Bases for the Preferential Plan from an Integrated Energy Resources Planning

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Abstract. This study presents the bases of a Preferential Plan obtained through a new methodology for energy planning, the IRP (Integrated Resources Planning of Energy) for the Power Sector, developed in GEPEA/EPUSP, Brazil. This Integrated Energy Resources Preferential Plan is a systemic compilation of energy resources obtained through an integrated in-time and geographic energy planning, denominated Integrated Resource Planning. The plan is developed using the methodology of Environmental and Energy Inventory; Listing and Drafting of Energy Resources; Calculation and Valuation of Energy Resources Full Potentials, Full Cost Analysis, Demand Forecasting and Resources Integration, after which the construction of plan effectively starts. Finally, the IRP Preferential Plan is a continuous up to date plan and a proposal for an alternative methodology for an energy planning for the power sector aimed at sustainable development through a complete overview among energy, environment and society, with its balanced importance.

1. Introduction

The purpose of this paper is to present the bases of the Preferential Energy Resources Plan, based on the Integrated Planning of Energy Resources (IRP) for the Electric Sector developed by GEPEA/EPUSP. It exposes aspects of data collection processes and information, stakeholder’s opinions, evaluations, data processing and analysis to demonstrate the importance and the comprehensiveness of a planning that seeks the definition of energy resources in a complete and balanced way.

In the proposed model, the factors impacted are treated with a parallel and balanced assessment of importance for deciding the optimum alternative during planning. This model has participatory of society, from stakeholders and interested and evaluates the main options on both the supply and demand for energy and is considered the lowest cost of impacts on the IRP reference factors (social, technical-economic, political and environmental). It is worth mentioning, in the IRP concept developed by GEPEA-USP, that the pursuit of the minimum cost is not related to a single momentary effective cost, since it depends on a series of combinations and decisions [1]. The minimum cost of the IRP represents the minimum cost from the combination of the chosen resources applied in the final planning period, in the considered dimensions. It corresponds to a balanced balance of competitive interests, between all those involved and interested in the process, in the referred period.
This work presents a more comprehensive and coordinated view of energy planning for the electric sector, internalizing some external costs during planning, and seeking the awareness and involvement of all stakeholders in electric generation projects, essential aspects of integrated planning. The inclusion of these entities in the planning process is a factor that makes it possible to characterize and compute multiple interests and obtain other perspectives in energy planning.

2. Integrated Energy Resources Planning Structure
The Integrated Resource Planning for the Electric Sector has four phases of development: survey of previous information; allocation of energy resources; integration of energy resources; and the preferential energy resource plan [2], [3], see the Figure 1.

![Figure 1. Primary modelling of the IRP process [4], [5].](image-url)

2.1. Preliminary Survey of Information
The objective of the collection of prior information is the composition of an information base that will
subsidize the later stages of the IRP. The acquisition of information is organized in three parts:

2.1.1. Environmental Inventory.
These inventory is a database that characterizes the region of study in detail: natural vocations, needs, limitations, vulnerabilities and facilities in the application of energy resources. It enables the planner to have a systemic view of a region with relevant information on energy flow, waste and exchange of inputs.

2.1.2. Listing and resources selection.
The list of energy resources is designed to identify all energy resources available for use throughout the planning horizon, regardless of technological characteristics, economic or accepted by society or specialists. This review covers both energy resources; Supply-Side and Demand-Side Resources which are evaluated and classified in the same way, being considered integrated and inseparable. The Supply-Side options are featured in the methodology of the IRP, the "duo" source / technology, i.e., the source of energy (solar, wind, thermal, hydro, etc.) and the technology used (photovoltaic panels, wind turbines, etc.). The demand-side resources are characterized by the association of measures of demand side management applied to an end use in a particular industry. For example, replacing incandescent bulbs by compact fluorescent, appliances demand controllers, chillers, high efficiency, fuel substitution and selection, etc.

2.1.3. Identification of stakeholders.
The aim is to raise all the actors, the government agencies that can participate in decision making, NGOs (nongovernmental organizations), society in general (organized) and specialists from various areas of knowledge. They are also raised about the regional specialists involved in the development process of the IRP. With this information (in detailed dimensions: social, environmental, political, technical-economic) are verified needs and abilities of regional electric power generation that is optimized for its energy matrix always seeking sustainable development. The participation of the stakeholders is made in a qualified manner through workshops and group dynamics, where energy resources are presented through the four dimensions of the IRP. The systemic study will guide the energy planner of the electric sector in the long term and, consequently, create a regional knowledge base, including the opinions and expectations of the stakeholders in the process, computed to a minimum total cost.

2.2. Calculation and Valuation of Full Potential (CVFP)
The assessment of the full potential of energy resources aims at the complete characterization of a resource (quantitative and qualitative) in the environmental, political, social and technical-economic dimensions. With this, the supply and demand side energy sources, sieved in the previous stages of the IRP, are characterized with calculated values, obtained and standardized in several parameters and indicators defined in this step [6].

The CVFP is the basis for the Complete Evaluation of Cost and consequently to the ranking of resources. It provides the input data to enable analysis and ranking of the portfolios of Energy Resources. In CVFP values are applied to each criteria and sub criteria defined for each energy resource. These values can be numeric, or only descriptive and characterizing a comparison between resources. The methodology for valuation of resources is designed to emphasize the local character of each resource. This leads to a deep study of the region, listing the types of available resources on the supply-side, the specific activities and habits of use of electricity by final consumers (industrial, residential, commercial, and public transport). One result of the valuation is the volume of energy that expresses the theoretical potential of each feature. Under these criteria and sub criteria applied common to both supply-side and demand-side all the resources are available in:

2.2.1. Technical-Economic Dimension.
Technical: Capacity factor; Domain technology; Facility technical-economic: cost of deployment, returning time and costs of O&M; Net Present Value (NPV); life; Capacity: Volume of Energy, Power.

2.2.2. Social Dimension.
Generation of jobs: During Construction; During Operation; Perception of Comfort; Influence on Development: Economic Activities; Infrastructure; Human Impact Resulting from Space Occupation: Displaced or injured person; Existence of Archaeological and Historical sites; Environmental Imbalance in the Social Environment: Noise Pollution; Impacts in Public Health; Impacts in Agriculture; Impacts on Buildings.

2.2.3. Environmental Dimension.
Terrestrial Environment: Waste - Solid, Waste - Liquid, Land Use; Aquatic: Water Consumption, Water Quality - Pollutant Emissions, Water Quality - Oxygen Demand - BOD at QDO; Water Quality - Temperature range; Water Quality - Modification of pH, change of flow volume; Air Environment: Air Pollutants - Gas, Air Pollutants - Particulate Matter, Greenhouse Gas, Greenhouse Punishment of the Ozone Layer.

2.2.4. Political Dimension.
Large Consumers Acceptance; Acceptance Distributors; Acceptance Generators; NGOs Acceptance; Population Acceptance; Great Consumers Motivation; Distributors Motivation; Generators Motivation, NGOs Motivation; Organized Society Motivation; Government Motivation; Gov. Support; Political Support; Tax Incentives; Property Source of Appeal; Property Exchange Variation Resource; Property Technology Resource; at Meeting Conjunct of Interests. Each feature analysed with the above criterion is divided into the following ranges of power ratings: up to 1 kW, 1-10 kW, 10-100 kW, 100-500 kW, 0.5-2 MW, 2-30 MW, 30-200 MW; above 200 MW.

2.3. The construction of the ranking
The Full Cost Analysis tool (FCA) is an important step for calculating full costs of a resource, where it is not possible pricing of an external cost (not paid by the user or company, but taxes the other elements of society) considers pricing in a holistic way. The use of FCA within the IRP is comprised of two distinct forms that converge to a single ranking of energy resources, making it necessary for the attributes, and alternatives are identical sub attributes for subsequent crossing of their information. For data processing software is used Decision Lens™ (DL) based on the method: Analysis Hierarchy Process (AHP), which performs comparisons peer-to-peer, for generating the two ranking: The Deterministic (data coming from valuation) and Holistic (data coming from the experts and stakeholders).

The overall ranking, which considers the average ranking between the holistic and deterministic, serves as a parameter for the Integration of Energy Resources and the construction of the Resources Portfolio. This ranking takes into account evidence, the choices of society and experts, with the energy resources in an orderly fashion, the best for the least suitable considering all costs and simultaneously through the technical dimensions-economic, political, social and environment. The presence of high energy limits of the table does not represent or ranking that is already deployed, or that there is the possibility of full implementation of all potential over the years. But that the potential available in that year is such that its limit is subtracted from the previously tapped potential.

The final ranking results in a list of energy resources, ordered from the most indicated to the least indicated, considering all the costs simultaneously, through the environmental, political, social and technical-economic dimensions.

2.4. Regional Mapping
The regional mapping allows verifying if the characteristics of a certain energy resource, coming from the Ranking, are ready to be inserted in the process of Integration of Resources. In other words, the
regional mapping behaves as a "momentary image" of the region at the moment of entry of the resource, and indicates if the characteristics of the energy resources meet the pre-established limits in the air, aquatic, anthropic and terrestrial environments of the legislation and rules in force. These indicators are referred to in the IRP as Restriction Vigilant.

For the elaboration of the regional mapping, the information of the environmental inventory is used, and the indexes and parameters of this information are updated to be used in the integration of the energy resources. Some indicators are defined in IRP in order to control the process of integrating resources.

2.4.1. Atmosphere Environment.
O3 (atmospheric), MP, VOHC (measuring volatile organic compounds - CH4, GHG;

2.4.2. Hydrosphere Environment.
Water Availability, BOD, PH, Land Use, Areas Unfit;

2.4.3. Anthropic Environment.
Urbanization degree, population growth, employment, HDI.

2.5. Demand Forecast
Surveys are conducted of data on energy demand and distributed primarily in consumer sectors such as residential, commercial, public, and industrial. In addition, energy scenarios are constructed in order to create a future reality of energy demands for the planning horizon of the study area. In a developing country, many variables must be considered to meet the energy demands: population growth, GDP, energy efficiency, level of electrification and distribution of energy, access to new technologies, regulatory frameworks, suppressed demands and growth infrastructure. It is used a scenario of projection of current socioeconomic factors and projected perspectives. This scenario represents a continuous growth in energy demand, with growth trends, distribution, and evolution of the sectors' efficiencies. The trend scenario adopts in its premises the consideration of energy policies, such as technology substitution, infrastructure improvements, political incentives to boost the growth of sectors and social perspectives.

The input data used are: Energy Balance of the Base Year, social data (number of houses, industrial production, etc.), demographic and economic growth rate by sector, technological parameters, cost per technology, international projections, environmental coefficients localities, energy intensities for end-use processes of the sectors of the economy and the rate of losses in the transmission and distribution of electric energy and energy efficiency.

As a result, the results are disaggregated by sectors of the economy in the demands of energy end uses, evolution of the rural/urban distribution, evolution of income distribution by classes, and modification in the profile of the use of energy services.

2.6. Integrating Resources
For the resource allocation process, the resources derived from the ranking are used, according to their classification. However, such a choice is made according to the realizable energy capacities of each one in its respective sector and potential in the year, and only when meeting the forecast of demand and the vigilant indicators of analysis of the region, at the moment of insertion of the resource. To the set of resources that meets year one, it is called the year one of the preferential plan. After the distribution in year one, the new conditions of the energy-environmental mapping and the demand revision for the next year i + 1 will be available, according to the time discretization. With these new conditions, the process will be fed back into the composition of the preferential plane of the moment i + 1. In this way, it is possible to verify in stage i + 1 the socioeconomic and environmental effects of the application of the plan at time i, to verify and reduce the uncertainties related to the preferential
plan, since it is possible to correct the options of the plan in function of the impacts caused. The preferential plan will be complete as n iterations are traversed, where n is the number of discretization made during the planning period. No action should be dismissed because of their classification, as in the IRP will still be considered variable temporal, geographic, political and resource availability, and may be viable for some time a feature here that early in the planning horizon is in lower positions in the ranking of energy resources.

Interferences between the energy potentials of the selected resources should be analyzed in the resource allocation process. That is, in demand resources the application of certain measures can reduce or eliminate the potential of others, who have similar end uses. Example: the application of equipment replacement, adjustment and sizing, energy selection and substitution, and the efficiency of combustion systems for any end use are concurrent with each other and the potential of one resource affects the others in its application. Another factor of application of demand resources is due to cultural, social or regulatory factors, which may influence the application rate, the potential of the energy resource, for the year of application.

For supply resources, equivalent technologies limit the estimated potential, in the vicinity of the predefined power range, in the list of energy resources. One example is the theoretical potentials of hydroelectric resources. When estimated alone in a power range, they represent the overall potential of the resource. However, the application of a hydropower resource of another power range may affect the potential of another and this reduction must be considered. Another example is the space factor, with competing resources such as biodiesel, sugarcane bagasse, alcohol, firewood and photovoltaic that compete for the same production space.

2.6.1. Scenarios Analysis.
In this step, the consistency analysis is performed with the objective of verifying how the preferential plan generated influences the envisaged energy demand and the temporal, geographic and environmental limits predetermined by the vigilant.

In this process of composition of the preferential plan, the new environmental, social and energy conditions are generated for the i + 1 moment, by reviewing the forecast of demand and the updates of the environmental indicators affected by the implantation of the preferential plan of the moment i. The analysis of the results may present inconsistencies between the objectives of the IRP and the regional characteristics or other factors. Major disparities may require a new consultation procedure with stakeholders or a revision of the proposed plan, with the aim of minimizing the uncertainties of the preferential plan. The conduction of plans that lead to the unavailability of resources to meet the preferential plan may indicate exaggerations in criteria established by the stakeholders, necessitating a review of the elaboration.

2.6.2. Socioeconomic and Environmental Analysis.
The complementary analyses of the stage of composition of scenarios are carried out. The objective is to evaluate the socioeconomic changes resulting from the application of resources at the moment i. It is important to highlight the multidisciplinary nature of the analyzes of the evolution of socioeconomic indicators of this stage. Thus, specialists from different specialties, in addition to the electrical sector specialist, should be included in the IRP process. The results will be evaluated under the requirements of the Vigilant IRP analysis elements.

2.6.3. Iterative Analysis.
The iterative process aims to improve the distribution of resources, considering the revision of the socio-environmental data affected by the entry of resources in the previous distribution. After the energy resources are distributed in a given year, the regional data are revised, due to the impacts of the resources applied in the previous year. The application of demand resource potentials through energy conservation and energy efficiency programs can change the projection of electricity demand to the next iteration, as well as affect the data used in the base year of the demand forecast. Likewise, supply
resources can, according to their characteristics, affect the socio-environmental environment, so that the mapping for the next iteration is reviewed. As a way to reduce these distortions, a review of demand forecast, and regional data is carried out after the first distribution of resources in each year, and integration is continued for the next year. The process of IRP has flexibility to be continually reassessed and adjusted their steps according to the advances of technology, environmental, political and social time for each application.

2.7. Preferential Plan
The energetic resources listed, sifted, classified, valued with their full potential and ranked by the FCA process are distributed throughout the planning period in the Integration of Resources aiming at meeting the forecast of demand and the limits and goals identified by the elements of vigilant analysis. As a result of the Integration process, the Integrated Preferred Energy Resources Plan is obtained. This is a collection of resources systematically analyzed with their respective potential, applicable and achievable, applied along the planning horizon and in the geography, in accordance with the demand of electricity and restrictions of the moment of insertion of the resource in the place.

The Integrated Resource Planning results meeting growing energy demand through the comprehensive plan of energy resources will be based on rational and efficient allocation of both resources: the supply and demand side, without distinction.

3. Conclusion
The bases of the Integrated Preferential Energy Resources Planning have the capacity to expose the ability of a region to an energy potential not traditionally observed or not observed with the appropriate importance. The extensive coverage of the plan and its modules allows, during the evolution of the preferential plan, the identification of deficiencies in different sectors, which result in the adoption of public policies in projects such as those applied in a case study [2].

It establishes a tool that will subsidize the development of policies of incentives to certain resources, programs of energy efficiency and conservation. Interchange among academic entities, partnerships with local entities and stakeholder involvement facilitate the dissemination of the concept of regional energy development and a basis for future planning for a given region.

Finally, the elaboration of the Integrated Preferential Resource Plan, especially for developing countries, can, in this sense, contribute intensely to the rational use of energy resources, to increase the reliability of the electric system, and to renew and expand the park generator for the identification of sectoral public policies, for the awareness of the stakeholders and essentially for a continuous planning evaluation, at the lowest total costs in the considered dimensions of the IRP, in actions consistent with sustainable development.

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