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Development of sustainable energy indexes by the utilization of new indicators: A comparative study

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Abstract:

Decision making to improve energy sustainability requires scientifically information based on sustainability. Since there are different sustainability targets and specific decision problems in this regard, hence to achieve these targets or solve these problems, relevant sustainability indicators are needed. In this study, is investigated and developed a variety of applicable indicators to enhance sustainable energy development index (SEDI). Indeed, the main aim of this study is to present new effective indicators related to sustainable development goals, investigating the most important challenges related to energy sustainability. Additionally, this work is following to find the main gaps which are as obstacles in achieving energy sustainability for 12 different countries. For do this, firstly the required data from international energy agency (IEA) and world bank gathered and then is analyzed.

Keywords: Energy sustainability, Indicators, Sub-indicators, Normalization

Nomenclature

AE	Access electricity
AREE	Amount renewable energy in electricity production
CO2	CO2 Emission
EC	Energy conversion
EEX	Energy import
EIM	Energy export
ELC	Electricity consumption
GDP	Gross domestic product
LA	Land Area
LE	Loss energy
POP	Population
RIFR	Renewable internal freshwater resources
SEDI	Sustainable Energy Development Index
TCO2	Total CO2 Emission
TEP	Total energy production
TEPR	Total energy production from renewable energy
TFCBT	Total final consumption of Biofuel and waste consumption
TFCC	Total final consumption in commercial
TFCET	Total final consumption of electricity in transport
TFCI	Total final consumption in industry
TFCFT	Total final consumption of fossil fuel in transport
TFFP	Total fuel fossil production

TFCR	Total final consumption in residential
TFCRC	Total final consumption renewable energy commercial
TFCRR	Total final consumption renewable energy residential
TFCT	Total final consumption in transport
TREP	Total Renewable energy production
TPES	Total primary energy supply
Vact	Actual number of indicators
X	Actual number
Xmax	Maximum number of indicators
Xmin	Minimum number of indicators
WAP	Waste and Pollution
x	Array1
y	Array2

1. Introduction

Energy importance is not cover on any one and is a vital need to human, hence the ways of energy providing is also most important (Ali Razmjoo et al., 2017; Shirmohammadi, Gilani, & Energy, 2018). The affordable and adequate energy supply has a key role to economic development and progress for each country especially in industrial sector (Armin Razmjoo, Shirmohammadi, Davarpanah, Pourfayaz, & Aslani, 2019). One the other hand, energy is a significant factor to achieve sustainable development goals, because use of energy is necessary for economic, environment and social development (Sorrell, 2010). At present main way to providing energy is fossil fuels but in this sense two main problems global warming and air pollution that threatens human life and plant and these are creating by fossil fuels. Indeed, the main cause of these problems is

CO_2 issue that create by fuel fossils (Shirmohammadi, Soltanieh, Romeo, & Energy, 2018). To more prevent of extent this problems, move toward to sustainability is useful and effective (Srirangan, Akawi, Moo-Young, & Chou, 2012). Sustainability is a sophisticated subjects and needs to conceptual and analytical discussion and study. Concept of sustainability has means that existing needs can be removed without the need for future generations to meet their needs (Finkbeiner, Schau, Lehmann, & Traverso, 2010). To achieve sustainability moreover specific variety indicators, it requires also regular monitoring of the impacts of selected policies and strategies. One of most important things related to sustainability is measuring a country's state of development and to monitor its progress or lack of progress towards sustainability. For example, policymakers in each country should have full knowledge of their current state of energy and sustainability in order to help alleviate the problems and develop the country. They must also have a conscious and balanced choice in terms of sustainability indicators so that they can provide development and operation conditions for country (Moldan, Janoušková, & Hák, 2012). In this regard, it can be mentioned that policy decisions are important to implement effective measurements to achieve sustainable development over time (Hezri & Hasan, 2004). Thus, energy sustainability indicators can be used as a strong tool in hand of policymakers to assess the level of sustainability of different areas and energy sectors and activities (McCool & Stankey, 2004). Many works in this regard has been conducted. Kemmler A, investigated energy indicators for tracking sustainability. They showed that, energy indicators is not only used for environmental and economic issues, also it is used and related for social issues (Kemmler & Spreng, 2007). Razmjoo A et al, investigated the role of renewable energy to achieve energy sustainability. They with a study for a city of Iran showed that renewable energy has a remarkable effect for achieving sustainability in energy (Ali Razmjoo, Davarpanah, & Effects, 2019). Assessing rural energy sustainability has been carried out by Brijesh M et al, in

developing countries. According to this analysis china has highest rural energy sustainability index among these countries and South Africa's has sixth rank. This shows that one of the most important causes for progress of south Africa, is more access to electrical and renewable energy especially in rural area (Mainali, Pachauri, Rao, & Silveira, 2014). Terrapon-Pfaff, J et al with investigate different project done, shows that one of the ways to reduce poverty in developing countries, is more access to sustainable and affordable energy services. They also showed that long-term of small sustainable energy projects in developing countries, is an effective and important factor to improve quality of life for inhabitants these countries (Terrapon-Pfaff, Dienst, König, & Ortiz, 2014). An applied quantitative methods to evaluating Energy Sustainability Using the Pressure-State-Response as a Case Study in China has been done by S Li, et al. They in this study and in three main dimensions of energy, economy and environment developed a sustainable energy index system including of 20 indicators. They showed to improve the energy sustainability in China's country, should be more effort in these three dimensions (Li & Li, 2019). Saygin, D et al investigated a benchmarking the energy use of energy-intensive industries in industrialized. They presented a comprehensive overview of the energy use, based on effective benchmark and indicators data with importance of energy efficiency indicators (Saygin, Worrell, Patel, & Gielen, 2011). Kaygusuz, K investigated a study relevant to energy situation in developing countries to achieve sustainable development, considered in this study. Also in this study, access to electrical energy equaly and implementing effective indicators to monitor progress, investigated as important factors to sustainable development. (Kaygusuz, 2012). Few S et al investigated the energy access via electricity storage to achieve energy sustainability. In this study through different interviews from companies and consumers, the best solutions in order to improve technologies and optimal management of energy presented (Few, Schmidt, & Gambhir, 2019). A critical review and analysis of energy access

programmers for sustainable development, presented by Subhes C. Bhattacharyya. In this paper investigated important energy indicators, on the other hand, emphasized on an overall revision related to access energy methods. In addition, in this study, suggested to more use of renewable energy as one of the proper way to access of energy (Bhattacharyya, 2012). RFR de Rangel Moreira et al, presented influential indicators relevant to energy sustainable. They in this study, to measure the energy sustainability, considered different methods to identify the academic and institutional sources of energy sustainability indicators (de Rangel Moreira & Cândido, 2016). Since sustainable energy development index (SEDI) is leading to achieving completed sustainability, so it needs more investigation. Use of these indicators by policymakers and sustainability experts can be effective to remove the most relevant problems in this regard and lead to more progress. Indeed, when sustainability is complete that all problems have been removed or be minimum. Hence, as much as possible can add more effective indicators to the SEDI, is useful to achieve to complete sustainability. These indicators are effective to progress a country, provided that they become implemented and enhanced properly. Indeed, the indicators of energy sustainability are a set of indicators according to required dimensions of SEDI including different themes and sub-themes and the same conceptual framework. Thus, the main purpose of this paper is focus on identify and presenting appropriate indicators to measure energy sustainability for different countries. This study has forth main novelties. First of all, this study investigates all of the weak points of SEDI method and in order to enhance them, presented a new method by effective indicators that can cover all of problems. Second of all, this study a new methodology to measure energy sustainability for different countries. Third of all, this study investigates the most influential indicators that has more effect on energy sustainability. Forth of all, this study trying

to find the energy sustainability problems related to 12 studied countries in this research and specify the weak and strong points them by analysis data.

2. Importance of indicators and their relationship in this study

Indicators are a strong tool to help the policymakers and energy expert to measure energy sustainability which is useful for policymakers, energy analysts and statisticians. Also, indicators give us a deeper understanding of the existing problems (Neves & Leal, 2010). Indeed, energy sustainability indicators, are selected by policymakers or energy experts (Lee & Huang, 2007). They can demonstrate to us, what need to be done to improve the weakness points in regard with the current energy system of a country. Thus, if we can identify and use them correctly, the political targets will be easily achieved (Wu & Wu, 2012). In this research, we present effective indicators related to energy sustainability that are appropriate for implementing in different countries. These presented indicators are to identify the weakness points of countries in the line of achieve to energy sustainability and can help us to identify the main gaps in energy sustainability policy. Actually, seven selected indicators are the minimum number of an influential group relevant to energy sustainability.

2.1. A groups of selected indicators (Seven selected indicators)

The most important cause for selecting this group of indicators is having a key role in most section of our life. Proper implementation of these indicators can make the high quality of life for all humans in the world. On the other hand, when we improve these indicators,

almost the most essential problems related to humans will be solved and obtains a high quality of the welfare for them. In this section, we describe this group of indicators as below separately.

- The use of fossil fuels is significant for development, but fossil fuels are the main source of carbon dioxide emissions, which is a greenhouse gas and causes environmental pollution and global warming.
- Renewable energy can help human beings to develop and supply energy. In addition, these resources are available and have a positive impact on the environment.
- The importance of transportation as a strategic sector for cities and countries is significant. This section can provide prosperity for residents and play an important role in energy consumption.
- Proper use of energy is most important for preventing significant energy loss. In this regard, it is important use of new energy-saving technologies.
- Access to affordable and easy energy is essential for all city residents. Providing new technology and creating the right policy can be effective to gain affordable and proper energy.
- Unexpected accidents can be the main cause of the problems and damage to a city and its people. Creating an adequate infrastructure and having the right program is one way to prevent this problem. In this regard, creating an appropriate policy, welfare insurance, and development is vital.
- The government plays an important role in the development of cities and countries. They can plan in all areas necessary for the people. Energy supply, the use of new technology, easy access to energy, etc., is part of the government's task.

3. Methodology of novel index calculation of SEDI

In this study, have investigated the Energy sustainability indicators for 12 countries. In fact, since to achieve energy sustainability the SEDI method is not complete and has some limitations, thus it should be improved and completed. Hence, at first, we investigated all of the energy indicators related to seven selected indicators in this research and after that, using correlation analysis chosen proper indicators and then we obtained the strong and weak points of each them. In the final step and according to this analysis, we obtained the weak and strong sections of each country based on existing indicators. Fig 1. Shows a schematic of energy supply from primary resources (Source: Authors). This figure was designed based on existing resource which use by different sections and with regard to seven selected indexes. As can see, resources will be divided in two main parts as total primary energy supply (TPES) and then these resources used in three important section such as transport, industrial and household used. In the end of this figure, these resource with breakdown impacts on waste and economic. This figure shows that to achieve energy sustainability based on resources, is need to proper planning and effective policy. Indeed, if we can modify the amount consumption of energy with consideration resources and use of them correctly in different section, without doubt will be have low problems in the future. As can see in fig 1 seven selected indicators were arranged based process.

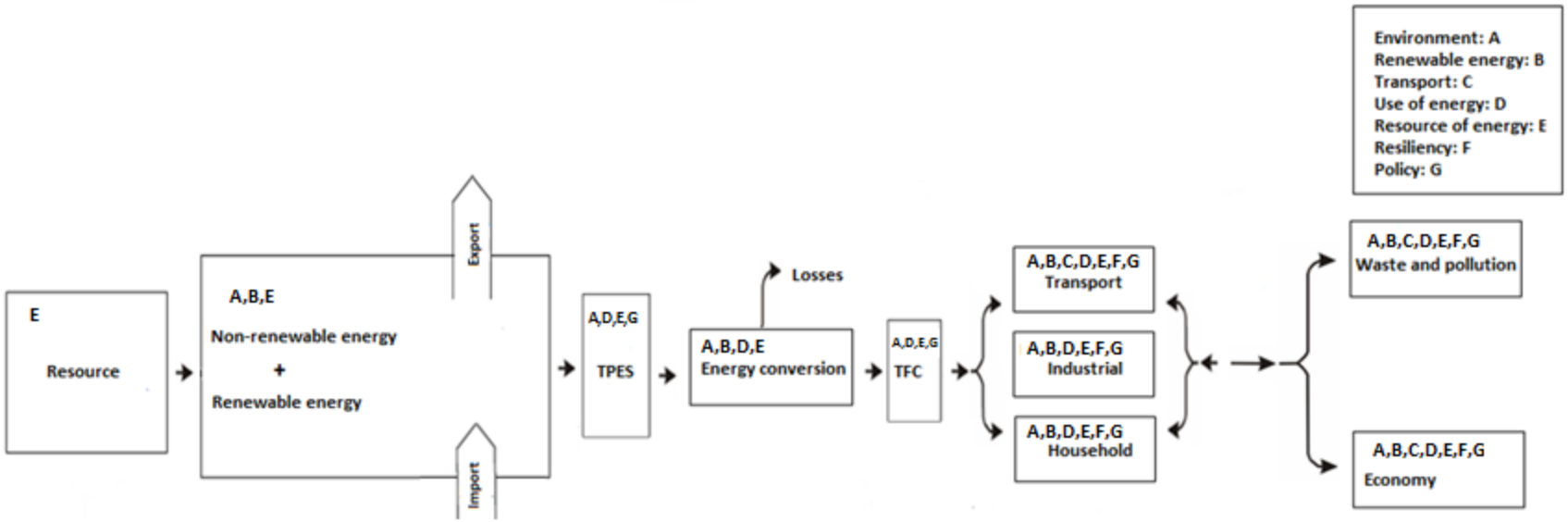

Fig 1. A schematic of energy supply from primary resources
Source: Authors

Table 1 shows the indicators and sub-indicators related to energy based on design of the fig 1. These indicators have most impact on energy sustainability.

Table 1. Influential indicators and sub-indicators based on design of the fig 1.

Sub-indicators/Indicators	Resource	TPES	EC	TFC	Transport	Industrial	Household	WAP	Economy
Total non-renewable and renewable energy	√	√	x	x	√	√	x	√	√
Total production energy by non-renewable energy	x	√	x	x	√	√	√	√	√
Total production energy by renewable energy	x	√	x	x	√	√	√	√	√
Non-renewable end renewable resource	√	√	√	√	√	√	√	√	√
Total consumption energy by non-renewable energy	x	x	x	√	√	√	√	√	√
Total consumption energy by renewable energy	x	x	x	√	√	√	√	√	√
Amount of CO_2 emission	x	√	√	√	√	√	x	√	√
Amount of investments in energy	x	√	x	√	√	√	√	√	√
Reduction fuel fossils by technology	x	x	√	√	√	√	x	√	√
Amount of energy intensity	x	√	x	√	√	√	√	√	√
Electrical consumption by renewable end non- renewable energy	x	x	x	√	√	√	√	√	√
Percent of economic growth by energy sector	x	√	√	x	√	√	x	√	√
Amount of investment on industrialization and energy	x	√	x	x	x	√	x	√	√
Amount of energy export and energy import	x	x	x	x	√	√	x	x	√

Table 2 shows the selected indicators related group of indicators before correlation. As it is clear in this table there are the most influential indicators related of group of indicators.

Table 2. Selected indicators related group of indicators before correlation

Group of indicators	**Sub-Indicator (Energy)**
Environmental impact	Total CO_2 (Mt of CO_2), CO_2/TPES(Mt CO_2), CO_2/population (Mt CO_2), CO_2/GDP (billion 2010 USD -Mt CO_2)
Renewable energy	Total Energy production from renewable energy /Renewable heat consumption, Amount of renewable energy in electricity production / Total Energy production from renewable energy (Ktoe), TFC Renewable energy consumption in Residential / Total Energy production from renewable energy (Ktoe), TFC Renewable energy consumption in Commercial / Total Energy production from renewable energy (Ktoe)

Transport	Total TFC in transport (Ktoe), TFC of Fuel fossils use in transport /Total TFC in transport (Ktoe), TFC of Electricity in transport /Total TFC in transport (Ktoe), TFC of biofuels and waste consumption /Total TFC in transport (Ktoe)
Use of energy:	Loss/TPES, TFC Residential /population (Ktoe), TFC Industry /population (Ktoe), TFC Commercial /population (Ktoe), TPES/GDP (Ktoe), Electricity consumption/population (Ktoe)
Resource access of energy	Total Energy production (Ktoe), Total fossil fuel production/Total Energy production, Renewable energy production/Total Energy production (Ktoe)
Resilient & safety	Access to electricity (Million population), Renewable internal freshwater resources, per capita (cubic meters), Electricity consumption/population (MWh/capita), CO_2 /population(Mt CO_2 /capita, Population/Land area(sq. km)
Policy	Energy exports /Energy imports (Mtoe), GNI Coefficient, GDP (billion 2010 USD)/population

3.1. Main cause to select these indicators

After gathered raw data, by correlation method analysis, were selected the proper indicators from between all of the existing sub-indicators before final analysis. These analyses show us which indicators are appropriate to final analysis and can effective for achieving energy sustainability in studied countries. Also selected indicators show us which sub-indicators if become controlled can be effective to achieve energy sustainability. Table 5 demonstrates the correlation analysis step for all of the existing indicators before final assessment. Table 3 shows the selected indicators after correlation and normalization step with related used formula.

Table 3. Selected indicators after correlation and normalization step

Group of indicators	Sub-Indicator formula
Environmental impact	CO_2/TPES
	CO_2 /Population
	CO_2/GDP
Renewable energy	Amount of renewable energy in electricity production / Total Energy production from renewable energy
	TFC Renewable energy consumption in Residential / Total Energy production from renewable energy
	TFC Renewable energy consumption in Commercial / Total Energy production from renewable energy
Transport	TFC of Fuel fossils use in transport /Total TFC in transport
	TFC of Electricity in transport /Total TFC in transport
Use of energy	Loss /TPES
	TFC /GDP
Resource access of energy	Total fossil fuel production/Total Energy production
	Renewable energy production/Total Energy production
Resilient & safety	Access to electricity
	Renewable internal freshwater resources, per capita
	Electricity consumption/population
Policy	GNI Coefficient

4. Result and discussion

To achieve an acceptable result in this study, firstly should be collected the required data for all of related sub- indicators with the main group of indicators. Therefore, in this regard the necessary data gathered for each country using IEA and Word bank. And after

these data should be investigated and arranged by breakdown formula. These raw data can help us to acquire the proper final sub-indicators that has remarkable effect to achieving energy sustainability for these countries. Table 4 shows all of selected indicators data before normalization. As can see a set of indicators were selected to better and comprehensive analysis for this study. The high number of these indicators allow us to better take making the decision also we can be select effective indicators accurately.

4.1. Correlation and Normalization importance

Correlation and normalization method of obtained numbers is used to achieve better results. Since the main target of this study is achieving energy sustainability, thus it is required that measure different sub- indicators based on related indicators and then obtain main results. In this regard after select all of sub-indicators that are related to each seven indicators, should be divided all of them into each other before the main correlation step accurately. After that, with normalization method of the raw data and according to situation of each main seven indicators, the appropriate sub-indicators will be obtained.

Table 4. Raw data selected of Indicators before normalization

Indicator / Country	New Zealand	Austria	Iran	Denmark	Poland	Peru	France	Romania	Turkey	Tunisia	Jordan	Slovakia
CO_2/POP	6.392	7.241	6.976	5.761	7.716	1.594	4.382	3.441	4.299	2.252	2.499	5.529
CO_2/GDP	0.17	0.15	1.156	0.094	0.511	0.264	0.104	0.341	0.302	0.51	0.774	0.285
TCO_2	30	63	563	33	293	51	293	68	339	25	24	30
CO_2 /TPES	1.427	1.891	2.273	1.995	2.95	2.114	1.199	2.142	2.479	2.273	2.674	1.181
TEPR	8720	9770	1940	3490	9030	4700	23900	6100	17130	1180	270	1600

AREE/TEPR	0.356	0.471	0.741	0.433	0.221	0.477	0.359	0.387	0.453	0.042	0.296	0.368
TFCFFT/TFCT	0.9981	0.9062	0.9991	0.9346	0.96	0.9578	0.9079	0.9396	0.9922	0.9966	1	0.9215
TFCET /TFCT	0.001	0.0314	0.0008	0.0086	0.0152	0.0005	0.0211	0.0156	0.0037	0.0033	0	0.0212
TFCT	4891	8559	44838	4160	18539	7873	43830	5762	26483	2388	2768	2448
LE/TPES	0.013	0.018	0.012	0.048	0.015	0.019	0.018	0.033	0.022	0.023	0.019	0.02
TFCI/POP	0.00009	0.0009	0.00054	0.00037	0.00038	0.00015	0.0004	0.00003	0.00033	0.00019	0.00011	0.00061
TFCR/POP	0.00003	0.00072	0.00068	0.00077	0.00051	0.00011	0.00059	0.00374	0.00026	0.00018	0.00013	0.00003
TFCC/POP	0.00026	0.0003	0.00014	0.00034	0.00022	0.00003	0.00034	0.000091	0.00015	0.00005	0.00004	0.00024
TPES/GDP	119380.6	79330.9	508546.2	47525.8	173310.6	124984.4	86896.1	159492.4	121852	224469.3	289516.1	157104.7
ELC/POP	8.523	8.275	3.135	5.935	4.187	1.18	7.149	2.682	3.094	1.531	1.874	5.16
TREP/TEP	0.5	0.9	0	0.3	0.1	0.2	0.2	0.2	0.5	0.2	0.8	0.3
TFFP/TEP	0.5	0.1	1	0.7	0.9	0.8	0	0.6	0.5	0.8	0.2	0.1
TEP	16,450.00	12,371.00	391,088.00	15,036.00	66,666.00	25,379.00	131,560.00	24,868.00	36,102.00	6,044.00	355	6,543.00
AE	100	100	100	100	100	94.9	100	100	100	100	100	100
RIFR	72,510.00	6,435.00	1,639.00	1,063.00	1,410.00	52,981.00	3,016.00	2,129.00	2,947.00	376	77	2,325.00
POP/LA	17.8	105.4	49.6	135.5	124	25	122.1	85.9	102.4	71.5	108.2	112.8
EEX /EIM	0.31	0.329	13.323	0.862	0.404	0.985	0.2	0.464	0.064	0.324	0.071	0.348
GNI	0.361	0.305	0.388	0.285	0.321	0.443	0.323	0.275	0.412	0.358	0.337	0.261
GDP /POP	38	48	6	61	15	6	42	10	14	4	3	19

4.2. Correlation and Normalization formulation:

As before mentioned, the correlation coefficient takes a value between -1 and 1 indicating perfect correlation and normalization is a value between 0 and 1. Returns the correlation coefficient of the Array1 and Array 2 cell ranges that is use to determine the relationship between two properties. Thus the correlation can be obtained as follows formula that extracted of the excel software:

$$Correl(X,Y) = \frac{\sum (x-\bar{x})(y-\bar{y})}{\sqrt{\sum (x-\bar{x})^2 \sum (y-\bar{y})^2}} \quad (1)$$

In this formula, n is $\bar{x}$ and $\bar{y}$ are the sample means average (array1) and average (array2).

Also the main below formula can be used to calculate normalization:

$$X_m = \frac{X\text{-}X_{min}}{X_{max}\text{-}X_{min}} \quad (2)$$

Where in this formula, X_m is indicator value, x is actual number; X_{min} is minimum number and X_{max} is maximum number. On the other hand, with regard to difference indicators with variety ranges and dimensions, the normalization technique that called UNDP method is used to obtain results (Iddrisu & Bhattacharyya, 2015).

$$V = \frac{V_{act}-V_{min}}{V_{max}-V_{min}} \quad (3)$$

$$V = \frac{V_{max}-V_{act}}{V_{max}-V_{min}} \quad (4)$$

To arrange the numbers equally, it should be considered that when a definition indicator should have high-value the eq.3 is better to use for normalization and when an indicator should have low value is better that use of eq.4 for normalization. In two formula V is the indicator value, V_{act} is the actual indicator such as a country, V_{max} is the maximum value of indicator and the V_{min} is the minimum value of the indicator. Table 5 show the correlation analysis step for all of the existing indicators before final assessment. In this table correlation method was performed for all arrays and in comparison each other with regard to main its indicator separately. This analysis help us to select appropriate sub-indicators in final step also this analysis shows which sub-indicators are more close to

energy sustainability before final selection. Of course, it is possible in this analysis instead of one sub-indicator, two sub-indicators be appropriate for the main indicators, thus each two them can be used in final selection step.

Table 5. The correlation analysis step for all of the existing indicators before final assessment

Indicator	**A**	**B**	**C**	**D**	**E**	**F**	
Environmental impact	CO_2/TPES	CO_2/Pop B	CO_2/GDP	Total CO_2			
Column	A-B	A-C	A-D	-			
Correlation number	0.906	0.535	0.239				
	B-C	B-D	-	-			
	0.023	0.393					
	C-D	-					
	0.531						
Renewable energy	TEPR	AREE/TEPR	RRe /TEPR	RCe/TEPR			
	A-B	A-C	A-D	-			
	0.047	0.232	0.3143				
	B-C	B-D	-				
	0.191	0.169					
	C-D	-					
	0.968						
Transport	BT /TFCT	TFCFFT/TFCT	TFCET /TFCT	TFCT			
	A-B	A-C	A-D	-			
	0.984	0.786	0.009				
	B-C	B-D	-				
	0.882	0.0005					
	C-D	-					
	0.024						
Use of energy	Loss/TPES	TFCI/POP	TFCR/POP	TFCC/POP	TPES/ GDP	EC/POP	TFC/GDP
	A-B	A-C	A-D	A-E	A-F	A-G	-

	0.164	0.427	0.16	0.423	0.055	0.323
	B-C	B-D	B-E	B-F	B-G	-
	0.225	0.559	0.017	0.481	0.157	
	C-D	C-E	C-F	C-G	-	
	0.096	0.031	0.108	0.067		
	D-E	D-F	D-G	-		
	0.488	0.903	0.195			
	E-F	E-G	-			
	466	0.0844				
	F-G	-				
	0.221					
Resource of energy	TREP/TEP	TFFP/TEP	TEP			
	A-B	A-C	-			
	0.592	0.513				
	B-C	-				
	0.352					
Resiliency	AE	RIFR	EC/POP	EC/POP	POP/LA	
	A-B	A-C	A-D	A-E	-	
	0.534	0.371	0.491	0.509		
	B-C	B-D	B-E	-		
	0.243	0.081	0.785			
	C-D	C-E	-			
	0.667	0.161				
	D-E	-				
	0.217					
Policy	EEX /EIM	GNI	GDP/POP			
	A-B	A-C	-			
	0.281	0.242				
	BC	-				
	0.425					

In this research the below formula was used to final calculation of each indicators.

$$U = \frac{\sum_{k=i}^{n}(1-V_x)+\sum_{y=n+1}^{m} U_y}{N} \quad (5)$$

In this formula N is the number of indicators and $1 - V_x$ is a ratio for the indicators that should be low value. In fact, when a definition indicator should have high-value is not need to use the $1 - V_x$ for it and it can be calculated without considering -1 for it and when the indicator should have low value is better that the use this equation $1 - V_x$. Table 6 demonstrates the obtained numbers of Indicators data after normalization step. Since the range of obtained data for easy analyses, should be identical, thus as can see in this table all numbers are arranged in 0 and 1 ranges by Minitab software.

Table 6. Sub-Indicators data after normalization

Indicator / Country	New Zealand	Austria	Iran	Denmark	Poland	Peru	France	Romania	Turkey	Tunisia	Jordan	Slovakia
CO_2/POP	0.783	0.922	0.879	0.681	1	0	0.455	0.301	0.441	0.107	0.147	0.642
CO_2/GDP	0.072	0.053	1	0	0.392	0.16	0.009	0.233	0.196	0.392	0.64	0.179
CO_2/TPES	0.139	0.401	0.617	0.46	1	0.527	0.01	0.543	0.734	0.617	0.844	0
AREE/TEPR	0.356	0.471	0.741	0.433	0.221	0.477	0.359	0.387	0.453	0.042	0.296	0.368
TFCRER/TEPR	0.002	0.014	0.001	0.003	0.007	0.004	0.004	0.001	0.108	0.041	0.47	0.003
TFCREC/TEPR	0.006	0.005	0.001	0.001	0.001	0.003	0.001	0.003	0	0.002	0.13	0.001
TFCFT/TFCT	0.998	0.906	0.999	0.934	0.96	0.957	0.907	0.939	0.992	0.996	1	0.921
TFCET /TFCT	0.001	0.031	0.001	0.008	0.015	0.001	0.021	0.015	0.003	0.003	0	0.021
LE/TPES	0.013	0.018	0.012	0.048	0.015	0.019	0.018	0.033	0.022	0.023	0.019	0.02
TFC/GDP	0.104	0.023	1	0.04	0.133	0.152	0.045	0.143	0.026	0.141	0	0.063

TREP/TEP	0.531	0.855	0.004	0.257	0.146	0.185	0.194	0.248	0.486	0.195	0.757	0.275
TFFP/TEP	0.467	0.143	0.991	0.742	0.853	0.814	0.007	0.633	0.513	0.792	0.242	0.115
AE	1	1	1	1	1	0	1	1	1	1	1	1
RIFR	1	0.088	0.022	0.014	0.018	0.73	0.041	0.028	0.039	0.004	0	0.031
ELC/POP	1	0.965	0.24	0.635	0.388	0	0.806	0.176	0.234	0.014	0.062	0.526
GNI	0.361	0.305	0.388	0.285	0.321	0.443	0.323	0.275	0.412	0.358	0.337	0.261
GDP /POP	0.603	0.776	0.052	1	0.207	0.052	0.672	0.121	0.19	0.017	0	0.276

4.2. Comprehensive discussion about obtained results after normalization for sub-indicators

To achieve logical results in this study, all country should be evaluated based each indicator separately. This stages have two main goals. First of all, it shows performance of each country based these indicators and then obtains weak and strong sections of these countries.

- **Environmental impacts:** In this factor the countries should have has low consumption of CO_2 that is better. Because this indicators emphases on low emission of fossil fuels.
- **Renewable energy:** High consumption of renewable energy has two benefits. Firstly, the decreasing the dependent of fossil fuels and secondly low pollution. Therefore, as possible as using renewable energy should be the priority for each country in energy sustainability plan.
- **Transport:** In this indicator, although fossil fuels are main resources of energy supply, but should be used renewable energy instead of fossil fuels and it can be performed during specified times slowly. Access to more electricity is recommended for

this indicator because it will have caused more use of public transport and it lead to low emission CO_2.

- **Use of Energy:** This indicator is low complicated. It means that if a country can more use of energy, actually it shows that this country is independent in energy import. But the most important thing in this regard is balance in the kind of energy that use in a country. In fact, countries should have correct consumption of energy.
- **Resource access of energy:** More resource for each country is a value, but correct usage them is more valuable. Actually, a country with an appropriate planning also effective policy can use energy resources properly in line of energy sustainability.
- **Resilient & safety:** Access to electricity, healthy water is more important in this indicator because providing primary requirements is very important for having the welfare of inhabitants.
- **Policy:** This indicator should be attended than other indicators. Because proper policies are one of the most important thing to progress and keep up the existing resources. Also appropriate policy can lead to achieve energy sustainability.

Table 7 shows the obtained number only for selected indicators after normalization stage. This numbers table including the amount of total energy consumption, amount of fossil fuel consumption, amount of renewable consumption based of resource and policy. As can see in this table, there are two remarkable colors green and red. In fact, it means for these countries the strong and weak indicators. The green color represents the desired indicators for same country and the red color red an undesirable indicator that needs improvement. Since that for easy arrangement of the raw numbers, the normalization should be in range 0 and 1, therefore, the maximum range for this table 1 and minimum is 0.

Table 7. The obtained number only for selected indicators after normalization stage and using 1 formula

Indicator / Country	Environmental impact	Renewable energy	Transport	Use of energy	Resource of energy	Resiliency	Policy
New Zealand	0.636	0.121	0.001	0.697	0.532	1	0.621
Austria	0.509	0.163	0.062	0.657	0.856	0.684	0.735
Iran	0.116	0.247	0.001	0.751	0.007	0.421	0.332
Denmark	0.588	0.146	0.044	0.546	0.258	0.55	0.858
Poland	0.163	0.076	0.027	0.509	0.147	0.469	0.443
Peru	0.736	0.161	0.028	0.377	0.186	0.243	0.304
France	0.81	0.121	0.061	0.613	0.594	0.616	0.675
Romania	0.605	0.13	0.04	0.438	0.308	0.401	0.423
Turkey	0.507	0.187	0.005	0.421	0.487	0.425	0.389
Tunisia	0.588	0.028	0.002	0.388	0.202	0.339	0.33
Jordan	0.411	0.299	0	0.358	0.758	0.354	0.332
Slovakia	0.691	0.124	0.052	0.528	0.58	0.519	0.507

Fig 2 shows status each country based obtained numbers of data and indicators. In this figure showed the performance of 12 studied country based on seven selected indicators. For example, in the resiliency indicators, New Zealand country has a better situation than other countries that is good situation for this country. On the other hand, and as can see in the use of energy indicators, Iran has most percent of energy consumption than other countries that this cannot be desirable for this country, as a result, in this policy should be revised as soon as possible.

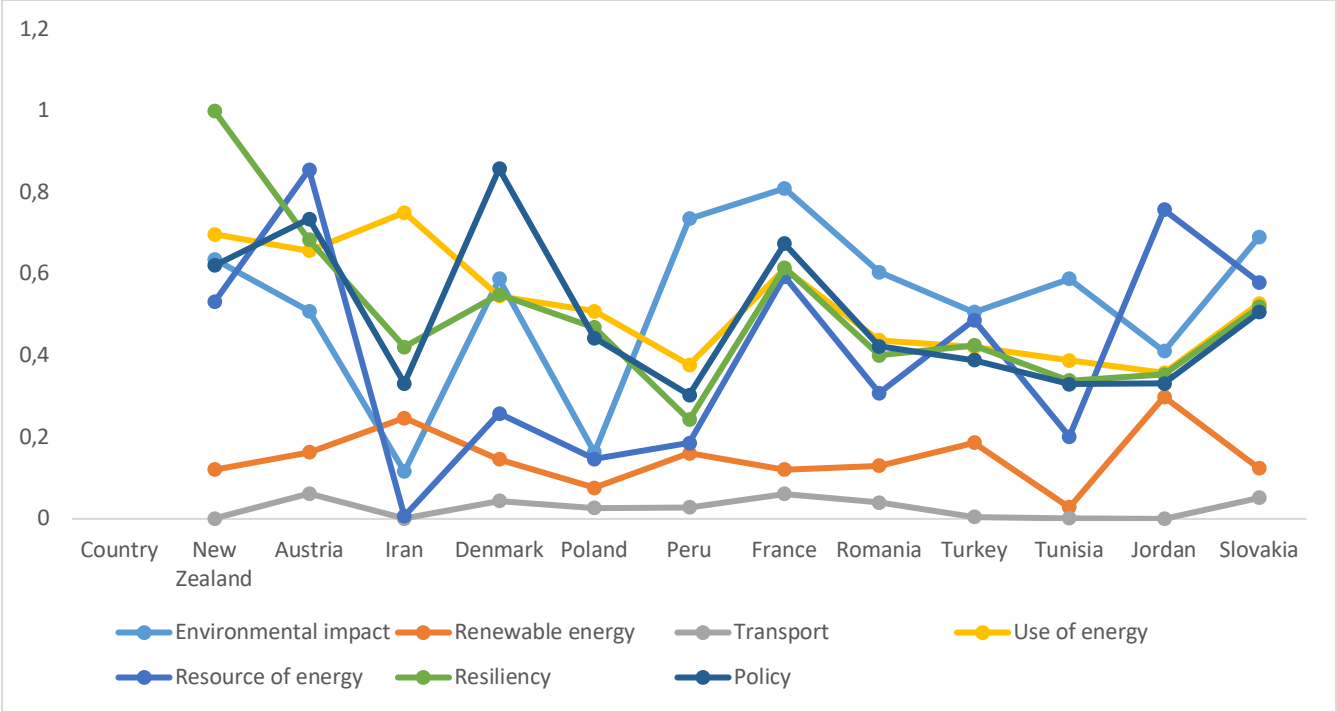

Fig 2. Status each country based obtained numbers of data and indicators

Fig 3 shows the chart number of each country based obtained numbers of data and indicators. All obtained numbers belong to main indicators are between 0 and 1 for all countries in this chart that shows the status them based on their existing data and analysis. In this figure, as can see for each indicators specified a range between 0 to 1 that shows situation of each country from the energy sustainability point of view. This divided range of indicators demonstrates that for these countries and in which indicators should make an essential change for achieving energy sustainability. In addition, which indicator need to be strengthened or continue the

existing situation of the indicator.

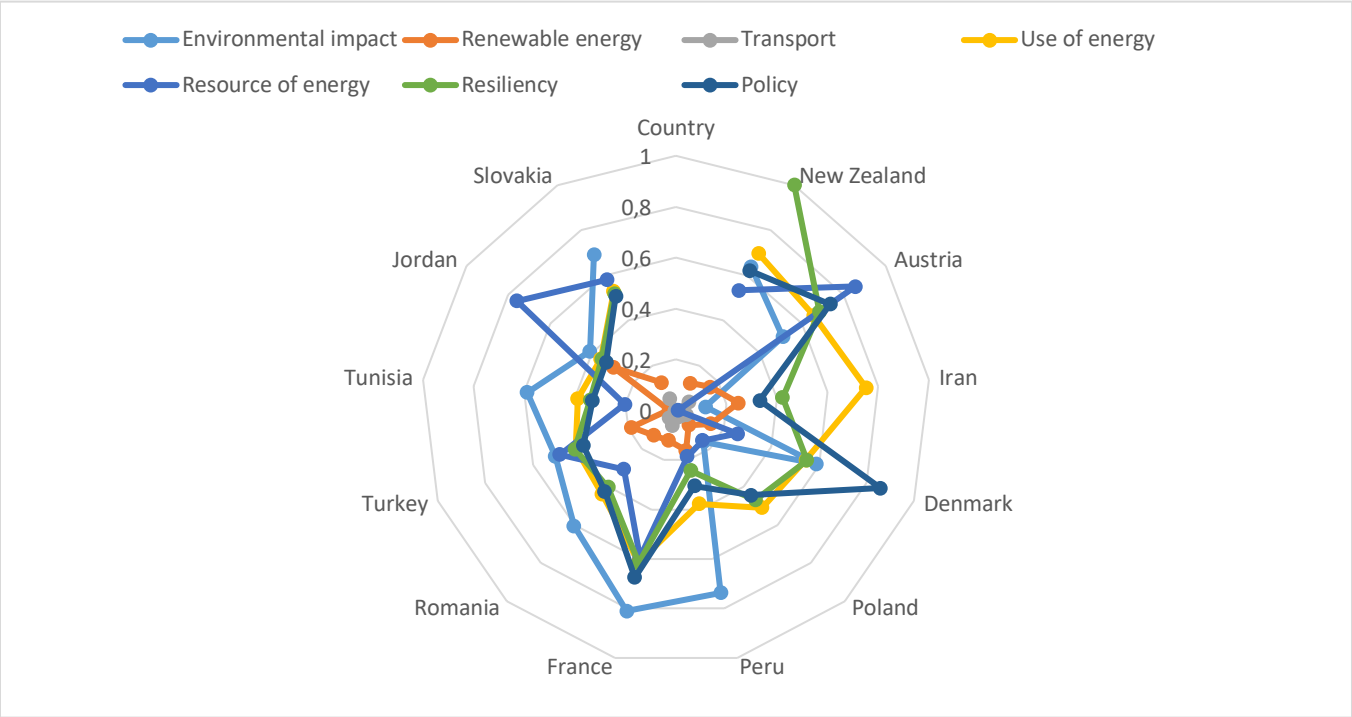

Fig 3. Chart number of each country based obtained numbers of data and indicators

5. Conclusion

Importance of energy sustainability is not cover on each person and country. In this regard take correct decisions by energy makers and energy experts are as a necessity to achieve this goal. Also, correct determination of energy indicators by them is effective and required to improve and enhance the infrastructure of energy sustainability. In this study, is developed the feasible indicators based on a previously presented method called Sustainable Energy Development Index (SEDI). In fact, this study was presented new indicators

and index to improve energy sustainability for different countries. At first during a deep study seven indicators in framework a group were selected and then related data for each one from the IEA and World Bank cites gathered and analyzed. The conceptual analysis results showed that to achieve energy sustainability is necessary that policymakers and energy experts with regular planning implement the applied policies. Policies such as lower use of fossil fuels over time and substitute them with renewable energy, more attention to public transport, proper utilization of resources, improving energy infrastructure and resiliency for city inhabitants and rural areas, providing energy access in all area, using new technology to optimizing energy consumption and to prevent energy loss. Also, numerical results for 12 studied countries that was presented with two colors green and red has been specified show that which indicators need to enhance and which indicators need to revised and implementing effective actions for it. For instance in the environment section and according to table 7, the policy of Iran due to more use of fossil fuels as main resource should be changed and move toward French country that has desirable situation in this index. Also, for other example and in transport section, Jordan country should be changed and improved the present its situation and use of effective plans of Australia country to achieve sustainability.

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