Developing a Decision-Making Dashboard for power losses attributes of Iran’s Electricity Distribution Network

Abstract
Efficient planning and operation of the power distribution networks are paramount. Losses along the power distribution network are responsible for the loss of a large deal of energy and capital every year. Numerous projects are being defined and implemented targeted around the idea of reducing losses, which are rather expressed and implemented in terms of an organization of the existing networks. Accordingly, we address a loss prioritization research project, with a case study on Iran's Electrical Distribution, to increase their productivity. Managers and experts of the Tehran Electrical Distribution Company comprised the statistical population. we used to collect their opinions via a questionnaire. The Decision-Making Trial and Evaluation Laboratory (DEMATEL) technique was then used to undertake a comparison among the identified factors, while Vlse Kriterijumsk Optimizacija Kompromisno Resenje (VIKOR) technique was used to select optimal alternatives. As a result, the most important and effective factors in developing power losses along power distribution networks were identified, and the optimal alternative to improve the trend of modification and optimisation activities on the distribution network was determined.
Keywords: Power Losses, Distribution Networks, Multiple-criteria decision-making (MCDM)

1. Introduction

A significant portion of power and energy produced in power plants is lost on the path from production unit to the consumer, and these losses depend on several parameters including network structure, equipment type, load density, consumption type and their share in total. The power loss is a significant problem affecting both the distribution companies as well as the electricity transmission and marketing. Power loss in two similar networks with equal consumption peak is different due to a variety of factors influencing power loss. Power loss plays an important role in planning, designing and exploiting the network and wide studies in order to identify and model power loss components are necessary (Heidari, 1999; Sánchez-Zuleta *et al*., 2017).

More than 50% losses of peak load pertain to distribution networks. Losses in electricity networks result in large amount of losses in energy and wealth each year, while this lost wealth could be used to improve electricity networks and develop them quantitatively and qualitatively, thus it is required to put much time and effort in studying these networks and proposing schemes for reducing power loss. Several projects are being implemented which aim to reduce power loss in distribution networks, which consequently employs incomprehensible methods and are based on accurate and scientific load estimation and they are mostly implemented by organizing existing networks where the output is usually far beyond the optimal design (Ramesh *et al*., 2009).

Nevertheless, the major contribution of this research is divided into two parts. Since efficient production and distribution of energy and electricity is the great importance in the global competitiveness which affected on the reduction of national costs and efficiency, this research is one of the unique works has been done in the Middle East especially in Iran in the field of power loss assessment. Moreover, decision-making tools and their application in optimal decision-making has been widely used in the last two decades. The combination of these techniques can help reduce the disadvantages of the techniques alone and take advantage of their combination. There is no work about the use of three VIKOR and DEMATEL and Analytical Network Process (ANP) tools (Feng *et al*., 2018) to assess power loss in any country.

Considering several identified factors which cause power loss in distribution networks, choosing the most effective factors is of great importance, thus DEMATEL which is based on pairwise comparison is used to achieve this goal. In the next step, VIKOR technique which is one of the most applicable models in decision-making and selecting the best option is used for multi-criteria optimisation of systems and improving distribution networks; the results are compared with current activities in distribution networks and the results are also analyzed.

This difference in the units generated and distributed is known as Loss of Transmission and Distribution. Transmission and Distribution loss are the values that are not paid for by the consumer (Jiguparmar, 2013)

T&D Losses = (Energy Input to feeder (Kwh) – Billed Energy to Consumer (Kwh)) / Energy Input kwh x 100

There are two types of Transmission and Distribution Losses:

1. Technical Losses
2. Non-Technical Losses (Commercial Losses)

Where technical losses are converted into heat and are mainly due to non-optimality of the system and its components, while non-technical losses are mainly computational losses. But the nature of commercial losses is totally different and it is not a direct loss of energy, but it is referred to those economic losses which are caused by power outage or power quality problems (Navani *et al*., 2014; Zuleta *et al*., 2017).

The paper is structured according to the following. Section 2 provides the problem statement. section 3 explains the literature review. The research methodology is described in section 4. Finally, conclusion of the research is expressed.

2. Problem Statement

Power network includes three units: production, transmission and distribution. Once electrical energy is produced in power plants, it is transmitted to consumers through transmission and distribution networks. In this path, some energy is lost due to different reasons (Müller *et al*., 2019). Investigating losses in the electrical engineering community is an unavoidable necessity, however, existing losses in transmission and production level is almost unavoidable. Considering the necessity of this issue and the government's decision for implementing targeted subsidies, all relevant organizations (regional electricity firms and distribution firms) are obliged to minimize losses in their own operational domain considering specific schedules which are determined annually and imparted in a specific time, in order to save electricity which is a national wealth (Navani *et al*., 2012; Navani *et al*., 2014; Tuttle *et al*., 2016). This national scheme which was proposed by CEO of Tavanir Company, and it was imparted to electric complex. And it needs innovations and efforts of experts, unlimited management and administrative capabilities for implementation.

3. Literature Review

By restructuring power distribution companies, energy loss management is one of the important measures to increase network efficiency. The most interruptions occur in power networks. Accordingly, technical loss monitoring and strategic planning for loss reduction is one of the main goals of the asset manager (Gheorghe *et al*., 2010; Dashti *et al*., 2018; Chen *et al*., 2019). Most of the current electricity policies and activities are commonly considered unsustainable. A closer look at the category of losses is important because the economic value of the energy produced (and destroyed) is much higher than the income from the sale of energy. Calculations show that reducing losses in the low-pressure distribution system and releasing the latent capacity is several times cheaper than building the power plant to compensate for the same amount of power lost (Satrio and Subiyanto, 2018; Zemo *et al*., 2019). Discussion about power losses started since oil war in 1970s, since then economic competition among different countries and decrease in production costs, competition among production units, transmission and distribution of electricity after privatization of electrical industry and obligation for clarifying costs caused researchers to study power loss reduction vastly especially in the electricity distribution firms (Chen and Zhao, 2020). Power loss index in the power distribution system is one of the important indicators of network efficiency. This index reflects the overall view of each distribution company on the proper use of equipment to deliver economic electricity to customers. Distribution network operators therefore need to calculate losses for various reasons, such as network planning, network loss reduction, non-physical loss computation and network performance evaluation, and decision-making on optimal network layout (Yongping, 2011; Monedero *et al*., 2012).

Researches on the topic of study can be divided into two parts: researches on energy losses and researches on decision-making. Studies performed in energy losses are presented in various papers. In 1993, Torabi studied experimentally statistical description of power losses in rural networks. A method is proposed to determine the real percentage of losses and loss reduction in distribution networks, determining losses in different in different consumption units and technical actions is proportional to consumption type and how consumption affects losses.

Tabatabaei *et al*. (1993) examined losses caused by electrical losses in the electrical industry. Energy loss statistics are reviewed and loss demand in peak hours of general network is estimated. Information of power loss is used to determine imposed losses and finally they have proposed some directions for implementing large loss projects. In addition, another study was investigated losses in electricity networks and proposing a method for reducing losses presented by Nikzad and Rahmnai (1993). Losses for 20 kV, low voltage lines and transformer posts is calculated 20.04 and finally estimated losses in these lines are presented.

Soleimanazar (1994) investigated energy losses in Hormozgan electricity network. Electric losses in different parts of Hormozgan electricity network are analyzed and the effect of environmental conditions on these losses is studied, finally scientific methods for reducing these losses are proposed. Golkar (1995) calculated losses in energy distribution lines using a new probabilistic method. By calculating these functions, variation range of losses in each branch of the system is determined. Mohammadian and Fayyaz (1996) dedicated analysis of loss factors and determining priority of reducing them in low voltage network of Mazandaran. Loss of lines calculates then they are categorized, analyzed and prioritized based on size. Ibrahim (2000) has studied managing loss reduction projects in distribution networks. An accurate and effective method for analysis of loss reduction has been proposed and a practical plan has been proposed for solving the problem. Alipour (2002) studied losses of distribution unit and its economic consequences. Factors influencing losses and their effectiveness are explained using obtained results. Kaboli and Ghasemloo Gheidari (2004) surveyed power loss in Zanjan's distribution network. They obtained a criterion for measuring effect of different parameters in distribution network's loss. Babachahi and Dashti (2007) developed strategic investigation of losses in Booshehr's distribution network. In their research, factors which create losses are identified and an approach based on SOWT matrix is proposed and strategic operations for reducing losses are described. Trifunovic *et al*. (2011) presented a method for the evaluation of the reductions in the technical and non-technical distribution losses in case of the mass use of compact fluorescent lamps (CFLs) in buildings in Serbia.

The paper showed that substantial reductions in both the technical and non-technical losses in the Serbian distribution power system can be achieved by applying energy efficient light sources. Rafiee *et al*. (2012) investigated experiences in reducing losses of distribution networks. Three factors were checked for evaluating effectiveness and performance of activities performed in order to decrease losses which include stored energy, investment costs and quantity. Later on, Zeidan *et al*. (2013) used a GA -based method in distribution system reconfiguration for reducing energy losses according to load variety and local renewable generation. Bashiri (2013) identified more than 100 technical projects and organizational processes.

Reducing losses in distribution networks was obtained by assessing their weight and importance degree in order to assess activities, processes, technical and non-technical projects. Promise and Economic (2015) had focused on the technical and non-technical losses estimated in the network on the Nigerian Economy. The network was analyzed using Power World Simulator (PWS). Ene *et al*. (2016) studied GA for minimizing consumption of stored energy. Results indicated that GA proposes efficient solutions for this problem. Sánchez-Zuleta *et al*. (2017) identified the characteristics incident to the detection of non-technical losses for two Colombian energy companies.

Satrio and Subiyanto (2018) presented modelling approach used to restructure electrical network configuration, reduce drop voltage, reduce power losses and add new distribution transformer to enhance reliability of power systems distribution. Result showed that the restructuring of the electricity network configuration and the addition of a new distribution transformer can be used as an effective method to reduce the voltage drop and the power losses.

Das and McFarlane (2019) studied Non-linear dynamics of electric power losses, electricity consumption, and GDP in Jamaica. For this small island nation, its electric power losses are egregiously large and are due mostly to the illegal abstraction of electricity. Result showed that reducing electric power losses would have a potentially positive effect on GDP growth. Aryanezhad (2019) examined a novel approach to detection and prevention of electricity pilferage over power distribution network. It was done in Iran. The experimental results show satisfactory performance. This technique curbs the non-technical losses by balancing the response to supply demand and by reducing additional tariff posed on genuine consumers. Chen *et al*. (2019) investigated online theoretical power loss calculation and management system. The system has been used to the theoretical line loss estimation and analysis in Zhejiang Power Network for two years. Jiao *et al*. (2019) introduced a new computational framework to account for uncertainties in active distribution network (ADN) planning in the presence of wind power, energy storage and electricity price.

Rubens and Noel (2019) built a conceptual framework to analyze the non-technical barriers, engagement of stakeholders and social risks to the proposed super grids in the US and Europe. In the selected case studies, they identified 12 non-technical circumstances that could impede the agreement, preparation, implementation and completion of a super grid project. Bhatt & Singh (2020) studied Stakeholders' role in distribution loss reduction technology (LRT) adoption in the Indian electricity sector. They concluded that loss reduction and LRT adoption policies can be implemented effectively by engaging customers through information sharing and, by showcasing advantages of LRT projects especially those leading to improvement in quality of electricity supply. Hellwig *et al*. (2020) proposed a difference-in-differences approach to estimating the impact of incentives on cost reduction in the context of German electricity networks. Result showed that higher-powered incentives lead to cost reduction.

Chen *et al*. (2020) studied an innovative waste-to-energy system integrated with a coal-fired power plant. Results showed that, due to the planned incorporation, the productivity of waste-to-electricity is improved by 9.16 percentage points with an additional net output of 3.71 MW. Ajoulabadi *et al*. (2020) investigated flexible scheduling of reconfigurable microgrid-based distribution networks considering demand response program. The optimisation aims to reduce total operating costs and losses with optimal networked microgrid reconfiguration. Mateo *et al*. (2020) combined three models. Six European networks have been identified for urban and semi-urban delivery areas in Germany, Italy and France. The results show strong differences in each of these countries in expected effects. According to researches done about technical and non-technical energy loss, they presented strategies to reduce loss. Reducing losses in distribution networks (technical and non-technical) was an essential goal for all countries.

However, some studies investigated energy systems by MCDM. Puhkar and Ramachandran (2004) studied stable energy using multi-criteria decision-making. Due to the superiority of PROMETHEE and ELECTRE techniques it was observed that the sequential analysis procedure is the most popular method. The findings are checked by different methods, developing interactive decision-making support systems and using fuzzy methods against uncertainty of data. In addition, Kharadmehr and Sobhani (2004) proposed calculating energy loss of distribution network in inaccurate environment using fuzzy theory. Fuzzy Arithmetic equations, load modeling and annual stability curve were simulated using MATLAB as fuzzy inaccurate numbers in load distribution equations and the results are compared with classical approach. Sadeghi *et al*. (2012) evaluated renewable energy sources (solar, geothermal, hydropower and wind energies) for generating electricity in province of Yazd (Iran) by Fuzzy Analytic Hierarchy Process (FAHP) and the Fuzzy TOPSIS. Results suggest solar energy is the most suitable form of renewable energy for the region under review. Wilmer *et al*. (2015) studied MCDM Support system for Renewability of Energy System in Islands. They suggested a perspective for proven energy planning concept on the island. Mardani *et al*. (2015) investigated stable and renewable energies using MCDM techniques. Findings shows that MCDM techniques can enable stakeholders and decision makers to solve some inherent ambiguities in environmental decisions, and this technique demonstrates the increasing interest of researchers to apply this method to different stages of stable energy and renewable systems.

Atabaki and Aryanpur (2018) examined Multi-objective optimisation for sustainable development of the power sector: An economic, environmental, and social analysis of Iran. The findings indicate that the economic scenario fulfills Iran's commitment to 4% emission reduction relative to the current trend. Feng *et al*. (2018) studied environmentally friendly MCDM of reliability-based product optimisation combining DEMATEL-based ANP, interval uncertainty and VIKOR. DANP helps the proposed method to process the complex correlations among product components using a concise hierarchy model. Chakraborty *et al*. (2018) studied an integrated DEMATEL–VIKOR Method-based approach for cotton fiber selection and evaluation. DEMATEL method addresses the interrelationships between different physical properties of cotton fibers while segregating them into cause and effect groups, whereas, VIKOR method helps rank all of the 17 cotton fibers considered from best to worst. Mousavizade & Shakibazad (2018) studied the critical success factors (CSF) of knowledge management (KM) in Iranian urban water and sewage companies (IUWSC) using interpretive structural modeling (ISM)- DEMATEL method. The findings showed that among the studied factors, strategies and goals would have the greatest effect on success of KM implementation and senior management support, and teamwork and organizational culture are other CSFs of KM in IUWSC. Abdel-Baset *et al*. (2019) studied an integrated neuromorphic ANP and VIKOR method for achieving sustainable supplier selection: a case study in importing field in Egypt. According to the findings, Taipei City is considered the best in the manufacturing process of its products, based on the three factors: economic, environment and social. Singapore is seen as the worst choice. Najar vazifedan and Avakh Darestani (2019) used DEMATEL for assessing outsourcing green logistics. Additionally, Table 1 summarizes the recent MCDM works.

Table 1. summary of recent MCDM works

Author	Year	Energy section	Country	Methodology							Case study/ Population	Fuzzy
				Review Work	DEMATEL	VIKOR	ANP	TOPSIS	AHP	Others		
Puhkar and Ramachandran	2004	stable energy	India	A review of more than 90 published papers								
Kharadmehr and Sobhani	2004	energy	Iran					√	√		Province Yazd, Iran	fuzzy
Sadeghi	2012	electricity	Iran						√		Iranian power plants in Yazd, Iran	fuzzy
Wilmer	2015	electricity	Islands						√	√	Island energy system	
Mardani	2015	sustainable and renewable energies		review of MCDM techniques (2003-2015)					√			
Feng *et al*.	2018	industrial products	china		√	√	√				waste tire shredder in china	
Chakraborty *et al*.	2018	cotton fibre	India		√	√					Textile Center of Texas Tech University, USA in the year 1997–1998	
Mousavizade & Shakibazad	2018	urban water and sewage	Iran		√						the experts in Iranian urban water and sewage	

Author	Year	Energy section	Country	Methodology							Case study/ Population	Fuzzy
				Review Work	DEMATEL	VIKOR	ANP	TOPSIS	AHP	Others		
											companies (IUWSC)	
Najar vazifedan and avakh darestani	2019	Petrochemical	Iran		√		√				senior logistic expert and manageme nt in Kurdistan, Iran	fuzzy
Abdel-Baset *et al*.	2019	Hardware, electrical devices, toys, housewares	Egypt			√	√				a large importing company	
This research	2020	Electricity losses	Iran		√	√	√				Tehran Province network, Iran	

Studies have shown that three methods of DEMATEL, ANP and VIKOR have been used in various industries and energy. A lot of studies have used one approach or a combination of the two methods. Of course, in the research of Feng *et al*. (2018) have employed these three methods together, but its case study was industrial products. But there is no work into the power losses using three methods. Therefore, it can be said that the present study is the only study using three methods to investigate the power losses.

There is no work has been done using MCDM for prioritizing losses in Tehran's Distribution Network; however, our proposed research can be used to improve loss projects. To this end, DEMATEL technique which is based on pairwise comparison is selected, effectiveness and impressibility of each factor is identified. Then ANP method was used to weight each factor and finally VIKOR was employed which is one of the applicable methods in decision-making and is developed for optimizing multi-criteria decision-making systems. And the most effective and most important options were selected, in fact, it is tried to compare and analyze the obtained results.

In this work, DEMATEL, ANP and VIKOR are combined which has not yet been studied. The capability of these tools is that they evaluate and weight models and then they sort factors. Considering the importance of the electric industry in Iran, this research has used MCDM combined with these three tools.

4. Methodology

First step is to collect information. One of the most common methods for collecting information is to use questionnaires through which information can be gathered in large scale (Hafeznia, 2009).

In order identify loss factors in distribution networks, first one needs to categorize gathered information through library studies. In order to design questionnaires for this work is used field studies done on papers published in Iran and International journals throughout recent 15 years about identifying and categorizing loss factors.

In the DEMATEL questionnaire, the criteria are first identified. This identification can be obtained by reviewing the literature and research background or Delphi method. Delphi method is one of the methods of collective opinions that is obtained by using the opinions of a number of experts based on Delphi panel. After identifying the final factors, we then form the DEMATEL matrix and place the appropriate number in the cells based on the high spectrum (Barghi & Shadrokh, 2020). The Vikor questionnaire consists of a standard-option matrix. This method has better optimisation than similar methods and uses the amount of usefulness and regret to rank the criteria (Yang *et al*., 2009).

Questions were adopted based on studies and papers proposed in national and international journals about reducing losses, field studies and current activities of Tehran distribution network for reducing losses. By categorizing information, some indices were considered for formulating the questionnaire. Since this study is done in Tehran distribution network, statistical population was selected among technical experts of Tehran distribution network with more than 5 years' experience.

4-1 Research Method

The research method of this investigation has been divided to different phases as follows. It formed based on the mentioned research gap.

4-1-1 Proposed Research Model

First, we selected decision factors based on previous studies. In the next step, our selected criteria were converted into different questionnaires based on MCDM tools for different applications, i.e., phase 2.

Then technical, non-technical and management branched were extracted and the problem was solved based on ANP, VIKOR and DEMATEL techniques, which outputs the rank, weight and priority of factors. Organizations can manage losses in distribution network system using these outputs and consider factors with high priority in their strategic plans (Figure 1).

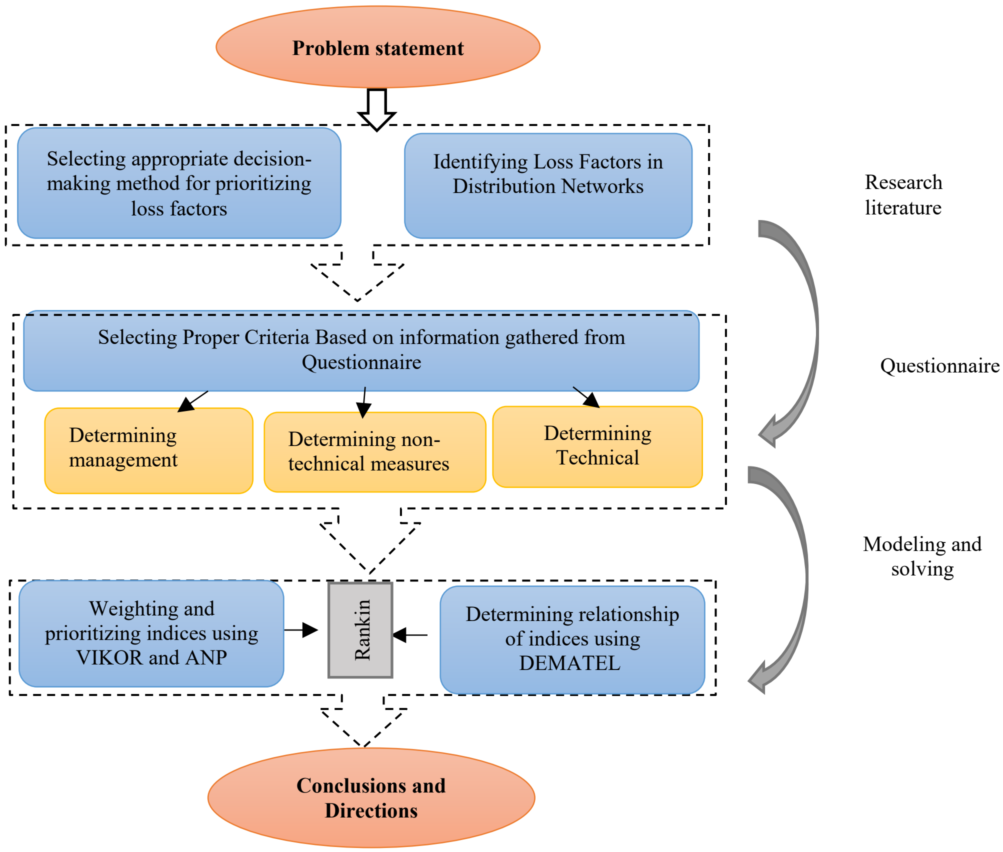

Figure 1. Flowchart of Proposed Research Model

4-1-2 Conceptual Model of the Research

After reviewing previous studies in phase 1, aim of the research which is identifying and ranking loss factors in distribution networks was specified. In phase 2, technical, non-technical and management branches were extracted. The problem is modeled and solved based on DEMATEL, VIKOR and ANP techniques and factors are ranked, weighted and prioritized at the output of phase 4 (Figure 2).

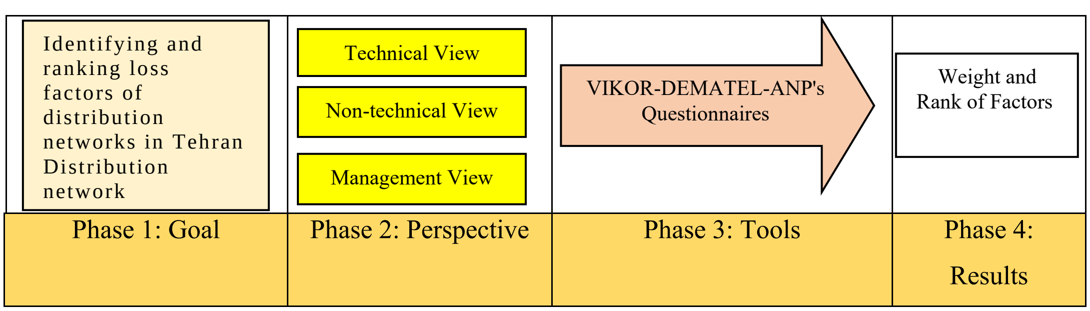

Figure 2. Conceptual Model of the Research

4-1-3 Selecting Criteria and Options

Regarding the previous steps, there would be two main criteria: technical and non-technical where each would have several sub-criteria which are presented in Table 2.

Table 2. Criteria and Sub-criteria of losses

Criteria	**Sub-criteria**	Definition	**Reference**
Technical Losses	Phase imbalance	The single-phase loads of the distribution system along with the asymmetry of the phases sometimes cause severe imbalances. On the other hand, the unbalance of the phases leads to the null flow, which in turn increases the energy losses in the wire.	Dickson K. Chembe Rajesh. R , Siva Sankari, E. (2015) Maxime Guymard 2012, Back ground paper for the world Bank Group Energy sector strategy 2009
	Unsuitable loading of transformers	As with the transmission system, the transmission network also passes through many devices on its way, each of which Depending on the type, technology of manufacture, and their lifetime, they waste a percentage of their energy.	Sohn *et al*., Takyo electrical co. Navani, J.p., *et al.* (2012), Al-badi, A. (2012), Maxime Guymard 2012
	Constructing long networks	feeders with non-standard length	Maxime Guymard 2012
	Selecting improper conductors	Conductors are the main cause of losses in power transmission and distribution lines. Therefore, selection of optimum diameter and number of conductors in each phase can play an important role economically.	Navani *et al.* (2012)
	Improper earth (network lines, equipment's and posts)	Inadequate or Improper earth systems will find high electrical resistance, which in unbalanced systems will result in voltage imbalances and energy losses.	Rajesh. R, Siva Sankari, E. (2015)
	Loose connections of the network	Losses on loose connections in the form of joules are wasted and cause the connection to heat up.	Gabriela A. 2013
	Using non-standard tools and equipment's	With regard to inadequate application of any standard in which it can cause damage to equipment and manpower, it is necessary to check and control equipment and components prior to use and after installation on the network.	Gabriela A. 2013, Rajesh. R , Siva Sankari, E., 2015, Soham Ghosh 2012
	Improper design of distribution networks	Lack of use of high-power transformers - Lack of transformer installation at load center of gravity - Optimal mismatch between transmission and overvoltage voltages and medium and low voltage	Manohar, J., Jinka,A. (2012)
	Old and eroded networks	Over time, the conductivity of copper conductors decreases and results in increased resistance of the power switch connector. Iron core losses of transformers, CTs and PTs increase with increasing life	Gabriela A. 2013

Criteria	Sub-criteria	Definition	Reference
		span, and the insulation losses of all equipment increase sharply due to the long-term insulation weakness.	
Non-technical losses (economic and management)	Using illegal electricity	There are a number of unauthorized uses such as faulty meters, removal of meters from the circuit.	Thomas B.Smith 2004, Takyo electrical co, William Yu , Micheal G. Pollit 2009 Back ground paper for the world Bank Group Energy sector strategy (2009); Monedero *et al*., 2011
	Reading measurement tools incorrectly	Failure to properly read the meters by the agents can cause the multi-rate tariff system to be ineffective.	Rajesh.R., Siva Sankari , E. (2015), Maxime Guymard 2012; Soham Ghosh (2012)
	Non-payment of bills by subscribers	Failure to pay the bills on time by the subscribers will result in delayed return of the capital and consequently loss of power.	Rajesh.R., Siva Sankari, E. (2015), Soham Ghosh 2012, Back ground paper for the world Bank Group Energy sector strategy (2009)
	Failure of measurement tools	inaccurate measurement	Rajesh.R., & Siva Sankari, E. (2015)
	Not recording consumption of electricity network	Failure to record the amount of light network consumption causes losses.	Rajesh.R., & Siva Sankari, E. (2015), Back ground paper for the world Bank Group Energy sector strategy 2009
	Incorrect Calculations	Calculations or other misstatements that lead to inaccurate bills can frustrate the accuracy of other metrics and waste part of the return on energy sales.	Takyo electrical co, Rajesh.R., & Siva Sankari, E. (2015), William Yo , Micheal G. Pollit (2009)
	Losses resulting from environmental conditions	It includes losses caused by moisture and Corona and so on	Rajesh.R., & Siva Sankari, E. (2015)

Selecting options correctly for VIKOR calculations deems necessary. In this research, options are defined as those activities which reduce losses. Thus, considering scope of this issue, experts' comments were used and these activities were categorized in 3 main classes:

-Low voltage network

-Medium voltage network

- 20 kV posts

4-2 Statistical Population and Statistical Sample

Since this research tries to identify and categorize loss factors in electricity distribution networks, statistical population of this research would be comprised of the experts and managers of Tehran Electricity Distribution Network. In many applications, researchers try to determine parameters of the population, however., direct access to the statistical population may not be feasible. In such situations, researchers have to deduct samples of the population for deducting intent parameters. Sample, is a smaller group of the population which is selected for analysis.

Since statistical population of this research is managers and experts of Tehran Distribution Network, which is 330 people in total, thus 21 regions of Tehran distribution network are selected as statistical sample and questionnaires are distributed among them. In order to determine the sample, most simple method is to use Cochran formula.

In Cochran Formula

$$n = Z^2 * qp/e^2 \qquad (1)$$

Which will give 176 as the required number of people in our sample.

$$n = Z^2 * qp/e^2 = 176.76 \qquad (2)$$

4-2-1 Statistical Population of research

Since this study is done in Tehran distribution network, statistical population was selected among technical experts of Tehran distribution network with more than 5 years' experience. (Appendix A)

4-2-2 Spatial Domain Adopted for Analysis

Spatial domain of the research is Tehran Electricity Distribution Network. Tehran Electricity Distribution Network has 22 executive regions and 4 Coordination and Monitoring Assistance and Strategic Headquarters which operate under the supervision of Tavanir (Figure 3).

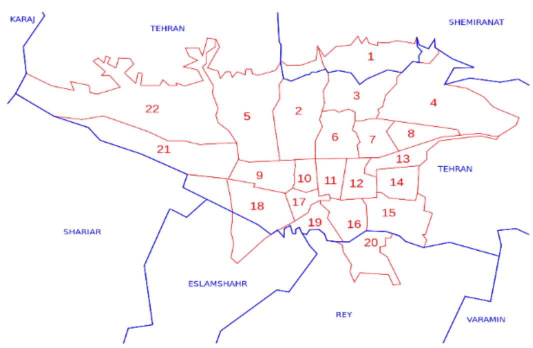

Figure 3. Tehran Electricity Distribution Domain

4-3- Data Gathering

There are several tools and methods for collecting information where each one is suitable for a specific type of data. All these methods have their own advantages and disadvantages; thus, utilization of multiple methods would have can benefit by complementing each other and to provide more precise data. In this research, library studies and questionnaire are used to gather information.

4-3-1 Designing DEMATEL Questionnaire

DEMATEL questionnaire is designed using identified criteria for reducing losses in distribution networks which were described in previous sections (Appendix B, C). Questions are answered with 5 options and each option is scored based on the following Table 3:

Table 3. Techniques range of 5 degrees DEMATEL

No effect	Very low effect	Low effect	High effect	Very high effect
0	1	2	3	4

Now the responder should be asked to determine effectiveness of each criterion. The important point is that the effect of each criterion on other criteria is not essentially mutual. Effects are determined based on experts' comments. 20 experts are selected for this purpose where geometric average of their comments is used as the decision matrix.

4-3-2 Designing VIKOR Questionnaire

Using ideas of 10 experts in Tehran Distribution Firm, a questionnaire was designed for VIKOR calculations.

4-4 Model and Equations

Methods used in this research are VIKOR and DEMATEL which are described in the following.

4-4-1 DEMATEL Technique

The DEMATEL technique was introduced by Fontela and Gabus (1972). The DEMETEL technique is one of a variety of decision-making methods based on pairwise comparisons, A well-known and comprehensive method for obtaining a structural model is the DEMATEL method. This method is based on graph theory, and allows us to visually plan and solve problems. It is considered an important tool for separating components of a complex system in the cause-effect chain. This deals with determining interdependent factors relationships and identifying critical ones through a visual structural model (Si *et al*., 2018; Seker *et al*., 2017; Mousavizade and Shakibazad, 2019). DEMATEL is based on graphs which can divide factors into cause and effect groups and extract their relationship as an understandable structured model. DEMATEL technique is generally developed for global complex problems.

4-4-1-1 Calculation of DEMATEL

DEMATEL technique is used to reflect mutual relations among factors in a way, that it would enable experts to describe their ideas about effects (direction and intensity) considering all the factors. It should be noted that the matrix obtained from DEMATEL technique shows the cause and effect relationship among factors and their effectiveness and impressibility. Calculation procedure of DEMATEL technique is as follows:

Step 1- Calculating direct relation matrix (M)

The data were collected from the respondents. When ideas of several experts are used, arithmetic average is used to from direct relation matrix.

Step 2- Calculating normal direct relation matrix

The normalized primary direct matrix was determined in this step as:

$$N=K*M \quad (3)$$

First all rows and columns are summed. Inverse of the largest row and column number forms K. (Najar Vazifedannand Avakh Darestani, 2019).

Step 3- Calculating complete relation matrix

It calculates the matrix of direct / indirect influence. This matrix represents the direct and indirect effects on one another by the matrix elements (factors). In order to calculate complete relation matrix, first unity matrix is formed. Then unity matrix is subtracted from normal matrix and the obtained matrix is inversed. Finally, normal matrix is multiplied by the inverse matrix: (Najar Vazifedannand Avakh Darestani, 2019)

$$T=N*(1-N)^{-}1 \quad (4)$$

Step 4- Demonstrating Network Relations Map

Threshold intensity should be calculated to determine Network Relations Map (NRM). Using this method, minor relation can be neglected and draw the major relations network. Only relations with values larger than threshold are demonstrated in NRM. In order to calculate threshold, average of matrix T should be calculated. After determining threshold, all values of matrix T which are smaller than threshold are set to zero. In this research, threshold is obtained 0.9. Thus, pattern of significant relations is in Appendix E: (Nilashia *et al*., 2019)

Considering the above pattern, Table 4 can be obtained.

Table 4. Pattern of causal relations among sub-criteria

Factors	D	R	D+R	D-R
Old and Eroded networks	2.06	1.77	3.83	0.29
Improper earth (network lines, equipment’s and posts	0.79	1.12	1.92	-0.33
sing non-standard tools and equipment’s	1.63	1.39	3.01	0.24
Loose connections of the network	1.29	1.63	2.92	-0.34
Improper length of the network	0.87	1.05	1.92	-0.18
Improper loading	1.46	1.85	3.30	-0.39
Phase imbalance	1.68	2.20	3.88	-0.51
Improper selection of conductors	1.10	1.36	2.46	-0.26
Improper design of distribution networks	2.34	1.84	4.18	0.51
Reading measurement equipment’s incorrectly	0.98	1.13	2.12	-0.15
Losses caused by environmental conditions	1.79	1.14	2.93	0.65
Failure of measurement devices	1.37	1.28	2.64	0.09
Lack of proper measurement devices	1.00	0.75	1.75	0.26
Thieving electricity	1.43	1.32	2.75	0.11
Wrong bill calculations	0.98	0.94	1.93	0.04

Analyzing Cause and Effect Relations

In the above table, sum of elements in each row (D) would reflect on the effectiveness of that factor over other factors used in the model. Accordingly, improper design of network is the most effective factor. Sum of elements in each column (R) for each factor shows impressibility of that factor from other factors of the system. Accordingly, phase imbalance has the most impressibility.

Horizontal vector (D+R) shows effectiveness and impressibility of the intended factor. In other words, the higher is D+R for a factor, that factor has the higher level of interaction with other factors of the system. Accordingly, improper design has the most interactions with other factors being studied.

Vertical vector (D-R) shows effectiveness of each factor. In general, if D-R is positive, variable is causal and if it is negative, variable is caused (Figure 4)

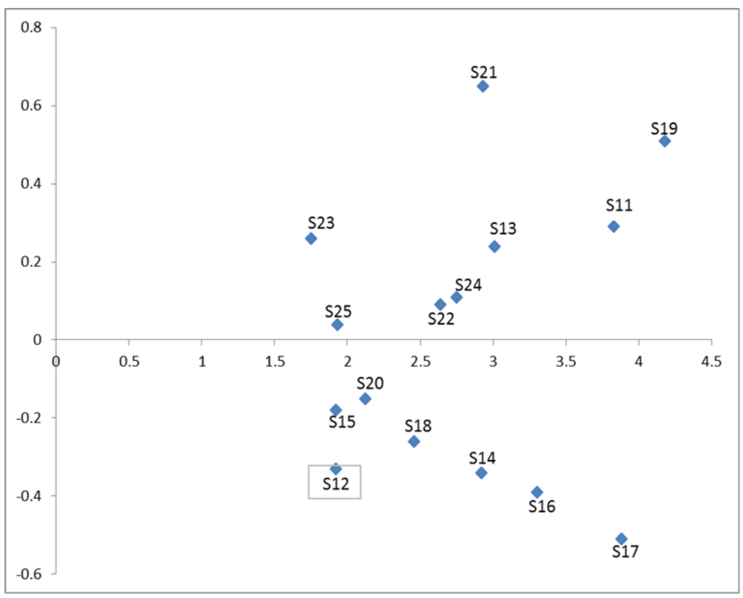

Figure 4. Cause and Effect relationship of factors

4-4-2 Weighting Factors using ANP

ANP is another decision-making technique which is very similar to AHP method. Any of these methods are constructed based on a series of assumptions. For example, if factors are independent and pair-wise comparisons are possible, AHP is the proper decision-making model but if factors are not independent, ANP is better. ANP considers complex relationship among decision elements through replacement of sequential structure with network structure. Thus, using ANP instead of AHP has increased in recent years. Advantage of ANP technique compared to other techniques is considering internal relations among factors. If there is an internal relation among criteria and sub-criteria, existing models are used to identify this relationship and then using pair-wise comparison these relations are also included in the model.

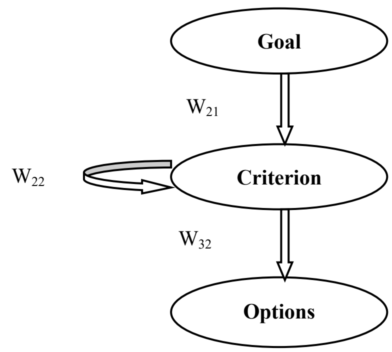

Figure 5: Conceptual Relations of ANP

Considering goal of the research, first an analytical model of the network is designed in Super Decision software based on identified criteria and sub-criteria. Since more than one expert are involved in this research, geometric average technique is used for prioritization (Figure 5).

4-4-3 Goal-centered Prioritization

For analysis, main criteria are compared pair-wisely first. For this purpose, a group of experts are considered then geometric average and normalization are used to calculate the eigenvector. Obtained numbers show importance coefficient of the main criteria. Calculations are presented in Table 5 and eigenvector is also represented with W1.

Table 5. Prioritization of Main Criteria based on Goal

	Technical loss	Non-technical loss	Geometric average	Normalized weight
Technical loss	1	2.714	1.647	0.731
Non-technical loss	0.368	1	0.607	0.269

According to Table 5, priority eigenvector W1 would be as follows.

$$W = \begin{matrix} Goal \\ Main\ Criteria \\ Options \end{matrix} \begin{bmatrix} 0 & 0 & 0 \\ W_{21} & W_{22} & 0 \\ 0 & W_{32} & I \end{bmatrix} \quad (5)$$

In addition, since only one pair-wise comparison is performed, calculating inconsistency rate is not significant and it is equal to zero. According to the obtained eigenvector:

Technical loss factor with normalized weight of 0.731 has the highest priority.

Non-technical loss with normalized weight of 0.269 ranks second in terms of priority.

4-4-4 Pair-wise Comparison of Sub-criteria

In the next step, sub-criteria of this study are compared pair-wisely. In this step, pair-wise comparisons are performed in 2 stages (number of criteria). In each stage, sub-criteria of each main criterion are compared pair-wisely.

4-4-4-1 Prioritization of Technical Loss's Sub-Criteria

Calculations done for prioritizing sub-criteria of technical loss since this criterion includes 9 indices, thus 36 pair-wise comparisons are performed (Table 6).

Table 6. Prioritizing sub-criteria of Technical Loss

Description	s11	s12	s13	s14	s15	s16	s17	s18	s19	Geometric average	Normalized weight
Old and Eroded networks	1	1.290	0.613	1.047	1.740	3.825	1.795	1.902	1.760	1.475	0.147
Improper earth (network lines, equipment's and posts	0.775	1	0.356	1.313	1.612	3.957	1.610	1.034	1.357	1.201	0.120
using non-standard tools and equipment's	1.631	2.812	1	1.898	3.311	2.550	3.078	2.548	1.992	2.188	0.219
Loose connections of the network	0.955	0.762	0.527	1	1.855	3.630	1.937	1.148	1.680	1.286	0.129
Improper length of the network	0.575	0.302	0.302	0.539	1	3.918	0.699	0.505	1.227	0.713	0.071
Improper loading	0.261	0.253	0.392	0.275	0.255	1	0.476	0.361	0.443	0.373	0.037
Phase imbalance	0.557	0.621	0.325	0.516	1.431	2.103	1	1.227	1.845	0.902	0.090
Improper selection of conductors	0.526	0.967	0.871	0.871	1.982	2.767	0.815	1	1.362	1.100	0.110
Improper design of distribution networks	0.568	0.737	0.502	0.595	0.815	2.255	0.542	0.734	1	0.767	0.077

According to the obtained eigenvector:

Sub-criterion of using non-standard equipment with normalized weight of 0.219 is ranked first in terms of priority. Old and eroded network is ranked the second with normalized weight of 0.147.

Loose network connection with normalized weight of 0.219 is ranked the third. Finally, improper loading of transformers with normalized weight of 0.037 is ranked the last. Inconsistency rate of comparisons is obtained 0.031 which is less than 0.1, thus performed comparisons are reliable.

4-4-4-2 Prioritizing Sub-criteria of non-technical Loss

Calculations for prioritizing sub-criteria of non-technical losses are presented in Table 7. Since this criterion includes 6 indices, 15 pair-wise comparisons are performed.

Table 7. Prioritizing Sub-criteria of Non-technical Losses

	S21	S22	S23	S24	S25	S26	Geometric Average	Normalized weight
Reading measurement devices incorrectly	1	1.240	1.886	1.361	0.525	0.923	1.075	0.168
Losses caused by environmental conditions	0.806	1	2.210	1.415	0.817	1.458	1.201	0.188
Measuring output of measurement devices incorrectly	0.530	0.453	1	1.596	0.692	3.294	0.978	0.153
Lack of measurement devices for recording consumption of lighting network	0.735	0.707	0.627	1	1.145	1.655	0.922	0.145
Thieving electricity	1.905	1.224	1.444	0.873	1	2.627	1.596	0.250
Wrong calculation in billing	1.084	0.686	0.304	0.604	0.381	1	0.611	0.096

A higher normalization weight indicates that the sub-criterion is a higher priority. According to the obtained eigenvector:

Thieving electricity with normalized weight of 0.25 is ranked the first. Losses caused by environmental conditions with normalized weight of 0.188 is ranked the second. Reading measurement devices with normalized weight of 0.168 is ranked the third. And finally, wrong billing calculation with normalized weight of 0.096 is ranked the last. Inconsistency rate of the comparisons is obtained as 0.07 which is lower than 0.1, thus comparisons are reliable.

4-4-5 VIKOR Technique

VIKOR is one of the most technically-celebrated models in decision making. This model was first proposed in 1984 based on collective agreement and having contradictory criteria and it is generally applied for solving discrete problems. This method is developed for multi-criteria optimisation of complex systems. VIKOR focuses on categorization and selection a set of options and determines consistent solutions for a problem with contradictory criteria, such that it is able to help decision makers to reach a final decision. Here, consistent solution is the closes solution to the ideal solution where consistency is referred to a mutual agreement.

In fact, VIKOR prioritizes or ranks options through evaluating options based on criteria. In this model, criteria are not weighted but criteria are evaluated through other methods and then options are ranked based on criteria and their combination with other criteria. In this model, there are several options which are evaluated independently based on several criteria and finally options are ranked based on value. The main difference of this model with sequential decision-making models is that unlike those models, pair-wise comparison is not performed among criteria and options and each option is evaluated independently (Figure 6).

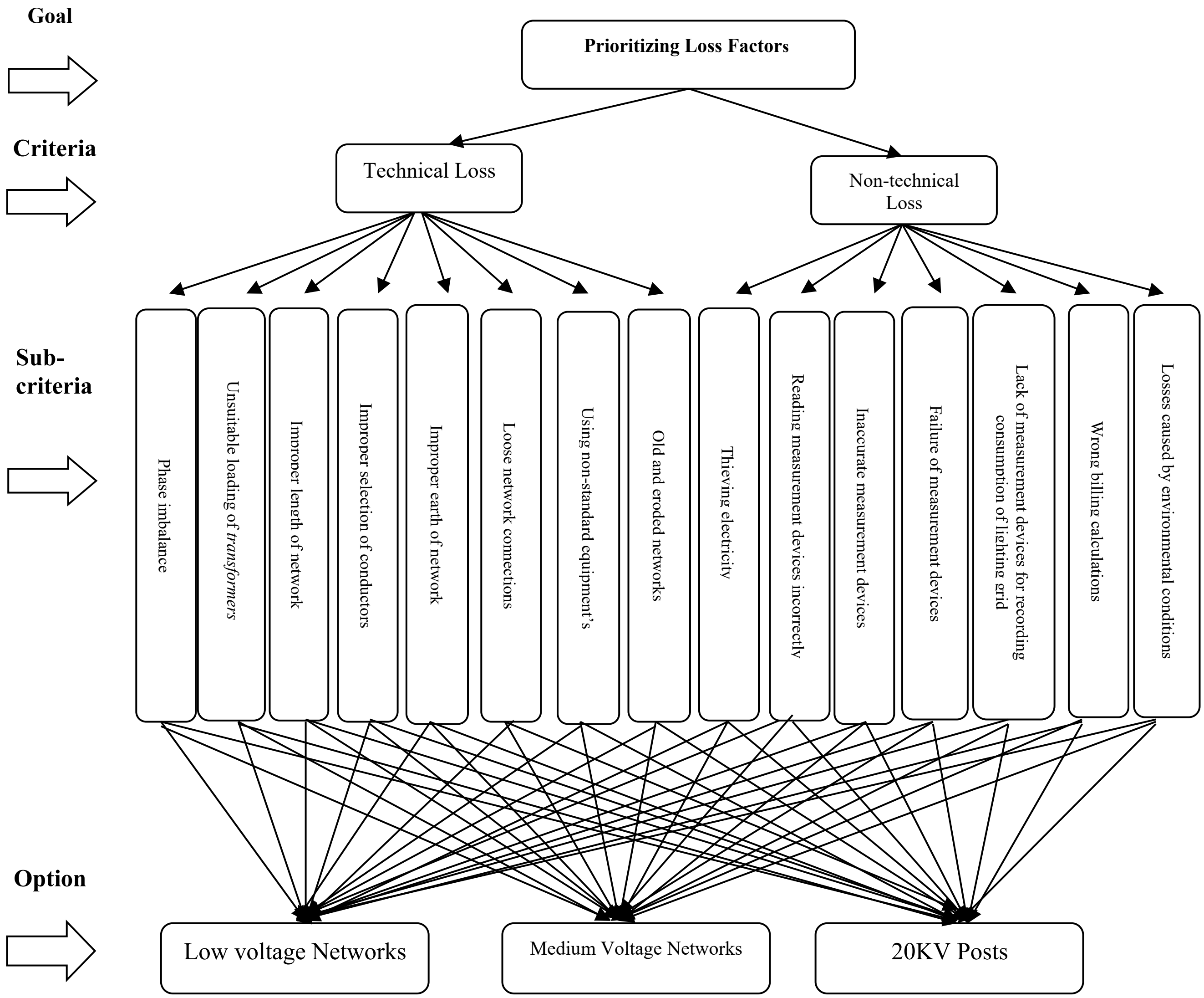

Figure 6. Conceptual Model of VIKOR

4-4-5-1 Calculation Procedure

Since loss reduction activities in ns, different activity sections are considered as options.

- Low voltage networks
- Medium voltage networks
- 20 kV Posts

Step 1: identifying criteria, options and fulfilling questionnaire

Main indices and options are identified. Thus, scoring matrix is formed based on criteria. In order to score options based on each criterion, 5-point Likert scale is used, where 20 experts are involved to design and fulfill VIKOR questionnaire (Appendix D).

Step 2: Obtaining Decision-Making Matrix

By fulfilling 10 questionnaires by senior experts of Tehran Distribution Firm using 5-point Likert scale and considering arithmetic average of their comments, decision making matrix is obtained.

Step 3: Normalizing Decision-Making Matrix

In order to normalize decision making matrix, first all matrix values are powered by 2 and is summed with summation of each column, then each column is squared root and finally each value is divided by root of the obtained number as follows.

$$r_{ij} = X_{ij} / \sqrt{\sum_{i=1}^{m} X_{ij}^2} \quad (6)$$

Where, X_{ij} is the value of each criterion for each option.

Step 4: Weighting Normal Matrix

In order to weight, values of normal matrix of each option are multiplied by weight of criteria.

Step 5: determining largest and smallest value of weighted normal matrix

In this step, largest and smallest value in each column is determined. Here, by largest value we mean the number which has the highest positive value and smallest value means the number which has the highest negative value. So, if our criterion is negative, largest number is reversed, that is largest becomes the smallest value and the smallest becomes the largest value and vice versa.

$$f_i^* = max_j f_{ij};\ f_i^- = min_j f_{ij} \quad (7)$$

Step 6: Determining desirability index (s) and dissatisfaction index (R)

In the next step, a desirability index is obtained for each criterion where their sum determined final index of the option S_j.

Largest S_j of each option for each criterion is the dissatisfaction index (R) of that option.

$$S_j = \sum_{i=1}^{n} w_i\ (f_i^* - f_{ij\,/\,f_i^* - f_i^-}); \quad (8)$$

$$R_j = max_i[\ w_i\ (f_i^* - f_{ij\,/\,f_i^* - f_i^-})\ ]$$

(9)

F^*= largest number of weighted normal matrix for each column

F_{ij}=number of intent options for each criterion in weighted normal matrix

f^-= smallest number of the weighted normal matrix for each column

Step 7: Calculating Q and Final Ranking of Options

At the end, final ranking of options is determined using the following formula.

$$Q_j = v.(S_j - S^-/S^* - S^-) + (1 - v).(R_j - R^-/R^* - R^-) \quad (10)$$

V= 0.5 constant

S_j= total value of S for each option

S= largest index value of S for each option

S^*=smallest index value for each option

R_j= total value of R for each option

R^-= largest index value of R for each option

R^*= smallest index value of R for each option

Final ranking calculation of option would be as follows. (Table 8 and Figure 7)

Table 8: Final ranking calculation of option

Alternatives	Weights
Q1	0.500
Q2	1.000
Q3	0.497

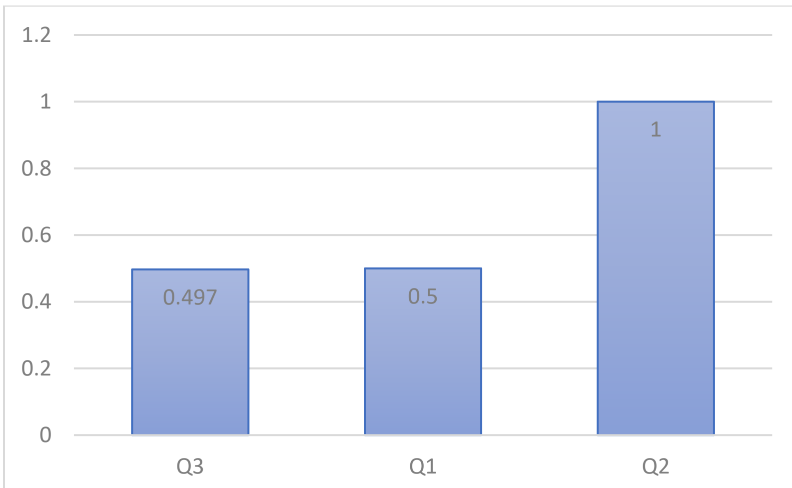

Figure 7. Final ranking calculation of option

Best option is the one with smallest Q. Finally, we have

$Q_3 > Q_1 > Q_2$

20 kV posts> low voltage network> medium voltage network

DEMATEL method was used for determining relation between indices where the final prioritization based on obtained weight is as follows Table 9 and Figure 8.

Table 9. Normal weights obtained in DEMATEL technique

Indices	Normal weight	Rank
Old and eroded networks	0.0967	1
Improper design of distribution networks	0.0938	2
Phase imbalance	0.0817	3
Using non-standard equipment's	0.0769	4
Failure of measurement devices	0.0736	5
Improper loading of transformers	0.0698	6
Losses caused by environmental conditions	0.0688	7
Wrong billing calculation	0.0676	8
Thieving electricity	0.0645	9
Loose network connections	0.0635	10

Indices	Normal weight	Rank
Lack of measurement devices for recording consumption of lighting grid	0.0557	11
Reading measurement devices incorrectly	0.054	12
Improper selection of conductors	0.0529	13
Improper length of the network	0.0419	14
Improper earth	0.0384	15

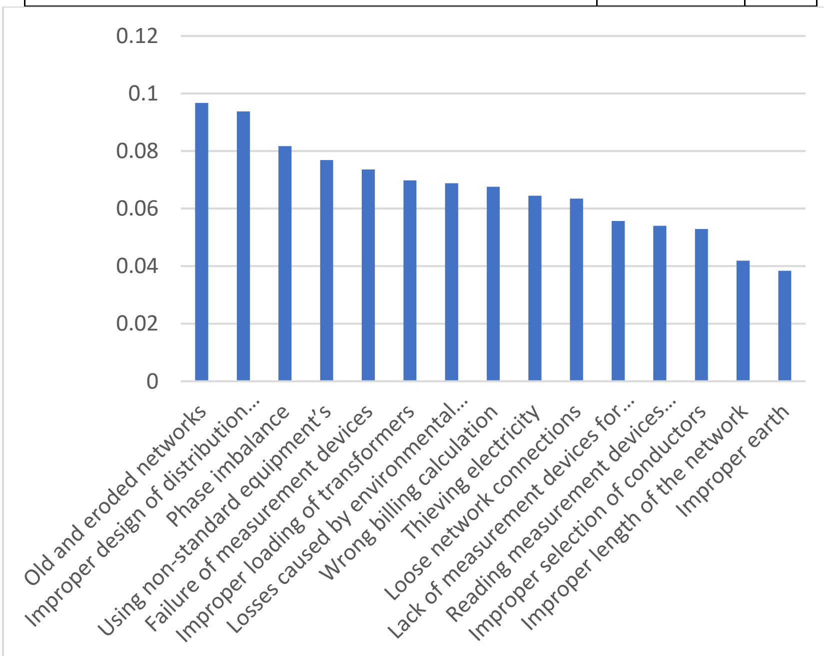

Figure 8. Normal weights obtained in DEMATEL technique

In the following and by involving 20 experts of distribution networks, ANP is used method for weighting indices and indices are prioritized.

5. Conclusion

The present study investigates and identifies the causes of losses in power distribution networks and attempts to prioritize them using the MCDM techniques associated with DEMATEL and VIKOR methods. Using the DEMATEL technique, the relationships between specified indices and Weights were determined by utilizing the ANP technique and Weighted indices were assigned to possible options using the VIKOR technique. Two main criteria were identified: Technical losses and Non-technical casualties. In the first step, using the DEMATEL method, the criterion of inappropriate designs of distribution networks is most effective and the phase imbalances have a high degree of effectiveness. In addition, the criterion of inappropriate design of distribution networks has the most interaction with the other criteria studied. Then, according to the opinion of 20 experts from the electricity distribution networks, the ANP method was used to weight the indicators and the indicators were prioritized. Comparing main criteria, technical loss with normalized weight of 0.731 is ranked first and non-technical loss with normalized weight of 0.269 is ranked second.

Result of technical loss section showed that comparing sub-criteria in two different sections of technical and non-technical losses, using non-standard equipment's with a normalized weight of 0.219 is ranked first and old and eroded networks with normalized weight of 0.147 are ranked second and loose network connections with a normalized weight of 0.129 are ranked third. Finally, improper loading of transformers with normalized weight of 0.037 is ranked last.

Under the non-technical loss criterion, result show that electricity thieving with normalized weight of 0.25 is ranked first, losses caused by environmental conditions with normalized weight of 0.188 are ranked second and reading measurement devices incorrectly with normalized weight of 0.168 are ranked third. Finally, wrong billing calculations with normalized weight of 0.096 are ranked last.

At the end, VIKOR technique was used to prioritize assignment of indices to options. According to the obtained Q in calculating VIKOR, optimisation activities in 20kV posts are ranked first, optimisation activities of low voltage networks are ranked second and optimisation activities of medium voltage networks are ranked third.

The result of work is also bench-marked with Ramesh et al (2009), Eseosa and Promise (2015) and Chen and Zhao (2020) that studied electricity losses. According to the results, it is recommended to standardize the power networks and relieve the network fatigue and ultimately reduce the power losses in the grid. The Ministry of Energy and its subsidiaries will install or construct power plants or buildings. Now they are auditing every two years by the Iranian Energy Efficiency Organization. Other industries in the country should also cooperate and support the above materials with the government. Other important measures include cooperation in the standardization of electrical equipment between neighboring countries, according to the capabilities of each country and the creation of trade between them, which will increase the capacity of the domestic manpower and create competition between them. Replacing the current technology with the technology of the old technology can improve the efficiency of the equipment. In order to educate and inform all people (policy makers, planners, producers and consumers) of every class and business, it is necessary to implement an optimal national energy education and awareness plan. In order to preserve the national capital of their country, people will be familiar with how to use the equipment at the right time considering the issue of purchasing standard equipment, how to design the building and the amount of light used to get things done and the correct design of electrical and mechanical installations.

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Appendix (A): Statistics of Human Resources in Tehran Electricity Distribution Network (Information Bank of statistical population in Tehran Electricity Network)

Service Location	Occupational unit							Education						Total
	10000	**20000**	**30000**	**40000**	**70000**	**80000**	**Total**	**Under Diploma**	**Diploma**	**Associate Degree**	**Bachelor of Science**	**M.Sc and PHd**	**Total**	
Southeast	179	240	248	301	236	32	1236	72	358	193	564	49	1236	1752
Southwest	147	207	199	295	396	24	1268	108	425	184	513	38	1268	2316
Northeast	172	172	297	372	402	39	1454	103	442	218	620	71	1454	2878
Northwest	192	333	326	417	456	52	1776	142	552	258	722	102	1776	3049
Strategic Headquarter	**162**	**91**	**476**	**466**	**24**	**20**	1239	**32**	**127**	**122**	**752**	**206**	1239	2502
Total	852	1043	1546	1851	1514	167	6973	457	1904	975	3171	466	6973	12497

Appendix (B) **DEMATEL Questionnaire (Technical Losses)**

Description		Technical Losses									Non-technical Losses					
		Phase imbalance	Unsuitable loading of transformers	Improper length of network	Improper selection of conductors	Improper earth of network	Loose network connections	Using non-standard equipment's	Improper design of distribution network	Old and eroded networks	Thieving electricity	Reading measurement devices incorrectly	Failure of measurement devices	Lack of measurement devices for recording consumption of	Wrong billing calculations	Losses caused by environmental condition's
Technical Losses	Phase imbalance															
	Unsuitable loading of transformers															
	Constructing long networks (feeders with non-standard length)															
	Selecting improper conductors															
	Improper earth (network lines, equipment's and posts)															
	Loose connections of the network															
	Using non-standard tools and equipment's															
	Improper design of distribution networks															
	Old and eroded networks															

Appendix (C) **DEMATEL Questionnaire (Non-technical Losses)**

Description		Technical Losses									Non-technical Losses					
		Phase imbalance	loading of transformers	Improper length of network	Improper selection of conductors	Improper earth of network	Loose network connections	Using non-standard	Improper design of distribution	Old and eroded networks	Thieving electricity	Reading measurement	Failure of measurement	Lack of measurement	Wrong billing calculations	environmental condition's
Non-technical Losses	Using illegal electricity															
	Reading measurement tools incorrectly															
	Customers do not pay bills															
	Failure of measurement tools (inaccurate measurement)															
	Not recording consumption of electricity network															
	Incorrect Calculations															
	Losses resulting from environmental conditions (losses caused by moisture and Corona, Losses caused by dust, losses cause by collision of tree branches)															

Appendix (D)**: VIKOR Questionnaire**

Losses caused by environmental condition's	Wrong billing calculations	Lack of measurement devices for recording	Failure of measurement devices	Reading measurement devices incorrectly	Thieving electricity	Old and eroded networks	Improper design of distribution network	Using non-standard equipment's	Loose network connections	Improper earth of network	Improper selection of conductors	Improper length of network	Unsuitable loading of transformers	Phase imbalance	Description
															Low voltage network
															Medium voltage network
															20 kV posts

Appendix (E): Pattern of Significant Relations among Sub-criteria

	s11	s12	s13	s14	s15	s16	s17	s18	s19	s20	s21	s22	s23	s24	s25
s11	-	o.12	0.17	0.21	0.10	0.20	0.19	0.15	0.18	0.12	0.15	0.10	-	0.15	-
s12	-	-	-	-	-	-	0.12	-	0.10	-	-	-	-	-	-
s13	0.15	0.11	-	0.17	-	0.14	0.16	0.13	0.14	-	0.11	0.10	-	0.10	-
s14	0.14	-	0.13	-	-	0.10	0.14	0.11	0.12	-	-	-	-	0.10	-
s15	-	-	-	-	-	-	0.14	-	0.13	-	-	-	-	-	-
s16	0.14	-	0.11	0.11	0.09	-	0.18	0.10	0.17	-	-	-	-	0.09	-
s17	0.15	0.10	0.11	0.14	0.10	0.20	-	0.12	0.16	-	-	0.09	-	0.12	-
s18	0.12	-	-	0.13	-	-	0.13	-	0.13	-	-	-	-	-	-
s19	0.21	0.18	0.17	0.22	0.19	0.24	0.26	0.22	-	-	0.15	0.10	-	0.10	-
s21	-	-	-	-	-	-	-	-	-	-	-	0.13	0.11	-	-
s21	0.18	0.11	0.13	0.18	0.11	0.17	0.17	0.16	0.19	-	-	-	-	0.10	-
s22	0.12	-	-	-	-	0.11	0.13	-	-	0.16	-	-	0.11	0.11	0.15
s23	-	-	-	-	-	-	0.10	-	-	0.10	-	-	-	-	0.13
s24	0.10	-	-	0.10	-	0.15	0.17	-	0.11	0.13	-	0.14	-	-	0.11
s25	-	-	-	-	-	-	0.10	-	-	-	-	0.12	0.10	-	-