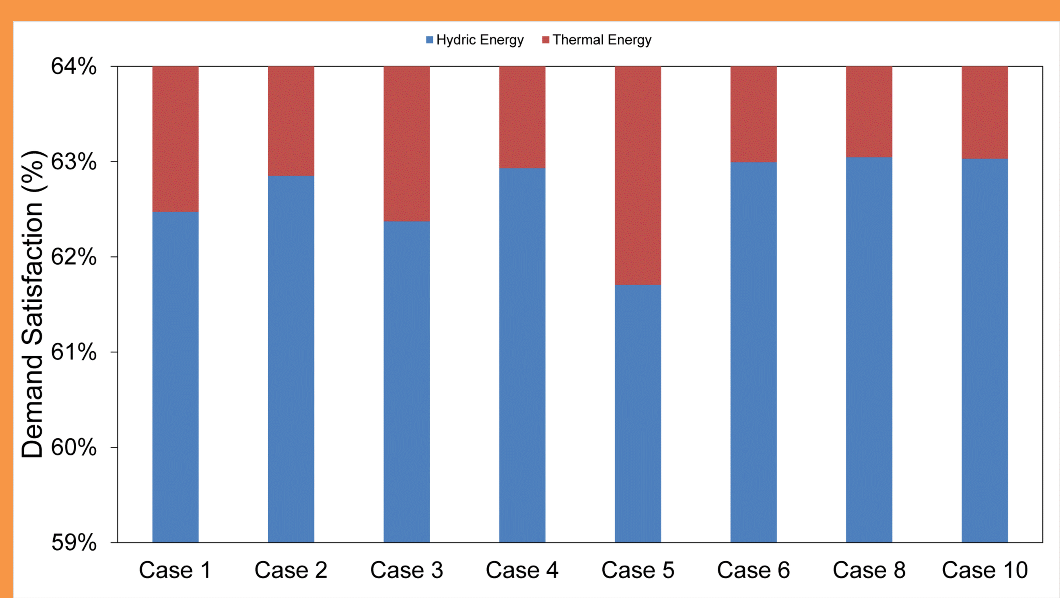


Definition of Case Studies

		Reservoir Management Policy	
		Water is Stored	Water is Released
Variation in River Flow Rate During Day 2	Increases 2%/hr	Case 1	Case 2
	Increases 1%/hr	Case 3	Case 4
	Remains Constant	Case 5	Case 6
	Decreases 1%/hr	Case 7	Case 8
	Decreases 2%/hr	Case 9	Case 10

Optimal Management Policies

The solutions here obtained represent economic optimal profiles with minimum operating costs for the hydrothermal dispatch of the power grid, and details the advised values for every practical interest variable, including the generation, transport and demand stages (effectively delivered power/energy at each plant, water volume stored/used in every dam, energy transported between nodes, among others).



Optimal Performance Indexes

	Total Cost (million U$D)	Total Thermal Energy (MWh)
Case 1	4.08	255773
Case 2	4.05	253201
Case 3	4.09	256444
Case 4	4.04	252649
Case 5	4.15	260994
Case 6	4.03	252220
Case 7	---Infeasible---	
Case 8	4.03	251855
Case 9	---Infeasible---	
Case 10	4.03	251972

It is then concluded that the operating costs, and therefore the electricity one, increases as the river flow rate decreases, as result of a lower generation capacity for the hydric generation, which needs to be fulfilled by thermal one. Moreover, a policy that allows water usage at the reservoirs derives in a larger availability of this resource, which in turn implies lower operating expenditures.

On the other hand, scenarios 7 and 9 originate infeasible conditions for the operation of the system, for example when storing water is required as the river inflow experiences a steep decrease over time. These cases represent real world situations where a well-planned water management policy needs to be defined and promptly implemented.