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Effective structure system tactic for important references for applying Renewable Energy policies in the Indian context

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ABSTRACT
Traditional fuels such as coal, wood, cow dung, petroleum, and others were used as a source of Energy for various tasks such as food preparation, illumination, and heating for a long time. Other places of the world have these conventional fossil fuels. The usage of Energy, in any form, is critical for every country's progress. India, like China, is a developing country with abundant energy resources. According to a new analysis, conventional resources would be depleted shortly. As a result, to meet the current demand for Energy from industry and home needs, one must choose an alternative or substitute for energy supplies. Renewable energy sources can be used to power both homes and businesses. At the policy and planning stages, this would necessitate planning and strategy for well-organized, sustainable, and justifiable renewable energy systems. Complex and plural existence would require a structural blueprint to reduce the complexity and difficulty involved. The goal of this project is to develop an efficient structural system for the utilization of renewable energy.

Keywords - Energy Systems, Interpretive Structural Model, Renewable Energy Sources, Structural Self Interaction Matrix.

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I. INTRODUCTION

Energy is essential for human survival. It is general knowledge that Energy is used in some way or another in all parts of existence. It is the most critical aspect of human consumption. Before 1973, oil was readily available at low prices, and most countries that required it were unconcerned about its supply. The age of safe and affordable oil came to an end in 1973. Egypt and Syria declared war on Israel in October 1973. In history, this conflict is known as the Yom-Kipper war.

The Arab delegation of the Organization of Petroleum Exporting Countries (OPEC) was enraged by this and replied by imposing an embargo on oil sales to the United Kingdom, United States, Canada, Japan, and the Netherlands. The prohibition shook the oil market and caused a supply deficit. Although embargoed countries were able to obtain oil from corporations that sold it to them from other sources, the widespread uncertainty caused prices to skyrocket. As a result, governments in capitalist economies began to consider alternative energy sources [1, 2].

Energy comes in a variety of forms, some of which are non-renewable and others that are renewable. Cow dung, coal, petroleum, nuclear power, and wood are examples of non-renewable energy sources. Solar, wind, and other energy sources are examples of renewable [3]. Human race has been using these energy resources from ages. Energy is employed in a variety of circumstances, including industries, residences, government offices, and nearly every aspect of existence. Since the power demand is growing day by day, there is a lot of pressure to supply energy with only these resources. This requirement can be fulfilled only by renewable energy sources [4].

India is not immune to a similar dilemma. Since the demand for Energy has increased over time, India has added various power sources such as hydropower facilities, thermal power plants, and nuclear power plants to meet the demand on a huge scale after independence [5]. The United States has a substantial edge in transitioning toward renewable Energy since its capacity for generating this energy is vast. According to recent research, the country's solar power capacity exceeds 10,000 GW, even though its wind power potential surpasses 2,000 GW.

In 2013, the NITI Aayog (India's erstwhile Planning Commission) began evaluation of the opportunities and obstacles for the fast deployment of renewable energies in the nation, conducted with the participation of stakeholders. The Initiative team was comprised of representatives from the Confederation for Indian Industries (CII), the Shakti Sustainable Federation (SSEF), and the Regulation Assistance Program (RAP).

The Initiative team conducted a stakeholder-driven exercise to address the issue of how the Indian power system must alter if India decides to place renewable energy (RE) at the center of the future system rather than at the periphery. The Steering Committee guided the initiative team [6][7].

In February 2015, the Initiative Team released its report, including a Roadmap Document that offered strategic interventions to help India meet its lofty renewable energy targets of 175 GW by 2022. It determined that new policies, programmers, and operational regulations are needed to get power from generation to end-users at reasonable pricing.

As a result, NITI Aayog agreed to assist states in accomplishing their goals. Although the government was already considering many of the Document's recommendations: For example, the draught RE law—the necessity for more synergy amongst state efforts to achieve India's 175 GW target is now under consideration, it was vital to emphasize the need of looked there at renewable energy industry as a whole to achieve long-term development. The achievements included the development of States Action Plans (SAPs) in nine Indian states as well as the gathering of many stakeholders to work together to achieve India's renewable energy goals on a common platform [8].

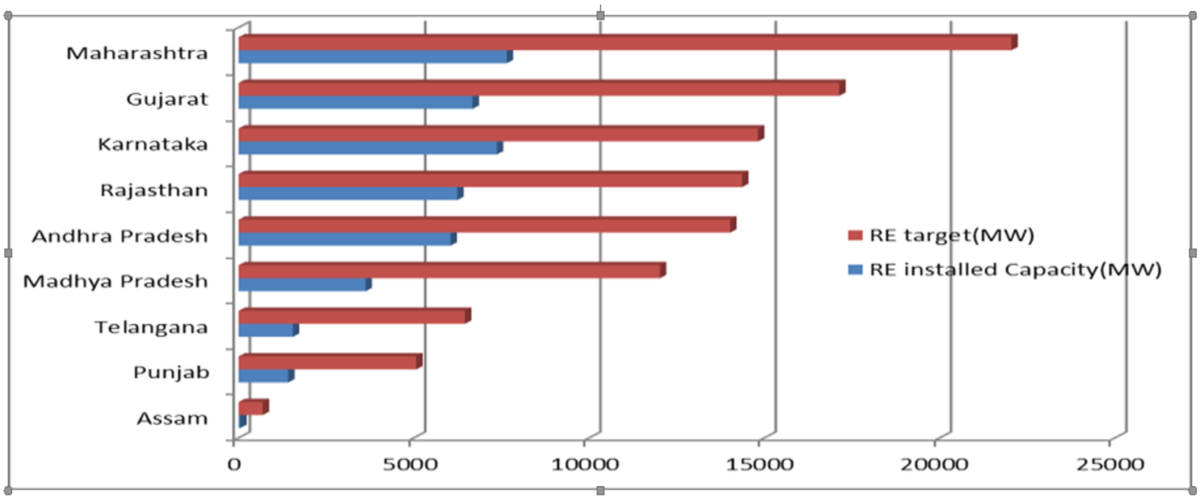

Fig.1 RE Target versus RE Installed Capacity

II. LITERATURE REVIEW

India's Renewable Power Roadmap 2030 discovered that new legislation and programmers would be implemented, and operational norms were required to enable renewable Energy from the generation point to the loads to assure fairness.

State Renewable Energy Capacity Addition Roadmap presented several proposals to assist states in expanding their renewable electricity capacity on a broad scale [9].

Many researchers have used ISM in such situations since the problem is complex and ambiguous. The following are a few examples of how these strategies can be used.

Bana et al., (2019) [10] utilized a wide range of environmental variables that affect the production of renewable energy. As ANN models have shown to be a useful tool, there have been several noteworthy contributions employing ANN models, all of which pertain to the real-time assessment of asset dependability and energy production, but for different goals. Each energy source is analyzed in detail, to provide readers with an overall picture of its relevance and recognize the potential of these methodologies for future dependability evaluation.

ISM was used by Nishi Kant Mishra et al. (2017) [11] to examine a customer-centric beef supply chain, and they used an extensive data methodology. Kuldip Arun Rade, Vilas A. Pharande, and R. Saini (2017) [12] suggested ISM recover thermal energy. Building energy performance gaps were studied using an interpretative structural modeling technique, which was designed and used to identify the most important components and examine their interconnections.

A research report by Rajesh Attri et al. (2017) [13] demonstrated numerous steps for using Interpretive Structural Modelling. The ISM-MICMAC analysis found that effective top management contribution, education and training, the establishment of role and responsibility, integration with organizational goals, assimilation with performance improvement methods, proper implementation strategy, and economic ability is the key critical success factors (CSFs). Vishal Kumar Bhosale and Ravi Kant (2016) [14] used the ISM fuzzy MICMAC technique to model the supply chain knowledge flow enablers. To overcome the implementation difficulties of electronic governance in Iran, Mehdi Anjali and colleagues (2016) [15] adopted a Fuzzy ISM approach. A.K. Dig Alwar et al. (2015) [16] used ISM to help India grow its electric vehicle market. The development of the electric vehicle market in India is influenced by a variety of variables. An Interpretive Structural Model (ISM) is used in this paper to highlight the most important aspects for the growth and promotion of the Electrical vehicle (EV) industry in India. Soham Chakraborty (2015) et al. [17] used the ISM method to assess sustainability challenges in Assam's tea industry. Consequently, stakeholders are prompted to take action to promote sustainability on a bigger and more improvised scale by the findings of the research. Mohammad Hussain et al. (2015) [18] used an ISM-ANP integrated framework to evaluate sustainable supply chain management strategies. This study's findings illustrate the importance of government laws, incentives, and listening to consumer feedback in ensuring sustainable supply chains.

Rachit Kumar Verma (2014) [19] used ISM and Topics to pick suppliers in the manufacturing industry. Therefore, the suggested approach is aimed at the Indian firework sector in the southern region of the country. Purchasing managers may use this research to discover the most important factor in selecting a supplier based on CSF.

As a result, these strategies can be utilized to reduce the complexity and ambiguity of large-scale renewable energy deployment in both resource-rich and resource-deficient states.

III. MOTIVATION AND OBJECTIVE

Significant elements and huge interrelationships make systems complex and hazy. The system's complexity and ambiguity make it difficult for academics and policymakers to grasp it fast. As a result, a structural template is required for clarity in a given situation. Interpretive Structural Modeling (ISM) is one of the techniques used to solve such issues. As a result, the scope of this project has been confined to the following goals.

To create the Hierarchical Structural Model, essential factors must be identified. The goal is to create an Interpretive Structural Model (ISM) for strategic planning in a given setting.

3.1 Identify critical variables to develop a hierarchical model

Indian renewable energy production has enormous potential on a massive scale, and the country is well-positioned to capitalize on this opportunity. It is necessary to investigate a wide range of inputs from secondary sources to identify components for the large-scale installation of renewable power.

Various factors for resource-rich and deficit states were advocated in State Renewable Capacity Addition. The system is complex and ambiguous due to the vast number of components.

Since there are significant elements, these elements were collected, edited, integrated, and key-worded from both resource-rich and resource-deficient nations into small groups to remove the complexity and ambiguity.

To determine the number of components needed for this objective, a workshop was held, and many academic specialists participated. The participation of business and government entities resulted in the identification of twelve important aspects. These are given in Table 1.

Table 1 Code, Description, and Keywords of Policy Elements

S. No.	Code	Description	Keyword	Remarks
1.	I1	Establishing regulatory standards for an independent renewable energy trading platform, strengthening incentive framework, and addressing operational challenges.	Regulatory Norms	Merged with Gj1,GJ6, Gj8,Gj9
2.	I2	Trading of renewable energy certificates (RECs) or trade between multiple clients seamlessly and efficiently Reciprocal energy credits (RECs) are a nationwide market mechanism developed by the Central Electricity Regulatory Commission (CERC)and other agencies.	Trading of RECs	Merged with GJ6,
3.	I3	The establishment of auxiliary markets to pool excess renewable energy resources to avoid shut down the situation by developing a clear policy framework to procure RE from resource-rich states	Create ancillary market	Merged with PJ2, MP6, AS1
4.	I4	Achieve a more equitable distribution of renewable energy (RE) resources amongst states with excess and deficit resources.	Enable states to trade and balance RE targets	Merged with MH8, AS1
5.	I5	Set up RE local distribution centers (LDCs) at central and regional levels and real-time monitoring of RE generation.	Set up RE LDCs	Merged with GJ2, GJ3,MH4, MH9,RJ1, RJ2, AS6, PJ1
6.	I6	Develop Predictive modeling methods to decrease mistakes in scheduling and real generating and assist states both technically and financially	Develop forecasting tools	Merged with GJ4, MH5, RJ3
7.	I7	Ensure compliance with renewable purchase obligation (RPO) targets for various states.	Compliance with RPO targets	
8.	I8	Provide financial support to states from various agencies.	Provide financial support to states	
9.	I9	Create a regional advisory structure to support and advise regulators in the coordination of their activities.	Create a regional advisory mechanism	
10.	I10	Provide states with financial incentives for attaining RPO objectives.	Create incentive plans	Merged with AP2, TEL 4, KAR2
11.	I11	Central agencies like NVVN, NTPC, and SECI would purchase extra renewable energy and distribute it to states that are in a renewable energy shortage.	Buy excess REpower	AP5
12.	I12	Engage public sector undertakings (PSUs) for procuring REpower.	Engage PSUs for procuring REpower	MP2

13.	I13	Incorporate green energy and avoid the development of excess capacity; governments should evaluate the expansion of conventional sources of energy in the future.	Prevent surplus capacity addition	AP4
14.	I14	The development of dispersed solar projects is being carried out via innovative Business models.	Develop solar projects	Merged GJ8, RJ9
15.	I15	Rapidly implementation of Renewable Generation Obligation (RGO).	Implement RGO rapidly	Merged GJ10, MH 11
16.	I16	Encourage to harness REpower in the tea sector	Harness RE potential in tea sector	AS4
17.	I17	Focus on developing central transmission utility (CTU)-connected renewable energy projects to facilitate the selling of renewable energy across state lines.	Develop CTU connected RE projects	Merged with GJ5, MH6, RJ4
18.	I18	Develop the solar-wind hybrid policy for encouraging investment.	Develop solar-wind hybrid policy	Merged with RJ8, MH1
19.	I19	Focus on RE storage technology that would require subsidy support from the government.	Focus on RE storage technology	Merged with TEL5, AP 1, KAR1, PJ4
20.	I20	Encourage the use of solar irrigation by introducing new and creative methods.	Promote solar irrigation	RJ7

To reduce complexity, a further convergence process has been utilized using the Nominal Group Technique (NGT). The opinion often identified experts were sought to rank these elements on a priority basis, and a cut-off level was decided. Triggering question was posed before them to prioritize each aspect based on weights assigned to each priority. The weighted sum for each element based on an opinion of experts was obtained and the one who bore maximum weight was placed at first rank.

Table 2 Ranking of Elements

Elements no.	**I (5)**	**II (4)**	**III (3)**	**IV (2)**	**V (1)**	**Weighted sum**	**Rank**
3.	2	2	-	1	-	20	1st
2.	2	1	1	1	-	19	2nd
1.	2	-	2	-	1	17	3rd
4.	-	3	1	1	-	17	3rd
6.	-	2	2	1	-	16	4th
9.	-	2	1	2	-	15	5th
7.	-	-	3	1	-	11	6th
12.	1	1	-	-	1	10	7th
8.	-	2	-	-	1	9	8th
11.	-	-	2	1	-	8	9th
10.	1	-	-	1	-	7	10th
5.	-	-	-	1	1	3	11th
14.	-	-	-	-	1	1	12th
16.	-	-	-	-	1	1	12th
19.	-	-	-	-	1	1	12th
13.	-	-	-	-	-	0	-
15.	-	-	-	-	-	0	-

17.	-	-	-	-	-	0	-
18.	-	-	-	-	-	0	-
20.	-	-	-	-	-	0	-

The experts believed that elements with a weighted sum of less than 3 should be deleted for developing the needed structure. All twelve elements have, therefore, been considered. These elements with their keywords are given in Table 3.

Table 3 Selected Descriptive Key Policy Elements for Renewable Energy System

S. No.	Keywords	Rank
1	Regulating norms	III
2	Trading of RECs	II
3	Create ancillary market	I
4	Enable states to trade as well as balance their renewable energy objectives	IV
5	Organize RE LDCs into a system.	VI
6	Develop World class forecasting tools	IX
7	Ensure compliance of RPO targets	VII
8	Provide financial support to states	XII
9	Create regional advisory mechanism	VIII
10	Create incentive plan	XI
11	Buy excess RE power	X
12	Engage PSUs for procuring RE power	V

3.2 Interpretive Structural Model (ISM) for strategic planning

Warfield firstly developed interpretive structural modeling in 1973. ISM helps to build relationships among elements of large systems. ISM transforms complex, unclear systems models into well-defined models that can be used for different processes. Warfield developed the method of ISM. It has been applied in many applications by various researchers. Interpretive structural modeling includes 'element set' and 'contextual relationship'. Many researchers have used ISM in their research [11, 12]. The contextual relation should essentially be transitive. The contextual relation 'Affects' has been used to develop the structure in the present work. ISM involves utilizing the power of graph theory and matrix algebra to go through Model Exchange Isomorphism to convert Mental Model to ISM through Structural Self Interaction Matrix (SSIM), Reachability Matrix, Lower Triangular Matrix, and Minimum Edge Adjacency Matrix for the pre-identified key policy elements.

3.2.1. Interpretive Structural Model (ISM) for strategic planning

The knowledge for developing SSIM has been acquired symbolically in terms of V, A, X, and O with the help of domain experts after discussion and consensus where these symbols have the following interpretation christened as rules as given below:

Rule 1: If element i has an effect on element j, but element j has no effect on element i then V should be used.

Rule 2: If element j affects element I but the element I do not affect element j, then put A.

Rule 3: If both elements i and j affect each other, put X.

Rule 4: If no elements affect each other, then put O.

Following the above exercise for the identified twelve elements, the SSIM has been developed in Table 4.

Table 4 Structural Self-Interaction Matrix

Regulating norms	A	A	A	V	V	A	A	V	V	V	V	1.
Trading of RECs	A	O	A	V	O	A	A	V	V	V	2.	
Create ancillary market	O	O	A	O	O	A	A	V	V	3.		
Enable states to trade and balance RE targets	A	A	A	V	O	A	A	V	4.			
Set up RE LDCs	A	A	O	A	A	A	A	5.				
Develop World-class forecasting tools	O	A	O	O	O	O	6.					
Ensure compliance of RPO targets	A	A	V	V	V	7.						
Provide financial support to states	O	O	A	O	8.							
Create regional advisory mechanism	O	O	O	9.								
Create incentive plan	A	O	10.									
Buy excess REpower	V	11.										
Engage PSUs for procuring REpower	12.											

3.2.2 Reachability matrix

To transform the SSIM's symbols V, A, X, and O into a reachability matrix, the numbers 0 and 1 are substituted for the letters V, A, X, and O, respectively, according to the following principles.

Rule 1: Replace SV by putting 1 in (i, j)th entry and o in (j, i)th entry Rule 2: Replace A by Putting 1 in (j, j)th entry and 0 in (i, j)th entry Rule 3: Replace X by Putting 1 in (i, j)th entry and 1 in (j, i)th entry Rule 4: Replace O by Putting 0 in (i, j)th entry and o in (j, i)th entry. The reachability matrix obtained is shown in Table 5.

Table 5 Reachability Matrix

Elements	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Driving Power**
1	1	1	1	1	1	0	0	1	1	0	0	0	7
2	0	1	1	1	1	0	0	0	1	0	0	0	5
3	0	0	1	1	1	0	0	0	0	0	0	0	3
4	0	0	0	1	1	0	0	0	1	0	0	0	3
5	0	0	0	0	1	0	0	0	0	0	0	0	1
6	1	1	1	1	1	1	0	0	0	0	0	0	6
7	1	1	1	1	1	0	1	1	1	1	0	1	10
8	0	0	0	0	1	0	0	1	0	0	0	0	2
9	0	0	0	0	1	0	0	0	1	0	0	0	2
10	1	1	1	1	0	0	0	1	0	1	0	0	6
11	1	0	0	1	1	1	1	0	0	0	1	1	7
12	1	1	0	1	1	0	0	0	0	1	0	1	6
Dependence Power	6	6	6	9	11	2	2	4	5	3	1	3	58

3.2.3 Partitioning of reachability matrix

The reachability matrix is used to determine the reachability sect or antecedent set, which are then used to indicate the degree of each element.

An element is at top level element if R(pi) = R(pi) ∩A(pi).

Table 6 shows the first iteration. Ten levels have thus been identified after consecutive iterations by eliminating the identified top element from the previous list in terms of reachability and precedence set. The levels that have been discovered are given in Table 7.

Table 6 Iteration one

S.no.	Reachability set R(pi)	Antecedent Set A(pi)	Intersection R(pi)∩A(pi)	Level
1.	1,2,3,4,5,8,9	1,6,7,10,11,12	1	
2.	2,3,4,5,9	1,2,6,7,10,12	2	
3.	3,4,5	1,2,3,6,7,10	3	
4.	4,5,9	1,2,3,4,6,7,10,11,12	4	
5.	5	1,2,3,4,5,6,7,8,9,11,12	5	I
6.	1,2,3,4,5,6	6,11	6	
7.	1,2,3,4,5,7,8,9,10,12	7,11	7	
8.	5,8	1,7,8,10	8	
9.	5,9	1,2,4,7,9	9	
10	1,2,3,4,8,10	7,10,12	10	
11	1,4,5,6,7,11,12	11	11	
12	1,2,4,5,10,12	7,11,12	12	

Table 7 Elements with their Identified Level

Level no.	Elements
1st	Set up RE LDCs (5)
2nd	Create regional advisory mechanism (9), provide financial support to states (8)
3rd	Trade and balance RE targets (4)
4th	Create ancillary market (3)
5th	Trading of RECs (2)
6th	Regulating norms (1)
7th	Handholding states to develop World-class forecasting tools (6) create incentive plan (10)
8th	Engage PSUs for procuring RE power (12)
9th	Ensure compliance of RPO targets (7)
10th	Buy excess RE power (11)

Table 8 Bottom Level Element

Elements No.	Reachability Set R(pi)	Antecedent Set A(pi)	Intersection R(pi)∩A(pi)	Level
1.	1,2,3,4,5,8,9	1,6,7,10,11,12	1	
2.	2,3,4,5,9	1,2,6,7,10,12	2	
3.	3,4,5	1,2,3,6,7,10	3	
4.	4,5,9	1,2,3,4,6,7,10,1 1,12	4	
5.	5	1,2,3,4,5,6,7,8, 9,11,12	5	
6.	1,2,3,4,5,6	6,11	6	
7.	1,2,3,4,5,7,8,9, 10,12	7,11	7	
8.	5,8	1,7,8,10	8	
9.	5,9	1,2,4,7,9	9	

10.	1,2,3,4,8,10	7,10,12	10	
11.	1,4,5,6,7,11,12	11	11	Bottom level element
12.	1,2,4,5,10,12	7,11,12	12	

3.2.4 Bottom level Element

An element is at bottom level if A (pi) = R (pi) ∩A (pi).

Element No 11 is the bottom-level element in the present problem. Finally, lower triangularization and structural models have been developed, presented in Table 9 and Figure 2.

Table 9 Lower Triangular Matrix

S. No.	**5**	**8**	**9**	**4**	**3**	**2**	**1**	**6**	**10**	**12**	**7**	**11**
5	1	0	0	0	0	0	0	0	0	0	0	0
8	1	1	0	0	0	0	0	0	0	0	0	0
9	1	0	1	0	0	0	0	0	0	0	0	0
4	1	0	1	1	0	0	0	0	0	0	0	0
3	1	0	0	1	1	0	0	0	0	0	0	0
2	1	0	1	1	1	1	0	0	0	0	0	0
1	1	1	1	1	1	1	1	0	0	0	0	0
6	1	0	0	1	1	1	1	1	0	0	0	0
10	0	1	0	1	1	1	1	0	1	0	0	0
12	1	0	0	1	0	1	1	0	1	1	0	0
7	1	1	1	1	1	1	1	0	1	1	1	0
11	1	0	0	1	0	0	1	1	0	1	1	1

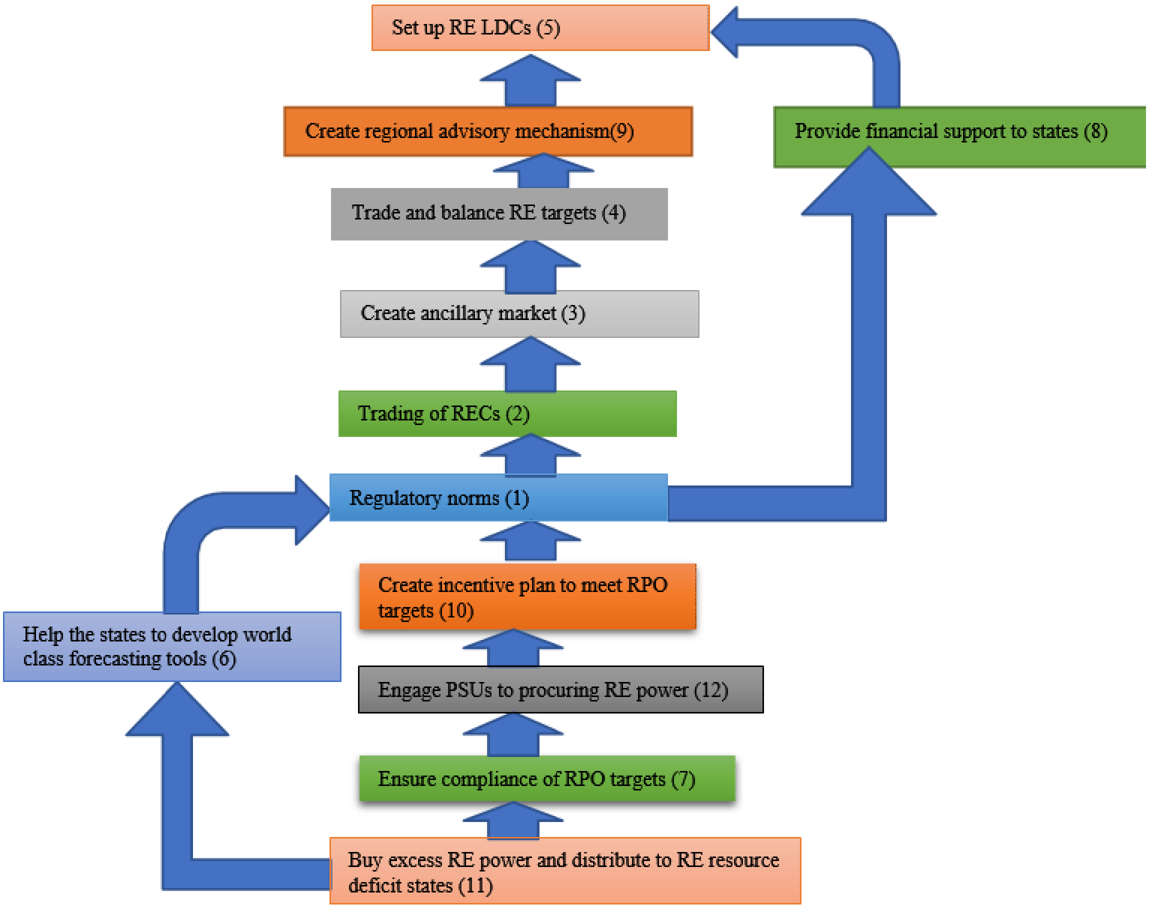

Fig. 2 Interpretive Structural Model

IV. MICMAC ANALYSIS

The complete form of MICMAC [20] is Matriced Impacts Croises-Multiplication Applique and Classement (cross-impact matrix multiplication applied to classification). In an Interpretive Structural Model (ISM) model, the relationship found are tested by the MICMAC analysis process. Elements are classified into four categories, as seen in Table 10, depending on their propelling and dependency power.

(i) Autonomous Elements: Elements in the first quadrant come in this category. These elements have weak dependence power and weak driving power. Seven parts (2, 3, 6, 8, 9, 10, and 12) are lying in this category.

(ii) Dependent Elements: Elements in the second quadrant come in this category. These components have a high degree of reliance power but a low degree of driving power. This category has just one element in this sector, which is number four.

(iii) Linkage Elements in the third quadrant come in this category. They have a lot of propulsion and a lot of dependency on each other. No element is lying in this category.

(iv) Independent Elements in the fourth quadrant come in this category. They have a lot of propulsion and a lot of dependency on each other. The three elements (1, 7, and 11) are lying in this category.

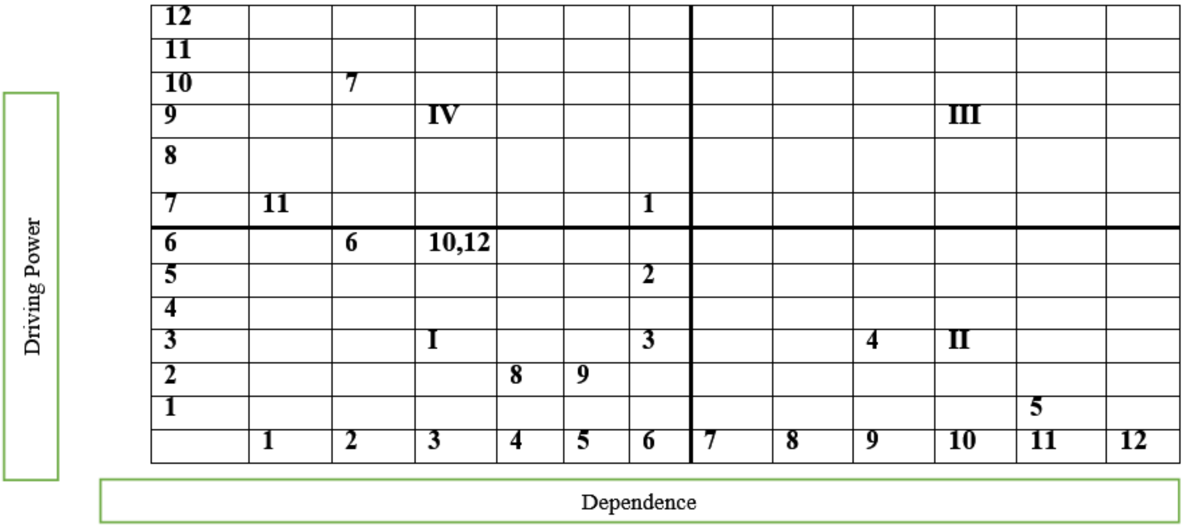

Fig. 3 Micmac analysis

V. CONCLUSION AND RECOMMENDATION

The developed ISM model reveals the following significant observations that can be considered a conclusive synopsis for applying renewable energy policies in the Indian context.

1. Elements Trading of RECs, creating an ancillary market, Develop World-class forecasting tools, providing financial support to states, creating regional advisory mechanism, creating incentive plan, and Engaging PSUs for procuring REpower have weak dependence power and weak driving power. Element Enable states to trade and balance RE targets have strong-weak driving power and dependence power. Elements (Regulating norms, ensuring compliance of RPO targets, and Buying excess REpower have weak dependence power and strong driving power.

2. The rapid deployment of RE with sustainability at a large scale can be achieved by putting in place RE LDCs (Element No. 5) at both the central and regional levels to help in power balancing across the nation that could be achieved by creating regional advisory mechanisms (Element No. 9) and providing financial support to states (Element No. 8). This would require enabling both the resource-rich and resource-deficit states to trade and balance them RE targets (Element No. 4), creating an ancillary market (Element No. 3) for pooling the REpower and trading of RECs (Element No. 2).

3. It is evident from the developed structure that Devising Regulatory Norms for Buying access REpower and Distribute it to RE resources Deficit State (Element No. 11). States must develop World Class Forecasting Tools (6), which would provide Financial Support to States (Element No 8). However, parallelly regulatory norms would require compliance of RPO Targets followed by the Engagement of PSUs for Procuring RE Power (Element No. 12) to Create an Incentive Plan to Meet RPO Targets (Element No.10).

4. It is clear from the structure that to achieve the aim of setting RE LDC's (Element No. 5), Regulatory Norms (Element No. 5), Trading of REC (Element No. 2), Create Ancillary Market (Element No. 3), Trade and Balance of RE targets (Element No. 4) are respectively action level elements in increasing level of hierarchy.

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