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Key performance indices for EDCs in Egypt

By:

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Abstract:

Continuity of supply is characterized by the number and duration of interruptions. Several indicators are used to evaluate the continuity of supply in transmission and distribution networks. The most widely used reliability indices are SAIFI, SAIDI, CAIDI, ENS and CENS (IEEE std. 1366-2000 and CIGRE study committee (C2). Regulation can aim to compensate customers for long supply interruptions, keep restoration time under control, and create incentives to reduce the total number and duration of interruptions. The paper presents and assessments the key performance indices for electric distribution system in Egypt, monitored, calculated and analysed by EGYPTERA to concentrate on the guideline values for distribution system, and to provide an optimal level of customer service.

Keywords:

power distribution; key Performance indices; performance evaluation; availability; energy not supplied.

* Egyptian Electric Utility and Consumer Protection Regulatory Agency, License and Tariff Sector.

1. Introduction:

The Egyptian Electricity Holding Company (EEHC) mission towards the society is to supply electricity to all types of consumers according to international performance standards taking into consideration all environmental, social and economic determinates and also the terms and conditions set by The Egyptian Electric Utility and Consumer Protection Regulatory Agency (EGYPTERA). EEHC has sixteen affiliated companies (six generation, nine distributions and the Egyptian Electricity Transmission Company)
The main objectives of electricity distribution company (EDC) are:
Distributing and selling to consumers on medium and low voltages.
Managing, operating and maintaining medium and low voltages grids in the company.
Ensuring high level of quality, availability and continuity of supply to distribution customers.
The following procedures have been taken to improve continuity of supply indices:
Analysis of the causes in case of increased unplanned interruptions and relate it to network renovation and rehabilitation plans.
Follow up the implementation of maintenance programs to insure optimizations of interruption of supply time and at the same time implementation of the maintenance procedures with high quality.
Intensive field inspections and data collection for interruptions.
Each EDC consists of number of geographical sectors, have number of districts. The district network consists of MV distributors, distribution transformers (MV/LV), and MV, LV lines, as shown in "Fig.1".

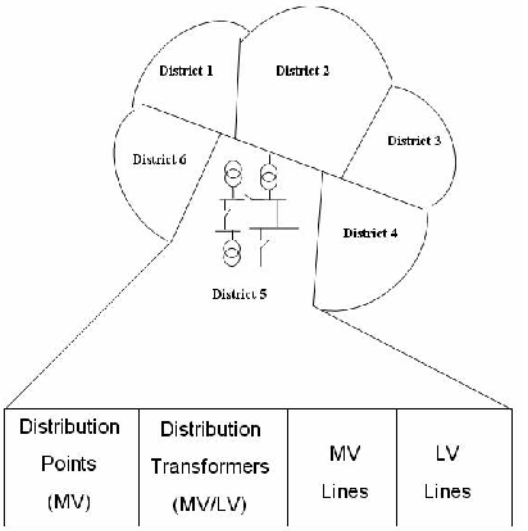

Figure (1): *Part of geographical area of an EDC*

EEHC and EGYPTERA use KPIs to trace the performance of EDCs. EGYPTERA most commonly uses KPIs: SAIFI, SAIDI, CAIDI, ENS and CENS.

The reduction of the required chip area is an important goal in the automatic layout generation of VLSI circuits. The further reduction in width for the standard cell layout design is important. Most of the channel routing (CR) techniques use only horizontal and vertical wires to complete …..

2. Basics of Distribution System

There are two regions of operation for a distribution system. These are: primary and secondary distribution systems. Primary distribution system comprises long feeders which can be overhead lines (OHLs) or underground cables that feed the secondary distribution networks. There are also protective equipment like fuses, reclosers and circuit breakers. Secondary distribution systems consist of distribution transformers, for stepping down the voltage from the primary distribution system to feed the load points. Short lines or cables are used to connect customers to the nearest transformer.
The system under study is radial distribution system. It uses primary or main feeders and lateral distributors. Many practical distribution systems have a single circuit main feeder and are referred to as radial systems. They have simple design and relatively low cost. They are susceptible to outages due to single contingencies.

3. *Data*

The data is executed from the EDCs database. There are different Tables with information about both urban and rural districts. The main yearly data Tables acquired are:
MV and LV lines (cables and OHL)
Capacity of distribution transformers
Maximum demand
Electric energy
Total number of customers
Frequency, magnitude and duration of interruptions, (only MV interruptions).
Energy not supplied.
Key performance indices

Recommended interruption indices or key performance indices (KPIs) are those defined in both IEEE 1366[1] and the CIGRE study committee C2 [2]:
SAIFI (System Average Interruption Frequency Index): the average number of sustained interruptions per customer during the year.
SAIDI (System Average Interruption Duration Index): the average time for which customers power supply is interrupted in a year.
CAIDI (Customer Average Interruption Duration Index): the average time required to restore service to the average customer per sustained interruption.
ENS (Energy Not Supplied): the summation of energy not supplied due to supply interruptions over a year period. Its cost is CENS (cost of energy not supplied).

4. Key performance indices

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5. System reliability KPIS

1- System Average Interruption Frequency Index (SAIFI)
It measures the average number of interruptions experienced by each customer. All planned and unplanned interruptions are used in calculating the index. SAIFI can be calculated as follows:

$$\text{SAIFI} = \frac{(\text{No. of interruptions during one year})}{(\text{No. of customers})} \qquad (1)$$

2- System Average Interruption Duration Index (SAIDI)
It measures the yearly average interruptions duration per customer. It can be calculated as follows:

$$\text{SAIDI} = \frac{(\sum \text{duration of interruption in min})}{(\text{No. of customers})} \qquad (2)$$

3- Customer Average Interruption Duration Index (CAIDI)
It measures the average time required to restore service to the average customer per interruption. The

following formula is employed for calculating CAIDI:

$$\text{CAIDI} = \frac{(\text{SAIDI})}{\text{SAIFI}} \qquad (3)$$

The following notes are applicable for SAIFI, SAIDI and CAIDI:

Calculation carried for each voltage level
Assuming total number of customers connected per MV feeder is 1000
EGYPTERA complies with the reliability indices targets as the three years average for example:

Target SAIFI = 1/3 (SAIFI 2007+SAIFI2008+SAIFI 2009) (4)

The KPI shall be calculated according to the following formula:

SAIFI KPI = 1-((actual SAIFI – target SAIFI)/target SAIFI)) (5)

If actual SAIFI is below target, then the KPI is considered 1, i.e. 100%

The same equations for SAIFI are also applicable for SAIDI and CAIDI.

The system reliability indices are rolling year by year in order to improve the performance. The annual improvement depends on the performance of interruption duration time: where the performance of the previous three years was low, the second improvement targets are higher according to table 1.

The results are that the reliability indices of the following year depend on both performances of the previous three years and rate of improvement / year. Tables (2), (3) and (4) represent the KPIs of SAIFI, SAIDI and CAIDI for nine EDCs respectively.

***Table (1):** Rate of Improvement*

SAIDI (and CAIDI)	Min /year	61-180
Improvement /year	**%**	1

***Table (2):** SAIFI KPI*

Company	SAIFI (Int/1000 Cust. / year)					SAIDI KPI
	2007	***2008***	***2009***	***Target***	***2010***	
EDC1	0.52	1.20	1.66	1.13	0.69	100 %
EDC2	0.90	0.96	0.92	0.93	0.79	100 %
EDC3	1.53	1.30	0.86	1.23	0.66	100 %
EDC4	0.59	0.41	0.38	0.46	1.57	-141%
EDC5	1.52	2.04	0.19	1.25	1.54	77 %
EDC6	0.37	0.22	0.24	0.28	0.15	100 %
EDC7	0.64	0.43	0.38	0.48	0.26	100 %
EDC8	0.98	0.79	0.57	0.78	0.46	100 %
EDC9	0.47	0.38	0.43	0.43	0.35	100 %

***Table (3):** SAIDI KPI*

Company	SAIDI (min/1000 Cust. / year)					SAIDI KPI
	2007	***2008***	***2009***	***Target***	***2010***	
EDC1	16.94	87.89	144.71	83.18	30.08	100%
EDC2	41.64	39.86	47.55	43.02	62.85	54%
EDC3	6.49	4.99	3.78	5.09	2.91	100%
EDC4	41.49	44.11	28.65	38.08	79.01	-7%
EDC5	30.55	29.4	12.68	24.21	32.54	66%
EDC6	48.96	25.47	31.17	35.2	15.77	100%
EDC7	46.16	25.28	22.52	31.32	15.14	100%
EDC8	71.42	70.37	50.41	64.07	34.06	100%
EDC9	33.43	41.63	51.76	42.27	32.65	100%

***Table (4):** CAIDI KPI*

Company	CAIDI in min					CAIDI KPI
	2007	***2008***	***2009***	***Target***	***2010***	
EDC1	16.94	87.89	144.71	64.35	43.87	100%
EDC2	41.64	39.86	47.55	46.53	79.09	30%
EDC3	6.49	4.99	3.78	4.16	4.42	94%
EDC4	41.49	44.11	28.65	84.52	50.33	100%
EDC5	30.55	29.4	12.68	34.05	21.07	100%
EDC6	48.96	25.47	31.17	125.78	104.91	100%
EDC7	46.16	25.28	22.52	63.38	59.02	100%
EDC8	71.42	70.37	50.41	83.46	74.26	100%
EDC9	33.43	41.63	51.76	99.9	93.97	100%

The notes:
1- KPIs are accepted for most EDCs
2- CAIDI for EDC3 is very small figure.
3- CAIDI KPI for EDC 2 indicated to bad figure, it must be improved.
4- SAIDI for EDC2 &EDC4 need to 1% improvement / year.
5- CAIDI for EDC2, EDC6, EDC7, EDC8, EDC9 need to 1% improvement /year.

6. Supply availability KPIs

Energy not supplied (ENS)

This is defined as the summation of energy not supplied due to supply interruptions over a year period. It can be calculated by using the following formula:

$$ENS = \sum [\text{interruption power (MW)} * \text{duration (h)}] \quad (6)$$

Cost of energy not supplies (CENS)

In principle, Electricity supply Interruption costs i.e. CENS consists of utility costs (revenue from unserved energy, costs of the supply restoration) and customer outage costs. The assessment of customer outage costs varies from country to country.

In some European countries national regulatory authorities have started implementing continuity regulation schemes since the present decade. The reference reliability indicators usually considered are SAIDI, SAIFI and ENS. As far as the distribution service is concerned, at the end of 2005 incentive /penalty schemes were in place in some European countries, surveyed by Council of European Energy Regulators [3].

In Egypt the regulatory agency has setup a scheme for benchmarking and performances evaluation. This scheme includes reliability indicators. A proposed article; in the distribution code request the service provide to compensate the consumers of unreliable power supply. This article is under evaluation and expected to be approved by 2012.

Table (5) Represents ENS as % of energy distributed in some European countries [3]
Table (6) represents CENS for distribution supply level in some European countries [4] (can be used as a guide)

TABLE (5): ENS as % of Energy distributed (% ENS /Year) [3]

Country	2003	2004
Finland	0.0001%	0.0001%
France	0.0006%	0.0005%
Great Britain	0.0001%	
Hungary	0.000%	0.0002%
Italy	0.0049%	0.0012%

Norway	0.0208%	0.0146%
Portugal	0.0026%	0.0012%
Spain	0.0002%	0.0006%
Sweden	0.0100%	0.000%

***TABLE (6)**: cost of ENS for distribution supply level [4]*

Country	Consumer sector	CENS (€/KWH)
Great Britain	All sectors	4.18
Sweden	urban	12.0
	Suburban	8.8
	rural	7.4
Norway	Resident	0.96
	commercial	11.8
	Industrial	7.9
Ireland	All sectors	7.2
Portugal	All sectors	1.5

The notes from tables (5) & (6) are:
1- The range of ENS % for European countries is between 0.0% (for Hungary) and 0.0208% (for Norway).
2- The lowest CENS is 0.96 €/KWh for resident in Norway, and the largest is 12 € /KWh for customer urban in Sweden.

Table (7) represents ENS /year (2009/2010) for 9 EDCs in Egypt.

***TABLE (7)**: ENS PER YEAR (2009/2010) FOR EDCS EGYPT*

Distribution company	Annual energy consumed (kWh)	ENS	
		M(kWh)	***%***
EDC1	14896.53	1.7903	0.0109
EDC2	18919.79	4992.83	26.389
EDC3	7717.60	1.377	0.0163
EDC4	7218.80	2.55	0.0353
EDC5	8975.80	66.48	0.7406
EDC6	8208.05	1.04	0.013
EDC7	20830.52	0.0010	
EDC8	9329.41		
EDC9	7348.70	2.37	0.0322

The notes:
1- ENS % for most of EDCS is closed to the results of European countries in table (5)

2- ENS % for EDC2 is very large this EDC has largest number of customers over Egypt. The plan to reduce this figure has been implemented.

7. Conclusion

The most main function of a recent electric utilities and regulatory is to provide electric power to its customers at the lowest possible cost with acceptable reliability levels.

EEHC and EGYPTERA use KPIS to trace the performance of EDCS. EGYPTERA most commonly uses SAIFI, SAIDI, CAIDI, ENS and CENS.

The system reliability indices are rolling year by year in order to improve the performance. The annual improvement depends on the performance of interruption duration time where the performances of the pervious three years were low, the second improvement target is 1% per year if SAIDI between 61- 180 min.

In Egypt the regulatory agency has set up a scheme for benchmarking and performance evaluation. This scheme includes reliability indicators. A proposed article, in the distribution code request the service provide to compensate the consumers of unreliable power supply. This article is under evaluation and expected to be approved by 2012.

The distribution system has received less attention with regards to reliability evaluation over the post decades when compared to generation and transmission systems.

This is mainly due to the fact that distribution systems are less capital intensive and failures in this part of the system have localized effects.

Reliability level for its delivery facilities and, where appropriate to improve performance.

The results are the reliability performance objectives for EDCs, ETC, and EPCs shall have threshold objective designed to help maintain the acceptable envelop.

The future study will aim to match between the indicators for EDCs and ETC. Also search the effects of conditions of EPCs indicator on all electric network components.

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