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Multicriteria Valuation of Supply Energy Resources within Integrated Resource Planning

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***Abstract*—This article presents the methodology of valuation of energy resources on supply-side under the Integrated Energy-Resources Planning (PIR). The valuation of energy resources is extremely important in energy planning and its methodology consists of conversion of qualitative contents of each attribute into corresponding numerical indicators capable of valuing each attribute. The purpose of this work is to systematize the accounting for the full potential of all energy resources locally available, which in general are not covered by traditional planning. Although the PIR comprises all available resources, this work focuses on the characterization of major energy resources, namely fossil fuels, biomass, wind energy and waste resources. The paper highlights the different methods of computation for the valuation of the analyzed resources, based on a set of attributes split over the environmental, social and political dimensions.**

***Keywords*— Energy, Valuation, Energy Planning, PIR, IRP**

Introduction

The Integrated Energy Resources Planning (PIR) is a methodology applied on the energy sector which aims at selecting energy resources to expand the supply of electricity [1]. Therefore, PIR methodology shall be capable of including, initially, a set of available energy resources and ordering them in terms of preference of use, in order to satisfy the necessity of the stakeholders either through regulatory implementation or strategic directions for investments and policies. Once the energy resources[1] are defined, the next step is called characterization.

In order to achieve a holistic analysis, the selected attributes have to enable an accounting of impacts associated to each energy resource. Put it another way, the goal of the selection of attributes is to enable an analysis that takes into account both internal and external costs of the project. Fig. 1 summarizes the valuation of energy resources.

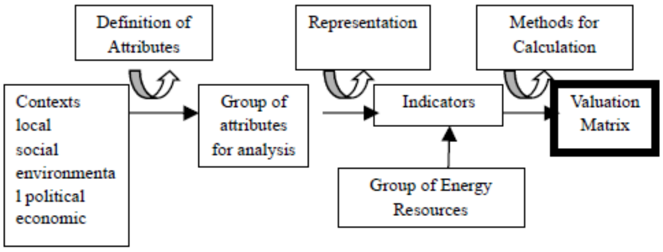

Figure 1:Valuation of energy resources

Definition of Attributes of Analysis

The selection of attributes to analyze the resources is a key process of the methodology and therefore, has to be carefully conducted in order to avoid negligence or overestimation of relevant elements regarding the resources' evaluation. The difficulty of this step lies on its linear nature, since the complexity of the environment – social, biological, geographical – and its interactions among a given resource have to be described in terms of a pre-defined and static set of finite attributes.

Under the umbrella of the PIR, four dimensions have to be considered: techno-economical, political, social and environmental. Each of the aforementioned dimensions amounts to an angle of view through which the energy issue is observed and represents the manifold circumstances where different stakeholders are situated.

The techno-economical dimension, which is out of the scope of this article, guarantees considerations about physical and economical efficiencies.

The social and environmental dimensions aggregate factors related to the impacts of energy production, since they analyze the interactions between energy production, environment and society, and thus, the sustainability of the energy resource.

The political dimension analyzes the acceptability of the stakeholders to each resource, including disputes and conflicts about energy sources [2].

1 Energy resource is the exploitation of an energy source with a specific technology

It is important to mention that the equal distribution of the weights among the four dimensions is a fundamental premise of PIR.

VALUATION OF ENERGY RESOURCES

The methodology of valuation of energy resources includes the translation of the content of each attribute into a corresponding numerical indicator and then, the calculation of each attribute for a given resource is performed.

This article focuses on the application of the methodology of valuation for the most important energy resources consumed in Brazil, in order to conduct the evaluation of resources as more extensive as possible, particularly regarding the viability of practical solutions. Table 1 presents the set of energy resources included in the analysis:

TABLE 1 – VALUATED ENERGY RESOURCES

NON-RENEWABLE RESOURCES		RENEWABLE RESOURCES	
Source	*Technology*	*Source*	*Technology*
Domestic Coal	Pulverized Coal	Wind	Eolic Turbines
	Fluidized Bed	Bagasse	Direct combustion
Imported Coal	Pulverized Coal		Gasification
	Fluidized Bed	Straw	Direct Combustion
Natural Gas	Simple Cycle		Gasification
	Combined Cycle	Sewage	Biodigestion
Light Fuel Oil	Gas turbine	Biodiesel	Transesterification
Heavy Fuel Oil	Water-steam cycle	Wood	Direct combustion
-	-	Vinasse	Biodigestion
		Sugarcane	Fermentation
		Rubbish	Biodigestion
			Incineration

Since the energy resource is composed of a source and the technology for its exploitation, each source is respectively associated with the most prominent technologies of electrical generation. Aiming at the viability of our work, we have decided to consider only the main large-scale technologies of energy generation, since they are suitable for new projects and present a good match with the defined attributes.

ENVIRONMENTAL DIMENSION

This dimension deals with the set of attributes that describes the influences of the resources on the environment, in terms of the following mediums: Atmospheric, Aquatic and Terrestrial. The sub-attributes can be seen in the table 2:

Table 2 – Attributes and Sub-Attributes of Environmental Dimension

ENVIRONMENTAL	ATTRIBUTES	ATMOSPHERIC	AQUATIC	TERRESTRIAL
	SUB-ATTRIBUTES	Emission of Air Pollutants	Emission of Water Pollutants	Land Demand
		Greenhouse effect	Water Consumption	Generation of Solid Waste

Source: Fujji, 2006

Atmospheric

Emission of Air Pollutants

Emission of air pollutants is a consequence of most energy resources. Due to the diversity of the analyzed energy resources, the whole life cycle of energy generation has to be taken into account. For instance, although wind energy presents zero emissions of air pollutants during its operation, the manufacturing of wind turbines as well as other components, do emit air pollutants. In the case of ethanol, most of emissions occur during the harvesting of sugarcane, whereas for fossil fuels, the main emissions are attributed during the actual energy generation. Table 3 presents the values of the attributes for fossil energy resources:

TABLE 3 – VALUATION OF FOSSIL ENERGY RESOURCES IN TERMS OF EMISSION OF AIR POLLUTANTS

POLLUTANT	DOMESTIC COAL		IMPORTED COAL		NATURAL GAS		FUEL OIL	
(kg/MWh)	Pulv. Coal	Fluid Bed	Pulv. Coal	Fluid. Bed	Simple Cycle	Comb. Cycle	Light	Heavy
CH_4	0,011	0,009	0,011	0,009	0,00857	0,0069	-	-
N_2O	0,016	0,013	0,015	0,012	0,00086	0,0007	-	-
CO	0,105	0,083	0,218	0,171	0,17143	0,1385	-	-
NMVOC	0,017	0,013	0,055	0,043	0,04286	0,0346	-	-
CO_2	1101.8	865.7	1032	810.9	480.86	388.39	900	675
SOXd	36,85	3,685	5,95	0,595	0,00111	-	2,2	16,9
TSP	5,455	4,286	5,455	4,286	0,00771	0,0062	-	-
PM10	2,727	2,143	2,727	2,143	0,00771	0,0062	0	0,09
PM2,5	1,091	0,857	1,091	0,857	0,00771	0,0062	-	-
NOX	4,972	1,989	3,273	1,309	1,28571	1,0385	-	-

Source: Tolmasquim, 2000 ; IPCC, 1996, EPA, 1995

Greehouse Effect

The potential of greenhouse effect is regarded to the emissions of air pollutants by correlating each gas emitted to its global warming potential. The table below shows another example of the valuation, namely the direct combustion of bagasse for electricity generation.

TABLE 4 - VALUATION OF DIRECT COMBUSTION OF BAGASSE IN TERMS OF GREENHOUSE EFFECT

Direct Combustion of Sugarcane Bagasse		
Pollutant	***Emission (kg/ ton. sugarcane)***	***Potential of Greenhouse effect (kg co2 eq/ ton sugarcane)***
CO_2	2,1	2,1
CH_4	0,062	1,42
NO_x	0,15	0,75
N_2O	0,0084	2,49
CO_2eq	-	6,76

Source: IPCC, 1996, EPA, 1995

Aquatic

The valuation of alteration of water quality is calculated in terms of liquid effluents (mass per unit energy), whereas the consumption of water is given by the volume of water per unit energy.

Water consumption takes place in different phases of energy generation. For instance, regarding thermoelectric power plants, more water is required during condensation of vapor exhaustion, whereas biomass generation requires more water during irrigation of crops and, in certain cases, during industrial phase.

Table 5 illustrates the valuation of water consumption using gasification of bagasse as example.

TABLE 5 - VALUATION OF WATER CONSUMPTION FOR GASEIFICATION OF BAGASSE

Gasification of sugarcane bagasse	
Phase	*Water consumption (kg water/ ton sugarcane)*
Agriculture	-
Vapor generation	300

It is important to mention that, although the cultivation of sugarcane requires water for crop irrigation, this value is neglected in this specific case, since the source used to generate energy (i.e the bagasse) is a residue obtained from ethanol production. All the impacts regarding the crop cultivation phase of sugarcane are considered solely on the valuation of the primary resource, namely ethanol.

Generation of Liquid Effluents

Before you In addition to water consumption, aquatic mediums can be impacted by liquid effluents generated along the energy gereration chain, especially when the resource requires pre-treatment or industrial processing.

These effluents might contain particulate matter, chemical compounds, corrosion products, oil residues, etc., presenting potential to cause negative impacts if they are directly emitted into the water. Table 6 presents the valuation of the analyzed attribute using ethanol resource as example.

TABLE 6 - VALUATION OF LIQUID EFFLUENTS FOR ETHANOL

Fermentation of Sugarcane (ETHANOL)	
Effluent	*(kg/ton ethanol)*
Water	1291199,4
Quaternary ammonium	0,0015
Polymer	0,0015
H2SO4	11,3125
Anti-foaming oils	0,15
Nutrients	0,128
NaOH	0,0025

Adapted from Ometto et al., 2007

Terrestrial Medium

Generation of Solid Waste

Regarding energy resources, solid wastes are generated mainly by combustion, industrial processing (particularly related to the treatment of energy sources) and purification of raw materials. Table 7 presents a list of solid wastes generated from fossil resources. In this case, we consider only the ash and the scoria, since they represent 99.9% of the total amount of solid wastes generated by thermoelectric power plants.

TABLE 7 - VALUATION OF SOLID WASTE FOR FOSSIL RESOURCES

Source	Technology	Category	Generation of ash and scoria (kg/MWh)
Domestic Coal	Pulverized Coal	1	57
	Fluidized Bed	2	57
Imported Coal	Pulverized Coal	3	57
	Fluidized Bed	4	57
Natural gas	Simple Cycle	5	0,068
	Combined Cycle	6	0,068
Light Fuel Oil	Gas turbine	7	0,2
Heavy fuel oil	Water-steam cycle	8	0,2

Footprint

The area demanded for energy production varies according to several project parameters. Nevertheless, it is possible to establish a correlation between demanded area and the resource used. For example, the area occupied by a coal-based thermoelectric power plant of 1800 MW containing cooling towers might reach up to 100 hectares, whereas for ethanol resource, the footprint varies according to crop cultivation techniques and climatic conditions. Although the variability of demanded area might be high in certain cases, standard values can be applied. For instance, ethanol resource is attributed with 0.24 hectares per liter of product. Table 8 presents the calculation of the attribute footprint for wind energy:

TABLE 8 - VALUATION OF FOOTPRINT FOR WIND ENERGY

Energy resource					*Diam. of rotor Φ [m]*[1]	*Footprint factor [m²/turb.]*
	Technology					
Source	*Principle conversion*	*Axis orientation*	*Type of facility*	*Output power*		
Wind	Eolic turbines	Horizontal	Onshore	2 - 3 MW	71	141148

[1] reference value relates to the eolic turbine E70, produced by Enercon GmbH

SOCIAL DIMENSION

This group deals with the attributes which describe the influence of the resources on the social dimension. The attributes are: Functional and aesthetic; Effects of the environmental impacts on the social environment (divided into three sub-attributes, namely Public Health, Agriculture and Constructions); Impacts from footprint and Influence in Development and Infrastructure [2].

TABLE 9 – ATTRIBUTE AND SUB-ATTRIBUTES OF SOCIAL

Attribute	**Functional and aethetic aspects**	**Effects of environmental impacts**	**Impact of footprint**	**Local development**
Sub-attribute		Public Health	Displaced people	
		Agriculture	Displacement of native people	
		Construction	Places of historic interest	

Source: Fujii, 2006

Resource Functionality

Functionality significantly affects the capacity of a resource to be integrated in the energy market, being particularly important in the case of microgeneration. According to Fuji, “the functionality of a resource strongly depends on its ease of operation and maintenance, because in many cases such operations are conducted by non-specialized workers”. Within this context, the evolution of technology plays a very relevant role, because the more well-known the technology, the more functional a resource is attributed.

Although the attribute “aesthetic aspects” appears to be irrelevant, it evaluates the comfort of those who are affected by the resource, and therefore becomes important within the social dimension. Once the local aesthetic conditions are to be modified by any resource, the local community might resist, reducing the resource's acceptability.

Therefore, the following algorithm was created in order to valuate this attribute in terms of numerical values. As an example, table 10 presents the attribute “functionality”, which was performed for biodigestion of vinasse.

TABLE 10 - VALUATION OF FUNCTIONALITY FOR BIODIGESTION OF VINASSE

Characteristic / Scoring	-1	0	1		Biodig. of Vinasse
Is the technology well-known?	no	little	yes	Valuation	0
Does it require specialized work?	yes	little	no		-1
What is sensation of comfort related to the resource?	uncomfortable	indifferent	comfortable		1

Adapted from Fernandes, 2004

Effects of environmental impacts on social dimension

The characterization of effects of environmental impacts on social dimension can be rationally performed, since it derives from environmental factors, such as emissions, which were obtained in the environmental dimension. Although the adverse effects of atmospheric emissions on human health, such as sulfur oxide, nitrogen oxide and particulate matter, are scientifically proven, values and correlations found in the literature vary considerably. Further examples of the valuation of effects of environmental impacts on social dimension are given for ethanol and straw gasification.

Impacts on public health

The adverse effects on the social dimension can be measured by multiple ways. In this case (i.e impacts on public health), the valuation was performed based on an adaptation of a danish methodology of life cycle assessment called EDIP. The methodology consists of measuring the toxicity potential for humans through the amount of equivalent compartment (i.e volume of water, soil or air) required to neutralize the effect produced by one gram of emitted effluent.

TABLE 11 - VALUATION OF IMPACTS ON PUBLIC HEALTH FOR ETHANOL AND STRAW GASIFICATION

Sub-attribute	Criteria of valuation	Energy resources			
		STRAW GASIFICATION		ETHANOL	
Public Health	Human toxicity AIR	1,89E+04	m^3 air/kWh	1,86E+09	m3 air/kg ethanol
		1,49E+06	m^3 air/kWh		
	Human toxicity WATER	0	-	0	-
	Human Toxicity SOIL	0	-	0	-

Adapted from Sánchez et al., 2006

Impacts on Constructions

Constructions are subject to natural deterioration caused by the weather. Nevertheless, this deterioration might be accelerated by deposition of pollutants, usually transported in acid rain, which is responsible for the most observed human-based process that chemically affects constructions within the region.

The valuation of each resource was done in terms of respectively atmospheric emissions of the most important pollutants that form acid rain and particulate matter, which impregnates on constructions' surfaces. Table 12 presents the valuated attribute for straw gasification and ethanol.

TABLE 12 - VALUATION OF IMPACTS ON CONSTRUCTIONS FOR ETHANOL AND STRAW GASIFICATION

Sub-attribute	Criteria	Energy resource					
		STRAW GASIFICATION				ETHANOL	
Constructions	Acidification	2,156		gSO2 eq/kWh		0,007	g NO_3^-/kg ethanol
		32,34		gSO2 eq/kWh			
	PM	100	mg/Nm3	3,08	mg/kWh	62,89	kg/kg ethanol
		1500	mg/Nm3	46,2	mg/kWh		

Adapted from Sánchez et al., 2006

Impacts on Agriculture

The most prominent effects that impact agriculture either by directly contaminating the crops or reducing crop yields are caused by atmospheric and aquatic emission of pollutants [2].

For instance, crop exposition to nitrogen compounds can, in the short term, increase shoot/root ratios. Additionally, crops become more sensitive to droughts, frosts and plagues, leading to higher rates of vulnerability to natural ecological changes. Whereas in the long term, it might increase crops' susceptibility to secondary stress and alterations of relations of competition, leading to a decrease of biodiversity.

Deposition of sulphuric acid is a consequence of atmospheric emissions of sulphur oxides that causes negative impacts in rivers and lakes, which directly affects the aquatic medium, alters the composition of soil's nutrients and increase solubility of metals. Thus, factors of atmospheric emissions of nitrogen and sulphur oxides are also used as indicators in this attribute.

Regarding qualitative alterations on the aquatic medium, we use the attribute generation of liquid effluents as an indicator that describes the influence of the resources on agriculture. Table 13 presents the results obtained for straw gasification and ethanol.

TABLE 13 - VALUATION OF IMPACTS ON AGRICULTURE OF STRAW GASIFICATION AND ETHANOL

Sub-attribute	Criteria of valuation	Energy resources					
		STRAW GASIFICATION				ETHANOL	
Agriculture	Eutrophication	18,2952		g NO3-eq/kWh		618241	g NO_3^-/kg ethanol
		33,6798		gNO3 eq/kWh			
	Acidification	9,4864		gSO2 eq/kWh		15713	g NO_3^-/kg ethanol
		17,4636		gSO2 eq/kWh			
		1500	mg/Nm3	46,2	mg/kWh		

Adapted from Sánchez et al., 2006

Influence on Local Development

The creation of new power plants is a potential factor of economic and social development. Among others, projects create jobs, boost housing and commercial sectors and increase tax revenues [2].

Nevertheless, one has to be aware of some important issues of this attribute. Regarding the creation of new jobs, a distinction between permanent and temporary jobs has to be done; while the phase of construction requires relatively more workers, who might come from other regions, the operational phase requires less workers, but its period is much longer and usually has a better effect in terms of local development. Yet, the attribute generation of jobs can be described either quantitatively (i.e absolute number of jobs) or qualitatively by using scales of intensity (e.g low, medium and high).

As an illustration of the valuation, we use the resource wood combustion. According to EMBRAPA, crops of eucalyptus requires annually 5 working days per hectare. Thus, assuming that one year has 260 working days, we have 1 job created for each 52 hectares. Thus, in the study area, which presents 3,706 hectares of eucalyptus crops destined to energy production, we have 72 employments per year.

POLITICAL DIMENSION

The political dimension seeks to consider the stakeholders' attitude towards a given resource. The attributes that describe this dimension are: Agent's motivation (i.e large-scale consumers, energy distributors, government, environmentalists, social movements and the society) and Ownership of energy source. Then, we define sub-attributes in order to describe the political dimension, showed in the table below.

TABLE 14 – ATTRIBUTES AND SUB-ATTRIBUTES OF POLITICAL DIMENSION

ATTRIBUTE	*ELEMENTS*	*AGENT'S MOTIVATION*
SUB-ATTRIBUTE	Ownership of energy source	Large-scale consumers
	Acceptance or Opposition to resource	Energy distributors
		Energy generators
	Government support	Government (local, regional, federal)
		Environmental Movement
	Interest Conflicts	Social Movement
		Society

Source: Fujii, 2006

Elements

Ownership of energy source

This attribute refers to legal competences of the people involved in energy planning in terms of their influence over the sources analyzed. Fundamentally, this ownership evaluation analyzes the power relationship between two elements: the planner, or planning contractor, and the natural source that will be used as energy source.

In order to describe this attribute, we use indicators based on three aspects of ownership: free accessibility, destined to multiple usages and government possession. In order to facilitate the analysis, we decide not to take into account aspects related to different perspectives of planners. Table 15 presents the valuation of this attribute for sewage biodigestion.

TABLE 15 - VALUATION OF OWNERSHIP OF ENERGY SOURCE FOR SEWAGE BIODIGESTION

	Characteristic / Scoring	-1	0	1		SEWAGE BIODIG.
Ownership of energy source	Is the energy source free for access?	no	maybe	yes	VALUATION	0
	Is the energy source destined to multiple uses?	yes	maybe	no		1
	Who is the owner of the source?	International	Both	Government		1

Acceptance or opposition to resource

This attribute deals with approval or opposition to resource by analyzing resistance imposed to each resource and it is calculated independently of other dimensions. Similarly to the attribute ownership of energy source, acceptance or opposition to resource makes use of indicators. Table 16 presents examples for the valuation of this attribute for different technologies of exploitation of coal. Although the indicators used in this case differ from the ones used in the last attribute (i.e ownership of energy source), the method of valuation is exactly the same.

TABLE 16 - VALUATION OF APPROVAL OR OPPOSITION TO RESOURCE OF COAL

Resource						*Level of Acceptance [rejection <0>/acceptance with conditions <1>/acceptance <2>]*
Source		*Technologie*				
		Type of combustion	Burner configuration	Working fluid	Cooling system	Society
COAL	NATIONAL	CP	tangential	subcritical	semi-open	-1
		CP	tangential	supercritical	semi-open	-1
		LFAC	-	subcritical	semi-open	-1

Government support

According to [2], “The government plays a very important role on energy planning processes by defining norms and public policies. This role is given by several ways, usually followed up by a legal framework.”

The types of legal frameworks adopted is diverse, varying from strict norm up to economic regulations, such as subsidies, rearrangement of taxation or special funding lines. Thus, given the complexity of the attribute and in order to facilitate the valuation process, an indicator is used, which has a limited capacity of representing all involved aspects. Table 17 shows a possible indicator used to valuate this attribute:

TABLE 17 - ALGORITHM OF VALUATION OF GOVERNMENT SUPPORT

Indicator	Characteristic
3	High support: subsidies, funding lines, tax exemption, etc.
2	Indifferent
1	Low support: legal restrictions, high bureaucratic process, etc

Before Yet, “Investments in alternative sources, fostered by governmental actions, such as PROINFA, have been taken place lately and therefore wind and biomasse have increased its share on the Brazilian energy market”. Thus, using the above algorithm, these sources are attributed with the maximum value (3), as it is then in the case of biomasse.

For instance, in case of direct combustion of straw, if we can take into account the tendency to mechanize sugarcane harvesting observed on regional initiatives. Thus, the calculation follows: Potential = Value x Production = 3 x 5.890.000 = 17.670.000 tons of straw.

Conflicts of interest

This attribute aims to analyze and emphasize differences of stakeholders' interests, which might undermine the viability of certain resources. Therefore, important stakeholders that influence decision-making have to be identified at a first step. Then, we proceed by verifying each stakeholders' opinion about the resource. The following example illustrates two conflicts of interest involving energy producer X energy distributor and energy distributor X consumer:

TABLE 18 - INDICATOR OF VALUATION FOR CONFLICTS OF INTERESTS

Indicator	Characteristic
3	Convergence of interests
2	Independent interests
1	Divergence of interests

Table 19 shows the valuation of the attribute conflicts of interest for sewage biodigestion.

TABLE 19 - VALUATION OF CONFLICTS OF INTEREST FOR SEWAGE BIODIGESTION

SEWAGE BIODIGESTION		
Interest	*Level*	*Potential*
Producer and Distributor	2	278.490
Distributor and consumer	2	278.490
Total	4	556.980

Agent's motivation

According to [2], this attribute seeks to consider political orientations or positions from several groups of society, or stakeholders, in relation to each one of the energy resources considered in energy planning. The underlying factors that shape decision-making and each group's orientation differ in each case. Basically, the interests are conjunctural, leading to different priorities that are adopted in each specific case. Put it another way, each group involved in energy planning takes into account different combinations of factors from the four analyzed dimensions (i.e techno-economical, environmental, social and political).

Thus, once more we can describe the attribute by using numerical indicators, such as -1, 0 and 1, in order to obtain a discrete qualitative measurement that translates each individual stakeholder's motivation.

Table 20 shows an example of the valuation of this attribute for biodigestion and incineration of rubbish.

TABLE 20 - VALUATION OF AGENT'S MOTIVATION FOR BIODIGESTION AND INCINERATION OF RUBBISH

	Characteristic / Scoring	-1	0	1	VALUATION	RUBBISH BIODIG.	RUBBISH INCIN.
Large-scale Consumers	Is the price relatevely high?	yes	medium	no		1	0
	Is it suitable for independent production?	no	medium	yes		1	1
	Does it comprise efficiency measures?	no	possibly	yes		0	1
Distributors	Does it comprise efficiency measures?	no	possibly	yes		0	1
Energy Producers	Is the source renewable?	no	-	yes		1	1
	Are the environmental impacts severe?	yes	medium	no		1	0
	Is it suitable for decentralized production?	no	possibly	yes		1	1
Government	Is the source renewable?	no	-	yes		1	1
	Are the environmental impacts severe?	yes	medium	no		1	0
	Is it suitable for decentralized production?	no	possibly	yes		1	1
Environmental Movements	Are the environmental impacts severe?	yes	medium	no		1	0
Social Movements	Does it involve displacement of people?	high	possibly	low		1	1
Society	Is the resource well accepted by society?	no	indifferent	yes		1	-1

FINAL CONSIDERATIONS

The valuation of energy supply constitutes a fundamental phase that contributes for qualitative and quantitative evaluation of energy resources under the umbrella of Integrated Energy Resources Planning (PIR).

The integration of 4 dimensions of analysis provides a complete perspective of the relationships and interdependencies of each energy resource and the social, environmental, geographical, political and cultural elements of a given region. Despite implicit limitations and constrains of the methodology, its structure of analysis enables critic approaches regarding the viability of energy resources, since it considers elements that are usually neglected by energy planners.

The valuation of supply energy resources together with the valuation of demand energy resources constitutes the step of integration in PIR, which leads to the creation of resource portfolios, scenarios and preferential plans included into energy planning.

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