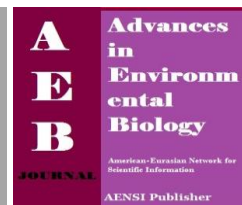




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Importance of clean production approaches implementation in order to achieve sustainable development: Classification of Iran's industrial sub-branches via Multiple Criteria Decision Making (MCDM)

¹Soleyman Iranzadeh and ²Morteza Khodakhah Amlashi

¹Associate Professor, Department of Management, College of Management, Tabriz Branch, Islamic Azad University, Tabriz, Iran.

²Department of Management, College of Management, East Azarbaijan Science and Research Branch, Islamic Azad University, Tabriz, Iran.

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ABSTRACT

In recent decades governmental obligations to obtain environmental standards and intense increase of customer's demands to green products; has fascinated managers to these concepts. Implementation of strategies which improve environmental functions, will observe many benefits to the organization, such as; energy sources saving, decrease of pollutions, decrease or deletion of scraps, creation of values for customers and finally elevation of organization productivity which will be noticed. This article begins with stating of clean production importance for organizations and industrial centers in Iran and will continue with state of effective factors on sections and industrial sub-groups for acceptance of clean production approaches via expressing of clean production benefits. In this article all of the industrial organizations have been classified into 8 main industrial groups which will be assessed regarding each of these factors. Finally to improve the accuracy of investigation results, two effective MCDM ways will be used for classification and their sum will be presented as final result.

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INTRODUCTION

Any operation which directly or indirectly, via using of safe chemical materials or redesigning of processes and products, causes of deletion or not forming of dangerous materials, would be named clean production. Actually clean production is such functions which would prevent of freeing harmful combinations in our environment [10]. Clean production means constant using of unite environmental strategy in processes, products and services in order to improve efficiency and decrease human and environmental dangers and is an essential pace in achieving sustainable development. World commission on environment in 1987 defines sustainable development as follow: "sustainable development is a change process by which using of sources, rout of investments, technological development tendency and fundamental changes all in coordination with together and in order to improve current and future potential in achieving human needs is being formed" [15]. Today's development assurance of each country depends on saving and optimistic using of finite and irreplaceable sources of that country so diversity of actions have been performed by governments to encounter this problem like applying of green laws and principles such as using of environment adapted raw materials in production and industrial centers, decreasing of oil and fossil energy using and refreshing and reusing of scraps. In recent years governmental obligations to obtain environmental standards and intense increase of customer's demands to green products has been improved but yet it is insufficient [3,9].

Forerunner companies on this line, via creation of desirability and satisfaction from environmental view, try to use clean production patterns as a strategic weapon for gaining sustainable competitive advantage. Acceptation of clean production concepts and principles could help to save energy and raw material resources, decrease or deletion guarantee of poisonous materials and decreasing amount of radiation pollution and wastages. United Nations Environment Program (UNEP) describes the goals of its clean production programs as follow: "Improving world knowledge of environmental strategies and industries encouragement to accept these strategies by means of governmental aids". Clean production approaches, which also are usable in production processes, include recovering, process change, factory process improvement, raw material displacement and

Corresponding Author: Morteza Khodakhah Amlashi, Department of Management, College of Management, East Azarbaijan Science and Research Branch, Islamic Azad University, Tabriz, Iran
E-mail: morteza_khodakhah@yahoo.com

...[6,8]. On the other side clean production could be achieved by other ways like: product redesigning, production process change and raw material displacement with materials contained low harmful chemical combinations. It should be mentioned that clean production by itself doesn't guarantee community achieving to sustainable development, particularly in community like Iran which has special characteristics such as official orders, economic system, cultural believes, environmental problems, young people majority and high rate of unemployment disaster. But expansion of these concepts like what this article does is an important pace in reaching to sustainable development.

Importance and necessity of clean production in Iran

Energy:

Iran is one of the most high energy users of the world. Infinite resources and low productivity from these resources and products not only has been caused lavishing of these divine gifts but also has been caused Iran to be the championship of consuming in the world. The rate of energy consuming in Iran is 3.5 times more than Turkey's, 14.5 times more than Japan's, 2 times more than China's, 4 times more than India's and 5 times more than world average. Among 16 countries of Asian Productivity Organization, Iran owns the 15th place which, having 1% of world population, consumes 9% of world energy. Gasoline consume of Iran is 11 liters per head, France is 1.5 liters per head and Canada is 5.6 liters per head. The rate of gas consuming in the world reached more than 3198 billion m³ in past years which Iran owns the 3rd place among 211 countries of the world. Electricity production of Iran is 215 billion KWH which, considering 70million population, is almost 2800 KWH per head and this is 3 times more than world standard. Ghee consume of Iran is almost 17 Kg per head which, in contrast with other countries, is very higher than world average of 12.5 Kg per head and by investigating of Iran's ghee consuming methods, this difference would be apparent.

Greenhouse Gases:

Greenhouse Gases include of steam, carbon dioxide, methane, nitrogen oxide and etc. Earth atmosphere, the air embarrassing the earth, traps the heat and so the air gets warmer [1]. Scientists named this phenomenon as greenhouse affect or earth warming. Based on the last Iran's national report to UN in 1994, the rate of greenhouse gas production in Iran was 350 million tons per year which today's it seems to reach more than 450 million tons per year. Based on declaration of responsible persons and above statistics, among 2nd group countries of Kyoto world protocol which are mainly improving countries, Iran is the fourth producer of greenhouse gases which %75 of that is related to high fuel and energy consuming. On this basis Iran owns the 18th ranking among world countries.

Plastics:

Excessive use of some products would endanger the environment, unfortunately plastics are such products. When petrochemical factories consume lots of energy to produce plastics, they produce lots of pollutions such as mercurial water pollutions and concurrently plastics themselves cause environmental pollution [7]. Normally it takes 250 to 500 years for plastics to break down, in addition they may import some poisons into lifecycle which cause the ecosystem exit from its normal condition. Plastics twist around trees, sink into the soil, choke the plants, pollute the water and drown marine animals which swallow them. Nevertheless, the use rate of plastics is increasing so rapidly which even medical beware about using methods of these materials have been useless as far as there have been debates about controlling of plastics (such as plastic bags) excessive use in our country Iran. Anyway, excessive use of any goods could lead to excessive use of energy for production and environmental damage; there are too many samples of goods which excessive use of them either in energy form or other forms, could damage environment. Detergents, cleaners and motor oil are only a few samples of these goods and seeing our environment carefully, we will recognize many others [16].

The role of clean production to achieve a sustainable development:

The anteriority principle:

The anteriority principle mentions that every required action has to be accomplished before that the environment faces damage and even before determining the limits. For example, companies desire to introduce their industrial garbage, containing non-examined chemicals, as safe and secure substances without using industrial cathartics and or without obtaining the environmental organizations certificates [19]. In fact, it seems necessary to demonstrate this claim that the industrial outputs are not dangerous for environment or if accepting the harmfulness, there is no safer way.

The prevention principle:

To avoid environment damages is more effective and cheaper than trying to clean and cure it. Prevention contains using harmless chemicals, removal of dangerous chemicals and replacing them with non-dangerous and

effective materials. By accurate utilization of poisonous chemicals and more secured processes, the reduction of unpleasant events seems to be predictable.

The public participation principle:

Nowadays, the environmental necessities for human survival are not covert for anybody; since everyday our environmental knowledge enhances. It seems indispensable achieving to information relevant to: dangerous compositions and radiations released by manufacturing engines, amount and kinds of materials used in manufacturing processes and chemical ingredients of productions. It can also accelerate the application of clean production procedure.

The holism principle:

It means planning to achieve development; and achieving to development guarantees economical welfare, social, cultural and political health, and sustained geographical environment [5]. Our geographical environment is like an integrated system which its function influences the whole system. The animal's relationships, within this complicated network, are created different ecosystems that any damage to any of them threatens the whole system. Thus many of experts look at environmental challenges as the universal problems. The clean production is an integral production approach discussing always this question: "What happens to a product during its life cycle?" However by solving one problem the newer one is being created, like changing the manufacturing processes, incapability to encounter the poisonous materials and repelling of industrial garbage, but, a systematic integral thinking seems to be necessary [14].

Required steps to achieve sustainable development:

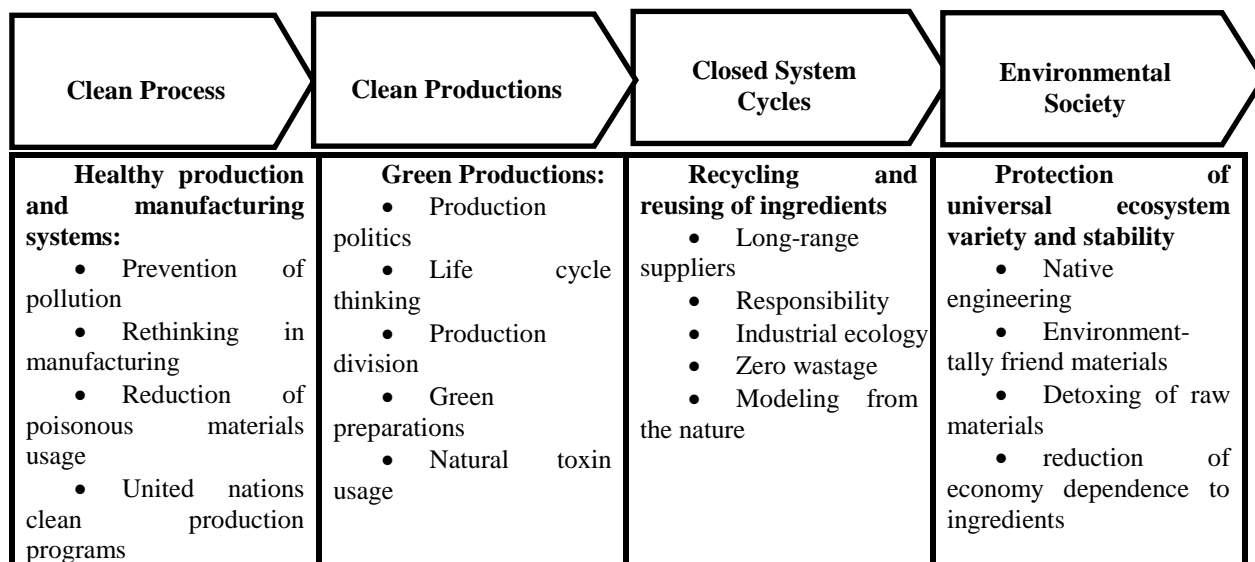


Fig. 1: Required steps to achieve sustainable development

Advantages and limits of clean production system implementation:

Advantages:

As it said, the most important advantage of clean production systems is their prevention or reduction of pollutant and poisonous materials. Clean production acts as a two-edged sword, and it can be led to a win-win success; that on the first edge the environmental quality and on the other one the production efficiency is settled. Also we can mention as the instances: the moral necessities regard and social commitments towards the society, customer satisfaction and better image of company, fair business and conviction of stockholders and beneficiaries to invest more, encouraging the employees, making brand for organization, reduction of wastage and improvement of production processes, changing of consuming patterns, sustainability of resources and reduction of costs on long period, raise of productivity in business and production processes, gaining competitive advantage on long period for the industry, correlation with regulations and governmental and international laws, reduction of immaterial risks occurred by environmental punishments, support of governments and municipals, creation of a positive vision towards changing and improving, acting on permanent development direction and helping to growth, avoiding massive environmental penalties, safe work condition for employees and reduction of danger, using university experts and talents and long-term cooperation between universities and companies in order to improve clean technologies, and at last, gathering international finances. Establishing these methods encourages and leads the managers of industries to achieve and to perceive a better long-range planning; and to compare with total approach of production, quality,

environment, work relationships, human resources, energy resources, raw materials and profitability.

Limits:

The implementation of clean production methods can be classified in two categories: technical and financial limits. For example the technical limits of developing countries are: shortage of knowledge related to pollution management achievements on decision-making level of organization, shortage of local experts of clean production, existence of fossil fuel and feeling of no need of changing the approach of production processes, low flexibility of functional or high levels of organization, not achievement to some clean technologies because of the hard sanctions, low level of international relationships and not accurate achievement to international markets and low general knowledge of environmental dangers in developing countries [17].

Financial limits are often challenging for small or medium organizations. Lack of investments to modernize the factory getting known that it can save their money, the length of rate of revenue in some industries, lack of confidence in superior level of management on profitability of clean production plans, high dependence of economy and private organizations to the government, lack or inexistence of internal or external finances on diverse parts of industry for many reasons like immediate vibration of economy and being expensive of experts wages, are some of financial limits.

Research method and tools:

Multiple attribute decision making (MADM) is considered as a sub-method of multiple decision making which is used often in researches and articles to rank the choices. In these problems, some choices are being analyzed and then are being ranked. Beside these choices, there are some indicators that must be determined by decision makers. To classify the different sections of industry in Iran, we have used the international standard industrial classification (ISIC). Using this standard, the industrial organizations can be classified in 8 below sections:

1. Food Production, beverages and tobacco
2. Clothing industry, Leather and Textiles
3. wood products and Woodcraft, including furniture
4. Paper Production, Paper Products, Printing and Publishing
5. Chemical production, Pharmaceutical products, Plastic, Petroleum and coal products
6. Production of non-metallic mineral products, Except petroleum and coal products
7. Main metal production
8. Prefabricated metal products, Machinery and equipment

According to the established classification, countries most factories and industrial organizations can be easily placed in these 8 categories.

Ghazinoory [5] Is used to index, All options will be evaluated in relation to the 6 following indexes:

1. The number of industrial units and companies in the Respective industry group
2. The amount of pollution and toxins produced by industrial activities
3. sustainability of Industrial pollution in environment (amount of Time required to hydrolyze)
4. The economic value of raw materials and resources in each industry group
5. Excretion and wastage elimination costs
6. Accessibility to Clean Technology

The decision matrix is based on Table 1. For the first indicator the quantitative data used from Iran's Ministry of Industries and Mines Existing data and For the remaining indicators , Experts and managers in the respective industry is used. Also According to span of the experts and professionals views and comments and In order to enhance the accuracy of the results, the fuzzy theory was used to obtain experts opinions. TOPSIS and VIKOR techniques has been used to prioritize subgroups that have The more accurate mathematical basis and High precision, and guarantees Very high degree of reliability and accuracy of the results. In calculating the indexes weights Entropy method has been applied wherein the weights are obtained through a decision matrix. Entropy method in the decision making is first time mentioned by Shannon. The idea of this method is that the scatter in the values of the index is greater that index is more important.

Table 1: Decision matrix

Weights obtained for each of the indicators	.1025	.1593	.2137	.1202	.1846	.1669
	decision making indexes					
Industrial subgroups	1	2	3	4	5	6
1. Food Production, beverages and tobacco	2067	1	1/5	1	1	5
2. Clothing industry, Leather and Textiles	786	3	1/3	3	1/3	3
3. wood products and Woodcraft, including furniture	205	1/5	1/5	1	1/5	1/3
4. Paper Production, Paper Products, Printing and Publishing	404	1/3	1/3	1	1/5	5
5. Chemical production, Pharmaceutical products, Plastic, Petroleum and coal products	3615	5	5	5	5	1/3
6. Production of non-metallic mineral	2397	3	1	1	3	1

products, Except petroleum and coal products						
7. Main metal production	763	1	1	1/3	1	1
8. Prefabricated metal products, Machinery and equipment	2505	1/3	3	5	1	1/3

Evaluation of Weights of indicators:

Any issue that is faced by a decision maker may have several indicators. So it is necessary to know the relative importance of indicators. Thus a weight is given to each indicator, Such that the summation of the weights is equal to 1. There are several methods for evaluating indexes weights, such as: Entropy method, Linmap Method, Least squares method and Eigenvector method. The main idea of this method is that the scatter in the values of an indicator is further, that index is more important. In this study, In order to assess the index weights Entropy method is used. In The following, steps of this method are presented:

Step 1: Calculate p_{ij}

In Information Theory, entropy is a measure of uncertainty which is defined by determined probability distribution P_i . According to Shannon's theory, P_{ij} is calculated by relation (4).

$$P_{ij} = \frac{a_{ij}}{\sum_{i=1}^m a_{ij}} ; \quad \forall j \quad (1)$$

Step 2: Calculate the value of entropy E_{ij}

J 'th index's entropy is calculated by using 5th relevance [13].

$$E_j = -k \sum_{i=1}^m [p_{ij} * \ln p_{ij}] ; \quad \forall j \quad (2)$$

Step 3: Calculate the value of Unreliability d_j

Unreliability or degrees of deviation of the data obtained for each indicator states that the respective indicator provides how much useful information for decision-making for decision maker. The value of d_j is calculated as relevance 6.

$$d_j = 1 - E(j); \quad \forall j \quad (3)$$

Step 4: calculate weights W_j

The weight of each index is calculated by using relevance 7.

$$w_j = \frac{d_j}{\sum_{j=1}^n d_j} \quad (4)$$

Table 2: Calculating the indicators weights by entropy method

	Indicator 1	Indicator 2	Indicator 3	Indicator 4	Indicator 5	Indicator 6
E_j	0.8672	0.7935	0.7230	0.8442	0.7608	0.7837
$d_j=1-E_j$	0.13284	0.2064	0.27696	0.15582	0.23919	0.21634
W_j	0.1025	0.1593	0.2137	0.1202	0.1845	0.1669

Results:

Topsis Method:

TOPSIS model first time proposed by Hwang and Yoon in 1981. This model is one of the best decision making models and Option is selected that has the least distance to the positive ideal solution and maximum distance to the negative ideal solution [13]. Results obtained by using this method are shown in Table 3 In short. It is noted that Industrial subgroups 5 (Chemical production, Pharmaceutical products, Plastic, Petroleum and coal products) is in the first priority, Industrial subgroups 8 (Prefabricated metal products, Machinery and equipment) is in the first priority, Industrial subgroups 6(Production of non-metallic mineral products, except petroleum and coal products) is in the first priority.

Table 3: Options ranking using TOPSIS method

priority	Industrial subgroup	score
1	Chemical production, Pharmaceutical products, Plastic, Petroleum and coal products	0.7295
2	Prefabricated metal products, Machinery and equipment	0.3900
3	Production of non-metallic mineral products, Except petroleum and coal products	0.3821
4	Food Production, beverages and tobacco	0.3154
5	Clothing industry, Leather and Textiles	0.3167
6	Paper Production, Paper Products, Printing and Publishing	0.2346
7	Main metal production	0.1576
8	wood products and Woodcraft, including furniture	0.0343

VIKOR Method:

This method specifies a ranking list of compromise solutions for MADM problems. This method focuses on ranking and selecting a set of options in the presence of conflicting criteria. In this method, Criteria for ranking the alternatives are based on proximity to the ideal solution. Results obtained by using this method are shown in Table 4 in short. This time it is also seen that Industrial subgroups 5 (Chemical production, Pharmaceutical products, Plastic, Petroleum and coal products) is in the first priority, Industrial subgroups 8 (Prefabricated metal products, Machinery and equipment) is in the first priority, Industrial subgroups 6 (Production of non-metallic mineral products, except petroleum and coal products) is in the first priority.

But the priorities change can be seen in other priorities. In fact, using the VIKOR method, we can set a priority to the series of options as these options are very close together in terms of ranking.

Table 4: Ranking option using VIKOR method

Priority	Industrial sub-group
1	Chemical products, Pharmaceutical products, plastic, petroleum and coal
2	Prefabricated metal products, machinery and equipment
3	Non-metallic mineral products, except petroleum products and coal
4	Clothing, leather and textiles industry Basic metal industries
5	Food industries, beverage and tobacco Manufacture of paper, paper products, printing and publishing Production of wood and wood products, including furniture

Conclusions and Recommendations:

There are many internal factors that force companies to implement green activities. First or, in other words, the most important factor is the cost. It means that being green can lead to greater performance of benefits and financial savings. Thus, using less input leads to less salvage and reduction in pollution. The second internal factor is the philosophy of the company. Once a company concerns environmental objective as well as other objectives and they involve these objectives in company philosophy, being green will be merged with company strategies and then, it will be integrate with its tactical activities. The third factor is establishing a competitive position in the market. Companies that consider environmental issues in production process will establish a competitive position to their competitors. Being green will be caused by external pressures, including: 1-Satisfying consumers demand: nowadays, companies and organizations have to place environmental protection related issues to their activity to satisfy customer demands, carrying out their social responsibilities and supporting consumer's right. Mac Donald restaurant is a typical sample that have changed its packing composition to support consumer's right and satisfy their demand. 2-Reaction to competitors actions: Once a company considers environmental concerns, other companies either have to change their production strategies and plan to aim at green or they will lose their market stocks. 3-Increasing government involvement: in different countries, government use different ways to protect environmental healthy, enacting new low and environmental regulations is one of these common ways. 4-Increasing environmental pollution: As environment got more polluted, companies must take steps toward green marketing and green movement. Pollution leads government and organization policies shift to green because of consumers' social pressure.

Also in Iran, companies and different industries depends on their activity step towards green movement in different approaches. Because of these differences, restrictions and rules are implemented differently about them. Differences due to the diverse nature of businesses and organizations in a wide expanse of the industry groups convince us to distinguish them in our view to rank them. A compilation of the results using MCDM techniques is summarized in table 5. The ranking by following methods are very similar to each other and according to them the sub-group 5 (Chemical products, Pharmaceutical products, plastic, petroleum and coal), 8 (Prefabricated metal products, machinery and equipment) and 6 (Non-metallic mineral products, except petroleum products and coal) are ranked 1 to 3.

Table 5: Final ranking of options

Industry sub-group	Ranked by TOPSIS method	Ranked by VIKOR method
1. Food industries, beverage and tobacco	4	5
2. Clothing, leather and textiles industry	5	4
3. Production of wood and wood products, including furniture	8	5
4. Manufacture of paper, paper products, printing and publishing	6	5
5. Chemical products, Pharmaceutical products, plastic, petroleum and coal	1	1
6. Non-metallic mineral products, except petroleum products and coal	3	3
7. Basic metal industries	7	4
8. Prefabricated metal products, machinery and equipment	2	2

Also these cases recommended for future researches:

1. Ranking subsets of each sub-group by MCDM technique (for example the sub-group Chemical products, Pharmaceutical products, plastic, petroleum and coal contained 5 parts: coke and petroleum products, chemical substances and chemical products, plastics and rubber, mining of coal and peat extraction, crude oil and gas).
2. Providing an integrated strategy for clean production and separating public and private organizations in its implementation.
3. Codification integrated green strategy for manufacture-services companies and considering the differences of such companies from manufacture-industry one in its implementation.
4. Studying how the implementation of clean technology would be in major industrial sectors and analyzing the cost - benefit of gaining accessing to these technologies.

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