STRATEGIC ENVIRONMENTAL ASSESSMENT – SEA OF THE HYDROELECTRIC GENERATION PROGRAM OF MINAS GERAIS – HGPMG AS AN ENVIRONMENTAL MANAGEMENT INSTRUMENT

Article · October 2017

DOI: 10.14268/ajhwes.2017.00049

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Volume 5 • Out. 2017
ISSN 2317-126X • US$: 15.00

American Journal of Hydropower, Water and Environment Systems

Technical Papers

IAHR AIRH

Published with the support of
Hydraulic Machinery and Systems
International Association

latinamerican
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IAHR DIVISION I: HYDRAULICS
TECHNICAL COMMITTEE: HYDRAULIC MACHINERY AND SYSTEMS

Federal University of Itajubá - UNIFEI
Av. BPS, 1303 - Bairro Pinheirinho
Itajubá - MG - Brasil - CEP: 37500-903

Catalographic card prepared by Mauá Library – Librarian Margareth Ribeiro – CRB_6/1700

R454

American Journal of Hydropower, Water and Environment Systems, LAWG-IAHR, v.1, 2014 – Itajubá: LAWG-IAHR, 2015 - v.5, out. 2017.

Trimestral,
Editors Chief: Geraldo Lúcio Tiago Filho/Eduard Egusquiza
Journalist in Charge: Adriana Barbosa – MTb_MG 05984
ISSN 2317-126X

1. Hydropower. 2. Water. 3. Enviroment Systems.
II. Latin American Working Group

LAWG-IAHR Executive Secretariat
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ISSN 2317-126X

American Journal of Hydropower, Water and Environment Systems

Editorial

We now come to the AJHPWS´s fifth edition.

This publication is one of the actions undertaken by the Latin American Working Group of IAHR´s Hydraulic Machines and Systems Committee.

The fight in searching new papers and prestige from scientific community is incessant. An effective contribution for sustainable development is one of our purposes.

All our researches have the potential to promote scientific knowledge and to support new policies aiming the development of new technologies from the technical, social and economic point of view, in addition to subsidize sustainable development and the quest for a better future.

Thus, dissemination of knowledge, methodologies and procedures of physical phenomena scientific modeling and solutions to reach technological development is one of the groups´ goals and consequently, of this journal.

In this case, this journal gradually becomes an eclectic vehicle within the limits of water resources and environment, if there are, and in addition it is interesting for the academy, considering that most part of papers come from research groups of several universities and research centers distributed in Brazil and Latin America.

This edition addresses several subjects such as: the project and building of a small hydropower plant aiming to become a learning tool for teaching and training of engineering students; suitability of an existing reservoir to operate as a mini hydropower plant, according to regulatory environment of not centralized micro generation in Brazil; comparative studies of methodologies for hydraulics transient calculation and finally, studies addressing management issues of water resources.

We do hope to contribute in any way in this direction. We look forward you to appreciate reading of selected papers for this edition of AJHWES.

Yours faithfully,
Geraldo Lucio Tiago Filho
Editor in Chief

Regina Mambeli Barros
Technical Editor
American Journal of Hydropower, Water and Environment Systems

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A publication of Latin American Working Group of the International Association for Hydro-Environment Engineering and Research-IAHR

All papers must be submitted in English. In case the author wants to translate the article through the journal all costs for the translation will be charged on the account of the author.

1. Formatting articles

1.1. Article structure

1.1.1 Subdivision - numbered sections

Divide your article into clearly defined and numbered sections. Subsections should be numbered 1.1 (then 1.1.1, 1.1.2, ...), 1.2, etc. (the abstract is not included in section numbering). Use this numbering also for internal cross-referencing: do not just refer to 'the text'. Any subsection may be given a brief heading. Each heading should appear on its own separate line.

1.1.2 Format

All text of the manuscript must be located within a 170 mm by 252 mm rectangle of a white A4 page or within 170 mm by 240 mm for the letter format. The margins are given in Table 1. An example of the page format is given in Fig. 1

[Table 1]: ***Page margin for manuscripts.***

Margin Position	Top	Bottom	Left	Right
Margin size (cm)	2.0	2.5	2.0	2.0

All text should be single spaced, black and in 12-point type. "Times News Roman" or a similar proportional font should be used. Total length 15 pages in Word.

The terminology given in the *IEC Technical Report for the Nomenclature of Hydraulic Machinery* is recommended.

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State the objectives of the work and provide an adequate background, avoiding a detailed literature survey or a summary of the results.

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Provide sufficient details to allow the work to be reproduced. Methods already published should be indicated by a reference: only relevant modifications should be described.

Theory/calculation

A Theory section should extend, not repeat, the background to the article already dealt with in the Introduction and lay the foundation for further work. In contrast, a Calculation section represents a practical development from a theoretical basis.

Results

Results should be clear and concise.

Discussion

This should explore the significance of the results of the work, not repeat them. A combined Results and Discussion section is often appropriate. Avoid extensive citations and discussion of published literature.

Conclusions

The main conclusions of the study may be presented in a short Conclusions section, which may stand alone or form a subsection of a Discussion or Results and Discussion section.

References

Within the text, references should be cited in numerical order according to their order of appearance. The numbered reference citation within text should be enclosed in brackets.

After the second edition all papers must have at least one reference of the American Journal of Hydropower, Water and Environment Systems.

Example: It was shown by Prusa [1] that the width of the plume decreases under these conditions.

In the case of two citations, the numbers should be separated by a comma [1,2]. In the case of more than two references, the numbers should be separated by a dash [5-7].

List of References. References to original sources for cited material should be listed together at the end of the paper; footnotes should not be used for this purpose. References should be arranged in numerical order according to the sequence of citations within the text. Each reference should include the last name of each author followed by his initials.

(1) Reference to journal articles and papers in serial publications should include:

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- full title of the cited article in quotes, title capitalization
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- full title of the publication
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- city of publication
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- last name of each author followed by their initials
- year of publication
- full title in quotes, title capitalization
- report number (if any)
- publisher or institution name, city

Sample References

[1] Ning, X., and Lovell, M. R., 2002, "On the Sliding Friction Characteristics of Unidirectional Continuous FRP Composites," ASME J. Tribol., 124(1), pp. 5-13.

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[8] Kwon, O. K., and Pletcher, R. H., 1981, "Prediction of the Incompressible Flow Over A Rearward-Facing Step," Technical Report No. HTL-26, CFD-4, Iowa State Univ., Ames, IA.

[9] Smith, R., 2002, "Conformal Lubricated Contact of Cylindrical Surfaces Involved in a Non-Steady Motion," Ph.D. thesis, http://www.cas.phys.unm.edu/rsmith/homepage.html

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Abstract

A concise and factual abstract is required. The abstract should state briefly the purpose of the research, the principal results and major conclusions. An abstract is often presented separately from the article, so it must be able to stand alone. For this reason, References should be avoided, but if essential, then cite the author(s) and year(s). Also, non-standard or uncommon abbreviations should be avoided, but if essential they must be defined at their first mention in the abstract itself.

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Acknowledgements

Collate acknowledgements in a separate section at the end of the article before the references and do not, therefore, include them on the title page, as a footnote to the title or otherwise. List here those individuals who provided help during the research (e.g., providing language help, writing assistance or proof reading the article, etc.).

Nomenclature and units

Follow internationally accepted rules and conventions: use the international system of units (SI). If other quantities are mentioned, give their equivalent in SI.

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Present simple formulae in the line of normal text where possible and use the solidus (/) instead of a horizontal line for small fractional terms, e.g., X/Y. In principle, variables are to be presented in italics. Powers of e are often more conveniently denoted by exp. Number consecutively any equations that have to be displayed separately from the text (if referred to explicitly in the text).

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American Journal of Hydropower, Water and Environment Systems

Number 5 **Out 2017**

Technical Papers

American Journal of Hydropower, Water and Environment Systems
Publisher: Acta Editora/LAWG-IAHR
DOI:10.14268/ajhwes.2017.00049
ISSN: 2317-126X
Subject Collection: Engineering,
Subject: engineering, measurement, environment Systems

STRATEGIC ENVIRONMENTAL ASSESSMENT – SEA OF THE HYDROELECTRIC GENERATION PROGRAM OF MINAS GERAIS – HGPMG AS AN ENVIRONMENTAL MANAGEMENT INSTRUMENT

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ABSTRACT

The Strategic Environmental Assessment – SEA, as an environmental management instrument, refers to the consequences of the policies, plans and programs (PPPs), usually within the scope of governmental initiatives, despite the fact that it can also be used in private organizations. It also allows the compatibility analyse of the PPP that is being studied comparing with others governmental PPPs (horizontal articulation). The SEA of the Minas Gerais Hydroelectric Generation Program (MGHGP) was organized in three big steps that were divided in six consecutives blocks of analysis, each one with a set of interdependent activities to be accomplished and the product to be generated. The study was entirely based in secondary data, thus, the results were associated to the availability and spatiality of the acquired information. The entire work was done considering the 175 hydroelectric plants (operation, concession and under construction), the 380 plants envisaged by the Minas Gerais Hydroelectric Generation Program (MGHGP), eight hydrographic basins from the territory of Minas Gerais, and 34 Water Resources Planning and Management – WRPMs. This article aims to discuss the obtained results and evaluate possible projections. it was evidenced the need to obtain the greatest possible expansion of the hydroelectric generating park in a sustainable way, what implies in the solution of equations that did not exist in the past, requiring the diversification of the Minas Gerais electrical matrix, the use of new technologies, the improvement of energy efficiency, as well as a holistic vision and technical capacity of the entities involved.

KEYWORDS: Knowledge network, environment, energetic planning.

1. INTRODUCTION

The strategic environmental assessment – SEA refers to the evaluation of the environmental consequences of policies, plans and programs (PPPs), generally within the scope of governmental initiatives, although it can also be applied in private organizations. It is a previous evaluation, which is equivalent, in a certain way, to the ones that areimplemented to projects, works or similar activities.

Nevertheless, the great SEA potential is in influencing the formulation of these PPPs by itself, as well as one of the main roles of the project's environmental impact assessment is to formulate project alternatives that avoid or reduce adverse impacts or to make it possible to obtain better environmental gains. The SEA has been established as a planning tool due to two factors:

- The adverse socio-environmental impacts of PPPs and;
- The inherent limitations of projects' environmental impacts assessment.

One of the reasons that have led to the international spread of the SEA is because it is flexible, which allows adapting it to distinct decision-making models. It has been already stated that there is not only one SEA model [1], that the SEA represents "a concept under multiple ways" [2], and that the SEA has the great advantage of being able to be adapted to nearly all ways and modalities of planning in different decision contexts [1], instead of forcing the changing of a decision-making model, as it has happened with the Environmental Impact Assessments – EIA of projects.

Regardless the chosen SEA approach, it is necessary to recognize that there is substantial differences between a SEA and the project impacts assessment. Acoording to Woods [3], in one of the first studies about PPPs' impact assessment, points to four major differences between the projects impacts assessment and the strategic assessment:

- Spatial delimitation precision: whereas the projects have a well established location, PPPs, excepting the land planning use, have less clear spatial delimitations;
- Detailing of actions: It is much superior in projects and it can be very indefinite in the case of policies;
- The time scale: the implementation period of a project is relatively short, whereas the duration of a policy or a plan can be very extended;
- The decision-making process and the involved institutions: while for projects there is a clear distinction between its proponent and the competent authority in approving it, PPPs are usually formulated and sanctioned by the same entity

The SEA would also enable the compatibility analysis of the PPP in question with other governmental PPPs (horizontal articulation). However, there is various practical difficulties, the following are highlighted:

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[2]Energy engineer and master in Electrical Engineer at Pontifícia Universidade Católica de Minas Gerais. Researcher at State Foundation of the Environment (Fundação Estadual do Meio Ambiente – FEAM). Lattes resume: http://lattes.cnpq.br/6661724494856451
[3]Physics (Bachelor) at UFMG, MSc Technical Sciences Nucleares at UFMG, PhD in Nuclear Safety and Industrial at University Pisa, Itália. PhD Department of Nuclear Engineering at UFMG. Adjunt Professor and Researcher at the Department of Nuclear Engineering UFMG. Lattes resume: http://lattes.cnpq.br/0382135664206404.
[4]Irene is currently the Director of Quality Management and Environmental Monitoring for the State Foundation for the Environment in Minas Gerais (FEAM). Irene's commitment to achieving high standards during her academic pursuits which included receiving the "très honorable" citation for her doctoral thesis in Chemical Analysis from the French Government is translated to those that she now leads at FEAM. Lattes resume: http://lattes.cnpq.br/6182533671673990
[5]Environmental Engineering student at Centro Universitário Newton Paiva. Intern at State Foundation of the Environment (Fundação Estadual do Meio Ambiente – FEAM). Lattes resume: http://lattes.cnpq.br/9519876602254143
[6]Energy Engineering student at PUC Minas. Intern at State Foundation of the Environment (FEAM).

- Sectoral planning and programs rarely are formulated in a clear way and without internal contradictions; and
- The already existing plans (which will supposedly be considered in the SEA) can be already incompatible among themselves.

Nevertheless, it is observed that there is an increasing interest in implementing the articulation between the SEA and other instruments applied in other decision-making levels and contexts, usually boosted by the expectancy that the previous implementation of a SEA can facilitate the approval and the licensing of projects. The possible advantages of the articulation are listed below:

- It allow the selection of potentially viable projects for posterior individual assessment;
- It foster the discussing and the "settlement" of strategic matters relative to the justification and the location of projects;
- It help the analysis of cumulative impacts (due to various similar projects or to different projects in the same region);
- It allow the implementation of the EIA of projects for local matters and to individual mitigations actions;
- It facilitate the approval of projects that are originated by PPPs or associated with them;

According to the Brazilian Ministry of the Environment [4], among the benefits that can be a result from the deployment of the SEA, some of the more important are:

- Comprehensive view of the environmental implications of the implementation of the governmental policies, plans and programs, whether they are relevant to the sectoral development or restricted to a specific region;
- The assurance that the environmental subjects will be properly handled;
- Facilitation of the connection of well structured environmental actions;
- Process of development of policies and environmentally sustainable and integrated planning;
- Anticipation of the probable impacts of necessary actions and projects to the implementation of policies, plans and programs that are being assessed;
- Better context to the assessment of cumulative environmental impacts that are potentially generated by the projects under discussion.

The contribution to a sustainability processes, the generation of a decision-making context that is wider and integrated with the environmental protection and the best capacity of assessment of cumulative impacts constitute the SEA most remarkable benefits, in its potential as an environmental policy instrument. In addition, the SEA has the benefit of facilitating the process of individual assessment of the implemented projects that are a result of the plans and programs that generated it.

The Table 1, brought up from the International Study on the Effectiveness of Environmental Assessment, systematize the SEA objectives, linking them to the mentioned benefits [5, 6].

Lastly, some basic points that can guide the implementation of the SEA in Brazil are:

- The SEA is a process and not a document or a report (despite the fact that the process has to be documented, usually as a report);
- The SEA is oriented to the (strategic) decision making process and it has to influence it;
- The SEA have to discuss the strategic options while they are still in course, so that it can influence the decisions;

[Table 1]: ***Objectives and benefits of SEA[5, 6].***

Support the process of sustainable development promotion	Enhance and facilitate the environmental impact assessment of projects
• Decision that integrate environmental and development aspects • Formulation of environmentally sustainable policies and plans • Consideration of options and environmental alternatives that are better and more practicable	• The earliest possible identification of potential impacts of governmental policies, plans and programs, and also of cumulative environmental effects of actions and projects that are necessary to its implementation • Consideration of strategic matters related to the justification of the necessity and also to the proposals of future projects' location • Reduction of the necessary time and resources to the assessment of individual projects' environmental impact

2. SEA - METHODOLOGICAL PROCEDURES

According to MMA [4] the technical procedures of the SEA involve a sequence of eight basic operational steps:

- **1° – Selection of strategic strategy proposals (Screening)**. This stage consists in the definition of applying to the SEA a certain PPP under analysis, this way avoiding delays in the processes of decision-making. An institutional intervention matrix and a preliminary assessment of the impacts resulting from the PPP should be defined, considering the likely direct, indirect and cumulative impacts and their synergies;
- **2° - Establishment of the timing (Timing)**. It is a question of verifying the PPP-type formulation schedules, in isolation and in conjunction with other stages of the SEA process, identifying cases of temporal incidence that may lead to problems and their adjustment measures;
- **3° – Definition of the content of the evaluation (Scoping).** In this step, the purposes of the SEA will be established. The identification of the objectives, target audience, indicators and stakeholders. Survey of information and characterization of relevant environmental issues;
- **4° – Evaluation of strategic impacts.** Prediction of environmental impacts resulting from the implementation of the APP. Identification of the changes that will possibly occur and decide if they are acceptable or not, providing subsidies for selection of the best alternative within the context of sustainability. Definition of monitoring actions of environmental quality and of the entities that are responsible for these activities and associated costs;
- **5° – Documentation and information.** This step consists of presenting the results of the previous ones and of the studies and technical analyzes of the SEA, in the form of a detailed document, in order to give a support for decision makers and to give subsidy for the preparation of the final formulation and decision documents regarding PPP;
- **6ª – Review.** This stage aims to control the quality of the process and the technical activities;
- **7ª – Decision making.** The final decision on the implementation of PPP can be taken with security and reliability;

- **8ª – Monitoring the implementation of the strategic decision.** This stage deals with the accomplishment of the actions of monitoring of the environmental quality predicted in the stage of analysis of the impacts.

According to Gonçalves [8], the SEA must to be adjusted to the different decision contexts, the different scales and evaluation objectives, and, therefore, being flexible in each case, in order to increase the chances of success in the implementation of the SEA.

3. HYDROELECTRIC GENERATION PROGRAM OF MINAS GERAIS STATE – HGPMG

The SEA, instrument of the Minas Gerais Hydroelectric Generation Program (HGPMG), held in 2007 by the Government of Minas Gerais for an energy scenario 2007 – 2027, aims to establish the conceptual and operational bases for decision making within the scope of the planning process of the Minas Gerais electric sector with respect to its purposes, strategic vision, projects and actions with the perspective of promoting the development of hydroelectric generation in an environmentally sustainable way.

The State Government, through the MGHGP, aims to generate equivalent energy to meet the state's energy demand from its own generating plant, in addition to expanding it to generate exportable surpluses. The SEA, used as a important planning tool will contribute to:

- Insert the environmental variable in the process of decision of organs and entities of the state government in which refers to investments in energy generation hydroelectric power plant;
- Evaluate the environmental and economic aspects of the of enterprises that make up the PGHMG 2007-2027, in order to aggregate a global analysis of its impacts positive and negative, as an antecedent to the process of environmental licensing of each enterprise;
- To obtain the balance of economic, social and environmental impacts of business clusters hydroelectric plants;
- Identify relevant projects that may have significant cumulative, in a given area, synergistic or even conflicting with the availability and uses of water or development.

The work was organized in 03 major phases, subdivided into 06 consecutive analysis blocks, each with a set of interdependent activities to be performed and product to be generated. In Block 01, the Initial Working Milestone is elaborated, based on the Term of Reference, with the purpose of guiding the evolution of the SEA of the MGHGP. In block 02, the characterizations and analyzes carried out had the objective of establishing the structure on which the development of the later stages, in their various themes, scopes, procedures and objectives would be carried out, guiding the directions to be followed, in order to guarantee the best results of the efforts. In this sense, all factors considered in the analyzes were characterized, in the scope of application of the SEA instrument to the MGHGP.

The Environmental Diagnosis (Block 03) comprised a critical analysis of the information identified in the socio-environmental characterization and, in this sense, is effectively a diagnosis, allowing to evolve with the dirigisme requirement. The study was based entirely on secondary data, and, therefore, results associated with the availability and spatiality of the information obtained. Throughout the Block 4 each one of the identified socio-environmental impacts were analyzed in theoretical approach, and it was also identified the degree of relative significance of each one of the impacts relative to all 380 hydroelectric uses planned by the MGHGP.

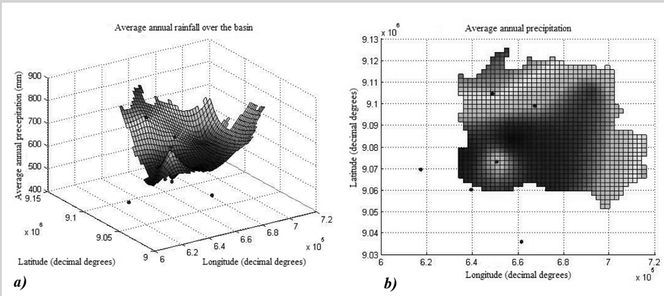
In Blocks 5 and 6, the analyze and forms of presentation of the Scenarios and the results of the EI, SEBI and EBI were consolidated. Among the eight Hydrographic Basins and respective WRPMs as presented in Table 2:

***[Table 2]:* Hydrographic Basins/WRPMs [8].**

HYDROGRAPHIC BASINS	WRPMs
São Francisco River basin	SF1 – HBC Rivers of Minas Gerais tributary to the Upper San Francisco
	SF2 – HBC of Pará river
	SF3 – HBC of Paraopeba river
	SF4 – HBC of the surroundings of the Três Marias Dam
	SF5 – HBC of das Velhas' river
	SF6 – HBC of Jequitaí and Pacuí rivers
	SF7 – HBC of the Minas Gerais' sub-basin of Paracatu river
	SF8 – HBC of Urucuia river
	SF9 – HBC of Pandeiros and Calindó rivers
	SF10 – HBC Minas Gerais' tributary of the Verde Grande river
Jequitinhonha River basin	JQ1 – HBC of the Upper Jequitinhonha river Tributaries
	JQ2 – HBC of Araçuaí river
	JQ3 – HBC of the Middle and Lower Jequitinhonha river Tributaries
Mucuri River basin	MU1 – HBC of Mucuri river
Doce River basin	DO1 – HBC of Piranga river
	DO2 – HBC of Piracicaba river
	DO3 – HBC Santo Antônio river
	DO4 – HBC of Upper Suaçuí river
	DO5 – HBC of Caratinga river
	DO6 – HBC Waters of Manhuaçu river
Paraíba do Sul River basin	PS1 – HBC of Minas Gerais' tributaries of Preto and Paraibuna rivers
Piracicaba/Jaguari River basin	PJ1 – HBC of Piracicaba/Jaguari rivers
Grande River basin	GD1 – HBC of High Grande river
	GD3 – HBC of the surroundings of Furnas dam
	GD4 – HBC of Verde river
	GD5 – HBC of Sapucaí river CBH
	GD6 – HBC of Minas Gerais' tributaries of Mogi-Guaçu/Pardo rivers
	GD7 – HBC of Minas Gerais tributaries of Middle Grande river
	GD8 – HBC Minas Gerais tributaries of Lower Grande river
Parnaíba River basin	PN1 – HBC of Dourados river
	PN3 – HBC Minas Gerais' tributaries of Lower Paranaíba river

Source: SEA of the MGHGP, 2007.

Figure 1 shows the existing hydroelectric plants and the 380 foreseen by the Minas Gerais Hydroelectric Generation Program (HGPMG), the territorial limits of the river basins (represented by the colors) and the WRPMs, identified by the abbreviations: SF1 to SF10, JQ1 to JQ3, MU1, DO1 to DO6, PS1 and PS2, PJ, GD1 to GD8 and DO6, PS1 and PS2, PJ, GD1 to GD8 and PN1 to PN3.



*[**Figure 4:** Hydrographic Basins, WRPMs and already existing and expected by the MGHGP [1].]*

Source: SEA of the MGHGP, 2007

4. DIAGNOSTICS AND IMPACTS

Diagnosis and environmental impacts (positive and negative) were synthesized in the form of 14 thematic panels that synthesize and interrelate impact indicators with those of diagnosis, by components that are synthesis of the following topics: water resources and aquatic ecosystems, physical environment and terrestrial ecosystems and socioeconomics. Each of the thematic panels presents the justification of the impact, methodological procedures used to read the diagnosis of hydroelectric power plant (HPP) insertion and impact, as well as the result of the impact by the HPP provided by the MGHGP and by the hydrographic basin / WRPM. Thematic panels are analyzed and presented by hydroelectric use, generating three indexes that structure this work of Strategic Environmental Assessment (SEA): Index of Environmental Impact (EI), Socioeconomic Benefits (SEBI) and of Energy Benefit (EBI). Through these indexes, each enterprise can be evaluated individually, receiving certain scores, which allow the elaboration of graphs.

For the indicators EI and SEBI, five classes or intervals of variation were established, making cuts with the purpose of maximizing the interclass standard deviation and minimizing the intraclass standard deviation, according to Tables 3 to 7:

- Very High - VH;
- High - H;
- Medium - M;
- Low - L;
- Very Low - VL or NS.

For the energy benefit or installed power, four intervals, or classes, were arbitrarily created, two of which are pertinent to the Small Hydroelectric Plants - SHPs and other two to the Hydroelectric Power Plants- HPPs.

[Table 3]: Thematic panel – Energy Generation [8].

Thematic Panel		Impact	Duration	Indicators					Observation
				VH	H	M	L	VL	Indicator Definition
Energy Generation	Increase in Energy Availability	Positive	Permanent	-	3	2	1	-	Comparatives of the resultant indexes of the adverse impacts and the socioeconomic benefits

Source: SEA of the MGHGP, 2007.

[Table 4]: Thematic panel – Energy Generation [8].

Thematic Panel		Impact	Duration	Indicators					Observation
				VH	H	M	L	VL	Indicator Definition
Water Resources	Hydraulic Dynamics Alteration	Negative	Permanent	>6	4 to 6	2 to 4	1 to 2	<1	Represents the interference related to the hydraulic dynamics alteration
	Intensification of Conflicts about Water Uses	Negative	Permanent	>1	0.5 to 1.0	10 to 50 days	<10 days	0	Indicates the current competition scenario for the usage of the superficial water resource
	Flow regulation	Positive	Permanent	>100 days	50 to 100 days	10 to 50 days	<10 days	0	It may not represent correctly all the approached cases and situations
	Alteration of water quality and aquatic ecosystems	Negative	Permanent	VH	H		L	NS	Variables confrontation: reservoir size x WQI/ Water quality impairment degree
	Depreciation of native ichthyofauna	Negative	Permanent	1≥40.7	29.3≤1<40.7	1<29.3	-	-	Qualitative evaluation associated to weighted weights

Source: SEA of the MGHGP, 2007.

[Table 5]: Thematic panel – Energy Generation [8].

Thematic Panel		Impact	Duration	Indicators					Observation
				VH	H	M	L	VL	Indicator Definition
Physical EnvironmentResources	Intensification of Erosive Processes and Sedimentation	Negative	Permanent	VH	H	M	L	VL	Index crossing (1 to 3) in the degree of susceptibility to erosion and sedimentation, with lithological units
	Loss of Mineral Potential (Mineral Rights)	Negative	Permanent	VH	H	M	L	VL	Data crossing between the reservoir size and the existence of mineral rights in the reservoir area and its surroundings

Source: SEA of the MGHGP, 2007.

[Table 6]: Thematic panel – Terrestrial ecosystems [8].

Thematic Panel		Impact	Duration	Indicators					Observation
				VH	H	M	L	VL	Indicator Definition
Terrestrial EcosystemsResources	Interference / Pressure over the terrestrial habitats and areas of conservationist interests that are legally protected	Negative	Permanent	VH	H	M	L	VL	Data crossing of reservoir size with the synthesis of the ambience reading
	Erosive and sedimentation processes intensification	Negative	Permanent	VH	H	M	L	VL	Index crossing (1 to 3) in the degree of susceptibility to erosion and sedimentation, with lithological units

Source: SEA of the MGHGP, 2007.

[Table 7]: Thematic panel – Socioeconomics [1].

Thematic Panel		Impact	Duration	Indicators					Observation
				VH	H	M	L	VL	Indicator Definition
Socioeconomics	Fiscal Added Value Expansion	-	-	2,053% - 355%	353% - 126%	124% - 30%	27% - 5%	<5%	Percentage value with reference to the fiscal added value
	Municipal Collection Increase due to the Financial Compensation			35% - 16%	15% - 10%	9% - 5%	4% - 1%	No data	Percentage Amount in Reference to the Total Revenue
	Urbanized Areas Interference	Negative	Permanent	VH	H	M	L	VL	Data crossing of the reservoir size with the distance of the urban core with regard to the dam (surroundings)
	Interference Over the Ways of Reproduction of Traditional Populations' Social Life and Over the Familiar Agriculture	Negative	Permanent	VH	H	M	L	VL	Data crossing of the reservoir size with the highest sensibility between reservoir counties (Interference probability over the traditional population and familiar agriculture)
	Interference over Archaeological Sites	Negative	Permanent	9 to 10	7 to 8	4 to 6	1 to 3	-	Data crossing of the reservoir size and the archaeological sites potential (obtained through the crossing of the native vegetation presence index with the potential of natural cavities)

Source: SEA of the MGHGP, 2007.

5. RESULTS AND DISCUSSIONS

5.1 – Sc enarios comparison of MGHGP's SEA

This study presents a set of information to be analyzed in order to construct different scenarios for each basin, considering all of the MGHGP enterprises. The acquired data indicate an expansion potential for the electrical generation in the state of Minas Gerais, through the assessment of the existing installed capacity, measured by MW for each Hydroelectric Power Station – HPS in operation, under construction or already granted. The scenarios elaborated in this study allow the assessment of the perspectives of the hydroelectric energy generation increase, along with other possible projections of the electrical energy increasing prospects. The Expansion Scenario of the Generation Park 1 considers that all of the potential enterprises of the State will be implemented, which characterizes it as a scenario with just a few social-environmental restrictions, or a none-restriction scenario. It is also a reference to the limits of the maximum expansion of hydroelectric generation parks. This reference is important in the search for the balance between the supply and demand of electrical energy of the state, and it aims the possibility of energy exporting to other parts of the country. This scenario presents an electrical generation of around 40.4 TWh per year, as represented in Table 8.

[Table 8]: Energy Characterization in Scenario I [8]

GENERATION PARK 1 EXPANSION SCENARIO				
Hydrographic Basins	N° of HPP	Power (MW)	Percentage in the Total Installed Power	Generated Energy (MWh)/year
São Francisco River	101	2925	38%	15.374.010
Jequitinhonha River	16	1051	14%	5.521.954
Mucuri River	1	23	0%	118.260
***Doce River**	114	2171	28%	11.410.434
Paraíba do Sul River	53	465	6%	2.445.144
Piracicaba e Jaguari Rivers	12	39	1%	202.882
Grande River	47	522	7%	2.742.392
Paranaíba River	36	496	6%	2.609.184
Total	**380**	**7691**	**100%**	**40.424.259**

** This study of SEA was performed before the environmental accident in the river Doce basin, which prevents this study, for lack of information to make a new evaluation.*

Source: SEA of the MGHGP, 2007

The Expansion Scenario of the Generation Park 2 opposes the first one, since the society from Minas Gerais imposes a certain degree of restriction to the implementation of this group of projects that is part of the electricity generation potential presented in Scenario 1. This is done through the work of the agencies responsible for the implementation of environmental licensing, therefore, reducing the Scenario 1 generation expansion. The enterprises that present a "Potential Environmental Restriction" were selected, and subsequently excluded from the expansion of the generation park. This potential was represented by the selection of projects that present an extremely high significance indicator of two environmental impacts related to biodiversity conservation (ichthyofauna and terrestrial habitats) and two other impacts related to socioeconomic interference (urban areas and traditional populations/ family farming). These impacts were selected because they had less control/mitigation possibilities. This scenario presents a generation energy in the order of 20.7 TWh per year, as presented in Table 9.

[Table 9]: Energy Characterization in Scenario II

GENERAGION PARK 2 CHARACTERIZATION SCENARIO				
Hydrographic Basin	N° of HPP	Power (MW)	Percentage in the Total Installed Power	Generated Energy (MWh)/year
São Francisco River	81	1.366	35%	7.180.957
Jequitinhonha River	9	331	8%	1.737.634
Mucuri River	1	23	1%	118.260
Doce River	84	1.186	30%	6.232.223
Paraíba do Sul River	50	414	11%	2.176.037
Piracicaba e Jaguari Rivers	9	33	1%	174.499
Grande River	45	449	11%	2.360.806
Paranaíba River	20	132	3%	693.897
Total	299	3.933	100%	**2.0674.313**

Source: SEA of the MGHGP, 2007.

To allow the analysis of accumulation by the hydrographic basin, it was constructed variables by the sum of the individual values of Power, Generated Energy, EI, SEBI and the number of enterprises. These variables working together provide the measuring of intensity of intervention by hydrographic basin or WRPM, this way allowing the comparison on the cumulativeness of the same geographic space. The other variable are of relative character, such as, the Average Power by HPS, the Generated Energy by flooded area, the Average Power by EI and the Average Power by SEBI point. The EI, SEBI and EBI results demonstrate the performance of each enterprise related to these indexes, providing a wider and more diverse perspective of the hydroelectric potential of Minas Gerais.

In Table 10, it is represented the reductions between the Scenario 1 and 2. Worth stressing, that there is a decrease of 73% of the river Parnaiba basin potential capacity, 53% of the river São Francisco basin, 69% of the river Jequitinhonha basin and 45% of the river Doce basin. There is also an accentuated decrease on the flooded area, in the order of 91%, 80%, 60% and 53%, respectively, in other words, more proportional to the reduction of the installed power. In relation to the Environmental Impact Score (EI) and the Socioeconomic Benefits Index (SEBI), in the comparative table, the columns "Score EI" and "Score SEBI", for these three basins (Parnaiba, São Francisco, Jequitinhonha e Doce), evidence a sharp decline relative to the negative impact (59%, 35%, 54% and 37%, respectively), as the losses of the associated benefits (64%, 49%, 55% and 45%, respectively), considering the exclusion of the HGPMG hydroelectric projects according to the most severe socio-environmental. restrictions.

[Table 10]: Comparative Reduction of Scenarios

COMPARATIVE REDUCTION									
Hydrographic Basins	N° of HPP	Power (MW)	Average Power by HPP	Generated Energy	Flooded Area (ha)	Score EI	Average Power by EI point	Score SEBI point	Average Power by SEBI point
São Francisco River	20%	53%	42%	53%	80%	35%	28%	49%	8%
Jequitinhonha River	44%	69%	44%	69%	60%	54%	32%	55%	30%
Mucuri River	0%	0%	0%	0%	0%	0%	0%	0%	0%
Doce River	26%	45%	26%	45%	53%	37%	14%	45%	0%
Paraíba do Sul River	6%	11%	6%	11%	6%	14%	-4%	4%	7%
Piracicaba and Jaguari Rivers	25%	14%	-15%	14%	0%	37%	-36%	23%	-12%
Grande River	4%	14%	10%	14%	24%	8%	6%	6%	8%
Paranaíba River	44%	73%	52%	73%	91%	59%	36%	64%	26%
Total	**21%**	**49%**	**35%**	**49%**	**71%**	**35%**	**21%**	**42%**	**11%**

Source: SEA of the MGHGP, 2007.

5.2 Use of the scenarios of the Integrated Development Plan of Minas Gerais – IDPMG

The projection of the electric power demand of the State of Minas Gerais was based on the scenarios elaborated in the context of the IDPMG for the 2007-2023 period as a support for the formulation of State's GDP hypothetical behavior, since the IDPMG also should support the strategic planning related to the implantation of electric power generating plants in the context of regional planning, considering also that the process of expansion of the generator base could be a support in the development of the State of Minas Gerais. According to the IDPMG, the increase in electricity generation should be associated with the growth of Minas Gerais' GPD. For this purpose, two scenarios designed by PMDI were adopted: Scenario I (Conquest of the Better Future) and Scenario III (Overcoming Adversities).

In the scenario I - Conquest of the Better Future, the state of Minas Gerais takes advantage of the main opportunities offered by the favorable external context and is part of a sustainable cycle of sustainable development, which combines high economic growth (5.0% to 5.5%), with added value and innovations in all sectors, a jump in educational levels, continuous reduction of poverty and social and regional inequalities, and recovery and conservation of environmental assets.

In Scenario III - Overcoming Adversities, the State of Minas Gerais overcomes great adversities in the external context, takes advantage of scarce opportunities and makes a leap towards the future, making the unfavorable environment a fertile ground for innovation and paradigm breakdown in various fields, With economic growth above the national average (3.5% to 4%) reinforced by the increase in exports and with increasing levels of innovation and value added in the productive sector.

The estimative, in the context of Scenario I - Conquest of the Best Future, for which the annual average GDP growth rate for the period 2003-2027 will be in the order of 5.40% per year up to 2027, and the energy consumption in 2005, which was around 41.9 TWh, assuming a GDP elasticity in relation to electricity consumption of 1.044, could reach 140.1 TWh in 2027, as shown below, that is, it will grow 5.8% a year, resulting in an increase in electricity consumption from 2005 to 2027, in the order of 98.2 TWh, as shown in Table 11.

[Table 11]: Scenario I – Conquest of the Best Future

Scenario I – Estimative of Increase in Electrical Energy Consumption – (2005 – 2027) Period		
Minas Gerais	**increase of electrical energy**	**Source**
Consumption 2005 (TWh) =	41.9	Estimative 5000 x 8000 (365 x 24w)
Consumption 2027 (Twh) =	140.1	Estimative
Consumption increase 2005 – 2027 (TWh) =	98.2	Estimative
Rate of consumption increase in the 2005 – 2030 period =	5.80%	Estimative
GDP (in billions of reais in 2005) =	174.0	Minas Gerais Energy Matrix 2007 – 2030
GPD (in billions of reais in 2027) =	553.4	Estimative
GDP increase in 2005 – 2027 period (in billions of reais in 2005)	379.4	Estimative
Increasing rate of PIB in the 2005 – 2027period (*) =	5.40%	(*) Scenario I
GDP elasticity related to electrical energy consumption (2005/1997)	1.044	Estimative = equal to the NEP (National Energy Plan)

Source: SEA of the MGHGP, 2007.

Following the same procedure, the estimate of Scenario III - Overcoming Adversity - shows an increase in electricity consumption from 2005 to 2017, in the order of 61.2 TWh, as shown in Table 12.

***[Table 12]:** Scenario III – Overcoming of Adversities*

Scenario III – Estimative of Increase in Electrical Energy Consumption – (2005 – 2027) Period		
Minas Gerais	**increase of electrical energy**	**Source**
Consumption 2005 (TWh) =	41.9	Estimative
Consumption 2027 (Twh) =	103.1	Estimative
Consumption increase 2005 – 2027 (TWh) =	61.2	Estimative
Rate of consumption increase in the 2005 – 2030 period =	4.18%	Estimative
GDP (in billions of reais in 2005) =	174.0	Minas Gerais Energy Matrix 2007 – 2030
GPD (in billions of reais in 2027) =	412.4	Estimative
GDP increase in 2005 – 2027 period (in billions of reais in 2005)	238.4	Estimative
Increasing rate of income in the 2005 – 2027period (*) =	4.00%	(*) Scenario III
GDP elasticity related to electrical energy consumption (2005/1997)	1.044	Estimative = equal to the NEP (National Energy Plan)

Source: SEA of the MGHGP, 2007.

The Expansion Scenario of Generation Park 1, presented by the MGHGP's SEA, evaluated the growth in the order of 40.4 TWh, then Scenario I - Conquest of the Best Future of the IDPMG, using all available potential without any restriction, economic or socio-environmental, covers about 40% of the necessary increment (98.2 TWh) to meet the demand of the State, that is, it is insufficient. For scenario III - Overcoming Adversity (61.2 TWh), the coverage of electricity consumption needs also presents a value that is far from MGHGP goal (40.4 TWh). For the Expansion Scenario of Generator Park 2, presented by the MGHGP' SEA, growth was evaluated in the order of 20.7 TWh, that is, it is also insufficient to meet the increase in consumption of the Scenarios I and III of the IDPMG (98. 2 TWh and 61.2 TWh, respectively). These planning exercises involving quantitative scenarios carried out by the government of Minas Gerais, which are outlined in the magnitude of the elasticity of gross domestic product expansion in relation to the electric energy consumption adopted in the estimations of 1.044, **deserve revision on these perspectives of consumption expansion**. It is thus evidenced the need to obtain the greatest expansion of the hydroelectric plant as possible and, in a sustainable way, what implies in the solution of equations that did not exist in the past, requiring, then, the diversification of the electric matrix of mining, the use of new technologies, the improvement of energy efficiency and a holistic vision and technical capacity on the part of the entities involved.

5.3 SEA Scenario comparison with the Electrical Grid of Minas Gerais

The Electrical Grid of Minas Gerais 2007-2030, published by the State Energy Council (CONER), elucidates that the generation and transmission of electric power of the state is integrated to the National Interconnected System (SIN), and its operation is made in an integrated manner by the National

Electric System Operator (ONS), with the aim of maintaining the synergistic gains of the coordinated operation and guaranteeing the continuity, quality and cost-effectiveness of the electricity supply. In this study of the State energy matrix, the logic of the Minas Gerais insertion into the SIN was modeled in the Model for Energy Supply Strategy Alternatives and their General Environmental Impact - MESSAGE, which decides whether it is worth increasing the generation capacity or importing energy, depending on the economicity.

The MESSAGE model is used to formulate and evaluate alternative energy supply strategies for a country or region. The model finds the optimal energy supply strategy according to user-defined constraints, for example limits on new investments, market penetration rates, availability and fuel trade. In short, this model allows the formulation of energy supply alternatives, according to constraints imposed by the operating, regulatory and market conditions associated with the sources available in the energy mix of the region under analysis.

The study created two scenarios to help the State public policies: the Reference Scenario and the Alternative Scenario. The Reference Scenario elucidates that the demand for electricity in the State of Minas Gerais grows throughout the period at an average annual rate of 4.09%, and in the same period, the total generation of energy within the State grows at a lower rate of 3.30%, thus obliging the need to import the energy difference generated and consumed from the rest of the country. In the period 2025-2030, the increase in demand is almost completely met by imports, with a little increase in electricity generation within the State. According to this scenario, "Minas Gerais goes from a net exporter to a net importer of electricity at the end of the analysis period, importing about 17% of the electricity consumed", as can be seen in Table 13.

[Table 13]: Reference Scenario [9]

	2005-2010	2010-2015	2015-2020	2020-2025	2025-2030
CONSUMED Average Annual Increase	3.70%	3.80%	4.10%	4.30%	4.50%
GENERATION Average Annual Increase	3.70%	3.80%	4.10%	4.30%	0.70%
DEPENDENCY Net import/ Demand				0.06%	17.10%

Source: Minas Gerais Energy Matrix (2007 – 2030)

The Alternative Scenario elucidates that the demand for electricity in the State of Minas Gerais grows at an average annual rate of 3.81%, while the generation grows at a rate of 3.43%, thus showing that the state will also arrive in 2030 as a net importer of electricity, with 8.7% of its demand being met by imports (Table 14). An important factor that occurs in this scenario is the depletion of the hydroelectric potential in the State, which follows the same trend of the previous scenario with a little different characteristic of evolution.

[Table 14]: Alternative Scenario [9]

	2005-2010	2010-2015	2015-2020	2020-2025	2025-2030
CONSUMED Average Annual Increase	3.40%	3.70%	3.80%	3.90%	4.20%
GENERATION Average Annual Increase	3.40%	3.70%	3.80%	3.90%	2.30%
DEPENDENCY Net import/ Demand					8.70%

Source: Minas Gerais Energy Matrix (2007 – 2030)

Therefore, in the Reference Scenario, the estimative is 17.1%, while in the Alternative Scenario this estimative falls to the level of 8.7%. Analyzing these data obtained in the study on the demand and generation of electricity in the State of Minas Gerais between 2025 and 2030, it is noted that in both scenarios there will be a need to import energy from other states to supply domestic demand.

If we compare with the data from the SEA scenarios of the MGHGP and the IDPMG, we find that although there is a discrepancy in the order of magnitude, both studies point to a need to import energy from other states, that is, the state of Minas Gerais stops having a privileged condition as an exporter to become an importer of electricity.

6. CONCLUSION

This study presents a set of information for an analyzing exercise that considers different scenarios within each hydrographic basin, considering all MGHGP enterprises. The verified data indicates the potential of the hydroelectric generation expansion in the state of Minas Gerais, through the evaluation of the current installed capacity of each basin, measured in MW per HPS in operation, under construction and granted. The scenarios elaborated in this study allow the analyse of the prospects in increasing the generation of energy by hydroelectric plants together, with possible projections of the electric energy demand behavior.

It is represented the reductions between the Scenarios 1 and 2 of MGHGP's SEA, where it can be seen a decrease of 73% of the Parnaiba basin potential capacity, 53% of the São Francisco basin, 69% in the Rio

Jequitinhonha basin and 45% in the Rio Doce basin. There is also an accentuated decrease on the flooded area, in the order of 91, 80, 60 and 53%, respectively, in other words, more proportional to the reduction of the installed power. The strategic environmental assessment tried to demonstrate that these rivers would be the most affected, so it suggests more support from environmental agencies in the treatment of new environmental licenses in them.

In the comparison of the scenarios of the MGHGP's SEA with the scenarios of the Integrated Development Plan of Minas Gerais – IDPMG, it was evidenced the need to obtain the greatest possible expansion of the hydroelectric generating park in a sustainable way, what implies in the solution of equations that did not exist in the past, requiring the diversification of the Minas Gerais electrical matrix, the use of new technologies, the improvement of energy efficiency, as well as a holistic vision and technical capacity of the entities involved.

In the comparison of the scenarios obtained from the study of MGHGP's SEA with the scenarios of the study of the Electrical Grid of Minas Gerais 2007-2030 it is observed that in both scenarios there will be a need to import energy from other states to supply domestic demand. These scenario projections tend to widen, due to the reduction of rainfall in the state, the increasing silting of rivers, the reduction of riparian forest and springs, and the lack of energy planning to diversify the energy matrix.

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