

# A Stratified Methodology for Selection of Distributed Generation Systems for Policy Makers in Tamil Nadu

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**ABSTRACT:** The sketch of the massive rise in demand as compared to generation was enforced on the system; electric services have been restructured so that operators will plan to implement alternative energy resources as we have varying environmental conditions and resource possibility. By enforcing, the environmental banks have been reduced in addition to the improvement of quality and reliability in the supply. As the contribution of distributed energy increases, it is essential to estimate the impact on the grid and consistently it becomes problematic in the division of authorities to report a correct decision on electing the type of distributed energy for a distinct region. The main motive is to determine various distributed energy options in TamilNadu with consideration of absolute attributes mainly environmental. Analytic hierarchy process (AHP) and Vlse Kriterijumska Optimizacija Kompromisno Resenje (VIKOR) are being used to analyze the corresponding priority of the chosen attributes and suitable distributed energy source options are decided which will useful for policy maker. This study would be effective to estimate the subsequent impacts of rising distributed power proportions and increase in policy makers.

**KEYWORDS:** Distributed Energy (DE) technologies, MADM, AHP, VIKOR, Environment, Priority

## I. INTRODUCTION

The essential purpose of distribution energy system is to fit the customer's demand after acquiring the quality electrical energy and closeness to the extreme consumer and huge cost to provide capital are the sense that make the important part of the utility, which endeavor to increment the accuracy of a regular power system. Sustainable energy systems are reasonable to have an elevated contribution of renewable energy with final expanding greenhouse gas discharge is crucial to search alternative disinfectant sources of energy and consolidate them into the current system before the overall resources are drained and damaged beyond recovery. With the integration of alternative sources, the productiveness is funded by operating in an economical and predictable way. The energy technologies considered as appraisal includes Solar PV, Wind turbine, Fuel cell, Diesel engine, Gas turbine, Biomass and Micro-Turbine.

Tamil Nadu has satisfactory, sufficient, inaugural renewable resource, encloses a majority land that receives the highest Wind radiation in the India. Generation quantity has been structured mostly through private sector investments and mainly being at most answerable, secure and fair policy framework. The Gross Domestic Product (GDP) is 10,472,807 Cr and the Economy of Tamil Nadu is in 23<sup>rd</sup> Position in terms of GDP growth of 14.22% in India as per 2014. A Multi Attribute Decision Making (MADM) methods is one among the finest technical assistance for extensive planning of utilities and applied to have priority in distributed energy technologies and among MADM, AHP and VIKOR method are used. AHP is used to solve the distribution energy planning with uncertainties to prioritize according to operational and technical, economical, environmental and social attributes. The respective attributes are split into different sub-attributes and the preference of all attributes using the AHP method and VIKOR method is carried out to regulate the preference of each attribute for final decision making among the zones of Tamil Nadu. Thus an active access to the decision of the best energy technologies is done and divided them into six different zones.

## II. PROPOSED STRATEGIC FRAMEWORK

In this paper, an approach to Distributed energy sources are planned based on Operation and Technical, Economic, Environmental and social attributes are presented. Operation and Technical Attributes is a major attribute in conditions of system performance and Economical attributes are very essential for concluding cost of energy formed by certain technology where various aspects of sub-attributes are being associated with main attributes. To obtain the relevant choice of sources in different districts of Tamil Nadu, pairwise observations are made among sources, considering each sub attribute and pairwise observations are built between sub attributes in regard to the main attribute. During pairwise observation, weights are assigned for the interest, the privilege attributes or the sub attributes.

In the process of decision making, it is rather challenging to provide perfect numeral values for Operation and Technical, Economical, Environmental and social attributes. Thus, for these types of task, the AHP method is considered which is having both quantitative and qualitative criteria and VIKOR method are used for process of decision making . The decision making framework subsists of three attributes as presented in Fig. 1.

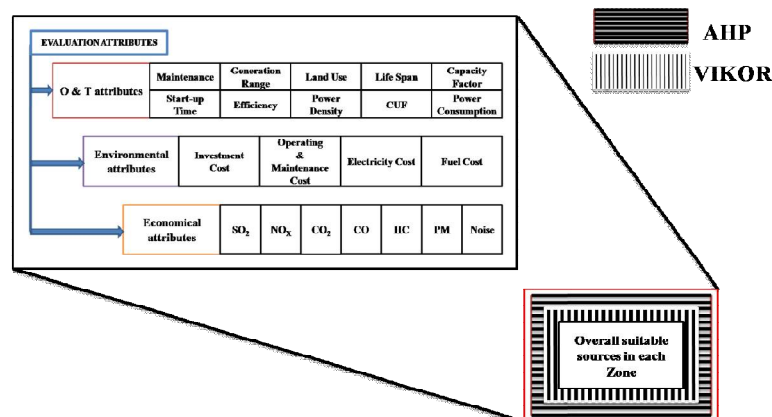


Figure.1 Flow diagram for DG planning in different districts of Andhra Pradesh

## III. EVALUATION ATTRIBUTES

### A. Operation and Technical attributes

Distributed energy has prominent in generating capacity in order to develop the scope in the current power system and various factors to be considered for integration of new distribution energy installations among them *Operation and Technical* should be analyzed and they will represent the specific applicability of various distribution systems confide in different considerations. Installation time is also major factors that are defined as the overall time required for installing the technology which includes setup and run time. However, all distribution systems have the skill in operating and controlling.

### B. Economical attributes

It plays a major role in any investment and it depends on many factors like basic investments, fuel tariff etc. Investment cost covers the primary and installation costs for integrating and the extent of fuel utilization of renewable sources will be less when compared to existing energy systems. While analyzing distribution system of a particular zone all the three constituents have to be considered.

### C. Environmental attributes

The increased consumption of fossil fuel margins for a hike, mixture of noxious gases, thus the attributes were considered sub-attributes as SO<sub>2</sub>, NOX, CO<sub>2</sub>, CO, HC, PM and Noise pollution. The economic advancement and growth in population are leading terms of statistical issues in Tamil Nadu being the abandoned increase of urbanization, extension and the huge growth of agriculture. World's most populated cities Chennai was one among them.

**D. Social attributes**

The Social aspects are very important in dealing the distributed energy sources for a long period between them acceptability of sources at regional, area and work establishment plays a major role in having hiked in energy sources. State Tamil Nadu like having different Operation and Technical, Economic and Environmental attributes should also have a social aspect which will lead to have a good selection and increase in distributed energy sources

**IV. ENERGY TECHNOLOGIES**

**A. Solar PV (SPV)**

Solar energy is the incandescent light and heat from the sun and the sun strap using a range of ever emerging technologies [4]. Solar farms are already installed at potential area like Sivagangai District (5 MW grid) and total installed capacity in the State by July, 2014 is 109.26 MW are running efficiently as per the distributed loads.

**B. Wind Turbine (WT)**

Wind energy depends on the potentials of wind present in places among them Muppandal wind farm as the total capacity of 1500MW, which is the largest in India. The total installed capacity is 7253MW as per Tamil Nadu Energy Development Agency (TEDA).

**C. Fuel Cell (FC)**

Tamil Nadu seeks prominent providers and strong that have the core ability in power generation and many Research and development of metal hydride storage is ongoing strengthen to set up and have many valuable aspects of power production, including huge potential efficiencies, no losses in performance when it is operating at any load.

**D. Diesel engine (DE)**

Among non-renewable choice, diesel engines have high potential, prevailing and preferred due to their excellent propelled and higher thermal efficiency in TamilNadu.

**E. Gas Turbine (GT)**

Gas turbines are at a gallop enhancing popular worldwide as it is mechanized by natural gas with many units which can meet the power demand. Natural gas bids the favor of hike in global efficiency of generation. The state has installed capacity of 3,925 MW and is producing just about 500 MW.

**F. Biomass (BM)**

Biomass mainly generates by the process of gasification, steam turbines and are generally listed as solid biomass, liquid biofuels and biogas among them biogas being the largely used for limited and off-grid applications, rural and bulk of gasifiers are provided for individual households.

**G. Micro-Turbines (MT)**

Micro-turbine units have a rated output that may vary between 30 kW to 400 kW. The most common configuration for a micro-turbine is a single-shaft machine having high rotational speeds that may vary between 50'000 and 120'000 RPM, depending on the specific capacity of the micro-turbine. This high-frequency output must first be rectified and then converted to the nominal 50 Hz.

**V. ANALYTIC HIERARCHY PROCESS (AHP)**

The Multi-attribute decision making (MADM) way is one among the well enough technical aids for critical planning and it electable the finest resource approach with a view to the chosen attributes [8, 9]. Identifying the principle and the alternatives and arranged in order form the pairwise estimation matrix. It is required for valuation of weights for reasoning principle and a similarity of target/option i and j handle a rate  $b_{ij}$ , explained in Table 1. Further, if  $b_{ij} = k$ , then  $b_{ji} = 1/k$  [10, 11].

Considering a problem to compute  $m$  option with  $n$  attributes, the pairwise observation of various targets has been shown in Table 2.

The corresponding weights can be figured out as normalized analytical means of the rows and geometrical mean is

figured out using 
$$h_i = \frac{1}{n} \sqrt[n]{\prod_{j=1}^n b_{ij}} \quad (1)$$

TABLE 1: Pairwise observation matrix of objectives

1	Objectives i and j are of equal importance
3	Objective i is weakly more important than j
5	Objective i is strongly more important than j
7	Objective i is very strongly more important than j
9	Objective i is extremely more important than j
2,4,6,8	Intermediate

TABLE 2: Pairwise observation matrix of objectives

	obj <sub>1</sub>	obj <sub>2</sub>	...	obj <sub>n</sub>	Priority
obj <sub>1</sub>	b <sub>11</sub>	b <sub>12</sub>	...	b <sub>1n</sub>	p <sub>1</sub>
obj <sub>2</sub>	b <sub>21</sub>	b <sub>22</sub>	...	b <sub>2n</sub>	p <sub>2</sub>
.	.	.	.	.	.
.	.	.	.	.	.
obj <sub>n</sub>	b <sub>n1</sub>	b <sub>n2</sub>	...	b <sub>nn</sub>	p <sub>n</sub>

TABLE 3: Random INDEX (RI) FOR NUMBER OF OBJECTIVES

1	2	3	4	5	6	7	8	9	10
0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

The priority of the *i*th attributes is obtained as  $p_i = \frac{h_i}{\sum_{i=1}^n h_i}$  (2)

Similarly, the pairwise objective matrix is made for attributes with respect to each objective and with *m* attributes for the *k*<sup>th</sup> objective, the preference of the *i*th attributes is obtained as  $h_{ki} = \sqrt[m]{\prod_{j=1}^m b_{kij}}$  (3)  $p_{ki} = \frac{h_{ki}}{\sum_{i=1}^m h_{ki}}$

(4)

The overall priority of the *m*th attributes were obtained as  $p_m = \sum_{i=1}^n \sum_{k=1}^n p_i p_{km}$  (5)

In the last step of the process, priorities are determined for individual and values represent the alternatives ability to attain the goal.

## V. VLSE KRITERIJUMSKA OPTIMIZACIJA KOMPROMISNO RESENJE (VIKOR)

VIKOR is a feasible in order to have the optimal solution and faculty of adjustment is consent attain by mutual benefits. For the estimation of VIKOR attributes, following steps have to be done:

**Step 1:** Determine objective and analyze the aspect values for individual alternative.

**Step 2:** Development of matrix pattern, the row of the matrix is set aside to single alternative and individual column to unit aspect and decision matrix is expressed as:

$$D = \begin{bmatrix} x_{11} & x_{12} & x_{13} & \dots & x_{1n} \\ x_{21} & x_{22} & x_{23} & \dots & x_{2n} \\ x_{31} & x_{32} & x_{33} & \dots & x_{3n} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ x_{m1} & x_{m2} & x_{m3} & \dots & x_{mn} \end{bmatrix} \quad (6)$$

**Step 3:** Develop the normalized matrix for decision using equation (6) with formula  $X_{ij}^* = \frac{X_{ij}}{\sum_{i=1}^n X_{ij}}$  (7)

**Step 4:** Confide in the corresponding attention of different attribute attains weight for every aspect using equation (8) which should be below and sum must be 1 and the variance (*V<sub>j</sub>*) of individual aspect is determined using  $W_j = \frac{V_j}{\sum_{j=1}^m V_j}$  &  $\sum_{j=1}^m w_j = 1$  (8)  $V_j = (\frac{1}{n}) \sum_{i=1}^n (X_{ij}^* - (X_{ij}^*)_{mean})^2$  (9)

**Step 5:** Collect the values of the criterion function for all the alternative *f<sub>ij</sub>*, *f<sub>ij</sub>* is the *j*th norm of different *X<sub>i</sub>*.

**Step 6:** Collect the maximum norm  $f_i^*$  and the minimum norm  $f_i^-$

$$f_j^* = \max_i f_{ij} = \max [ (f_{ij}) | i = 1, 2, \dots, n ] \quad (10a)$$

$$f_j^- = \min_i f_{ij} = \min [ (f_{ij}) | i = 1, 2, \dots, n ] \quad (10b)$$

**Step 7:** Calculate utility and regret for all alternatives using equations (11a) & (11b):

(a) Utility 
$$S_i = \frac{\sum_{j=1}^m w_j (f_j^* - f_{ij})}{f_j^* - f_j^-} \quad (11a)$$

(b) Regret 
$$R_i = \max_j [W_j (f_j^* - f_{ij}) / (f_j^* - f_j^-)] \quad (11b)$$

**Step 8:** Calculate the equivalent of VIKOR ratio for individual using 
$$Q_i = v \frac{S_i - S^*}{S^- - S^*} + (1 - v) \frac{(R_i - R^*)}{R^- - R^*} \quad (12)$$

$$S^* = \min_i S_i = \min [ (S_i) | i = 1, 2, \dots, n ] \quad S^- = \max_i S_i = \max [ (S_i) | i = 1, 2, \dots, n ] \quad (13 a), (13b)$$

$$R^* = \min_i R_i = \min [ (R_i) | i = 1, 2, \dots, n ] \quad R^- = \max_i R_i = \max [ (R_i) | i = 1, 2, \dots, n ] \quad (14 a), (14b)$$

v & 1-v are the weight for maximum value of all utility generally set to 0.5 and weight of the specific regret.

**Step 9:** Rank of the alternative is made using equation (12) in which less value demonstrates a superior quality

## VI. CASE STUDY: TAMILNADU

Tamil Nadu, the 11th Largest state in India covers 130058 sq.km(50,216 sq miles) and has a coastline of about 910 km (600 miles). It is 7th most populous state With a population of about 74,319,357 million, nearly 6 % of India's population. It is divided into 32 districts and climate ranges from dry sub-humid to semi-arid, but the state has the distribution of two monsoon seasons south-west monsoon from June to September and north east monsoon from October to December. This particular feature has helped Tamil Nadu to become a favored wind power destination because of monsoon winds contributes a bulk amount of annual wind power generation. The State of TamilNadu is rich in renewable energy sources, especially wind and solar. Currently, approximately one-fourth of renewable energy sources exist in TamilNadu only. The cost of Renewable Energy Source based generation is increasing with time because of price deviations and supply constraints. Different government agencies such as the energy department, TNEB, TEDA, State planning commission and TamilNadu electricity regulatory (TNERC) will develop technical, administrative and communication capacities. The capital required for increasing renewable sources capability advances, rise in funds.

Distribution energy system is a vast perception which consists of discrete technologies, although diesel/gas retaliante machines enclose most capacity installed and technologies include its different attributes such as operational and technical, economical, environmental, etc. Multi-attribute decision making approach is one of the perfect technical aids of electric utilities the objective is to present a comparative assessment designed at a certain interest for different technologies. Each criteria are split into several sub-criteria, and decision process is applied in order to represent a sensitive case is implemented to determine the importance of state regulations on final decisions which help decision makers and private investors in the development of distributed generation. In the current task, adequate way for decision of the perfect energy technologies according to operational and technical, economical, and environmental attributes, initially it involves the priority by consideration of different attributes using the AHP method and method of making a decision for every attribute using Topics simultaneously. This method is executed to determine the priority of individual attributes in order to make a final decision over various zones in Tamil Nadu.

The total installed generation capacity in TN is 20716.52 (MW\*\*) and different individual capacities: Tamil Nadu generates around 35% of India's total wind capacity. Now, Tamil Nadu has become a leader in Wind Power in India. On the Muppandal wind farm, Tamil Nadu the total capacity is 1500MW, which is the largest in India. As per TEDA, the total installed capacity in Tamil Nadu is 7253MW [5]. The state came up with an ambitious solar energy policy in 2012, with the goal of 3000 MW of solar power in Tamil Nadu by 2015 [6]. Gas in MW - 1,026.30, Diesel in MW - 411.66, Micro-Turbine in MW - 2,182.20, Biomass in MW - 38.20

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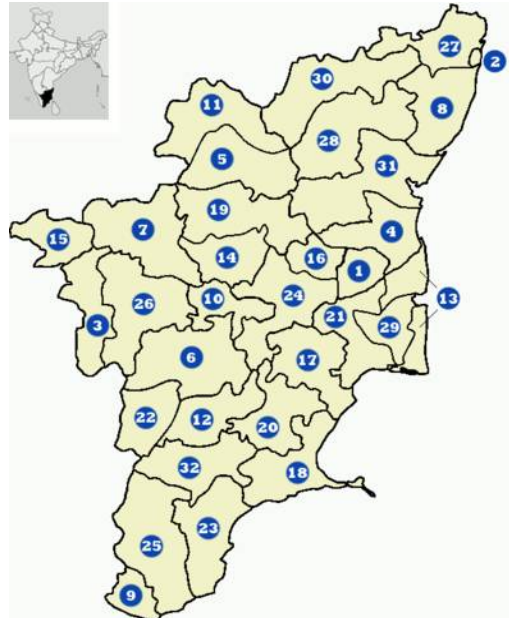


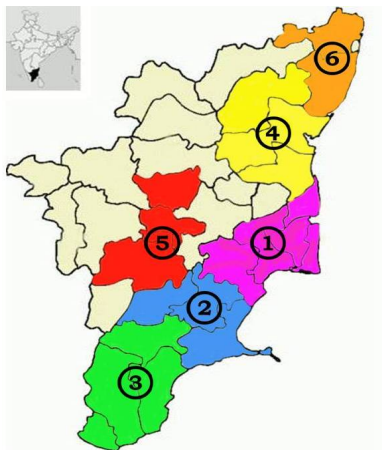
Figure.2 DistrictsFlow diagram for DG planning in different districts of Andhra Pradesh

Table 4: Districts with Potential of Distribution Energy Sources

S.No	District Name	No. on Map	SPV	WT	FC	DE	GT	BM	MT
1	Coimbatore	3	E	I	I	I	I	I	I
2	Cuddalore	4	I	G	I	I	I	I	G
3	Dindigul	6	I	I	G	I	I	G	I
4	Kanchipuram	8	E	I	I	G	I	I	I
5	kanyakumari	9	I	G	I	I	I	I	G
6	kanur	10	I	I	I	I	I	G	I
7	madhuri	12	I	G	I	I	I	G	G
8	Nagapattinam	13	I	E	I	I	G	I	G
9	Namakkal	14	I	I	I	I	I	G	I
10	pudukkottai	17	I	I	G	G	G	E	I
11	Rammanathapuram	18	I	I	I	I	G	E	G
12	Sivaganga	20	I	I	G	G	I	G	I
13	Thanjavur	21	I	I	I	I	G	E	G
14	Thoothukudi	23	I	G	I	I	I	E	I
15	Thirunelveli	25	I	E	I	I	I	I	G
16	Thiruvallur	27	I	G	I	I	I	I	I
17	Tiruvannamalai	28	G	I	I	I	I	I	I
18	Thiruvarur	29	I	I	G	I	E	E	I
19	Villupuram	31	I	I	I	G	I	I	I
20	Virudhunagar	32	I	G	I	I	I	G	I

SPV=Solar PV, WT=Wind Turbine, FC=Fuel Cell, DE=Diesel Engine, GT=Gas Turbine, BM=Biomass, MT=Micro-Turbine,  
E= Excellent, G= Good, I= Intermediate

Figure 2 represents districts present in Tamil Nadu state; Table 4 represents various potential districts with distribution energy sources. From Table 4 districts are combined by considering potential distributed sources and done with different zones as shown in Table 5 which are represented in Figure 3



**Figure 3: Geographical representation of different zones of electricity generation from DES in Tamil Nadu State**

**Table 5: Potential Zones of Combined Distribution Energy Sources**

Zones	No. on Map	SPV	WT	FC	DE	GT	BM	MT
Zone 1	13, 17, 21, 29	I	E	I	G	E	E	G
Zone 2	12, 18, 20	I	G	I	G	G	E	G
Zone 3	9,23,25,32	I	E	I	I	I	E	G
Zone 4	4,28,31	G	G	I	G	I	I	I
Zone 5	6,10,14	I	I	I	I	I	I	I
Zone 6	8,27	E	G	I	G	I	I	I

SPV=Solar PV, WT=Wind Turbine, FC=Fuel Cell, DE=Diesel Engine, GT=Gas Turbine, BM=Biomass, MT=Micro-Turbine,

E= Excellent, G= Good, I= Intermediate

Table 6 presents various Operational and technical attributes related to distributed energy sources. Similarly, the Economic and Environmental attributes of the distributed energy sources are presented in Tables 7 and 8 respectively. Table 9 presents various Social attributes of distribution Energy Sources which are considered as per the Operational and technical, Economic and Environmental attributes at different zones of the state. The data from these tables have been utilized to perform pairwise comparisons and determine right preferences among various distributed energy sources in which it is illustrated by states of High, Medium and Low. High is used for the regions those have enormous and sufficient amount of resources but not enormous. Medium state is used for regions in which the resources are available in medium quantity. Low state is used for regions lacking the amount of a particular resource.

**Table: 6 Operational and Technical attributes of Distribution Energy Sources**

Energy technologies	Maintenance (hr/yr)	Generation range	Land use (kW/m <sup>2</sup> )	Life Span	Capacity Factor (%)	Start-up time	Efficiency (%)	power density	CUF
SPV	20	17	0.02	20	20	0	40	25	22
WT	40	20	0.01	30	17	9	60	40	25
F C	35	50	10	30	10	10	45	150	35
DE	25	25	9	45	12	11	30	100	30
GT	45	55	12	55	15	11	50	200	60
BM	15	65	15	10	8	9	20	35	50
MT	42	35	5	5	9	4	50	20	40

SPV=Solar PV, WT=Wind Turbine, FC=Fuel Cell, DE=Diesel Engine, GT=Gas Turbine, BM=Biomass, MT=Micro-Turbine,

**Table: 7 Economical attributes of Distribution Energy Sources**

Energy technologies	IC	O & M	EC	FCT
SPV	6000	0.02	0.3	0
WT	2500	0.033	0.08	0
FC	3500	0.01	0.09	0.2
DE	300	0.01	0.12	0.06
GT	750	0.015	0.15	0.05
BM	1500	0.017	0.11	0.03
MT	3500	0.04	0.09	0.15

SPV=Solar PV, WT=Wind Turbine, FC=Fuel Cell, DE=Diesel Engine, GT=Gas Turbine, BM=Biomass, MT=Micro-Turbine,

IC=Investment Cost, O&M=Operational & Maintenance Cost, EC=Electricity Cost, FCT=Fuel Cost

**Table: 8 Environmental attributes of Distribution Energy Sources**

Energy technologies	SO2	NOX	CO2	CO	HC	PM	Noise
SPV	0	0	0	0	0	0	0
WT	0	0	0	0	0	0	60
FC	0.026	0.03	650	0.014	0.35	0	45
DE	15	12	670	5.7	1.7	0.4	70
GT	0.7	1	435	0.12	0.5	0.01	80
BM	0.5	0.85	40	0.08	0.2	0.02	35
MT	0.3	0.04	15	0.15	0.35	0	40

**Table: 9 Social attributes of Distribution Energy Sources**

Energy technologies	SA	RE	WE
SPV	High	High	High
WT	Low	Medium	Medium
FC	High	Medium	High
DE	Low	High	Medium
GT	Low	Medium	Medium
BM	Medium	High	Low
MT	Low	Medium	Low

SC=Social Acceptability, RE=Resource availability, WE=Work establishment

For finding the best technologies in terms of Operational and technical attributes, initial pairwise comparisons are made between sources with respect to each sub attributes by considering the data of Table 10 then pairwise comparisons are formed between energy sources on the subject of maintenance based on the data given in Table 11. Similarly, Table 12 presents the pairwise relation of sub-attributes with respect to the economical attributes and pairwise relations of sub-attributes with respect to the Investment Cost are done as presented in Table 13



**TABLE 10** Pairwise comparison of sub-attributes with respect to Operational and technical attributes

	Maintenance	Generation range	Land use	Life Span	Capacity Factor	Start-up time	Efficiency	Power density	CUF
Maintenance	1	3	4	7	5	2	3	6	4
Generation range	1/3	1	2	5	3	1/2	5	4	2
Land use	1/4	1/2	1	4	2	1/3	1/2	3	1/3
Life Span	1/7	1/5	1/4	1	1/3	1/6	1/3	1/2	1/4
Capacity Factor	1/5	1/3	1/2	3	1	1/4	1/3	2	1/2
Start-up time	1/2	2	3	6	4	1	2	5	3
Efficiency	1/3	1/5	2	3	3	1/2	1	4	1/2
Power density	1/6	1/4	1/3	2	1/2	1/5	1/4	1	1/3
CUF	1/4	1/2	3	4	2	1/3	2	3	1

**TABLE 11** Pairwise comparison of sub-attributes with respect to Maintenance attributes

	Maintenance	Generation range	Land use	Life Span	Capacity Factor	Start-up time	Efficiency	Power density	CUF
Maintenance	1	3	4	7	5	2	3	6	4
Generation range	1/3	1	2	5	3	1/2	5	4	2
Land use	1/4	1/2	1	4	2	1/3	1/2	3	1/3
Life Span	1/7	1/5	1/4	1	1/3	1/6	1/3	1/2	1/4
Capacity Factor	1/5	1/3	1/2	3	1	1/4	1/3	2	1/2
Start-up time	1/2	2	3	6	4	1	2	5	3
Efficiency	1/3	1/5	2	3	3	1/2	1	4	1/2
Power density	1/6	1/4	1/3	2	1/2	1/5	1/4	1	1/3
CUF	1/4	1/2	3	4	2	1/3	2	3	1

**TABLE 12: Pairwise relation of sub-attributes with respect to the economical attributes**

	IC	O & M	EC	FCT
IC	1	2	5	4
O&M	1/2	1	3	6
EC	1/5	1/3	1	2
FCT	1/4	1/6	1/2	1

IC=Investment Cost, O&M=Operational & Maintenance Cost, EC=Electricity Cost, FCT=Fuel Cost

**TABLE 13: Pairwise relation of sub-attributes with respect to Investment Cost**

	IC	O & M	EC	FCT
IC	1	2	5	4
O&M	1/2	1	3	6
EC	1/5	1/3	1	2
FCT	1/4	1/6	1/2	1

Similarly, Table 14 &15 presents the pairwise relation of sub-attributes with respect to the environmental and social attributes based on the collected information; weights are selected to different sources on subject to discrete sub-attributes related to above mentioned attributes from the AHP method are given to TOPSIS method and the priority to various energy technologies with respect to different kinds of sub-attributes obtained.

**TABLE 14: Pairwise comparison of sub-attributes with respect to the environmental attributes**

	SO2	NOX	CO2	CO	HC	PM	Noise
SO2	1	2	1/3	1/2	1/4	1/5	3
NOX	1/2	1	1/2	1/3	1/5	1/6	2
CO2	3	2	1	2	1/2	1/3	5
CO	2	3	1/2	1	1/3	1/4	4
HC	4	5	2	3	1	1/2	6
PM	5	6	3	4	2	1	7
Noise	1/3	1/2	1/5	1/4	1/6	1/7	1

**TABLE 15: Pairwise relation of sub-attributes with respect to the Social attributes**

	SA	RE	WE
SA	1	2	5
RE	1/2	1	3
WE	1/5	1/3	1

SC=Social Acceptability, RE=Resource availability, WE=Work establishment

**About tables**

**TABLE 12 Priority of various DG technologies and sub-attributes with respect to operational and technical aspects**

ET	M	GR	LU	LS	CF	ST	E	PD	CUF
SPV	0.225532037	0.153352	0.000834	0.232889	0.554061	0	0.343947	0.090476	0.210394
WT	0.451064075	0.180415	0.000417	0.349334	0.470952	0.394676	0.51592	0.144762	0.239084
FC	0.394681065	0.451037	0.417029	0.349334	0.277031	0.438529	0.38694	0.542859	0.334718
DE	0.281915047	0.225518	0.375326	0.524	0.332437	0.482382	0.25796	0.361906	0.286901
GT	0.507447084	0.49614	0.500434	0.640445	0.415546	0.482382	0.429934	0.723811	0.573802
BM	0.169149028	0.586348	0.625543	0.116445	0.221625	0.394676	0.171973	0.126667	0.478168
MT	0.473617279	0.315726	0.208514	0.058222	0.249328	0.175412	0.429934	0.072381	0.382534

ET=Energy Technologies, SPV=Solar PV, WT=Wind Turbine, FC=Fuel Cell, DE=Diesel Engine, GT=Gas Turbine, BM=Biomass, MT=Micro-Turbine, M=Maintenance (hr/yr), GR=Generation range, LU=Land Use (kW/m<sup>2</sup>), LS=Life Span, CF=Capacity Factor, ST=Startup time, E= Efficiency, PD=Power density, P=Priority

**TABLE 12 Priority of various DG technologies and sub-attributes with respect to economical aspects**

ET	IC	O & M	EC	FCT
SPV	0.718923857	0.324314848	0.746277893	0
WT	0.299551607	0.5351195	0.199007438	0
FC	0.41937225	0.162157424	0.223883368	0.758643242
DE	0.035946193	0.162157424	0.298511157	0.227592973
GT	0.089865482	0.243236136	0.373138946	0.18966081
BM	0.179730964	0.275667621	0.273635227	0.113796486
MT	0.41937225	0.648629697	0.223883368	0.568982431

ET=Energy Technologies, SPV=Solar PV, WT=Wind Turbine, FC=Fuel Cell, DE=Diesel Engine, GT=Gas Turbine, BM=Biomass, MT=Micro-Turbine, IC=Investment Cost, O&M=Operational & Maintenance Cost, EC=Electricity Cost, FCT=Fuel Cost, P=Priority

#### About Zones

Land usage contributes various socioeconomic benefits, but usually appears at significant cost for the environment. Despite major economic costs will be estimated into decisions with land use, maximum environmental levels are not. These environmental level matters diversities among different costs for a few land uses which are prominent to an ineffective land allocation. For example, Planners may not take all the infrastructural and environmental payment generated by their projects. Province yields the pair of open area and agricultural commodities. Although labors will be rewarded for the assets they produce and are not allowed to be refunded for the free zone. Private dependence and nonprofit systems will have more important preference in land conservation.

The Operation of locally based, long-term maintenance and management suggestions has been promoted as a demanding aspect in attaining smart growth. The enticement based way has discrete choice in the explicit land usage control. In the position where the human and natural procedures collaborate in a complex manner, brink and nonlinear act are feasible to continue and the environmental expenditures will have hike and tricky to further development of zoning would be favorable. The administration challenge is to recognize when the scheme among neighborhood of alike brink. A few regional authorities have made rules and other done with outlining and regulation of new distributed energy sources. All regulation is an antagonistic problem in more associations, specifically which are facing more particularly those facing expeditious urbanization and many proponents argue are made to increase in planning protests and the increment of property expenses. Conversely, undisciplined development will wipe out the essential environment, social attributes and long term economic growth. Critics of new distributed energy sources, supervision command those anxieties disproportionate . They disagree that development of urban is a formal market case that apportions new distributed energy sources, and authority favour to up the regulation because they hardly take the regulation cost. A few policy quotas that desires at control of development in urban areas will ultimately changes the basic aspect of the Tamil Nadu. Policymakers must prevent the appealing for aspects for all irregular distributed energy sources, arrangements to market decline and appoint demanding settlements that may block the activities function of market strengths. Policymakers should crack to determine the energy sources for market decline that cause the desirable development and location complication at their background. A new distributed energy sources, management must drive equity between public private activity and worth.

#### VII. CONCLUSION

This paper presents a model for selecting various distributed energy technologies in different districts (regions) of Tamil Nadu based on operational and technical, economical, and environmental aspects. Investments in distributed energy have the potential to reach the huge increasing demand with a competing environment which encourages lowest cost. The selection of attributes and their weights are done and model has been tested and analyzed in six zones of Tamil Nadu. The proposed model may be helpful for policy makers, electricity generating companies for optimal allocation of their budget in investments and State electricity planners to devise a plan for various DG

technologies in each of the regions of Tamil Nadu. The model developed is stretched to hold the changes in the weight as per the needs and circumstances of attributes.

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