Comparative Analysis and Evaluation of Critical Success Factors and Barriers of Power Quality Programme Implementation Failure in Developing Countries

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Abstract—The aim of this paper is to study the implementation of a Power Quality Programme (PQP) framework, and the obstacles and barriers faced by Libyan Distribution Networks (LDNs) in implementing a PQP. Firstly, to identify the most critical success factors that would have a major impact on PQP implementation in LDNs. Five Critical Success Factors (CSFs) for PQP were identified to examine the level of power quality in LDNs. They are PQ awareness, PQ disturbances, PQ management commitment, PQ employee's participation and training and PQ customers' satisfaction. It revealed that all five CSFs were significantly affected by the level of PQ awareness, and the suspension of PQP implementation. An appropriate PQP framework was developed for the purpose of this study to guide LDNs as a case study on developing countries. The proposed PQP framework model was validated based on the identified CSFs, and the barriers and benefits of PQP, which were analysed using different techniques based on both SPSS and NVivo software. The PQP framework was developed from the findings based on the responses of 397 PQ survey participants, and supported by 44 face-to-face semi-structured interviews conducted with professionals and expert LDNs staff. Out of 16 PQP barriers, 13 were statistically significant, which indicated that Libya distribution systems have already surmounted various barriers to implementing a PQP effectively. This framework encourages and guides the implementation teams to have an obvious and clear awareness and vision of how to prevent existing obstacles from reappearing in different forms, leading to long-term PQP improvements. There were 11 overall benefits of PQP implementation, which would have a positive impact on LDNs.

Keywords— CSFs of PQP, PQP Barriers, PQP Benefits, Libyan Distribution Networks, Developing Countries, PQP Framework, PQP Roadmap.

1 Introduction

In recent years, PQPs have become one of the most recent services offered to distribution companies, both private and state suppliers. For any distribution system to satisfy its consumers, the utility must keep improving PQ in a way, which accommodates the increased demand for electricity [1][2]. This requires a PQP to be implemented to start tackling the difficulties facing the distribution utilities in sustaining a high standard of PQ. A PQP can help in reducing the huge number of complaints from end users, and the costs represented in the damage to their equipment [3]. It can also have a positive impact on the electrical distribution companies, improving their service and saving some of the significant resources spent. Therefore, distribution companies need to implement a PQ investigation programme, given all the facts indicating an increase in PQDs, particularly in the last two decades [4].

On the other hand, PQP implementation is essential for the future of PQ, especially in urban, rural and remote areas in developing countries [5][6]. PQPs allow distribution utilities to improve the power supply by conducting such programmes regularly to reduce end users' complaints, and satisfy them in a way appropriate to their expectations. In addition, implementing a PQP can overcome barriers, including the lack of: a clear strategy, end user awareness, accommodation for economic growth, equipment standards, distribution network design, planning and infrastructure, resources, staff awareness, skills and experience, top management responsibility and commitment, training courses and support, and financial resources, as well as PQ measurement, consultants, standards, monitoring and databases. Furthermore, PQPs can increase the knowledge and skills of distribution utilities' staff by overcoming the complicated PQDs that most frequently occur by offering them education and training courses to raise PQ awareness.

2 Power Quality Programmes (PQPs)

PQPs are particularly successful in developed countries rather than developing countries, due to the rapid adoption of sophisticated technology, as well as the higher level of PQ awareness among most of the end users, who recognize its importance. Furthermore, power suppliers in developed regions are trying to establish a high level of PQ standards in a short time, due to pressure from large industrial customers, as the use of sophisticated equipment increases[4]. Developing countries should exploit the PQP experience of developed countries to help in overcoming the shortcomings mentioned above in large and small distribution systems. PQP implementation will require effort from top management,

staff and end users. In addition, government-controlled distribution utilities need support from public and private sector bodies in raising PQ awareness, so as to become part of their culture.

The absence of PQ awareness will lead to significant effect on both utilities' and end users' equipment, costing them money. Therefore, there is a need for a "PQ awareness programme", which would be responsible for spreading PQP services across the distribution systems, and can provide those services to the utilities that need to improve PQ performance [1]. As a result, table1 states the cost of industries and end users suffer losses due to poor PQ and the failure of implementing PQP.

TABLE 1

COST OF INDUSTRIES AND END USERS LOSSES DUE TO POOR POWER QUALITY

Industrial Type	PQ Disturbances	Total Cost	Authors
Large Brazilian Customer	Harmonics, Voltage Sag, Interruption	1.2 $ million annually	[7]
International's paper mill in Deferiet, New York	Voltage sag, Power Interruption	$1 million annually	[8]
Textile Industrial plant Italy	Voltage sag	235,600 $ million annually	[9]
plastics manufacturing facility	Voltage sag	1.7 $ million annually	[10]
Production Problems in a Plastics plant	Voltage sags Momentary interruptions	30$ million annually	[11]
Information Technology Equipment (ITE) Industry	Transients, Outages Voltage sags	4 $ million annually	[12]
Champion International Corporation's Deferiet Paper Mill in Deferiet, NY	Voltage sags	1 $ million annually	[13]
Semiconductor Industry China	Power Interruption	1.5 $ million annually	[14]
DuPont International Company	Outage	75 $ million annually	[15]
Industrial Process Equipment Germany	Voltage sags, Power Interruption	€32 billion	[16]
Industrial and Commercial Power Systems	Voltage sags	2 $ million annually	[17]
Electrical Power Quality and Utilisation Industrial sectors 8 Developed Countries Austria, France, Italy, Poland, Portugal, Slovenia, Spain and United Kingdom	Voltage dips, Short interruptions, Long interruptions, Harmonics, Transients, and surges	€150 billion	[18]
Massachusetts' industrial and Digital Economy Companies USA	Voltage Fluctuations, Voltage sags Outage	1.4 $ billion annually	[19]
industrial & digital economy companies USA	voltage dips, short interruptions	119$ to 188 $ billion Ann	[20]
The semiconductor industry in Taiwan	voltage dip	€ 1.7 million annually	[21]
plastic extrusion industry Singapore	A short interruptions voltage dip	€ 3 million annually	[22]
steel industry Sweden	Voltage dip	€ 2.4 million annually	[23]
California businesses DE, CPM , and F&ES industries sectors	outages	18.8 $ billion annually	[24]
A glass factory in France	Outages, Harmonic Distortions, Power supply reliability, Voltage dips	€1 million annually	[25]
Cost to Customer of Power Quality Disturbances UK	Transients, Interruption	£ 200 million annually	[26]
Industrial and Domestic sectors, 330 large power users , South Africa	Voltage sag and transients	$ 350 million annually	[27]
domestic and industrial customers , Norway	Transient, overvoltage, voltage dips	€107.6 million annually	[28]
industrial customers, Sweden	short interruption and voltage sag	€157 million annually	
industrial and residential customers, France	Long interruptions and voltage quality	€37 million annually	
256 industrial companies, Italy	long interruption and voltage sag	€180 million annually	

To classify the barriers facing the implementation of a PQP and also the expected benefits from implementing such a programme, a literature review has been carried out and is summarized in two sections, namely PQP barriers and PQP benefits:

3 BARRIERS TO IMPLEMENTING A PQP

Since 1980, PQ issues have been causing real and significant disturbances to the distribution systems and end users, becoming a global concern. Hence, the lack of awareness of PQ could result in utilities still suffering from PQ problems caused by end users' sensitive equipment for industrial, agriculture, residential and commercial [1]. Therefore, providing sufficient introduction, definitions and explanations for the most widespread PQ terms, will help in identifying the more common PQ disturbances that occur. Moreover, those producing or using the power, in particular in less developed countries, should understand what PQ means. The reason is that as long as the concept of PQ is misunderstood by both the staff of the electrical distribution

company and the end users, then the severity of PQ issues will increase every day, because the demand for power will increase and even double [29].

Several authors and researchers have determined different aspects of barriers according to their experience and their studies on the implementation of PQP.

A study in the UK revealed eight major categories of PQP barriers: lack of staff awareness regarding PQ issues; lack of enough resources; lack of PQ training courses; lack of top management committed to implementing good PQP; lack of long-term strategy for successful implementation; lack of end users' awareness; lack of PQ standards and lack of regular maintenance [30]. A study conducted by Ghatol and Kushare found two aspects of PQP barriers in less developed countries; lack of network designing; and lack of end users' awareness regarding power quality [31]. A survey in the USA, conducted for the North American Delivery Systems found two barriers to PQP implementation; lack of customer cooperation i.e. illegal connection made by end users; and lack of top management responsibility to face customer complaints [32]. A study in a Massachusetts distribution system found three barriers to PQP implementation; lack of PQ standards; lack of cooperation by end users; and lack of management commitment regarding end users' complaints [19].

A study by EPRI in the USA pointed out nine components of PQP implementation barriers; lack of top management commitment, support and encouragement; lack of skills, knowledge and experience among engineers' and technicians; lack of proper teams to analyse PQ disturbances; lack of training courses; and lack of a PQ database [33]. Another study in the USA, Asia, Africa, Australia, South America and Europe revealed a lack of power quality awareness among end users; and lack of PQ training courses [34]. A further study in the USA revealed two barriers believed to hinder the successful implementation of PQP; lack of a utilities distribution structure; and lack of suitable management structure and operation [35]. A study in Malaysia found that five barriers to implementing a PQP were a ; lack of education programs; lack of PQ awareness and guidelines; lack of training courses and support; lack of continuing research and development; and lack of financial incentives to encourage the staff to resolve PQ issues [36].

A survey conducted in 8 developed European countries, namely; Austria, France, Italy, Poland, Portugal, Slovenia, Spain and the UK, found that a lack of end users' awareness; lack of employee awareness and skills; lack of management commitment; and lack of PQ measurements and maintenance are the main barriers to PQP implementation. These factors have led to huge economic losses in Europe, exceeding €150bn annually [37]. Another survey in Europe found that the main difficulties encountered during the implementation of PQP are lack of PQ awareness among top management, engineers and end users; lack of network designing, due to increased power demand; lack of PQ standards; lack of PQ measurement [25].

A study in Canada revealed that three main factors impede the wider spread of PQPs; lack of PQ consultants; lack of PQ standards; and lack of PQ awareness on the part of end users [38]. A study in the Netherlands found five significant difficulties in implementing PQP, namely; lack of a distribution networks infrastructure; failure to handle end users' complaints so as to identify the underlying problems; lack of PQ contracts between suppliers and end users; increasing sensitive electronic equipments; lack of PQ training courses to raise the education and awareness levels of engineers to understand consumers' complaints better [39].

Another study in Germany found twelve barriers to PQP implementation; lack of distribution network designing, structure and size; lack of data on end users' load characteristics and structure; inadequate background and experience among employees regarding PQ; lack of PQ standards; lack of PQ measurement; lack of management planning and strategy [32]. A study in India found two major barriers to PQP implementation; lack of PQ measurement; lack of PQ awareness and skills among employees [40]. A second study in India found four significant categories of PQP barriers; lack of planning and designing the distribution network; lack of proper PQ teams; lack of PQ monitoring and databases to analyze customer complaints; and lack of PQ standards [41]. In Pakistan, a study found that lack of understanding PQ disturbances is a major obstacle to the implementation of a PQP to be achieved [42].

A study conducted by Moncrief, Dougherty, Richardson, and Craven found five main barriers to PQP implementation; lack of end users' awareness; lack of PQ equipment standards; lack of PQ awareness among employees; lack of PQ monitoring and databases regarding end users' complaints as a form of assistance to the utilities; lack of PQ measurements [43]. A study in Latin America found three barriers encountered during the implementation of PQP; lack of PQ monitoring and datasets; lack of PQ standards; lack of PQ employee' awareness and experience [44]. A study in Brazil found seven factors as the main barriers to PQP implementation; lack of distribution networks infrastructure; lack of studies and research; lack of distribution network design; lack of management planning; lack of technician and engineer skills and experience; lack of end users' awareness; lack of a clear strategy[45]. The 16 PQP barriers are listed in table 2.

TABLE 2

LIST OF POWER QUALITY PROGRAM BARRIERS

Item No	PQP Barriers
BA1	lack of staff awareness, skills and experience
BA2	lack of end users awareness
BA3	lack of customer cooperation
BA4	lack of long-term strategy and planning
BA5	lack of top management commitment
BA6	lack of network designing
BA7	lack of distribution networks infrastructure
BA8	lack of conducting research and studies
BA9	lack of top management responsibility
BA10	lack of training courses, and support
BA11	lack of financial resources
BA12	lack of enough incentives
BA13	lack of PQ measurement
BA14	lack of PQ consultants
BA15	lack of PQ standards
BA16	lack of PQ monitoring and database

4 POWER QUALITY SURVEY IN LIBYAN DISTRIBUTION NETWORKS

The rapid growth of the Libyan economy began in 1999 [46, 47]. Therefore, since the early 1999, tackling PQ events has been a priority for Libyan distribution systems (LDSs) [48, 49]. Since Before that, from 1991 to 1999, Libya was under a political, economic and trade blockade. Thus, the increase in peak load was not as rapid as it is nowadays; it was 4,756 MW in 2008, and expected to increase to 18,417 MW by 2025 [50] . Moreover, the level of power delivered was not at its worst level, this is mainly because sensitive equipments were not yet introduced widely before 1999. The current and grown new Libya economy is mainly based on digital equipments and high technology, such as sensitive electronic equipment and electrical tools used in industrial, commercial, and residential setting, which are very susceptible to PQ variations. Nonetheless, LDNs have not been implemented PQP to increase the level of awareness, as economic well being increased among all end users, and to measure the level of disturbances in the last two decades, current and future. The impact of PQ issues would be reduced, if a PQP was implemented to increase the level of PQ awareness due to competitiveness of a rapid developing economy [1]. As a result, since 1999 LDNs have suffered bad power quality.

Despite previous PQP frameworks' contributions to understanding the barriers and benefits of implementing PQP, they are not sufficient to explain the particular circumstances of PQ issues in LDNs. Therefore, after the comprehensive literature review, and the findings from the field study, and in order to gain full understanding of the LDNs case, there was a need to develop a PQP framework due to possible reasons:

- There is a lack of PQP implementation resulting from a lack of management strategy to cope with the expansion in generation and transmission systems.
- There is a lack of PQ standards to be followed by the company in any evaluation or comparison of PQD records in the Libyan distribution systems.
- There is a lack of employee experience and skills arising from a lack of awareness of PQ, and so employees are not equipped to deal with PQ problems technically.
- There is a lack of end user awareness of the concept of PQ given the excessive use of non-linear loads and sensitive equipment.
- There is a lack of management planning in the proper design of distribution networks.
- There is a lack of control over the import of electronic equipment since 1999, due to competitive marketing and deregulation.

In response to this, there was significant need to conduct a PQ survey. The survey was designed based on the literature review derived for this study. It is revealed that lack of PQ awareness is the main issue for Libyan west, east and south distribution networks. Table 3 shows the type of distribution networks along with the categories of end users involved in the study. Large distribution networks were considered to have more categories of end users; the western distribution network (WDN1), southern distribution network (SDN2) and eastern distribution network (EDN3).

TABLE 3

TYPE OF LIBYAN DISTRIBUTION NETWORKS (LDNS)

Distribution Networks	Residential	Commercial	Industrial	Agricultural
WDN1	√	√	√	
SDN2	√		√	√
EDN3	√		√	√

Power quality survey was designed to answer two main objectives;

1. To investigate the main reasons underlying PQP barriers leading to PQDs in LDNs.
2. To identify the most critically significant factors, PQP barriers that would have a major impact on PQDs and PQP implementation, in order to facilitate developing PQP framework as guidelines through which LDNs could implement, maintain, and improve the power supply, in terms of quality, for end users.

5 RESEARCH METHOD AND SURVEY INSTRUMENT

The above literature review helps the researcher to understand the different barriers to PQP implementation and the expected benefits of PQP. Two stages of data analysis

were applied to answer the research objectives. The first stage involved PQ survey questionnaire data collection, conducted during April-June 2010. The second stage involved interview survey data collection, conducted in late December 2010 and early January 2011 in LDNs. PQ survey was designed based on six factors, identified as CSFs for PQP implementation with total sub-factors comprising 34 items, where four factors were also identified as the main PQP barriers, with a total of 16 items to measure the level of PQP implementation,
397 PQ survey respondents participated in assessing the current level of PQ and the implementation level of PQP from LDNs staff involved in PQ improvements, including head managers, middle managers, engineers, technicians and employees, who have between 6 to 15 years' experience giving a response rate of 81%. The data were analysed by using Statistical Package for Social Science (SPSS) software, version 18. Moreover, 44 face-to-face semi-structured interviews were conducted with professionals, experts in LDNs, and staff in four departments, which are distribution, planning, training and customer departments, including head managers, engineers, technicians and employees, to state the difficulties and barriers facing LDNs in implementing PQP and to make the developed PQP framework more valid. Data gathered by the questionnaire from the distribution system respondents were checked in terms of accuracy, outliers and, normality; then analyzed using (SPSS) software.

6 POWER QUALITY SURVEY RESULTS AND DISCUSSION

Some of the power quality disturbances include: harmonics, short interruptions, long interruptions, voltage sags & swells, under voltage, over voltage, flicker & unbalance, transient & surge, low power factor and voltage collapse. These disturbances are considered in the statistical analysis presented in this paper. Results obtained from the survey indicate the current status of power quality in Libyan distribution utility staff's point of view. Almost 400 responses have been provided by one of the 3 major distribution networks, indicating opinions of the level of PQ among both residential, agriculture, commercial and industrial users.

6.1 Main Sources of PQ Disturbances

Fig. 1 shows the differences between the equipment causing PQ problems across the three networks. The figure shows that electronics equipment is the largest source of PQDs. Although electronic equipments can be seen as a small load compare to, say, air conditioning loads; the disturbances generated by electronic equipments is extremely large with total harmonic distortion reaching 200% [29]. All loads shown in Fig.1 are non-linear loads and it is these types of loads which are in the increase. Approximately 54.3% respondents refer to Air conditioning equipment, which was the top causing of power quality problems in the three networks, which are operated intensively when the temperature rises, reaching 50 Celsius. As mentioned earlier, the effect of these equipment categories varied from one network to another, due to being combined with varying user's categories in the three networks.

Fig. 1: Sources of PQ Disturbances - by responses %

6.2 PQ Disturbances Affecting Networks

Fig. 2 illustrates the repeated level of power quality disturbances (PQDs) are occurred across the three networks. The disturbances which considered as highly significant are long interruption is pointed approximately 45 % in WDN, 34 % EDN and 52% SDN. Voltage sags and swells are other disturbances which are considered to be as highly significant and recorded 44 % in WDN, 30% in EDN and 43% in SDN among other disturbances and they are occur so often in both three networks. Roughly 43 % in WDN, 26% in EDN and 44% in SDN refer to under voltage as one of the most disturbances which occur constantly. This was clear evidence that both three networks are affected due to main sources of equipments mentioned earlier in Fig. 1. However, the rest of other PQDs are not as significant as the long power interruption, under voltage and sags and swell.

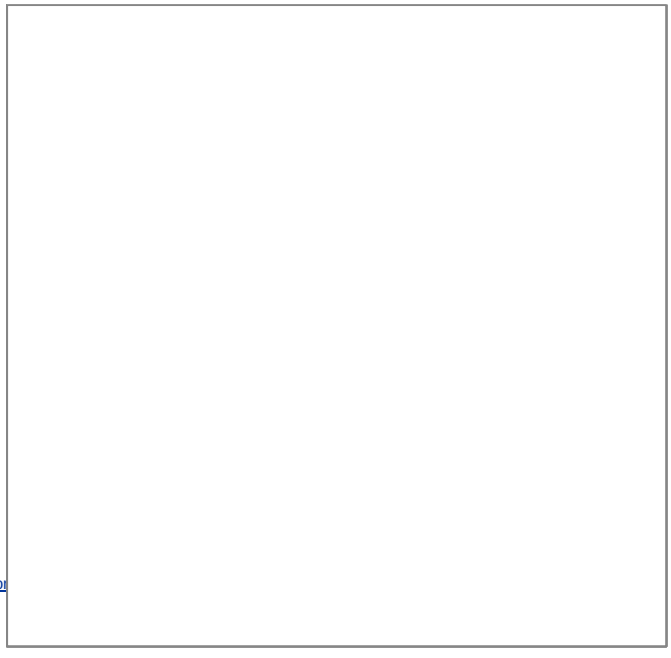

Fig. 2: PQ Disturbances Affecting Network- %

In addition, Fig. 2 indicates that Around 42 % of the participating respondents refer to low power factor is one of the disturbances, which caused PQ problems, especially in SDN due to heavy loads such as the Great Man-Made River Projects pumping plants and random private agriculture projects are connected to this network.

6.3 Causes of PQ Disturbances

Fig. 3 shows the most common group causing PQDs. Lack of PQ awareness is considerably seen as the highest significant factor of causing the problems, where 31 % of the respondents cited that. As lack of awareness, approximately 26% of the end users connected illegally, as well as it increased the excessive use of electronic equipments, which introduced after 1999 of causing PQDs. This was due to non-linear equipments, which are very sensitive to power supply variation (long interruption 79%). In addition, lack of network designing at higher level as the third factor caused PQDs by 20 %. Therefore, the demand on the power generated has led the industries to demand and share it along with the increase demand in the domestic sector in the same line. These complex combinations required LDN to have power quality programs to make the network more efficient due to the complex interconnection. Figure 3 gives more details about each aspect causes PQ issues with level of percentage by respondents.

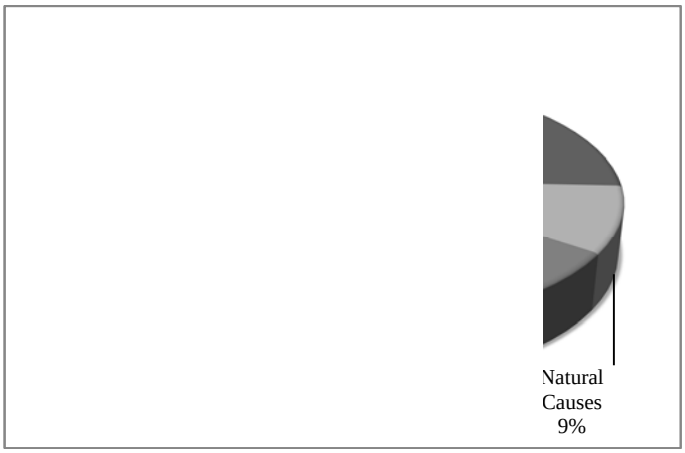

Fig. 3: Causes of PQ Disturbances - by responses %

7 CRITICAL SUCCESS FACTORS OF PQP

Table 4 shows the Pearson correlation between all pairs of the five CSFs, which used in this study to identify if there is any significant correlation among these factors to implement PQP. The five factors were PQDs Definitions, PQCS (Customer Satisfaction), PQMC (Management Commitment), PQEPT (Employee Participation and Training) and PQ (Customers and Company Awareness) throughout the three networks.

TABLE 4
PEARSON'S CORRELATION THE CSFS OF PQP IN THREE NETWORKS

Networks	CSFs of PQP	PQDs	PQCS	PQMC	PQEPT	PQA
West Network	PQ Disturbances (PQDs)	1				
	Customers Satisfaction (CS)	0.256**	1			
	Management Commitment (MC)	0.299**	0.486**	1		
	Employees Participation and Training (EPT)	0.361**	0.482**	0.485**	1	
	PQ Awareness (PQA)	0.559**	0.595**	0.597**	0.621**	1
East Network	CSFs of PQP	PQDs	PQCS	PQMC	PQEPT	PQA
	PQ Disturbances (PQDs)	1				
	Customers Satisfaction (CS)	0.408**	1			
	Management Commitment (MC)	0.338**	0.470**	1		
	Employees Participation and Training (EPT)	0.486**	0.641**	0.554**	1	
	PQ Awareness (PQA)	0.568**	0.610**	0.431**	0.551**	1
South Network	CSFs of PQP	PQDs	PQCS	PQMC	PQEPT	PQA
	PQ Disturbances (PQDs)	1				
	Customers Satisfaction (CS)	0.618**	1			
	Management Commitment (MC)	0.442**	0.464**	1		
	Employees Participation and Training (EPT)	0.481**	0.497**	0.665**	1	
	PQ Awareness (PQA)	0.661**	0.715**	0.554**	0.657**	1

From table 4, it is clear that the correlations of the entire five CSFs of PQP are positive and statistically significant. High correlation appeared between the Employee Participation and Training (PQEPT) and PQ Awareness (PQA), with Pearson's Coefficient (r) of (0.621**) in the west network. Another high correlation appeared between the Employee Participation and Training (PQEPT) with Customer Satisfaction (PQCS) with (0.641**) in east network. Customer Satisfaction (PQCS) with PQ Awareness (PQA) were highly correlated (0. 715**), which was strong enough be proved statistically in south network. The correlations within the CSFs of PQP were tested to check the PQP implementation in LDNs. The test pointed out that all five factors were positively correlated. On the other hand, in order to find the significant answer concerning objective two, which is to identify the most important and significant factors to assess PQP implementation within LDNs, which could be applied and adapted internationally. In response, the relative importance index method (RII) was used to identify the relative importance of each critical success factor (CSF) in west, east and south distribution networks, as shown in table 5.

CSFs	West Network		East Network		South Network		Overall	
	RII	Rank	RII	Rank	RII	Rank	RII	Rank
PQCS	3.149	5	3.229	5	3.171	5	3.186	5
PQMC	5.661	3	5.438	2	5.398	3	5.499	3
PQEPT	4.431	4	4.501	4	4.355	4	4.429	4
PQAw	6.493	1	6.691	1	6.626	1	6.603	1
PQDs	5.679	2	5.357	3	6.078	2	5.704	2

TABLE 5
THE RESULTS OF THE RII AND THE RANK OF CSFS AFFECTING PQP IMPLEMENTATION

Table 5 illustrates the most important CSFs, which significantly affected PQP implementation according to each west, east and south distribution network current level. These are 1) PQ awareness, 2) PQ disturbances, 3) PQ management commitment, 4) PQ employees participation and training and 5) PQ customers satisfaction. According to LDNs, it seems that PQ awareness was the most important factor, which delayed the implementation of PQP, as it was ranked first among all CSFs, with relative index (RII) = 6.493 for west distribution network, 6.691 for east distribution network, and 6.626 south distribution network. This agreement between all three distribution networks may be referred to lack of PQ awareness among LDNs top management to implement PQP effectively. Consequently, this can confirm that the ranked importance factors of all five CSFs of PQP are positive, and statistically significant among west, east and south distribution network, since the p-values (Sig.) are less than 0.05.

8 POWER QUALITY PROGRAMME BARRIERS

Respondents were asked to define how far any of the 16 PQP potential barriers (BA) cause current difficulties in implementing a PQP in LDNs. The 16 PQP barriers are listed in table 6. All factors were designed in a five-point Likert scale format (1=not applicable; 2= very low extent; 3= low extent; 4= moderate; 5= high extent). Data gathered were checked once more in terms of accuracy, outliers and, normality; then analysed using (SPSS) software version 18.1 [51]. Barriers BA 1-4 belong to factor 1 and can be categorized under 'lack of PQP awareness', whereas barriers BA 5-9, belong to factor 2 and are categorized as 'lack of PQP top management attention'. Barriers BA 10-12 belong to factor 3 and pertain to 'lack of PQP resources' and finally barriers BA 13-16 belong to factor 4, dealing with 'lack of PQP involvement'[52].

TABLE 6
LIST OF PQP BARRIERS MEAN, STD. DEVIATION AND SIGNIFICANT VALUES

Items	Factors	Barriers	Sig	Mean	S.D
BA1	F1: Lack of PQP Awareness	lack of staff awareness, skills and experience	0.035	3.44	1.335
BA2		lack of end users awareness	0.033	3.68	1.349
BA3		lack of customer cooperation	0.337	3.52	1.321
BA4		lack of long-term strategy and planning	0.036	3.16	1.407
BA5	F2: Lack of PQP Top Management Attention	lack of top management commitment	0.044	3.51	1.411
BA6		lack of network designing	0.049	3.52	1.332
BA7		lack of distribution networks infrastructure	0.021	3.47	1.332
BA8		lack of conducting research and studies	0.447	3.01	0.863
BA9		lack of top management responsibility	0.043	3.34	0.732
BA10	F3: Lack of PQP Resources	lack of training courses, education and support	0.022	3.06	0.952
BA11		lack of enough resources	0.044	3.09	0.965

BA12		lack of financial incentives	0.242	3.09	1.002
BA13	F4: Lack of PQP Involvement	lack of PQ measurement	0.031	3.76	1.015
BA14		lack of PQ consultants	0.041	3.81	0.934
BA15		lack of PQ standards	0.029	3.75	1.068
BA16		lack of PQ monitoring and database	0.028	3.94	0.997
Overall Mean				3.44	1.126

Table 6 illustrates the ANOVA test along with the list of PQP Barriers Mean, Std. Deviation and Sig values. Out of 16 barriers, 13 were statistically significantly different at the P value <0.05. The significant PQP barriers were BA1, lack of staff awareness, skills and experience, BA2, lack of end users awareness, BA4, lack of long-term strategy and planning, BA5, lack of top management commitment, BA6, lack of network designing, BA7, lack of distribution networks infrastructure, BA9, lack of top management responsibility, BA10 lack of training courses, education and support, BA11, lack of sufficient resources, BA13, lack of PQ measurement, BA14, lack of PQ consultants, BA15, lack of PQ standards, and BA16, lack of PQ monitoring and database.

Table 7 illustrates the post-hoc tests to point out, where the differences lie between PQP factors among LDNs after obtaining the significant values from the ANOVA table. If the Sig. value was equal to or less than 0.05 then the asterisks (*) in the column mean difference indicate that the three LDNs being compared are significantly different from one another at the p< 0.05 level with PQP factors.

TABLE 7
POST-HOC MULTIPLE COMPARISONS USING THE TUKEY HSD TEST

Dependent Variable	(I) Which Network do you work at?	(J) Which Network do you work at?	Mean Difference (I-J)	Std. Error	Sig.
PQP Awareness	DN1	DN3	-.228(*)	0.078	0.010
		DN2	-0.079	0.083	0.606
	DN3	DN1	.228(*)	0.078	0.010
		DN2	0.149	0.086	0.193
	DN2	DN1	0.079	0.083	0.606
		DN3	-0.149	0.086	0.193
PQP Top Management Attention	DN1	DN3	-0.183(*)	0.066	0.016
		DN2	-0.155	0.070	0.069
	DN3	DN1	0.183(*)	0.066	0.016
		DN2	0.028	0.073	0.924
	DN2	DN1	0.155	0.070	0.069
		DN3	-0.028	0.073	0.924
PQP Resources	DN1	DN3	0.140	0.106	0.383
		DN2	-0.178	0.112	0.252
	DN3	DN1	-0.140	0.106	0.383
		DN2	-0.317(*)	0.117	0.019
	DN2	DN1	0.178	0.112	0.252
		DN3	0.317(*)	0.117	0.019
PQP Involvement	DN1	DN3	-0.150(*)	0.060	0.033
		DN2	-0.084	0.063	0.377
	DN3	DN1	0.150(*)	0.060	0.033
		DN2	0.066	0.066	0.578
	DN2	DN1	0.084	0.063	0.377
		DN3	-0.066	0.066	0.578

In brief, a post-hoc Least Significance Difference (LSD) test was carried for the four PQP framework factors. The respondents agreed that PQP factors have significant effect on LDNs in terms of level of PQP Awareness, PQP Top Management Attention, PQP Resources and PQP Involvement. As a result, it can be said that LDNs have so far struggled to implement PQP effectively [53][54].

9 THE RELATIVE IMPORTANCE INDEX (RII) AND RANK OF PQP BARRIERS IMPLEMENTATION

The relative importance index is technique, which has been used widely in different types of questionnaire to rate each factor based on the weight given by the respondents [55]. It is very important to state, which significant barrier is most affecting the implementation of PQP. The relative importance index method (RII) is employed in this thesis to identify,

which one of the sixteenth PQP barriers is most affected the implementation of PQP in three LDNs west, east and south after the significant level is obtained.

The relative importance index (RII) and rank of PQP barriers, which are considered as the key factors affecting the implementation of PQP presented in table 8. Lack of PQ standards has been ranked the first factor affecting the implementation of PQP by the west distribution network respondents (RII) = 0.541 and east distribution network respondents (RII) = 0.543 respondents. However, this factor has been ranked as third by south distribution network respondents (RII) = 0.532. The overall rank for this factor among all factors with relative index (RII) = 0.538. It is noted that this factor identified as most important for west and east distribution network as they lack of PQ standards, which affect both the supplier and end user. Moreover, this factor has affected the end user sensitive equipments as well as the distribution network operators to assess the level of PQ. As a result, end user complaint regarding PQDs due to lack of PQ standards. Lack of staff awareness, skills and experience has been ranked the second factor affecting the implementation of PQP by east respondents (RII) = 0.542 and south distribution network respondents (RII) = 0.546. However, this factor has been ranked as third by west distribution network respondents (RII) = 0.525. The overall rank for this factor among all factors with relative index (RII) = 0.537. This factor is considered as a significant obstacle for LDNs staff, whereby they could not improve PQDs, satisfy end user, identified PQDs roots, increase their knowledge and skills, aware end user regarding PQ issues and the most important element their contribution in implementing PQP.

TABLE 8
PRESENTED THE RELATIVE IMPORTANCE INDEX (RII) AND PQP BARRIERS RANKING

Items	Barriers	West Network		East Network		South Network		Overall	
		RII	Rank	RII	Rank	RII	Rank	RII	Rank
BA1	lack of staff awareness, skills and experience	0.525	3	0.542	2	0.546	2	0.537	2
BA2	lack of end users awareness	0.447	8	0.481	5	0.459	10	0.462	8
BA3	lack of customer cooperation	0.518	4	0.523	4	0.562	1	0.534	3
BA4	lack of long-term strategy, planning	0.501	5	0.468	7	0.493	7	0.487	5
BA5	lack of top management commitment	0.471	6	0.435	9	0.458	11	0.454	9
BA6	lack of network designing	0.532	2	0.525	3	0.514	5	0.523	4
BA7	lack of DNs infrastructure	0.441	11	0.447	8	0.439	13	0.442	11
BA8	lack of conducting research and studies	0.443	9	0.432	10	0.515	4	0.463	7
BA9	lack of top management responsibility	0.423	13	0.412	13	0.462	8	0.432	12
BA10	lack of training education courses	0.408	14	0.358	16	0.441	12	0.402	16
BA11	lack of enough resources, , and support	0.398	15	0.407	14	0.428	14	0.411	14
BA12	lack of financial incentives	0.456	7	0.421	11	0.461	9	0.446	10
BA13	lack of PQ measurement	0.392	16	0.406	15	0.424	16	0.407	15
BA14	lack of PQ consultants	0.442	10	0.474	6	0.502	6	0.472	6
BA15	lack of PQ standards	0.541	1	0.543	1	0.532	3	0.538	1
BA16	lack of PQ monitoring and database	0.427	12	0.415	12	0.426	15	0.422	13

As indicated in table 8, lack of customer cooperation has been ranked by the west respondents as the fourth factor with RII equal 0.518. It has been ranked by the east respondents as the fourth factor with RII equal 0.523 and has been ranked by the south respondents as the first factor with RII equal 0.562.

The overall rank for this factor among all factors with relative index (RII) = 0.534. The three distribution network respondents considered this factor as an important due to the neglect of end user to cooperate with LDN management in order to improve PQDs and implement PQP. As a result, the end user are not satisfied about the bad PQ they utilize as well as their complaints are not taken seriously. Therefore, this factor affects directly on PQP implementation as they do not trust LDN department to take their suggestion into account, when measuring or improving PQDs. If customers are not cooperated as part of PQP implementation, the implementation will suffer from issues of considering end user satisfaction to estimate the real outcome expected from such programme. This result confirms what Grady and Noyola stated regarding PQP implementation, if customer cooperated, which will give necessary and sufficient results needed [56]. In addition, table 8 presented the relative importance index (RII) and rank of PQP barriers, which indicated the most affecting barriers on the implementation from 1 to 16, based on the three LDNs respondents respectively. The relative importance index (RII) and the rank closes to one is considered most important factors affecting on PQP implementation in three west, east and south LDNs. Therefore, from table 8, LDNs need to consider and evaluate each importance barrier based on its rank, which affecting on the whole programme

implementation in order to make significant change on PQDs. This can be done by link all the four factors of PQP framework together in order to make dramatically change within time specified.

10 Interview Results

The PQP is the first and most significant factor chosen to assess how top management and staff bear their commitment to, and support for implementing PQP. Their commitments are to understand PQ definition, and the difficulties and benefits of implementing PQP. It was clear that without establishing a clear vision of these factors, which have significant effect on LDNs, then any efforts aimed at improving PQ issues will be a waste in both time and resources. Table 9 shows PQP barriers, which affect LDNs in implementing the PQP framework, and the significant effect of each barrier on each department.

TABLE 9: PQP FRAMEWORK EFFECT BY BARRIER ON EACH DEPARTMENT

PQP Barriers	Customer Department	Planning Department	Distribution Department	Training Department
1 : Lack of Infrastructure	0%	36.17%	46.29%	17.54%
2 : Lack of Customer Awareness	2.57%	18.22%	56.19%	23.02%
3 : Lack of Enough Resources	0%	10.33%	11.65%	78.01%
4 : Lack of Long Term Strategy	4.55%	29.46%	17.83%	48.16%
5 : Lack of Management Commitment	0.42%	29.32%	26.45%	43.81%
6 : Lack of Networks Designing	4.11%	55.53%	26.13%	14.23%
7 : Lack of PQ Measurement	2.13%	49.41%	43.74%	4.73%
8 : Lack of PQ Standards	0%	61.65%	19.63%	18.72%
9 : Lack of PQ Training Courses	0%	15.15%	3.72%	81.13%
10 : Lack of Regular Maintenance	0%	45.79%	27.97%	26.25%
11 : Lack of Staff Awareness	0.73%	32.1%	38.54%	28.63%
12 : Lack of Top Management Responsibility	0%	80.42%	19.58%	0%

Table 9 illustrates the most common PQP barriers, which affect LDNs in implementing the PQP framework. As can be seen, the four departments, which are supposed to implement PQP, are affected by the twelve PQP barriers. The level of each barrier and its effect on each department are identified by the interviewees. In general, the table shows that all PQP barriers (they are all above 15%) seriously affect LDNs progressing to implement a PQP. One of the clear points is that there was no PQP awareness, which can at least match the significant increase in PQP barriers.

These results indicate that LDNs have not implemented PQP. It showed that the top management has not paid enough attention, support, commitment and responsibility to setting up long-term strategies to implement PQP. Therefore, LDNs have lost LD 464 million annually due to poor PQ and the failure to implement PQP [57]. Moreover, most of members of staff involved in implementing PQDs are middle managers, 52.4% of who held of high diploma qualifications, which is considered the minimum educational level. This means that they are not highly knowledgeable and aware enough to cope with the current severe level of power quality as well; moreover, this level of education would not enable them to understand and participate in implementing PQP. Almost 38% of engineers and technicians have between 6 and15 years of experience, but lack awareness and skills. They should be better taught and trained before they can deal with PQP implementation.

11 Developed PQP Framework

The four PQP framework factors each have their own variables, derived from the literature review, to determine the assumptions, which should exist in LDNs, in order to implement the PQP framework. As a result, an acceptable model was developed based on these factors. It is clear that all these factors are significantly correlated, since all p values are less than (<0.05) and are substantially affected by the implementation of PQP in LDNs, as shown in Fig.4.

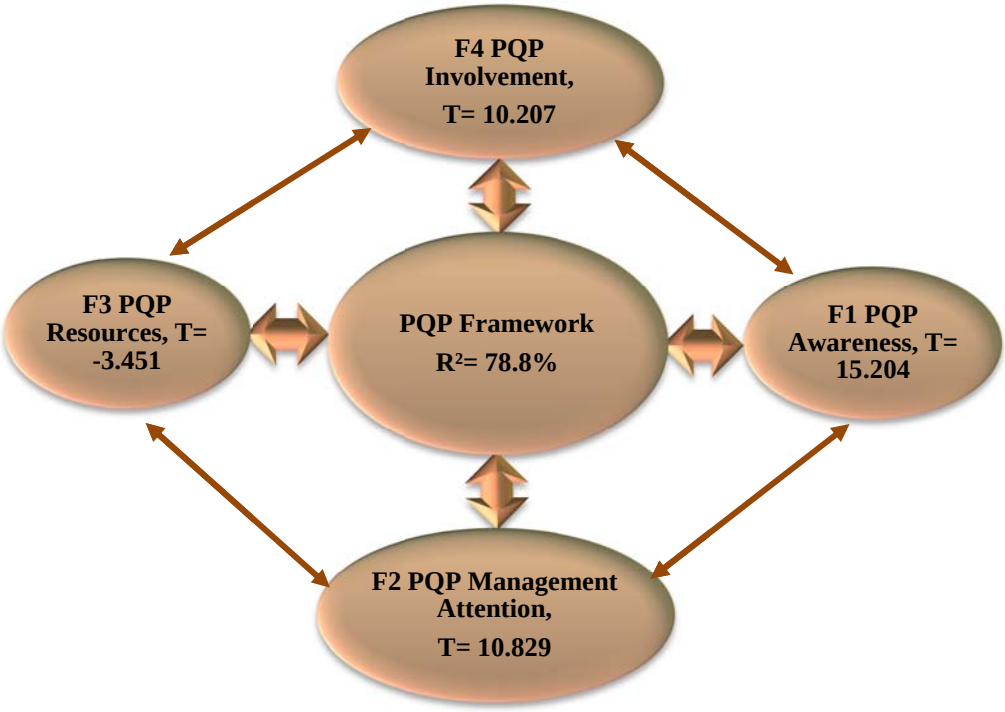

Fig. 4: Developed Model for PQP Framework Implementation

Figure 4 and Table 10 showed that the value of R^2 was 78.8% for this model, which indicated how much of the variability in the outcome was explained by the predictors, which are (PQP Awareness, PQP Management commitment, PQP Resources, and PQP involvement). Since all factors of the model were statistically significant ($p < 0.05$). This also indicated that the validity of this model is very good. As a result, this model can be accepted and applied for LDNs to implement PQP, since all the predictors increase by one unit (see β value) as these constructs explained 78.8% of PQP implementation construct ($R^2 = 0.788$).

TABLE 10
CONTRIBUTION FACTORS OF PQP FRAMEWORK IMPLEMENTATION

	B	Std .Error	β	T	P	R^2	Collinearity Statistics	
Constant PQP Framework	0.717	0.109		6.588	<0.001	0.788	Tolerance	VIF
F1 PQP Awareness	0.516	0.034	0.546	15.204	<0.000		0.474	2.112
F2 PQP Management Attention	0.201	0.019	0.314	10.829	<0.000		0.729	1.373
F3 PQP Resources	-0.065	0.019	0.099	-3.451	<0.001		0.740	1.351
F4 PQP Involvement	0.206	0.020	0.289	10.207	<0.000		0.763	1.310

The factors highly contributed to the model were F1 PQP Awareness (β=0.546, p< 0.05), which makes for the strongest unique contribution factor explaining the outcome of the model [58], and has significantly positive effect on PQP framework implementation and has explained 54.6%

(T=15.204). F2 PQP Management Attention (β=0.314, p < 0.05), which has significant positive effect on PQP framework

implementation and has explained 31.4% (T =10.829), when the variance is explained by all other predictor factors in the model. F3 PQP Resources (β=0.099, p < 0.05), which has significantly positive effect on PQP framework implementation and has explained 10% (T=-3.451), indicating that it made less contribution [58]. F4 PQP Involvement (β=0.289, p < 0.05), which has significant positive effect on PQP framework implementation, and has explained 29% (T= 10.207). It revealed that all these factors significant positive contributors, and have an effect on the implementation of PQP in LDNs in terms of PQP Awareness, PQP Management commitment, PQP Resources, and PQP involvement, as shown in figure 4.

11.1 A ROADMAP FOR POWER QUALITY PROGRAM FRAMEWORK

The PQP framework is consisted three essential phases. Phase one designed to increase the awareness level. Phase two is involved in preparation of PQP, which contains seven crucial requirements. Phase three is designed to prevent the outstanding problems from phase 1 and 2 of not reoccurring again to determine both the weaknesses and obstacles facing the implementation, to reach a high level of power quality. Therefore, PQP framework is influenced by top management's awareness, which must move from studies and recommendation to practice. This framework is designed as a guideline for implementation of PQP in the Libyan distribution networks environment. The progress of this framework and moving through from phase to other will be depended on the level of awareness, knowledge, skills gained respectively after each phase performed. Figures. 5, 6, and 7 show the three phases of the proposed model PQP of framework respectively.

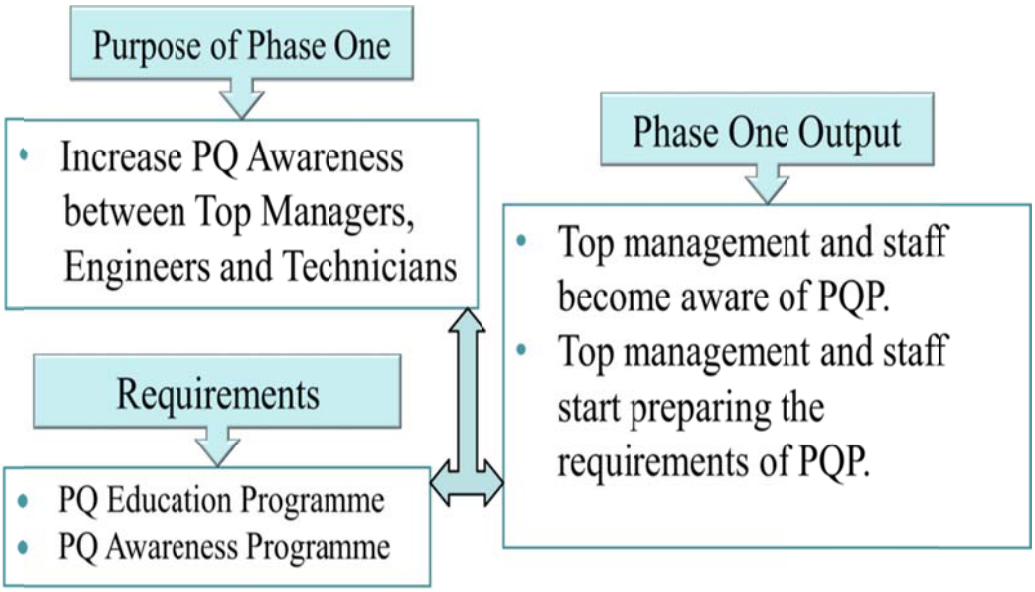

Fig. 5. Phase One Awareness of PQP framework

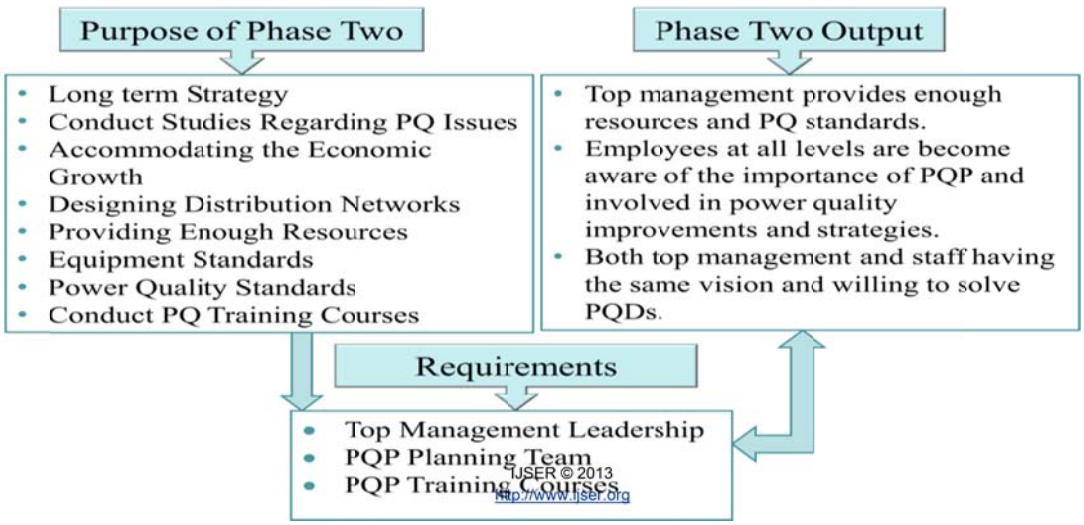

Fig. 6. Phase Two Preparation of PQP framework

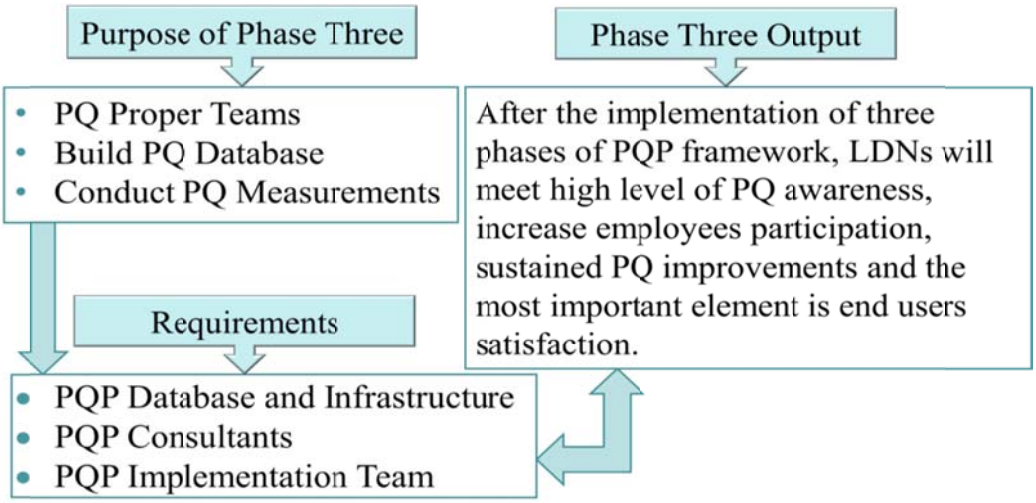

Fig. 7. Phase Three Implementation of PQP framework

Table 11 explains the three phases of the proposed PQP framework. The progress of this framework and moving through from one phase to another depends on the level of awareness, knowledge, and skills gained after each phase is completed.

TABLE 11
PQP FRAMEWORK PROCESS STAGES DEVELOPED FOR THE PURPOSE OF THIS RESEARCH

Framework Process	Objectives	Purpose
Stage One: Awareness	To determine the present level of knowledge and awareness regarding PQ among LDNs staff.	• Motivating the top management to be eager and enthusiastic to start implementing the PQP based on the staff knowledge and awareness • Understand the importance of PQP and its features
Stage Two: Preparation	To state the actual needs of PQP, in terms of training, management planning, and commitment, and providing enough resources to implement PQP.	• Gain top management commitment and responsibility • Providing enough resources regarding the implementation of PQP • Accommodating economic growth • Involve staff at all levels; engineers, technicians and top managers • Top managers, engineers, and technicians from all departments have become aware of the importance of PQP
Stage Three: implementation	To investigate and solve the main reasons underlying PQ disturbances in LDNs.	Monitor and collect PQ data Focus on existing end user complaints regarding PQDs Identify the real causes underlying PQDs Considering all conditions in the contracts by taking legal action against illegal connections by end users

PQP implementation requires great attention from top management that can help the distribution networks to achieve their goals in converting the studies and recommendations into practice by implementing a PQP practically.

11.2 Benefits of PQP Framework Implementation

The mean level of PQP benefits indicates whether or not LDNs will gain significant outcomes after PQP is implemented successfully following the roadmap process for each phase. In response, participants were asked to judge how far one of 11 PQP possible benefits (BN) would be achieved by implementing PQP within Libyan distribution systems. The 11 PQP expected benefits are listed in table 12. All factors were designed in a five-point Likert scale format (1= not sure; 2=negative; 3= moderate; 4= positive; 5= very positive). The response scale of the survey was divided into three levels of outcome, where (1.51 to ≤ 2.50 was negative, 2.51to ≤ 3.50, moderate and, 3.51to ≤ 5 positive).

TABLE 12
LIST OF MEANS LEVEL OF PQP BENEFITS

Item	PQP Benefits	DN1	DN2	DN3	Overall
BN1	Increasing the end users awareness	3.84	3.96	3.45	3.75
BN2	Increasing the end users satisfaction	3.91	3.56	3.54	3.67
BN3	Improving PQ performance	3.65	3.68	3.54	3.62
BN4	Reducing the end users complaints	3.51	3.52	3.68	3.57
BN5	Monitor & Measuring PQ disturbances	3.48	3.48	3.82	3.59
BN6	providing PQ diagnosis system and database	3.73	3.56	3.67	3.65
BN7	Reducing the huge losses of PQ cost	3.52	3.48	3.69	3.56
BN8	Increasing the top management awareness	3.76	3.88	3.82	3.82
BN9	Increasing the employee skills and awareness	4.25	3.31	3.75	3.77
BN10	Increasing PQ training courses	3.43	3.68	3.73	3.61
BN11	Providing strategic planning	3.48	3.66	3.61	3.58

The overall outcomes of implementing the PQP presented in figure 4 and table 12, which would have a positive impact on LDNs after implementing the PQP framework can be tangible, such as increasing end users' awareness, increasing their satisfaction, improving PQ performance, reducing end users' complaints, monitoring and measuring PQDs, providing PQ diagnostic systems and databases, reducing the huge losses associated with PQ, increasing top management awareness, increasing employee skills and awareness, increasing PQ training courses and providing strategic planning in LDNs. As explained in sections 7 and 8, both the CSFs and barriers of PQP framework implementation are correlated and belong to each other to affect PQP implementation and how they significantly influence PQ improvement within LDNs. Therefore, from the field study conducted in this research, the positive benefits of implementing PQP are not accidental, but can be obtained simultaneously after creating trigger changes in the framework implementation requirements. These are to be carried continuously, and help in finding the outstanding barriers, and defining each difficulty separately, whether it belongs to technical or non-technical issues [34].

In addition, the relative importance index (RII) and rank of PQP benefits is identified, in that which one of the 11 PQP benefits is most important for three LDNs after implementing the three phases of PQP respectively. Table 13 presented the relative importance index (RII) and ranks of PQP benefit results.

TABLE 13
THE RELATIVE IMPORTANCE INDEX (RII) AND RANK OF PQP BENEFITS

PQP Benefits	West Network		East Network		South Network		Overall	
	RII	Rank	RII	Rank	RII	Rank	RII	Rank
Increasing the end users awareness	0.559	10	0.541	9	0.613	9	0.571	9
Increasing the end users satisfaction	0.547	11	0.529	11	0.575	11	0.551	11
Improving PQ performance	0.573	9	0.531	10	0.579	10	0.561	10
Reducing the end users complaints	0.625	7	0.619	7	0.654	8	0.632	8
Monitor & Measuring PQ disturbances	0.664	6	0.701	2	0.708	6	0.691	6
providing PQ diagnosis system and database	0.742	1	0.723	1	0.742	2	0.735	1
Reducing the huge losses of PQ cost	0.703	2	0.693	4	0.718	4	0.704	4
Increasing the top management awareness	0.623	8	0.606	8	0.676	7	0.635	7
Increasing the employee skills and awareness	0.689	4	0.681	6	0.745	1	0.705	3
Increasing PQ training courses	0.694	3	0.697	3	0.728	3	0.706	2
Providing strategic planning	0.686	5	0.691	5	0.711	5	0.696	5

As indicated in table 13, providing a PQ diagnosis system and database has been ranked the first benefit by west network respondents RII = 0.742 and by east network respondents RII = 0.723. However, this factor has been ranked as second by south distribution network respondents RII = 0.742. According to the three distribution network respondents, the overall rank for this factor RII = 0.735, which indicated agreement on how it is very significant for LDNs to prepare and build a PQ database and diagnostic systems. This is due to lack of measurement and monitoring archives to compare past measurements with current ones, in order to identify the problems roots and the factors beyond them. Moreover, the three distribution network respondents have ranked increasing PQ training courses as the second important factor among all PQP benefits with relative index (RII) = 0.706. However, this factor was ranked third by each network, but the overall ranking was the second. This is mainly because if LDNs staff have enough training courses, then PQP implementation can performed and conducted to monitor PQDs with accurate outcome.

Increasing the employee skills and awareness has been ranked the third important factor of PQP benefit RII =0.705. It has been ranked by west network respondents RII = 0.689, by east network respondents RII = 0.681 and by south network respondents RII = 0.745. PQDs were not solved due lack of staff awareness, which affect PQP implementation and rise the end user complaint's. Therefore, increasing the employee skills and awareness considered one of the most important benefits that LDNs will gain after implementing the PQP framework successfully. The three first factors can be considered as the most important benefits for three distribution networks, which are: providing PQ diagnosis system and database, increasing PQ training courses and increasing the employee skills and awareness. These factors may have a direct change on LDNs staff and end user after implementing PQP. It can be seen from table 13, the relative importance index (RII) and rank of PQP benefits show the top important factors from 1 to 11, which are categorised based on the three LDNs respondents, as they decided, which benefit is most important for each distribution network, after implementing PQP successfully.

12 CONCLUSION

A power quality survey was conducted in LDNs west, east and south, networks as example one of distribution utilities in less developed countries. The survey provided various conclusions about occurrence of PQ issues, their sources and equipment affected LDNs. The results showed that most power quality issues were due to lack of PQ awareness and

knowledge on part of Libyan distribution staff and customers. The rapid economic growth was a very significant factor causing huge PQDs in LDNs after 1999. Statistical data also show that in the last two decades, LDNs have not implemented PQP. This due to the absence of a PQ department resulted by lack of awareness on the part of top management regarding the importance of power quality. As a result, lack of power quality awareness has led LDNs to face twelve significant difficulties through not implementing PQP.

A new model of PQP framework is developed and proposed to guideline LDNs improves PQDs.. WDN1 faces three factors; F1, lack of PQP awareness, F2, lack of PQP top management attention, and F4, lack of PQP involvement, whereas EDN3 faces F1, lack of PQP awareness, F2, lack of PQP top management attention, F3, lack of PQP resources and F4, lack of PQP involvement and SDN2 faces F3, lack of PQP resources. As a result, it can be said that LDNs have so far struggled to implement PQP effectively. These four factors appeared in USA, European, India, Malaysia, Latin America, Brazil, Germany, Pakistan, Austria, France, Italy, Poland, Portugal, Slovenia, Spain and UK. For that reason, LDN must implement PQP based on increasing the level of awareness as the economic level is increased due to competitiveness of rapid developed projects. Thus, without adequate knowledge, awareness, planning, designing, preparation, training, PQ standards, clear strategy, and most important the support of top management for this programme, PQDs will never end and their severity will affect all end users. Finally, the regression was sufficiently representative to conclude that the relationship between the model and the depended variables of PQP is very strong and not accident. The developed PQP framework significantly contributed as following:

- The implementation of PQP will enable LDNs to step forward, to tackle any PQ problems by setting up a clear and long term strategy, with the most crucial objectives, by involving all the departments and staff, who have direct relation and are responsible for improving PQDs.
- If the proposed framework is adopted and adapted to suit the General Electricity Company of Libya (GECOL) circumstances of PQ problems, it will help them to make a smooth transformation from poor PQ in the network to efficiency and effectiveness that satisfy their customers.
- This study indicates that PQP framework implementation will grow rapidly and will become one of the key approaches for most distribution companies in solving PQDs. Nonetheless, it will take more time for some utilities in under-developed countries, such as GECOL, to employ it and gain the significant and expected improvements.

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