2020 IEEE PES/IAS PowerAfrica

Developing an Environmental Decision Making Model for Optimal Solar and Wind Energy Utilization

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***Abstract*—Energy plays a prominent role in human society. As a result of technological and industrial development, the demand for energy is rapidly increasing. Existing power sources that are mainly non-renewables are leaving an unacceptable legacy of waste and pollution apart from diminishing stock of fuels. This problem has led to emergence of Solar and Wind Energy Technology which is considered to be free and clean to the environment. As a matter of fact, this statement is false and therefore, it is important to investigate the environmental impacts of these two sources of energy for optimal utilization. A model is developed to aid in decision making on social, health, ecosystem and emission impacts. This model uses Modified ReCiPe and PowerSizing models on MATLAB. The simulated results show that solar PV causes Ozone depletion by 30.15% while wind reduces it by 81.86%. The user friendly decisions are made from the EEDMM chart.**

***Index Terms*—EEDMM, Environmental Impacts, PowerSizing Model, ReCiPe Model, Solar and Wind Energy**

I. INTRODUCTION

A. EEDMM Introduction

Decision-making model is a mathematical model that helps the experts make decisions on the optimal utilization of wind and solar sources of energy. This is possible by considering variety of impacts by ranking, prioritizing, and choosing from several given options. Technological advancements have led to the availability of myriad decision-making tools. Decision-Making model should support the process, not being used as the dominant force; it should free experts to adjust their focus into just implementation of the technical details, of the method employed in making of the decision, such as focusing on the fundamental value of judgments.

Wind and Solar energies, if used conveniently, can provide adequate energy for many uses without environmental exploitation. These sources of energy have both long term and short term effects to the environment. These effects include social, health, ecosystem and emission levels. Economic and Environmental Decision Making Model (EEDMM) considers the following mid-point indicators to achieve end-point scores: Ozone depletion (H1), Human toxicity (H2), Ionization radiation (H3), Particulate matter formation (H4), Photochemical oxidation formation (H5), Climate change (H6), Terrestrial acidification (E1), Terrestrial eco-toxicity (E2), Marine/freshwater eco-toxicity (E3), Marine/freshwater eutrophication (E4), Land occupation (E5) and Land transformation (E6). In additions to these indicators, EEDMM also makes decisions on the level of CO_2, SO_2 and NO_x emissions from both solar and wind sources of energy.

This model gathers all these input parameters and finally makes decisions whether or not the wind/solar project is invalid, recommended or highly recommended. The decisions made here can assist experts in implementation process in order to save the environment for current and future generations.

ReCiPe (life cycle assessment model) is modified for environmental concerns while PowerSizing model is helping in determination of the initial cost of investment of a project.

B. Contribution

Many other decision making tools for renewable energy have not collectively made judgments on social, health, ecosystems and emission levels for both solar and wind sources of energy. Many experts have continued implementing wind/solar projects by assuming that these energies are free and clean. This proposed model tends to make decisions based on the outlined impacts for optimal utilization of the energies in order to save current and future generations against exploitations of natural resources and surroundings.

II. LITERATURE REVIEW

Benson O. Ojwang, et al [1] proposed a Social Impact on Investment Decision Making Tool (SIIDMT) for wind and solar energy sources with resource cost as constraint. The authors used PowerSizing model to determine the initial cost of investment in which this cost depended on the optimum power sizing exponential, of wind and solar, of 0.45 and 0.15 respectively for optimum cost. The paper found that there is no direct impact of this cost on the probability of the project outcome. For valid social impacts, SIIDMT should be over 50% which gives a probability of not less than 75%. In terms of philanthropic investment level, the authors recommend that the cost should not be less than 90% of the initial cost of the project. This paper, however, did not consider other impact indicators. Thus the effects of health, ecosystem and emissions on environment were not reported.

Moses Peter Musau, et al (2017) [2] proposed an Environmental Decision Making Tool for Renewable Energy (EDMTRE) with the resources cost as constraints. The authors used the midpoint indicators of the Modified ReCiPe version 1.3 model to indicate the negative environmental impacts while the more accurate cubic cost function was used to model the positive impacts on health and ecosystem. In addition to health and ecosystem, the proposed research also looked into reduction of emission. It was concluded

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that, with resource cost as a constraint, the determination of optimal environmental benefits is accurate. The findings indicate that the adverse effects of wind are four times less than those of solar. However, no research has been done on resource cost using the end-point indicator and no social aspect has been considered in the development of EDMTRE.

Table 1 shows some of the selected reviewed tools on decision making on health, ecosystem and emissions for solar and wind energy sources.

The possible gaps, from table 1, clearly indicate that there is need to have a very robust tool for making decisions on solar and wind energy sources based on the impacts they have on the environment. This paper only proposes a mathematical model for decision making.

III. PROBLEM FORMULATION

Formulation starts by the decision on the possible initial cost of investment for a new solar/wind project. This formulation considers variable cost (labor, direct materials) and fixed cost (capital equipment cost).

$$\mathrm{ICOI}-\mathrm{WS}_{\mathrm{new}}=\frac{\mathrm{CI}_{\mathrm{t}}}{\mathrm{CI}_{\mathrm{n}}}\left(\frac{\mathrm{AR}_{\mathrm{new}}}{\mathrm{AR}_{\mathrm{exist}}}\right)^{\mathrm{x}}\mathrm{ICOI}-\mathrm{WS}_{\mathrm{exist}} \qquad (1)$$

Where, $\mathrm{ICOI}-\mathrm{WS}_{\mathrm{new}}$ is the optimized new resource cost ($) for wind and/or solar PV, CI_{t} is cost index value today, CI_{n} is the cost index value n years ago, $\mathrm{AR}_{\mathrm{new}}$ is the amount of new resources (kWp), $\mathrm{AR}_{\mathrm{exist}}$ is the amount of existing resources (kWp), $\mathrm{x}=[0\ 1]$ is the PowerSizing exponent provided by resource manufacturer and $\mathrm{ICOI}-\mathrm{WS}_{\mathrm{exist}}$ is the estimated existing resource cost. This equation (1) is modified from PowerSizing Model.

With this cost in place, we can therefore go ahead and make decisions on social impacts on investment as formulated in [1]. This model identifies the effectiveness of capital and other resources utilization of a project towards creating value for the community in terms of environmental, social and economic impacts. In measuring the social impacts on investment, the following elements were considered; cost of resources invested ($\mathrm{ICOI}-\mathrm{WS}_{\mathrm{new}}$), project outputs ($P_O$), that is, final products including trained human resource within the community, outcomes in terms of improved standards of living or new jobs created within the community and net impact to the community resulting from the project.

$$SIIDMMOU=\frac{SIV-(\mathrm{ICOI}-\mathrm{WS}_{\mathrm{new}})}{(\mathrm{ICOI}-\mathrm{WS}_{\mathrm{new}})}\,X\,100\% \qquad (2)$$

Where $SIIDMMOU$ is the social impact on investment (%) and SIV is the social impact value given by equation (3).

$$SIV=\frac{P_O X P\{P_O\} X P_I}{P_C} \qquad (3)$$

With P_O being project outcome ($), $P\{P_O\}$is the probability of the project outcome, P_I is the philanthropic investment ($) and P_C is the project total cost ($).

After making decisions on the social impacts on investment, we then model health and ecosystem model for optimal utilization of these energies. This is formulated in [2] as:

$$HEDMMOU=Ce(E_i) \qquad (4)$$

Where $HEDMMOU$ is the Health and Ecosystem Decision Making Model for the environment, C is the characterization factor and $e(E_i)$ is the environmental impact based on stressor matrix S, that is,

$$e(E_i)=S(E_i) \qquad (5)$$

The next step is to make decision on the emission levels. An objective function for minimization of emissions is formulated in [2] as:

$$E(P_{j,3})=\alpha_{3,j}P_{t,j}^{3}+\alpha_{2,j}P_{t,j}^{2}+\alpha_{1,j}P_{t,j}^{1}+\alpha_{0,j}+\gamma_{3,j}e^{(\lambda_{3,j}\ \ P_j)}+\gamma_{2,j} \qquad (6)$$

In which $E(P_{j,3})$ = EMII (Emissions Minimization Impact Index) in tones per hour.

Table 1: Review of Tools and the Gaps

Ref	Tool	Content	Possible Gaps
[4]	Homer Energy	• Designing, modeling and analysis of renewable energy systems by considering wind speed, solar irradiation and load profile. • Optimization of renewable energy system based on the lowest TNPC	• Only considers CO_2 emissions in its analysis of RE systems • Does not consider social impacts directly • Does not consider health impacts directly
[4]	ETAP®	• Monitoring, controlling and optimization of the performance of power generation and transmission using a suite of programs. • Evaluation of real time data for reliability, security and performance of an electrical system. • Checking and controlling of the environmental emission levels for electrical systems. • Forecasting of load and planning of power generation schedule.	• The model does not address the social impacts of RE directly. • ETAP® does not make decisions on health impacts due to RE systems.
[5]	GTAP	• Calculating the amount of energy and carbon emissions based on fuel usage.	• No health impact is optimized by the tool
[6] [7]	LCC	• Looking for effectiveness of energy consumption efficiency and reduction of CO_2 emissions.	• Only considers economic impacts of a project. No social and health impacts are tackled directly. • Considers only CO_2 emissions which are not the only emissions in the ecosystem.
[8]	WASP	• Finding the optimal generation capacity of various methods of power being employed to find the optimal generation capacity accounting for fuel availability constraint. • Optimization tool for energy generation planning. • Time placing environmental emissions like CO2 in its centrality for the reduction.	• The tool does not directly address the social and health impacts caused by the solar and wind energies.

The cost implication of EMII can be computed using environmental cost factor. $\gamma_{3,j}$, $\gamma_{2,j}$ and $\lambda_{3,j}$ are factors of emission as result of ramping effect of the jth unit whereas $\alpha_{0,j}$, $\alpha_{1,j}$, $\alpha_{2,j}$ and $\alpha_{3,j}$ are the coefficients of the emissions of the j^{th} unit. CO_2, NO_X and SO_2 are the 3 main emissions that are factored.

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OEFCCSW objective function is formulated as:

$$\text{OEFCCSW} = E\left(P_{j,3}\right) = \sum_{j=1}^{L} E\left(P_{1,t,s}, P_{2,s,t}, P_{3,t,s}\right) \quad (7)$$

Where L= total number of renewable energy sources (solar PV and wind) and thermal

$$L = PV + W + T \quad (8)$$

In which PV =number of solar generators, W= number of wind turbines and T = number of thermal generators in the power system.

Objective function

Finally, this model is formulated, EEDMMM, (from equations (1), (2), (4) and (7)) by minimizing the overall objective function as:

$$minimize\left\{\left[\left[(1 - SIIDMMOU) + Ce(E_i)\right] + hE\left(P_{j,3}\right)\right] + \beta(\text{ICOI} - \text{WS}_{\text{new}})\right\} \quad (9)$$

Where h is the negative and positive impacts' weighting factor for solar and wind renewable whereas β is the weighting factor on the resource cost function in relation to the environmental impacts.

Subject to:

$$0 < SIIDMMOU \leq SIIDMMOU^{max} \quad (10)$$

$$\text{ICOI} - \text{WS}_{\text{new}} \geq \text{ICOI} - \text{WS}_{\text{exist}} \text{ if } CI_t > CI_n \text{ for } \text{AR}_{\text{new}} \geq \text{AR}_{\text{exist}} \quad (11)$$

$$\beta(\text{ICOI} - \text{WS}_{\text{new}}) \leq EEDMM \leq \{\beta(\text{ICOI} - \text{WS}_{\text{new}}) + SIIDMMOU_{min} + Ce(E_i)_{max} + hE\left(P_{j,3}\right)_{max}\} \quad (12)$$

IV. METHODS

Modified ReCiPe 1.3 mid-point indicators are used to get the end-point scores for the environmental impacts from solar and wind.

Modified ReCiPe 1.3

ReCiPe is one of the available life cycle assessment models. A life cycle assessment refers to the factual assessing of the life span of equipment through its useful years in terms of sustainability. It looks at the inputs and outputs of the equipment as well as the effect of social and economic decisions to the life of infrastructure. The aspects considered are production, distribution, operation and the disposal at the end of useful life. Phases of LCA are [9] – [12]:

i. Goal and Scope – defines reasons for executing LCA, determines the scope and then defines the product and operation boundaries.
ii. Inventory Analysis – defines the environmental inputs and outputs such as energy and raw materials emitted as well as the waste streams.
iii. Impact Assessment – Here the environmental impact is determined.
iv. Interpretation – The conclusions are well substantiated and shared with decision makers for the final decision to be made.

Midpoint level characterization

At this level characterization is done using equation (13) [10]:

$$I_m = \sum_j Q_{m,j} m_j \quad (13)$$

Where I_m *is* the indicator outcome for category *m* midpoint impact, $Q_{m,j}$ the factor of characterization which links intervention *j* with category *m* midpoint impact and m_j is the magnitude of intervention.

Endpoint level characterization

At this level, there are 2 ways in obtaining characterization. The first one involves intervention devoid of intermediate points [11] and is calculated as:

$$I_e = \sum_j Q_{e,j} m_j \quad (14)$$

Where I_e *is* the indicator outcome for category *e* endpoint impact, $Q_{e,j}$ is the factor of characterization which links intervention *j* with category *e* midpoint impact and m_j the magnitude of interventionQ_{ei}.

The 2nd way starts from the intermediate midpoints [11]. The formula is:

$$I_e = \sum_{im} Q_{eim} m_{im} \quad (15)$$

Where m_{im} *is* the indicator outcome for category *im* midpoint impact, Q_{eim} is the factor of characterization which links category *im* midpoint impact with category *e* endpoint impact and I_e is the indicator outcome for category *e* endpoint impact.

The inputs for this ReCiPe model are raw materials used, land used, and waste materials such as VOS (Value of Solar), CFCs, PAH (Polycyclic Aromatic Hydrocarbon), cadmium(Cd) , phenyl (P) and emissions from combustion of fuel such as CO_2, NO_2 and SO_2 [11].

V. RESULTS AND ANALYSIS

A 2.5MW size of solar and wind projects were considered to aid in the determination of the new initial cost of investment of solar/wind project. The results are shown in Table 2.

Table 2 shows that as the cost index ratio increases, the initial costs of investment also increase. Therefore, a better decision needs to be made on when the investment should be initiated. An elaborate decision making 3D graph is shown in Figure 1.

Table 2: 2.5MW Initial Cost of Investment

Source of Energy	ICOI-WSnew for CIR = 1	ICOI-WSnew for CIR = 1.04	ICOI-WSnew for CIR = 1.12
Solar	5.34617	5.56002	5.98771
Wind	5.59017	5.81378	6.26099

From Figures 1, the existing cost of investment increase, as the percentage changes remain slightly constant at 20%. This work, however, uses the results here to determine SIIDMOU as formulated in equation (2).

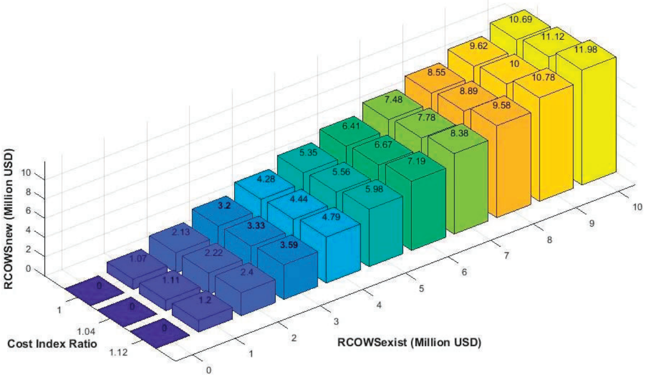

Figure 1: Plot of ICOI-WSnew versus ICOI-WSexist for varying Cost Index Ratios for Optimal Solar/Wind Utilization

As elaborate illustrations from [1], Table 3 illustrates the results for SIV and SIIDMOU for Solar Energy Project.

According to the decisions made based on social impacts like level of philanthropic investments, project outcome and total project cost, from Table 4, the SIIDMMOU is only valid when it is positive, that is, greater than 0. For instance, it was observed that the valid SIIDMMOU is reached upon when the probability outcomes are 0.72, 0.75 and 0.81 for cost index ratios 1, 1.04 and 1.12 respectively. The highest SIIDMMOU is 0.4 (the best) and the lowest is -1 (the worst) for a 2.5MW renewable energy project. After knowing the probability of project outcome, the decision is made and settles on the best probability project outcome.

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Table 3: Solar PV SIV and SIIDMOU

P(P_o)	CIR = 1		CIR = 1.04		CIR = 1.12	
	SIV (million USD)	SIIDMMOU	SIV (million USD)	SIIDMMOU	SIV (million USD)	SIIDMMOU
0	0	-1.0000	0	-1.0000	0	-1.0000
0.1	0.7412	-0.8614	0.7412	-0.8667	0.7412	-0.8762
0.2	1.4823	-0.7227	1.4823	-0.7334	1.4823	-0.7524
0.3	2.2235	-0.5841	2.2235	-0.6001	2.2235	-0.6287
0.4	2.9646	-0.4455	2.9646	-0.4668	2.9646	-0.5049
0.5	3.7058	-0.3068	3.7058	-0.3335	3.7058	-0.3811
0.6	4.4470	-0.1682	4.4470	-0.2002	4.4470	-0.2573
0.7	5.1881	-0.0296	5.1881	-0.0669	5.1881	-0.1335
0.8	5.9293	0.1091	5.9293	0.0664	5.9293	-0.0098
0.9	6.6704	0.2477	6.6704	0.1997	6.6704	0.1140
1.0	7.4416	0.3863	7.4416	0.3330	7.4416	0.2378

Once this decision is reached upon, the Social Impact Value (in million USD) is determined. This equates the social impacts to monetary value. This assists investors to allocate optimum costs for social responsibilities of a project to the community – both direct and indirect responsibilities. When valid SIIDMMOU is ignored, there would be lack of employment opportunities, displacement of the local community and poor infrastructural development.

Once the decision on SIV has been made, there is need to investigate Health and Ecosystem Impacts. Here, Modified ReCiPe 1.3 with mid-point indicators is used to determine the end-point results.

Health Impacts

Table 4 shows the end-point results for different health mid-point indicators. Thermal has been used as a conventional energy source. The mid-point indicators for Human Health that were considered include: H1 – Ozone depletion, H2 - Human Toxicity, H3 – Ionization Radiation, H4 – Particulate Matter Formation, H5 – Photochemical Oxidant formation and H6 – Climate change.

Table 4: Health Endpoint Scores

Midpoint Indicator	Endpoint Scores (kg/kWh)		
	Wind	Solar	Thermal
Ozone Depletion, H1	1.6059	6.1851	8.8549
Human Toxicity, H2	7.5389	27.8809	91.5034
Ionization Radiation, H3	50.3340	300.098	150.623
Particulate Matter Formation, H4	22.5611	39.5767	160.515
Photochemical Oxidation Formation, H5	3.0026	3.0082	3.7301
Climate Change, H6	2.0099	2.0016	2.3054

From Table 4, it is observed that the use of wind reduces H1 by 81.86% and use of Solar increases H1 by only 30.15%. From the ReCiPe model, ozone depletion is related to NO_x. Solar, in comparison to wind, has larger negative contribution to ozone depletion because of the Chemicals used in PV cells such as Nitrogen trifluoride and sulfur hexafluoride that are used in the production of the solar cells. Use of wind reduces H2 by 91.76% while Solar reduces H2 by 62.04%, and Hydropower reduces H2 by 69.53%. Human toxicity effects result from exposure to fine particles, tropospheric ozone and ionizing radiation. Wind reduces H3 by 66.58% and solar increases H3 by 99.24%. Wind reduces H4 by 85.94% as Solar reduces H4 by 75.34%. As in the case of global warming, solar has the highest negative contribution to particulate matter formation compared to. Wind reduces H5 by 19.50% while Solar reduces H5 by 19.35%. Generally, the deployment of RE reduces photochemical oxidant formation significantly. Wind reduces H6 by 12.82% while Solar reduces H6 by 13.17%.

Ecosystem Impacts

These impacts are shown in Table 5.

Table 5: Ecosystem Endpoint Scores

Midpoint Indicator	Endpoint Scores		
	Wind	Solar	Thermal
Terrestrial Acidification, E1	1.0053	1.1151	3.3055
Terrestrial Eco-toxicity, E2	0.0020	0.0044	0.0045
Marine/Freshwater Eco-toxicity, E3	1.2103	1.4659	4.0158
Marine/Freshwater Eutrophication, E4	1.0011	1.0029	1.3563
Land Occupation, E5	2.2634	2.9058	26.0159
Land Transformation, E6	2.6100	5.7400	17.3100

From Table 5, it is observed that wind reduces E1 by 69.58% while Solar reduces E1 by 66.26%. Terrestrial acidification is closely associated with SO_2. Of the two REs studied, solar has higher SO_2 emissions than wind. Wind reduces E2 by 55.56 and solar reduces it by 2.22%. Solar has higher negative contribution to terrestrial Eco-toxicity. Wind reduces E4 by 26.18% as opposed to solar which reduces E4 by 26.06%. Wind reduces E5 by 91.30% while solar by 88.83%. Land occupation encompasses both agricultural and urban land. The situation with land occupation sometime leads to eviction of people to pave way for the construction of these RES of Energies. There is Land degradation and habitat loss when large scale solar facilities are set up compared to wind sources of energy. Wind reduces E6 by 84.92% and solar reduces the land transformation by 66.83%.

Emissions

Table 6 shows optimized emissions from solar, wind and thermal sources of energy.

Table 6: Optimized Emissions from Thermal, Wind and Solar Energy Sources

Source	Main type of emission	75% Nominal Load (kg/kWh)		Nominal Load (kg/kWh)		125%Nominal Load (kg/kWh)	
Wind	Carcino genic	0.487		0.510		0.539	
Solar	Carcino genic	0.154		0.275		0.397	
Thermal	CO_2	0.9100	0.921	0.9167	0.941	0.9234	0.962
	SO_2	0.0069		0.0136		0.0204	
	NO_x	0.0042		0.0109		0.0177	

From Table 6, it can be observed that wind reduces the level of emissions from noise, dust, CO_2, SO_2 and NO_x by 47.19% for 75%NL, 45.80% for 100%NL and 43.97% for 125%NL cumulatively. Similarly, solar reduces the level of emissions by 83.25% for 75%NL, 70.79% for 100%NL and 58.74% for 125%NL. The trend shows that as the nominal load increases, the percentage emissions changes keep on decreasing although the overall level of emissions per unit energy will be increased.

Once the initial cost of investment is determined and the social impact on investment decision is made as well as the health and ecosystem impacts and emissions are analyzed, a decision is then made by optimizing all the considered factors together. Here the EEDMM comes to play.

EEDMM

The decisions are made based on whether the cost of investment is inadequate, adequate or too high, the social impact on investment is valid or invalid and whether or not the health and ecosystem impacts and emissions are favorable. The simulated results from the EEDMM are shown in Table 7. It can be observed that as the cost index ratios increase, the EEDMM is also increasing. This is due to the fact that the initial cost of investment will increase as well as Social Impact Value (SIV) which leads to higher project outcome.

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Table 7: EEDMM Results for 2.5MW RE with different Cost Index Ratios

Instances	CIRs		
	1	**1.04**	**1.12**
1	1.5000	1.5200	1.5600
2	41.0873	41.1327	41.2222
2	80.6746	80.7453	80.8843
4	120.2620	120.3580	120.5465
5	159.8493	159.9706	160.2087
6	199.4366	199.5833	199.8709
7	239.0239	239.1959	239.5330
8	278.6112	278.8086	279.1952
9	318.1986	318.4212	318.8574
10	357.7859	358.0339	358.5196
11	397.3732	397.6465	398.1817

Based on these, some decisions have to be made on the Social Impacts, Health Impacts, Ecosystem Impacts and Emissions for optimum conditions leading to overall decision on whether the project is invalid, recommended or highly recommended. These are summarized in Table 8.

Table 8: EEDMM Decisions based on the Output Results

EEDMM	**Social Impacts**	**Health Impacts**	**Ecosystem Impacts**	**Emissions**	**Resource Cost**	**Overall Decision**
0 – 100	Invalid	Unfavorable	Unfavorable	Unfavorable	Inadequate	Invalid Project
101 – 200	Invalid	Unfavorable	Unfavorable	Unfavorable	Adequate	Invalid Project
201 – 300	Invalid	Favorable	Favorable	Favorable	Adequate	Recommended
300 – 400	Valid	Slightly Favorable	Slightly Favorable	Favorable	Adequate	Highly recommended
>400	Valid	Unfavorable	Unfavorable	Unfavorable	Too high	Invalid Project

The results from Table 8 are represented as a chart in Figure 3. This chart is referred to as EEDMM chart that is useful to the end user for decision making once the output from EEDMM is known.

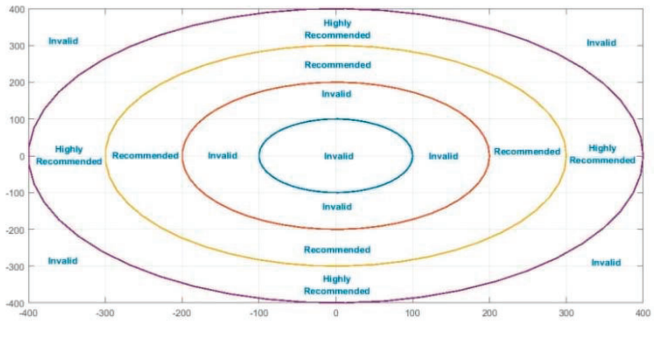

Figure 3: EEDMM Chart

VI. CONCLUSION AND FUTURE SUGGESTIONS

EEDMM has been formulated and the simulated results were validated with 2.5MW wind and solar PV capacity of energy. The Social Impact on Investment Decision Making Model for Optimal Utilization was made and concluded that SIIDMMOU is only valid when it is positive. For a 2.5MW plant capacity, at least a probability of project outcome above 0.72 is required. It is also concluded that during manufacturing, transportation, installation, operation and maintenance and decommissioning solar or wind plant, emissions are recorded which cause health and ecosystem effects. These also lead to increase in fuel costs. Hence, it proves that Solar and "*Wind Energy Sources are not clean and free".* For a constant energy generation, an increase in nominal load increases the emissions level but reduces a change in increase in emissions. Solar and Wind, however, reduce the level of emissions when compared to the conventional thermal energy. Based on the midpoint indicators for health, ecosystem, social and economics, EEDMM optimizes the endpoint scores in order to make decision on the validity of a project. The EEDMM chart is useful to the end user in decision making once the EEDMM output is known.

Further works need to be done from this proposed model to come up with a robust tool that could make decisions based on the environmental (health, ecosystem, social and emissions) and technical impacts besides economic impacts. Further modification of the ReCiPe version to include political aspects as an area of protection is proposed. This is because the decisions to set up the RE technologies is reliant on the country's development policies and approval of the relevant authorities.

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