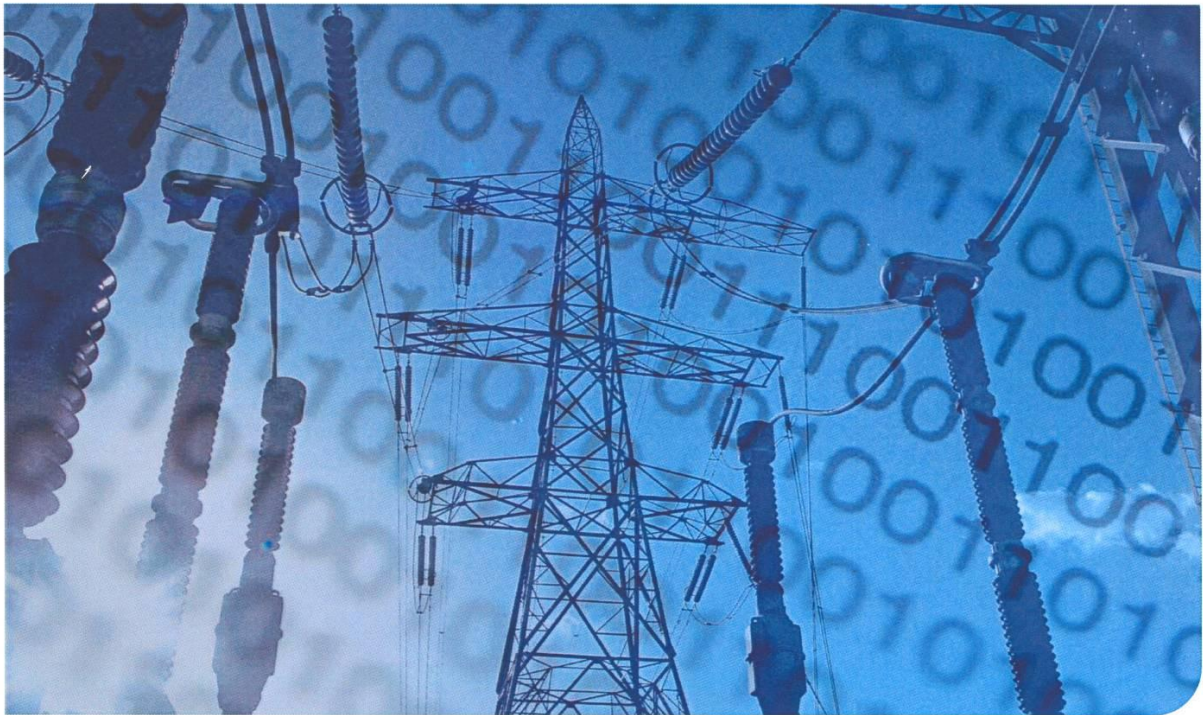


Development of KPI's for the Electricity Sector in the Kingdom of Saudi Arabia

KPI Manual



Submitted to: Electricity & Co-generation Regulatory Authority of the Kingdom of Saudi Arabia

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ANNEX 1: REFERENCE FOR CALCULATING GENERATION PERFORMANCE INDICES & EVENTS REPORTING INSTRUCTIONS - ADAPTED FROM SEC

1 INTRODUCTION

1.1 BACKGROUND

The purpose of this KPI Manual is to detail to the licensed companies of the Saudi power sector how KPI's should be calculated. This will provide a base for consistency in the reporting of the KPI's countrywide.

As a consequence of the definitions and conventions adopted for a country-wide KPI scheme, some of the licensed companies may have to adapt their KPI monitoring tools in order to match the definitions presented here, so that at the end all companies of each subsector (Generation, Transmission, Distribution, Customer Service) will apply the same definitions and conventions in order to provide a consistency frame at national level.

This manual also sets out the underlying data records that the utility will need to maintain. The utility should maintain records in which the data required for the KPI computation and subsequent reporting will be based. A template file will be provided by ECRA for this purpose. The records and underlying data should be made available to ECRA when audits are being performed. These records should be saved by the utility for a period of **at least 5 years**.

1.2 OUTLINE OF THIS MANUAL

This report is structured as follows: Chapters 2 till 5 have a uniform structure and respectively deal with the four sub-sectors namely Generation (Chapter 2), Transmission and Distribution (Chapter 3), and Customer Service (Chapter 4).

Note that some KPI's apply both to Transmission and Distribution level so that the related definition is given once, ensuring thereby consistency and clarity for possible further updates of the document. When applicable, specific issues of Transmission and specific issues for Distributions will be dealt with.

2 GENERATION

2.1 DEFINITIONS

The definitions and the mathematical equations for the calculations of the different KPI's are given in next sections and for details we refer to Annex 1 of this manual which contains:

- SEC-Reference for calculation generation performance indices & events reporting instructions- February 2009

Additional information can be found in:

- NERC-Generation Availability Data System- Reporting Instructions, January 2008
- IEEE-762 –IEEE Standard Definitions for Use in Reporting Electric Generating Unit Reliability, Availability and Productivity

For a clear understanding of the different states of a unit and an understanding of the definitions the next figure is a useful reference.

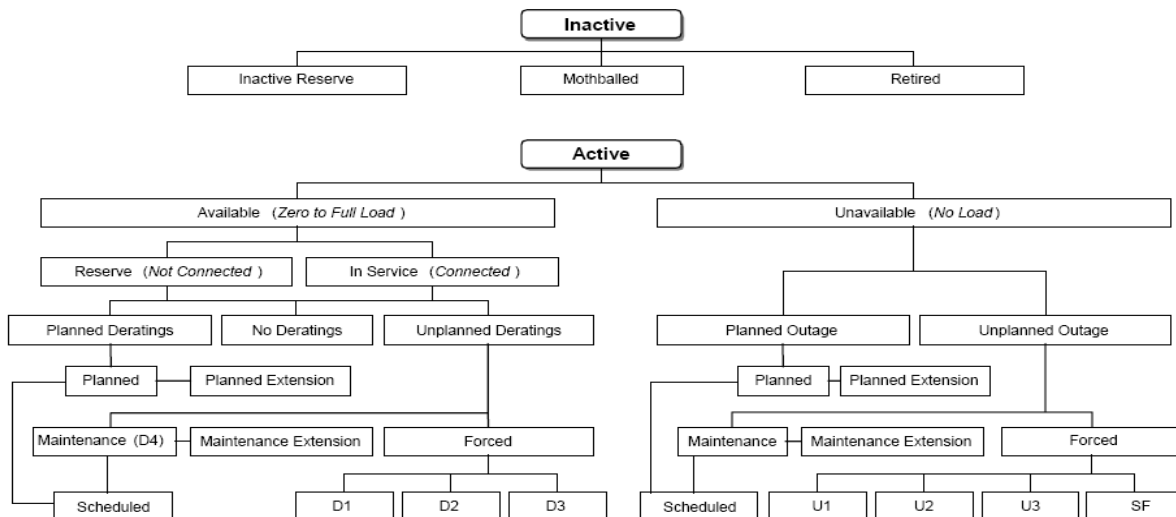


Figure 2. 1 Availability and definitions of outages according to NERC.

2.2 KPI FORMULA

2.2.1 G1: Availability Factor

The Availability Factor is a measure of the extent to which the generation unit is actually available for electricity production. It is defined for any considered period of time as the ratio between the period of time that a unit is able to provide service and the considered period.

The Availability Factor for a given generation unit is defined as follows.

$$AF = \frac{\text{Available Hours}}{\text{Period Hours}} * 100 \%$$

Where:

- Available Hours (Hrs): Sum of all Service Hours, Reserve Shutdown Hours, or: Period Hours – (Planned Outage Hours + Forced Outage Hours + Maintenance Outages Hours).
- Service Hours (Hrs): Total number of hours a unit was electrically connected to the transmission system.
- Reserve Shutdown Hours (Hrs): Total number of hours the unit was available for service but not electrically connected to the transmission system for economic reasons.
- Period Hours (Hrs): Sum of all Service Hours, Reserve Shutdown Hours, Planned Outage Hours, Maintenance Outages Hours and Forced Outage Hours.
- Forced Outage Hours (Hrs): Sum of all hours experienced during Forced Outages.
- Planned Outage Hours (Hrs): Sum of all hours experienced during Planned Outages and Planned Outage Extensions
- Planned Outages: The removal of a unit from service to perform work on specific components that is scheduled well in advance and has a predetermined start date and duration (e. g., annual overhaul, inspections, testing).
- Maintenance Outage Hours (Hrs): Sum of all hours experienced during Maintenance Outages and Maintenance Outage Extensions.

- Maintenance Outage: The removal of a unit from service to perform work on specific components that can be deferred beyond the end of the next weekend.

In the case of multiple units, the indicator should be weighted by the net maximum capacity to arrive at the Weighted Availability Factor (WAF). In case the net maximum capacity is not available the gross maximum capacity must be used.

$$WAF = \frac{\sum (\text{Available Hours} * \text{Net Maximum Capacity})}{\sum (\text{Period Hours} * \text{Net Maximum Capacity})} * 100 \%$$

2.2.2 G2: Forced Outage Factor

A forced outage is an unplanned component failure. These can be divided into four categories (immediate (U1), delayed (U2), postponed (U3), start-up failure (SF)).

The Forced Outage Factor for a given generation unit is defined as follows:

$$FOF = \frac{\text{Forced Outage Hours}}{\text{Period Hours}} * 100 \%$$

Where:

- Forced Outage Hours (Hrs): Sum of all hours experienced during Forced Outages.
- Forced Outage: An unplanned component failure (U1: immediate, U2: delayed, U3: postponed, U4: start-up failure) or other condition that requires the unit be removed from service immediately, within six hours, or before the end of the next weekend.
 - U1 is an outage that requires immediate removal of a unit from service, another outage state, or a reserve shutdown state. This type of outage usually results from immediate mechanical/electrical/hydraulic control systems trip or operator trip in response to unit alarms.
 - Delayed U2 is an outage that does not require immediate removal of a unit from the in-service state but requires removal within six hours. This type of outage can only occur while the unit is in service.

- U3 is an outage that can be postponed beyond 6 hours but requires that the unit will be removed from the in-service state before the end of the next weekend. This outage can only occur while the unit is in service.
- Start-up failure (SF) is an outage that results when a unit is unable to synchronize within its specified start-up time following an outage or reserve shutdown.
- Period Hours (Hrs): Sum of all Service Hours, Reserve Shutdown Hours, Planned Outage Hours, Maintenance Outages Hours and Forced Outage Hours.

In the case of multiple units, the indicator should be weighted by the net maximum capacity to arrive at the Weighted Forced Outage Factor (WFOF). In case the net maximum capacity is not available the gross maximum capacity must be used.

$$WFOF = \frac{\sum (\text{Forced Outage Hours} * \text{Net Maximum Capacity})}{\sum (\text{Period Hours} * \text{Net Maximum Capacity})} * 100 \%$$

2.2.3 G3: Scheduled Outage Factor

The Scheduled Outage Factor is an indication of the frequency of outages that were planned or related to maintenance activities. Scheduled outages is defined as the sum of planned and maintenance outages and their extensions.

The Scheduled Outage Factor for a given generation unit is defined as follows:

$$SOF = \frac{\text{Scheduled Outage Hours}}{\text{Period Hours}} * 100 \%$$

Where:

- Scheduled Outage Hours (Hrs): Sum of all hours experienced during Planned Outages, Maintenance Outages, and any Scheduled Outage Extensions of Maintenance Outages and Planned Outages.

- **Planned Outages:** The removal of a unit from service to perform work on specific components that is scheduled well in advance and has a predetermined start date and duration (e. g., annual overhaul, inspections, testing).
- **Maintenance Outages:** The removal of a unit from service to perform work on specific components that can be deferred beyond the end of the next weekend, but requires the unit be removed from service before the next planned outage. Typically, Maintenance Outages may occur any time during the year, have flexible start dates, and may or may not have predetermined durations.
- **Period Hours (Hrs):** Sum of all Service Hours, Reserve Shutdown Hours, Planned Outage Hours, Maintenance Outages Hours and Forced Outage Hours.

In the case of multiple units, the indicator should be weighted by the net maximum capacity to arrive at the Weighted Scheduled Outage Factor (WSOF). In case the net maximum capacity is not available the gross maximum capacity must be used.

$$WSOF = \frac{\sum (\text{Scheduled Outage Hours} * \text{Net Maximum Capacity})}{\sum [(\text{Period Hours} * \text{Net Maximum Capacity})]} * 100 \%$$

2.2.4 **G4: Equivalent Forced Outage Rate**

Units can be derated due to forced or planned outage. It is very common for a unit to be partially derated due to technical problems.. The equivalent outage factor refers to the conversion of partial outages including capacity constraints to equivalent full outages.

The Equivalent Forced Outage Rate for a given generation unit is defined as follows:

$$EFOR = \frac{[(\text{Forced Outage Hours}) + (\text{Equivalent Forced Derated Hours})]}{[(\text{Forced Outage Hours}) + \text{Service Hours} + (\text{Equivalent Forced Derated Hours during Reserve Shutdown Hours})]} * 100 \%$$

Where:

- Forced Outage Hours (Hrs): Sum of all hours of Forced Outages
- Equivalent Forced Derated Hours (Hrs): Sum of [(Forced Derated Hours * Size of Reduction) / Net Maximum Capacity]
- Forced Derated Hours (Hrs): Sum of all hours experienced during Forced Deratings.
- Forced Derating: An unplanned component failure or other condition that requires the load on the unit be reduced immediately, within six hours, or before the end of the next weekend.
- Size of Reduction: It is determined by subtracting the Net Available Capacity from the Net Dependable Capacity. In case of multiple derating, the Size of Reduction is the difference in the Net Available Capacity of the unit prior to the initiation of the derating and the reported Net Available Capacity as a result of the derating.
- Gross Available Capacity (MW): Greatest Capacity at which a unit can operate with a reduction imposed by a Derating.
- Net Available Capacity (MW): Gross Available Capacity – Unit Capacity Utilized for that unit's station service or auxiliaries.
- Gross Maximum Capacity (MW): Maximum capacity a unit can sustain over a specified period of time when not restricted by seasonal or other deratings.
- Net Maximum Capacity (MW): Gross Maximum Capacity – Unit Capacity Utilized for that unit's station service or auxiliaries.
- Service Hours (Hrs): Total number of hours a unit was electrically connected to the transmission system.
- Equivalent Forced Derated Hours during Reserve Shutdowns (Hrs):
 - Sum of [(Forced Derated Hours during Reserve Shutdowns only * Size of Reduction) / Net Maximum Capacity]
 - Reserve Shutdown: A state in which the unit was available for service but not electrically connected to the transmission system for economic reasons
 - Reserve Shutdown Hours (Hrs): Total number of hours of Reserve Shutdown.

In the case of multiple units, the indicator should be weighted by the net maximum capacity to arrive at the Weighted Equivalent Forced Outage Rate (WEFOR). In case the net maximum capacity is not available the gross maximum capacity must be used.

$$WEFOR = \frac{\sum [(Forced Outage Hours + Equivalent Forced Derated Hours) * (Net Maximum Capacity)]}{\sum [(Forced Outage Hours + Service Hours + Equivalent Forced Derated Hours during Reserve Shut Down Hours) * (Net Maximum Capacity)]} * 100 \%$$

2.2.5 G5: Starting Reliability

Starting Reliability is the ratio between the number of successful unit starts and the number of attempted starts. An unsuccessful unit start or starting failure is a situation where a unit is unable to synchronize within its specific start-up time. The starting failure begins when the problem preventing the unit from synchronizing occurs. It ends when the unit is synchronized, another starting failure occurs, or the unit enters another permissible state.

Measurement of starting failures is important if a unit has to ramp-up very quickly in case of forced outages of one of the other units. If a unit has many starting problems this may also lead to frequency and voltage changes in the system. The starting failure is particularly important for units that must start very often such as peaking units.

The Starting Reliability for a given generation unit is defined as follows.

$$SR = \frac{\text{Actual Unit Starts}}{\text{Attempted Unit Starts}} * 100 \%$$

Where:

- Actual Unit Starts: Number of times the unit was synchronized.
- Attempted Unit Starts: Number of attempts to synchronize the unit. Repeated failures to start for the same cause, without attempting corrective action, are considered a single attempt.

For multiple units the following equation must be used

$$SR = \frac{\sum (\text{Actual Unit Starts})}{\sum (\text{Attempted Unit Starts})} * 100$$

According to NERC the starting reliability is not weighted.

2.2.6 G6: Gross Capacity Factor¹

The capacity factor is related to the dispatch of the unit; in very simple terms it shows the extent to which the generator is used. A high capacity factor implies that the unit is used as base load unit while a low capacity factor indicates that a unit is used as peak load unit.

The Gross Capacity Factor is defined as follows:

$$GCF = \frac{\text{Gross Actual Generation}}{\text{Period Hours} * \text{Gross Maximum Capacity}} * 100 \%$$

Where:

- Gross Actual Generation (MWh): Actual number of electrical megawatt hours generated by the unit during the period being considered.
- Period Hours (Hrs): Sum of all Service Hours, Reserve Shutdown Hours, Planned Outage Hours, Maintenance Outages Hours and Forced Outage Hours.
- Gross Maximum Capacity (MW).

In the case of multiple units, the indicator should be calculated as follows:

$$GCF = \frac{\sum (\text{Gross Actual Generation})}{\sum (\text{Period Hours} * \text{Gross Maximum Capacity})} * 100 \%$$

¹ According to NERC and IEEE-762. Special energy weighted equations are not necessary for energy terms (GCF and NCF) because these factors are inherently energy weighted. See also equations 7. 12-7. 13 of IEEE-762.

Special energy weighted equations are not necessary for energy terms (GCF and NCF) because these factors are inherently energy weighted

2.2.7 **G7: Net Capacity Factor²**

The Net Capacity Factor is similar as the Gross Capacity Factor but considers the net rather than gross capacity.

The Net Capacity Factor is defined as:

$$NCF = \frac{\text{Net Actual Generation}}{\text{Period Hours} * \text{Net Maximum Capacity}} * 100 \%$$

Where:

- Net Actual Generation (MWh): Actual number of electrical megawatt hours generated by the unit during the period being considered (Gross Actual Generation) minus any generation (MWh) utilized for that unit's station service or auxiliaries.
- Period Hours (Hrs): Sum of all Service Hours, Reserve Shutdown Hours, Planned Outage Hours, Maintenance Outages Hours and Forced Outage Hours.
- Net Maximum Capacity (MW)

In the case of multiple units, the indicator should be calculated as follows:

$$NCF = \frac{\sum (\text{Net Actual Generation})}{\sum (\text{Period Hours} * \text{Net Maximum Capacity})} * 100 \%$$

Special energy weighted equations are not necessary for energy terms (GCF and NCF) because these factors are inherently energy weighted.

² See footnote 1

2.2.8 Service Factor (Supporting information)

The Service Factor is defined as the ratio between the total number of hours a unit was electrically connected to the transmission system divided by the number of hours in the period. The factor is important for the dispatch of a unit (base load versus peak load). A high service factor of a unit indicates that unit is used as base load unit and a low service factor indicates that the unit is used as peaking unit.

The Service Factor for a given generation unit is defined as follows:

$$SF = \frac{\text{Service Hours}}{\text{Period Hours}} * 100 \%$$

Where:

- Service Hours (Hrs): Total number of hours a unit was electrically connected to the transmission system.
- Period Hours (Hrs): Sum of all Service Hours, Reserve Shutdown Hours, Planned Outage Hours, Maintenance Outages Hours and Forced Outage Hours.

In the case of multiple units, the indicator should be weighted by the net maximum capacity to arrive at the Weighted Service Factor (WSF). If the net maximum capacity is not available the gross maximum capacity must be used.

$$WSF = \frac{\sum (\text{Service Hours} * \text{Net Maximum Capacity})}{\sum (\text{Period Hours} * \text{Net Maximum Capacity})} * 100 \%$$

2.2.9 Gross Maximum Capacity (Supporting information)

The Gross Maximum Capacity (GMC) is supporting information that should be reported as part of the KPI framework.

The Gross Maximum Capacity (GMC) is defined as the maximum capacity (MW) a unit can sustain over a specified period of time when not restricted by seasonal or other de-ratings.

It should be noted that the gross maximum capacity will be that capacity of a unit as prescribed by ISO at 15 °C at sea level and a relative humidity at 60%.

2.2.10 **Net Maximum Capacity (Supporting information)**

The Net Maximum Capacity is defined as the Gross Maximum Capacity minus the unit capacity (MW) utilized for that unit's station service or auxiliaries

2.2.11 **Gross Actual Generation (Supporting information)**

The Gross Actual Generation (GAC) is supporting information that should be reported as part of the KPI framework.

The Gross Actual Generation (GAG) is the actual number of electrical megawatt hours generated by the unit during the period being considered.

2.2.12 **Net Actual Generation (Supporting information)**

The Net Actual Generation (GAC) is supporting information that should be reported as part of the KPI framework.

The Net Actual Generation (NAG) is defined as the actual number of electrical megawatt hours generated by the unit by the period being considered (Gross Actual Generation) minus any generation (MWh) utilized for that unit's station service or auxiliaries.

2.2.13 **Gross Annual Heat Rate (Supporting information)**

The Gross Annual Heat Rate (GAHR) is supporting information that should be reported as part of the KPI framework.

Gross Annual Heat Rate (GAHR) is defined as the ratio of thermal energy of the fuel consumed (LHV-British thermal units) and the gross electricity generated by the same period. The heat rate in case of co-generation (production of electricity and steam production for hydrocarbon facilities or desalination units) is difficult to estimate. It is proposed to report the heat rate only for electricity production units and not for cogeneration units.

2.3 TIME PERIOD

All KPI's for Generation are reported on an annual basis from the 1st of January at 0:00 am and up to 31st of December at 11:59 pm of the given year.

2.4 CLASSIFICATION

Each utility/company has to report to ECRA. All KPI's for Generation should be reported according to the following classification:

- Starting Reliability
 - For Simply Cycle units only
- Gross Annual Heat Rate
 - Per technology: Simple Cycle (SC), Steam Cycle (ST), Combined Cycle (CCGT), Diesel Generator (DG)
 - Not for Cogeneration (COGEN)
- All other KPI's:
 - Per technology: Simple Cycle (SC), Steam Cycle (ST), Combined Cycle (CCGT), Diesel Generator (DG), Cogeneration (COGEN)
- All KPI's:
 - Per administrative region (insofar applicable to the utility): Riyadh, Makkah, Madinah, Qasim, Eastern Region, Asir, Tabouk, Hail, Northern Border Region, Jizan, Najran, Al-Baha, Al-Jouf.

2.5 REPORTING

For each region, the following KPIs should be reported for all units of given technology that are located in the given administrative area, according to the following schedules:

Steam Cycle (ST)

Key Performance Indicator	KPI	UNIT	Total	Riyadh	...	Al-Jouf
G1. Weighted Availability Factor	WAF	%				
G2. Weighted Forced Outage Factor	WFOF	%				
G3. Weighted Equivalent Forced Outage Rate	WEFOR	%				
G4. Weighted Scheduled Outage Factor	WSOF	%				
G6. Gross Capacity Factor	GCF	%				
G7. Net Capacity Factor	NCF	%				
Additional information						
Weighted Service Factor	WSF	%				
Gross maximum capacity	GMC	MW				
Net maximum capacity	NMC	MW				
Gross actual generation	GAG	MWh				
Net actual generation	NAG	MWh				
Gross annual heat rate	GAHR	Btu/kWh				

Simple Cycle (SC)						
Key Performance Indicator	KPI	UNIT	Total	Riyadh	...	Al-Jouf
G1. Weighted Availability Factor	WAF	%				
G2. Weighted Forced Outage Factor	WFOF	%				
G3. Weighted Equivalent Forced Outage Rate	WEFOR	%				
G4. Weighted Scheduled Outage Factor	WSOF	%				
G5. Starting Reliability	SR	%				
G6. Gross Capacity Factor	GCF	%				
G7. Net Capacity Factor	NCF	%				
Additional information						
Weighted Service Factor	WSF	%				
Gross maximum capacity	GMC	MW				
Net maximum capacity	NMC	MW				
Gross actual generation	GAG	MWh				
Net actual generation	NAG	MWh				
Gross annual heat rate	GAHR	Btu/kWh				
Combined Cycle (CCGT)						

Key Performance Indicator	KPI	UNIT	Total	Riyadh	...	Al-Jouf
G1. Weighted Availability Factor	WAF	%				
G2. Weighted Forced Outage Factor	WFOF	%				
G3. Weighted Equivalent Forced Outage Rate	WEFOR	%				
G4. Weighted Scheduled Outage Factor	WSOF	%				
G6. Gross Capacity Factor	GCF	%				
G7. Net Capacity Factor	NCF	%				
Additional information						
Weighted Service Factor	WSF	%				
Gross maximum capacity	GMC	MW				
Net maximum capacity	NMC	MW				
Gross actual generation	GAG	MWh				
Net actual generation	NAG	MWh				
Gross annual heat rate	GAHR	Btu/kWh				

Diesel Generators						
Key Performance Indicator	KPI	UNIT	Total	Riyadh	...	Al-Jouf
G1. Weighted Availability Factor	WAF	%				
G2. Weighted Forced Outage Factor	WFOF	%				
G3. Weighted Equivalent Forced Outage Rate	WEFOR	%				
G4. Weighted Scheduled Outage Factor	WSOF	%				
G6. Gross Capacity Factor	GCF	%				
G7. Net Capacity Factor	NCF	%				
Additional information						
Weighted Service Factor	WSF	%				
Gross maximum capacity	GMC	MW				
Net maximum capacity	NMC	MW				
Gross actual generation	GAG	MWh				
Net actual generation	NAG	MWh				
Gross annual heat rate	GAHR	Btu/kWh				

Cogeneration						
Key Performance Indicator	KPI	UNIT	Total	Riyadh	...	Al-Jouf
G1. Weighted Availability Factor	WAF	%				
G2. Weighted Forced Outage Factor	WFOF	%				
G3. Weighted Equivalent Forced Outage Rate	WEFOR	%				
G4. Weighted Scheduled Outage Factor	WSOF	%				
G6. Gross Capacity Factor	GCF	%				
G7. Net Capacity Factor	NCF	%				
Additional information						
Weighted Service Factor	WSF	%				
Gross maximum capacity	GMC	MW				
Net maximum capacity	NMC	MW				
Gross actual generation	GAG	MWh				

2.6 RECORDS TO BE MAINTAINED

The utility should maintain records in which the data required for the KPI computation and subsequent reporting will be based. A template file will be provided by ECRA for this purpose. The records and underlying data should be made available to ECRA when audits are being performed. These records should be saved by the utility for a period of at least 5 years. Note also that these records prescribe the minimal information that should be registered; the utility is free to register additional information that it considers necessary.

2.6.1 Generating Unit Records

For each generating unit, the following information should be kept in records as shown in the following schedule:

Data	Unit	Value
Year	--	
Plant Name	--	
Generating Unit Name	--	

Administrative Region	--	
Technology (SC, ST, CCGT,DG, COGEN)	--	
Gross Maximum Capacity (GMC)	MW	
Net Maximum Capacity (NMC)	MW	
Gross actual generation (GAG)	MWh	
Net actual generation (NAG)	MWh	
Available Hours	Hours	
Service Hours	Hours	
Forced Outages		
Forced Outage Hours – U1	Hours	
Forced Outage Hours – U2	Hours	
Forced Outage Hours – U3	Hours	
Forced Outage Hours – SF	Hours	
Planned Outages		
Planned Outage Hours - PO	Hours	
Planned Outage Hours – SE of PO	Hours	
Maintenance Outages		
Maintenance Outage Hours - MO	Hours	
Maintenance Outage Hours– SE of MO	Hours	
Actual Unit Starts	#	
Starting Failures	#	
Reserve Shutdown Hours	Hours	
Equivalent Forced Derated Hours	Hours	
Equivalent Forced Derated Hours During Reserve Shutdown	Hours	
Availability Factor (AF)	%	
Forced outage Factor (FOF)	%	
Scheduled Outage Factor (SOF)	%	
Equivalent Forced Outage Rate (EFOR)	%	
Starting Reliability (SR)	%	
Gross Capacity Factor (GCF)	%	
Net Capacity Factor (NCF)	%	
Service Factor (SF)	%	
Gross Annual Heat Rate	Btu/kWh	

Notes:

1. The Starting Reliability is needed to be recorded for simple cycle units only
2. The Gross Annual Heat Rate is not needed to be recorded for cogeneration units

2.6.2 Event Records

A record should be maintained where each event for each unit is registered. This information will form the basis for the computation of the KPI's to be reported to ECRA. Instructions for event reporting including definitions is given in Annex I. The following schedule indicates the information that will need to be recorded. The event log needs to be kept for each unit that is operated by the utility.

Event ID	Unit	Event Type	Start Date	Start Time	End Date	End Time	NERC Code or Codes according to Annex 1	Available Gross Capacity	Available Net Capacity	Problem Description
1										
2....										

An example of the data to be recorded using the schedule is shown as follows:

Event ID	Unit	Event Type	Start Date	Start Time	End Date	End Time	NERC Code	Available Gross Capacity	Available Net Capacity	Problem Description
1	100	SF	15.01.07	08:00	15.01.07	21:00	5048	0	0	Gas turbine tripped on delta t at the burners during trials
2	200	PO	30.01.07	07:00	30.01.07	12:00	3700	0	0	Due to modification of neighbouring plant, house load not loaded
3	200	U1	31.01.07	10:25	31.01.07	16:00	5072	0	0	Loose bolt in connection of the burner to the burner flange, as a result of which the hot gasses from the combustion chamber blew to outside
4	200	U1	02.02.07	11:00	02.02.07	14:00	5048	0	0	Gas turbine tripped on too large delta t exhaust gasses. Cause of this was a damaged connection of measurement apparatus.
5	200	MO	05.02.07	08:00	05.02.07	17:00	5290	0	0	Gas turbine not available due to activities of metering department
6	200	MO	07.02.07	08:00	07.02.07	17:00	5290	0	0	Gas turbine not available due to activities of metering department
7	200	PO	12.02.07	14:00	12.02.07	14:45	3700	0	0	House load no voltage because of work on the substation switches
8	300	MO	12.02.07	08:00	12.02.07	17:00	5043	0	0	Exchange new gas supply filter
9	300	U3	20.02.07	12:20	20.02.07	12:50	5048	0	0	Faulty photo cells adjusted

3 TRANSMISSION AND DISTRIBUTION

This chapter details the KPI's of both Transmission and Distribution:

- ENS (T)
- MAIFI (T&D)
- SAIDI (T&D)
- SAIFI (T&D)
- Outages per 100 km (T)
- Number of Voltage Dips (T)
- Losses (T&D)

Supplemental information (to be provided by all companies of the T&D sector):

- Energy Injected (MWh) : energy supplied to the network (T&D)
- Demand (MWh): total Energy Supplied or Energy Outgoing from the network (MWh) plus the Energy Not Supplied (MWh) (T&D)
- Peak demand (MW): maximum level of the instant load of the network (excluding any declared generation) (T&D)
- Date and time of the peak demand: date (dd-mm-yy) and time (hh:mm:ss)
- Number of delivery points: number of connections having a meter (T&D)
- Number of voltage dips reducing the load (T)
- Total Circuit Length: sum of the lengths (in km) of all power lines and cables of the system (T&D)

3.1 DEFINITIONS

3.1.1 Definitions related to organizational issues:

- **Department:** one of the electricity distribution departments of the utility
- **Distribution Network:** The network operated by the distribution company, these being at nominal voltage levels (strictly) below 110 kV (specific to Saudi context).
- **Transmission Network:** The network operated by the transmission company, these being at nominal voltage levels of 110 kV and above (specific to Saudi context).
- **Customer:** delivery point of any physical or legal entity (normally with an electricity consumption meter, although in 2009 some delivery points of the transmission network were not yet fitted with meters). As a consequence a large enterprise having several delivery points (with meter) will be treated as several customers (the same number as the number of delivery points). This concept is necessary to distinguish reliability performance or improvements that is provided by the network utility from the same provided (arranged) by the customers, for example when a large enterprise decides to divide its supply into several delivery points in order to organize itself a redundancy in case of supply interruption.
- **Delivery Point :** point of supply by the network company to a third party (i.e. another legal entity or person)
- **Number of customers:** Number of above mentioned delivery points
- **Total number of customers:** The average number of customers served by the distribution company, defined as the average number of customers at 1st January and at 31st December of the year

3.1.2 Definitions related to interruptions:

- **Outage:** Unscheduled unavailability of a network component. When the redundancy in the network topology and capacity is sufficient (this is the case during the normal operation of transmission network that comply with the n-1 criteria), outages usually do not lead to interruptions. On the contrary, in networks operated radially (like distribution networks, in general) or not complying with the n-1 criteria, outages of main components (such as a line or a transformer) lead to supply interruptions of

customers. Single phase faults and double phase faults on three phase circuits are considered as outages.

- **Interruption:** An event where one or more customers experience loss of electricity supply. An interruption is due to one or more outages. Loss of load due to voltage dips, frequency deviation or more generally due to the triggering of a protection device at customer installations are not considered as “interruptions” but rather as customer installation internal problems (about which the customer is however free to write a complaint). Single phase loss of supply and double phase loss of supply on three phase circuits are considered as interruptions.
- **Force Majeure Interruption** (definition from the Grid Code, see latest version if newer than this document): “Force Majeure shall mean any act of God, labor disturbance, act of the public enemy, war, insurrection, riot, fire, storm or flood, explosion, breakage or accident to machinery or Equipment, any order, regulation or restriction imposed by governmental, military or lawfully established civilian authorities, or any other cause beyond a party’s control. A Force Majeure event does not include an act of negligence or intentional wrongdoing. ”
- **Planned Interruption:** interruption that has been noticed to customers, indicating them the start date and time of the interruption, the stop date and time of the interruption, and the reason of the interruption, as per the customer information rules in place in the Grid Code (information to customers may take several forms and is usually based on postal mailing). Planned interruptions are scheduled, for instance, to carry out maintenance works that can hardly be performed on live circuits, construction works and in some cases new connections. Planned interruptions can only be classified as “planned” if they comply with the noticing rules specified in the Grid Code, other wise the interruption is classified as “unplanned”: therefore a recording of the notice to customers must be archived by the licensed company for the case an audit is conducted.
- **Other excluded interruptions:** these interruptions depend on the sub-sector and relate to the origin of the interruption. These consist in “Generation interruption” for the Transmission sector and “Generation and Transmission interruption” for the Distribution sector). Interruptions due to customer installations or other downstream installation are not part of “Other excluded interruptions” since they have to be prevented by appropriate protections of the licensed company to avoid such kind of downstream faults to spread into the monitored network. This category has been defined so that the definition of “Force Majeure” is single and applies to a same list of

events and conditions for all sub-sectors of the power sector (Generation, Transmission, Distribution, and Customer Service).

- **Unplanned Interruption:** interruption that is not classified as “planned interruption” or “Force Majeure interruption”, or “Other excluded interruption”.
- **Voltage Dip:** brief reduction of the supply mains voltage of more than the normally acceptable voltage deviation (10% voltage reduction from the nominal value) and less than 99 % voltage deviation from the nominal value. A reduction of more than 99 % of the rms voltage³ is classified as an interruption (EN 61000-4-11 IEC 1000-4-11 and IEC 61000-4-11). Note that some countries (Canada, for example) use another definition where dips of more than 90% voltage reduction are considered as interruptions⁴.
- **Nb of Voltage Dips:** number of all voltage dips
- **Nb of Voltage Dips Reducing Load:** number of all voltage dips that let to load reduction
- **Global Nb of Voltage Dips:** number of all voltage dips, disregarding their impact.

3.1.3 Definitions related to timing of interruptions:

- **Duration:** The time between the moment of the start of the interruption and the moment at which supply to all customers affected by the interruption is restored. In case of a stepwise restoration of supply, the interruption can be divided into several groups of customer, each having a different restoration time, hence another duration of interruption.
- **Sustained Interruption:** interruption of which the duration is (strictly) longer than 5 minutes
- **Momentary Interruption:** interruption of which the duration is less (or equal) to 5 minutes
- **Start time:** time (hh:mm:ss) and date (dd/mm/yy) of an interruption

³ Voltage Quality Regulation Europe KEMA 07-0356 ECI

⁴ CA Vtech-VoltageSags&Interruptions,SWHitesell

- **Time period** : the period for which the KPI is computed. Unless specified as another period, this period is one year, as it is the case in most countries. However, the utilities are free to report internally the KPI's with shorter periods (like quarterly) so that they will assess themselves progressively if they are close or far from the target.

3.2 ENERGY NOT SUPPLIED (ENS)

This KPI is applicable to Transmission⁵.

3.2.1 Background

The Energy Not Supplied or Energy Not Served (ENS) measures the total energy that could not be supplied as expected at delivery points during a given year. Considering all interruptions that occurred in the year in the transmission network, this indicator ignores the possible reconfigurations that the distribution network can implement to limit the interruptions to final consumers connected at distribution level. As a whole it indicates the deviation of the transmission service from its duty level.

3.2.2 KPI Formula

The ENS is expressed in MWh (see definitions below) and is a component of the AIT which is a KPI already monitored by SEC Transmission. The ENS expressed in MWh significantly varies with the size of a country (both the demand level and the number and length of circuits). For this reason, the ENS is normalized by the amount of Energy Supplied (ES) so that the ENS/ES can be presented as a percentage, enabling further comparison with other countries.

$$ENS = \sum_i (P_i \cdot D_i)$$

$$ENS / ES = \frac{ENS}{Demand - ENS}$$

⁵ In the future, the ENS could also be monitored at Distribution level if the power level interrupted can be estimated (typically for LV) or measured (with the SCADA supervising the MV network). For the time being, the ENS is proposed only in transmission.

$$AIT = \frac{60 * \sum_i (P_i \cdot D_i)}{(Demand / YrHrs)}$$

Where:

- **P_i**: Power interrupted for interruption “i”, in MW
- **D_i**: Duration of interruption “i”, in hours
- **Demand**: Number of electrical megawatt hours demanded during the period being considered (the demand being the Energy Served plus the Energy Not Served).
- **YrHrs (Hrs)**: Number of Hours in the year: 8760 in a normal year, 8784 in a leap year.

3.2.3 Time Period

The KPI is reported on an annual basis i. e. for all interruptions that *start* on or after 1st of January at 0:00 am and up to 31st of December at 11:59 pm of the given year.

3.2.4 Classification

The ENS indicator relates to all interruptions, sustained or momentary.

The KPI is reported according to the following classification

- Type of interruption: Planned, Unplanned, Generation, Force Majeure
- Location of the interruption: 69 kV to 380 kV voltage levels, voltage levels < 69 kV

3.2.5 Reporting

The KPI should be reported according to the following schedule:

T1. Energy Not Supplied (ENS)				
CATEGORY	UNIT	Total	69 kV to 380 kV	< 69 kV
Planned	MWh			
Unplanned	MWh			
Generation	MWh			

Force Majeure	MWh			
Total	MWh			

As supplemental information, the following information should also be reported according to the following schedule:

Supplemental Information - Transmission				
CATEGORY	UNIT	Total	69 kV to 380 kV	< 69 kV
Energy Supplied	MWh			
Peak Demand	MW			
Time of Peak Demand	dd-mm-yy, hh:mm			

3.2.6 Records to be maintained

The utility should maintain records in which the data required for the KPI computation and subsequent reporting will be based. A template file will be provided by ECRA for this purpose. The records and underlying data should be made available to ECRA when audits are being performed. These records should be saved by the utility for a period of at least 5 years. Note also that these records prescribe the minimal information that should be registered; the utility is free to register additional information that it considers necessary.

For each interruption, a new record shall be made by the utility. This record will contain the following information specific to that interruption. These records are the ones that will be audited by ECRA. From these records the KPI computations should take place.

Interruption	Start Date/Time	End Date/Time	Power interrupted	Nr. Delivery Points affected	Cause and location	Volt. level	Category
#	dd-mm-yy hh:mm	dd-mm-yy hh:mm	MW	#		kV	P, U, G, FM
1							
....							

3.2.7 Example of KPI Computation

The following example illustrates the way in which the KPI is calculated:

Interruption	Start Date/Time	End Date/Time	Power interrupted	Nr. Delivery Points affected	Cause and location	Volt. level	Category
#	dd-mm-yy	dd-mm-yy	MW	#		kV	P, U, G, FM

	hh:mm	hh:mm					
1	15/2/09 9: 20	15/2/09 9: 50	15	200	S/S 5, tfo 2	115	U
2	18/6/09 23: 55	19/6/09 0: 10	10	100	S/S 2 tfo 3	380	U

$$\text{ENS} = 15 \text{ MW} \times 0.5 \text{ h} + 10 \text{ MW} \times 0.25 \text{ h} = 10 \text{ MWh}$$

3.3 MOMENTARY AVERAGE INTERRUPTION FREQUENCY INDEX (MAIFI)

This KPI is applicable to both Transmission and Distribution.

3.3.1 Background

The Momentary Average Interruption Frequency Index (MAIFI) measures the frequency of momentary (or short) interruptions for a given year. Short interruptions are those that last equal or less than 5 minutes. Considering all interruptions that occurred in the year, this indicator is defined as the ratio between the total for all short interruptions of the number of customers that experienced the short interruption, and the total number of customers.

3.3.2 KPI Formula

The MAIFI indicator relates to momentary interruptions, while a similar indicator exists for sustained interruptions (SAIFI).

$$MAIFI = \frac{\sum_i (M_i)}{N_T}$$

- i : Index of momentary interruptions i.e. with a duration shorter or equal 5 minutes
- M_i : Number of customers for which the supply was interrupted by momentary interruption “ i ” and during a duration “ d_i ”, in minutes
- N_T : Total Number of customers in the Network

3.3.3 Time Period

The KPI is reported on an annual basis i. e. for all interruptions that *start* on or after 1st of January at 0:00 am and up to 31st of December at 11:59 pm of the given year.

3.3.4 Classification

In Transmission, the KPI is reported according to the following classification

- Type of interruption: Planned, Unplanned, Generation, Force Majeure
- Location of the interruption: 69 kV to 380 kV voltage levels, voltage levels < 69 kV

In Distribution, the KPI is reported according to the following classification

- Voltage level: Medium Voltage (MV) only
- Type of interruption: Planned, Unplanned, Generation/Transmission, Force Majeure
- Per department of the utility

3.3.5 Reporting

In Transmission, the KPI should be reported according to the following schedule (for transmission and distribution, respectively):

T4. MAIFI-T				
CATEGORY	UNIT	Total	69 to380 kV	< 69 kV
Planned	Interruption/Customer			
Unplanned	Interruption/Customer			
Generation	Interruption/Customer			
Force Majeure	Interruption/Customer			
Total	Interruption/Customer			

D3. MAIFI

CATEGORY	UNIT	Total	Department 1
Planned	Interruption/Customer			
Unplanned	Interruption/Customer			
Gen. & Trans.	Interruption/Customer			
Force Majeure	Interruption/Customer			
Total	Interruption/Customer			

As supplemental information, the number of delivery points should also be reported according to the following schedule (for transmission and distribution, respectively):

Supplemental Information – Transmission				
CATEGORY	UNIT	Total	69 kV to 380 kV	< 69 kV
Nr. Of Delivery Points	Nr.			

Supplemental Information – Distribution				
CATEGORY	UNIT	Total	Department 1
Nr. Of Delivery Points	Nr.			

3.3.6 Records to be maintained

The utility should maintain records in which the data required for the KPI computation and subsequent reporting will be based. A template file will be provided by ECRA for this purpose. The records and underlying data should be made available to ECRA when audits are being performed. These records should be saved by the utility for a period of at least 5 years. Note also that these records prescribe the minimal information that should be registered; the utility is free to register additional information that it considers necessary.

For transmission, the same record as under the ENS KPI should be maintained:

Interrupti	Start Date/	End	Power	Nr. Delivery	Cause	Volt.	Category
------------	-------------	-----	-------	--------------	-------	-------	----------

on	Time	Date/Time	interrupted	Points affected	and location	level	
#	dd-mm-yy hh:mm	dd-mm-yy hh:mm	MW	#		kV	P, U, G, FM
1							
....							

For distribution, the following records should be maintained for each department:

Interruption	Start Date/ Time	End Date/Time	Nr. Delivery Points affected	Cause and location	Category
#	dd-mm-yy hh:mm	dd-mm-yy hh:mm	#		P, U, G&T, FM
1					
....					

3.3.7 Example of KPI Computation

The following example illustrates the way in which the KPI is calculated:

Interruption	Start Date/ Time	End Date/ Time	Nr. delivery points affected	Cause and location	Category (P, U, G or G&T, FM)
1	9: 20	9: 24	100	S/S 5, tfo 2	U
2	20: 30	20: 33	200	S/S 2 tfo 3	U

Suppose $N_T = 1000$ delivery points.

$$MAIFI = (100+200)/1000 = 0.3$$

3.3.8 Additional Information

Momentary interruptions are defined by IEEE standard as having a duration below 5 min. Several countries use a threshold shorter, of 3 min. or even 1min. Since the number of interruption of duration below 1 min and 5 min is rather low, there is no huge importance in reducing the threshold from 5 min to 3 min or 1 min.

3.4 SYSTEM AVERAGE INTERRUPTION DURATION INDEX (SAIDI)

This KPI is applicable to both Transmission and Distribution.

3.4.1 Background

The System Average Interruption Duration Index (SAIDI) measures the average of the total duration of long interruptions affecting the average delivery point for a given year. Long interruptions are those that last longer than 5 minutes.

Considering all long interruptions that occurred in the year, this indicator is defined as the ratio between the total for all long interruptions of the number of customers that experienced the interruption times the duration of the interruption, and the total number of customers. For Transmission, this KPI is sometimes noted SAIDI-T. For the convenience, the same acronym SAIDI will be used here for both Transmission and Distribution.

3.4.2 KPI Formula

The SAIDI indicator relates to sustained interruptions only.

$$SAIDI = \frac{\sum_i (N_i \cdot d_i)}{N_T}$$

- i : Index of interruptions with a duration longer than 5 minutes
- d_i : Duration of interruption “ i ”, in minutes
- N_i : Number of Delivery Points for which the supply was interrupted by interruption “ i ” and during a duration “ d_i ”, in minutes
- N_T : Total Number of Delivery Points in the Network (Transmission network or Distribution network)

3.4.3 Time Period

The KPI is reported on an annual basis i. e. for all interruptions that *start* on or after 1st of January at 0:00 am and up to 31st of December at 11:59 pm of the given year.

3.4.4 Classification

In Transmission the KPI is reported according to the following classification:

- Type of interruption: Planned, Unplanned, Generation, Force Majeure
- Location of the interruption: 69 kV to 380 kV voltage levels, voltage levels < 69 kV

In Distribution the KPI is reported according to the following classification:

- Voltage level: Medium Voltage (MV) only
- Type of interruption: Planned, Unplanned, G&T, Force Majeure
- Per department of the utility

3.4.5 Reporting

In Transmission the KPI should be reported according to the following schedule for transmission and distribution, respectively):

T2. SAIDI-T				
CATEGORY	UNIT	Total	69 kV to 380 kV	< 69 kV
Planned	Interruption/Customer			
Unplanned	Interruption/Customer			
Generation	Interruption/Customer			
Force Majeure	Interruption/Customer			
Total	Interruption/Customer			
D1. SAIDI				
CATEGORY	UNIT	Total	Department 1
Planned	Minutes/Customer			
Unplanned	Minutes/Customer			
Gen. & Trans.	Minutes/Customer			
Force Majeure	Minutes/Customer			
Total	Minutes/Customer			

3.4.6 Records to be maintained

The same records as defined under section 3.3.6 for MAIFI should be maintained for SAIDI as well.

3.4.7 Example of KPI Computation

The following example illustrates the way in which the KPI is calculated.

Interruption	Start Date/ Time	End Date/ Time	Nr. delivery points affected	Cause and location	Category (P, U, G or G&T, FM)
1	9: 20	9:30	100	S/S 5, tfo 2	U
2	20: 30	20: 50	200	S/S 2 tfo 3	U

Suppose the total number of customers (NT) being 10 000 and that there were only two interruptions during the year, as described above:

$$SAIDI = \frac{\sum_i (N_i \cdot d_i)}{N_T} = \frac{100 * 10 + 200 * 20}{10000} = 0.5 \text{ min}$$

3.5 SYSTEM AVERAGE INTERRUPTION FREQUENCY INDEX (SAIFI)

This KPI is applicable to Transmission and Distribution.

3.5.1 Background

The System Average Interruption Frequency Index (SAIFI) measures the frequency of long interruptions for a given year. Long interruptions are those that last longer than 5 minutes. Considering all interruptions that occurred in the year, this indicator is defined as the ratio between the total for all interruptions of the number of customers that experienced the interruption, and the total number of customers.

3.5.2 KPI Formula

The SAIFI indicator relates to sustained interruptions, while a similar indicator exists for momentary interruptions (MAIFI). In transmission, the indicator is referred as SAIFI-T and its definition is the same as in distribution provided that the concept of customers and delivery points are identical. In order to be general, the term "Delivery Point" will be adopted.

$$SAIFI = \frac{\sum_i (N_i)}{N_T}$$

- Index of interruptions with a duration longer than 5 minutes
- N_i : Number of delivery points for which the supply was interrupted by interruption “i” and during a duration “ d_i ”, in minutes
- N_T : Total Number of Delivery Points in the network

3.5.3 Time Period

The KPI is reported on an annual basis i. e. for all interruptions that *start* on or after 1st of January at 0:00 am and up to 31st of December at 11:59 pm of the given year.

3.5.4 Classification

In Transmission the KPI is reported according to the following classification:

- Type of interruption: Planned, Unplanned, Generation, Force Majeure
- Location of the interruption: 69 kV to 380 kV voltage levels, voltage levels < 69 kV

In Distribution the KPI is reported according to the following classification:

- Voltage level: Medium Voltage (MV) only
- Type of interruption: Planned, Unplanned, G&T, Force Majeure
- Per department of the utility

3.5.5 Reporting

In Transmission the KPI should be reported according to the following schedule for transmission and distribution, respectively):

T3. SAIFI-T				
CATEGORY	UNIT	Total	69 kV to 380 kV	< 69 kV
Planned	Interruption/Customer			
Unplanned	Interruption/Customer			
Generation	Interruption/Customer			
Force Majeure	Interruption/Customer			
Total	Interruption/Customer			

D2. SAIFI				
CATEGORY	UNIT	Total	Department 1
Planned	Interruption/Customer			
Unplanned	Interruption/Customer			
Gen. & Trans.	Interruption/Customer			
Force Majeure	Interruption/Customer			
Total	Interruption/Customer			

3.5.6 Records to be maintained

The same records as defined under section 3.3.6 for MAIFI should be maintained for SAIDI as well.

3.5.7 Example of KPI Computation

The following example illustrates the way in which the KPI is calculated:

Interruption	Start Date/ Time	End Date/ Time	Nr. delivery points affected	Cause and location	Category (P, U, G or G&T, FM)
1	9: 20	9:30	100	S/S 5, tfo 2	U
2	20: 30	20: 50	200	S/S 2 tfo 3	U

Suppose $N_T = 1000$ delivery points.

$$SAIFI = (100+200)/1000 = 0.3$$

3.6 OUTAGES PER 100 KM

This KPI is applicable to Transmission.

3.6.1 Background

The “Nr. Outages per 100 km” index measures the total number of outages divided by the total length of the network circuits, multiplied by a hundred.

3.6.2 KPI Formula

The “Nr. Outages per 100 km” indicator relates to all circuit outages, whether leading or not to an interruption, irrespective of the duration.

$$NbOutages100km = \frac{\sum_i (CircuitOutages_i)}{TotalCircuitLength} * 100$$

- i : Index of circuit
- $CircuitOutages_i$: Number of outages on circuit “ i ” during the year
- $TotalCircuitLength$: sum of the lengths (in km) of all power lines and cables of the system

3.6.3 Time Period

The KPI is reported on an annual basis i. e. for all interruptions that *start* on or after 1st of January at 0:00 am and up to 31st of December at 11:59 pm of the given year.

3.6.4 Classification

The KPI is reported according to the following classification

- Type of interruption: Planned, Unplanned, Generation, Force Majeure

- Voltage level of the Outage: 69 kV to 380 kV voltage level, other voltage levels

3.6.5 Reporting

The “NbOutages100km” KPI should be reported according to the following schedule for transmission and distribution, respectively):

T5. Out100km				
CATEGORY	UNIT	Total	69 kV to 380 kV	< 69 kV
Planned	Outages/100 km			
Unplanned	Outages/100 km			
Generation	Outages/100 km			
Force Majeure	Outages/100 km			
Total	Outages/100 km			

The following supplemental information needs to be reported as well:

Supplemental Information - Transmission				
CATEGORY	UNIT	Total	69 kV to 380 kV	< 69 kV
Total Circuit Length	km			

3.6.6 Records to be maintained

The utility should maintain records in which the data required for the KPI computation and subsequent reporting will be based. A template file will be provided by ECRA for this purpose. The records and underlying data should be made available to ECRA when audits are being performed. These records should be saved by the utility for a period of at least 5 years. Note also that these records prescribe the minimal information that should be registered; the utility is free to register additional information that it considers necessary.

For each interruption, a new record shall be made by the utility. This record will contain the following information specific to that interruption:

Outage	Start Date/ Time	End Date/ Time	Voltage Level	Cause and location	Category
#	dd-mm-yy hh:mm	dd-mm-yy hh:mm			P, U, G, FM

3.6.7 Example of KPI Computation

The following example illustrates the way in which the KPI is calculated:

Outage	Start Date/ Time	End Date/ Time	Voltage Level	Cause and location	Category
#	dd-mm-yy hh:mm	dd-mm-yy hh:mm			P, U, G, FM
1	9: 20	9: 52	66kV	S/S 5, tfo 2	U
...					
23	20: 30	20: 33	380 kV	S/S 2 tfo 3	U

Suppose the total length of the power network is 14 000 km:

Suppose the list of outages is as above, 23 outages in the “Unplanned” category (U):

$Out_{100km} = 100 * (23/14000) = 0.1642$ for the “U” category

3.6.8 Additional Information

Only outages of power circuits are taken into account (lines, cables, transformers and their accessories that are in series, like circuit breakers and Current Transformers). Shunt component are not taken into account as far as their outage does not prevent the operation of the circuit(s) they relate to.

3.7 NUMBER OF VOLTAGE DIPS

This KPI is applicable to Transmission.

3.7.1 Background

The presence of voltage dips is probably the most common voltage quality problem in transmission networks. This issue has been identified as a concern by some large industrial companies in Saudi Arabia. The Number of Voltage Dips measures the frequency of voltage dips for a given year. The electricity company has however very few possibilities for action against voltage dips, if any (apart increasing the short-circuit power and reducing the exposure to some causes of short-circuits).

3.7.2 KPI Formula

The Nr. Voltage Dips indicator relates to all voltage reductions of 10 % to 99%, but the company is allowed to limit the count to those voltage dips that caused a loss of load provided that as supplemental information the total number of voltage dips is provided.

3.7.3 Time Period

The KPI is reported on an annual basis i. e. for all interruptions that *start* on or after 1st of January at 0:00 am and up to 31st of December at 11:59 pm of the given year.

3.7.4 Classification

The KPI is reported according to the following classification

- Type of interruption: Planned, Unplanned, Generation, Force Majeure
- Location of the interruption: 69 kV to 380 kV voltage level, other voltage levels

3.7.5 Reporting

Since most voltage dips are transmitted to all voltage levels present around the cause of the voltage dip, the “Nr. Voltage Dips” KPI should be reported with figures for “all voltage levels” as follows. These are broken down as the KPI’s per related to interruptions, although most probably the categories “Planned”, “Generation”, “Force Majeure” will be subject to a zero value:

T6. Voltage Dips				
CATEGORY	UNIT	Total	69 kV to 380	< 69 kV

			kV	
Planned	Nr.			
Unplanned	Nr.			
Generation	Nr.			
Force Majeure	Nr.			
Total	Nr.			

3.7.6 Records to be maintained

The utility should maintain records in which the data required for the KPI computation and subsequent reporting will be based. A template file will be provided by ECRA for this purpose. The records and underlying data should be made available to ECRA when audits are being performed. These records should be saved by the utility for a period of at least 5 years. Note also that these records prescribe the minimal information that should be registered; the utility is free to register additional information that it considers necessary.

For each voltage dip, a new record shall be made by the utility. This record will contain the following information specific to that voltage dip:

Voltage Dip	Start Date/Time	End Date/Time	Maximum Depth relative to nominal	Cause and location (if known)	Category
#	dd-mm-yy hh:mm	dd-mm-yy hh:mm	%		P, U, G, FM
1					
2					

3.7.7 Example of KPI Computation

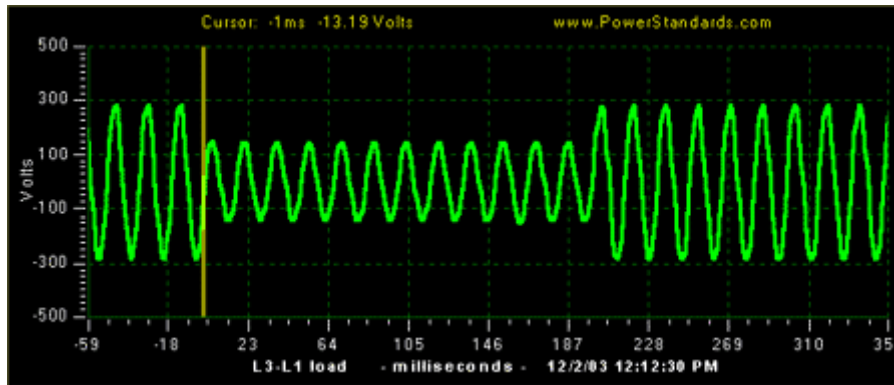
Self-explanatory: the number of voltage dips should be the number of the voltage dips measured at the substations. Since several substations will record a same voltage dip (but having a depth that depends on the distance to the cause of the dip), only one record is to be stored. The proposed rule is to save only the records that have a start “date/time” different of more than one second (voltage dips measured by the various substations at the same time are likely to be due to the same cause and should be recorded only once): those

record having a start “date/time” equal (in hours, minutes, second) are supposed to relate to the same dip, and among these only the one having the highest depth has to be recorded.

3.7.8 Additional Information

(from <http://www.powerstandards.com/tutorials/sagsandswells.htm>)

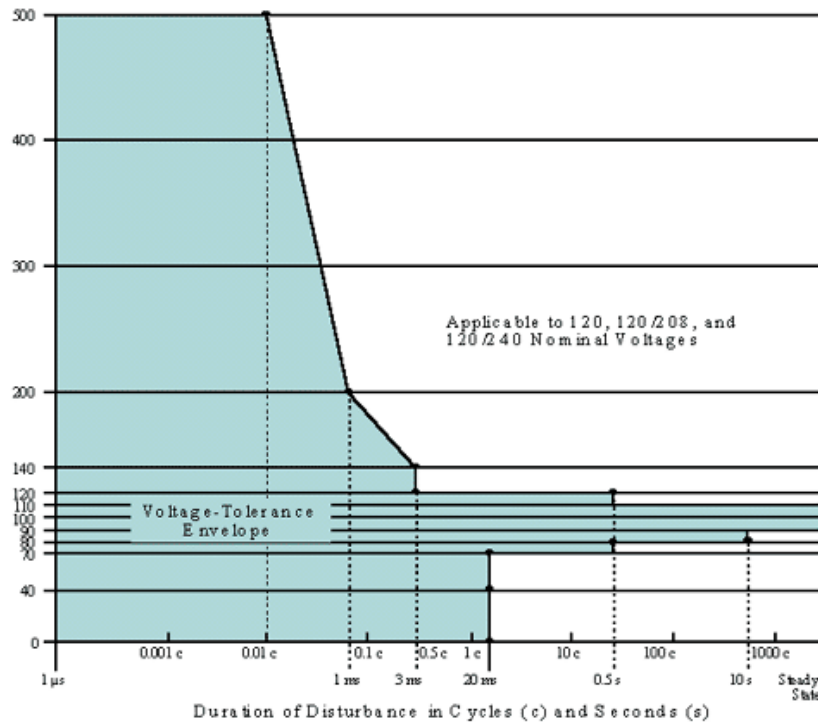
Voltage dips or voltage sags are caused by abrupt increases in loads such as short circuits or faults, motors starting, or electric heaters turning on, or they are caused by abrupt increases in source impedance, typically caused by a loose connection. **Voltage swells** are almost always caused by an abrupt reduction in load on a circuit with a poor or damaged voltage regulator, although they can also be caused by a damaged or loose neutral connection.



Voltage dips are the most common power disturbance. At a typical industrial site, it is not unusual to see several dips per year at the service entrance, and far more at equipment terminals.

Voltage dips can arrive from the utility; however, in most cases, the majority of dips are generated inside a building. For example, in residential wiring, the most common cause of voltage sags is the starting current drawn by refrigerator and air conditioning motors.

Dips do not generally disturb incandescent or fluorescent lighting, motors, or heaters. However, some electronic equipment lacks sufficient internal energy storage and, therefore, cannot ride through sags in the supply voltage. Equipment may be able to ride through very brief, deep dips, or it may be able to ride through longer but shallower dips.



1996 Version of the IT Industry Tolerance Curves (update from original CBEMA curve). The vertical axis is percent of nominal voltage. "Well-designed" equipment should be able to tolerate any power event that lies in the shaded area. Note that the curve includes voltage dips, swells, and [transient overvoltages](#).

The semiconductor industry developed a more recent specification ([SEMI F47](#)) for tools used in the semiconductor industry in an effort to achieve better ride through of equipment for commonly occurring voltage dips and therefore improving the overall process performance. It is basically the same as the ITI Curve but specifies an improved ride through requirement down to 50% retained voltage for the first 200 msec. Many short voltage dips are covered by this additional requirement. IEC 61000-4-11 and IEC 61000-4-34 provide similar voltage dip immunity standards.

Many utilities have benchmarked performance of the supply system for voltage dips but it has not been the general practice to specify any required performance levels for the system. Performance is often specified using the SARFI index that provides a count of all events with magnitudes and durations outside of some specifications. For instance, SARFI-70 would provide a count of all voltage dips with a retained voltage less than 70% (regardless of duration). SARFI-ITIC would provide a count of all voltage dips that exceeded the ride through specifications of the ITI Curve.

The table below provides a summary of voltage dip performance levels from a few major benchmarking efforts. Note that these are average performance levels and it would not be reasonable to develop limits based on an average expected performance (although these are the correct values to use when evaluating the economics of investments in ride through solutions).

	SARFI-10	SARFI-70	SARFI-80	SARFI-90
EPRI DPQ Project (US)	4.6	17.7	27.3	49.7
UNIPED Mixed Systems (Europe)	16	44		103.1
UNIPED Cable Systems (Europe)	1.4	11		34.6
South Africa	9	47	78	153

Example of average voltage dip performance from major benchmarking projects. These values represent voltage dip performance on medium voltage systems.

The voltage dip performance can vary dramatically for different kinds of systems (rural vs. urban, overhead vs. underground). It may be important to include some of these important factors in the specification of the power quality grades.

It will also be important to specify the performance for momentary interruptions. These events can be a particular problem for customers and are not included in most assessments of reliability. A further step in setting KPI's could be to introduce as a KPI a measurement of the sudden load decrease that occur simultaneously to the voltage dip, or an equivalent KPI⁶ as it is officially already monitored by SEC Transmission.

A report⁷ recommended that the SARFI indices be calculated for the following magnitude and duration categories. This could become a further step in monitoring voltage dips in the future:

SARFI Index	0-0.2 seconds	0.2-0.5 seconds	0.5-3 seconds	3-60 seconds	TOTAL
SARFI(90)					
SARFI(80)					
SARFI(70)					
SARFI(50)					
SARFI(10) - Interruptions					

Recommended magnitude and duration categories for calculating voltage dip performance.

The reasons for these categories were explained as follows:

- The 90% level provides an indication of performance for the most sensitive equipment.

⁶ (VDSI: Total MW loss of loads along the year due to voltage dip only, divided by system peak)

⁷ CEA Technologies report prepared by Electrotek Concepts

- The 80% level corresponds to an important break point on the ITI curve and some sensitive equipment may be susceptible to even short sags at this level.
- The 70% level corresponds to the sensitivity level of a wide group of industrial and commercial equipment and is probably the most important performance level to specify.
- The 50% level is important, especially for the semiconductor industry, since they have adopted a standard that specifies ride through at this level.
- Interruptions affect all customers so it is important to specify this level separately. These will usually have longer durations than the voltage sags.
- The first range of durations is up to 0.2 seconds (12 cycles at 60 Hz). This is the range specified by the semiconductor industry that equipment should be able to ride through sags as long as the minimum voltage is above 50%.
- The second range is up to 0.5 seconds. This corresponds to the specification in the ITIC standard for equipment ride through as long as the minimum voltage is above 70%. It is also an important break point in the definition of sag durations in IEEE 1159 (instantaneous vs. momentary).
- The third duration range is up to 3 seconds. This is an important break point in IEEE 1159 and in IEC standards (momentary to temporary).
- The final duration is up to one minute. Events longer than one minute are characterized as long duration events and are part of the system voltage regulation performance, rather than voltage sags.

Supplemental Information - Transmission						
CATEGORY			UNIT	Total	69 kV to 380 kV	< 69 kV
Nb	Voltage Dips	Reducing Load	#			

3.8 NETWORK LOSSES

This KPI is applicable to both Transmission and Distribution.

3.8.1 Background

The Losses are evaluated by computing the difference of the energy injected into the network and the energy outgoing from the network. This applies to both the transmission network and the distribution network separately. Since meters are presently (2009) being installed at the interface between the transmission and distribution network, the accurate estimates may not be available in 2009.

3.8.2 KPI Formula

The Losses indicator relates to the yearly energy injected in the network.

$$Losses(\%) = \frac{EnIn - EnOut}{EnIn} * 100$$

- EnIn: Energy injected in the network in MWh
- EnOut: Energy outgoing from the network in MWh

3.8.3 Time Period

The KPI is reported on an annual basis from the 1st of January at 0:00 am and up to 31st of December at 11:59 pm of the given year.

3.8.4 Classification

For transmission and for distribution, the Losses KPI is reported without classification i.e. for the whole network (transmission network on the one hand, distribution network on the other)

3.8.5 Reporting

The KPI should be reported according to the following schedule for transmission and distribution, respectively):

T7. Network Losses		
CATEGORY	UNIT	Total
Total System	%	

D4. Network Losses		
CATEGORY	UNIT	Total
Total System	%	

The following supplemental information needs to be reported as well:

Supplemental Information - Transmission

CATEGORY	UNIT	Total	69 kV to 380 kV	< 69 kV
Energy Injected	MWh			

From its definition based on metering from the energy meter, losses include both technical losses and possible theft of electricity if any (consumptions that are not metered plus meter inaccuracies). Separating losses into technical and non-technical components would be the subject of dedicated studies involving many load-flow computations for the various load periods of the year. Therefore, there is no distinction made at this level between technical and non-technical losses.

3.8.6 Records to be maintained

The utility should maintain records in which the data required for the KPI computation and subsequent reporting will be based. A template file will be provided by ECRA for this purpose. The records and underlying data should be made available to ECRA when audits are being performed. These records should be saved by the utility for a period of at least 5 years. Note also that these records prescribe the minimal information that should be registered; the utility is free to register additional information that it considers necessary.

For each period (depending on the company, a period can be a day, a week, a month, ...) a record should state the injected energy metered and the energy outgoing, as follows.

Period	Metering Point	Injection (MWh)	Consumption (MWh)
1			
..			
N			
Total Out			

This applies to both the transmission network and the distribution network.

3.8.7 Example of KPI Computation

The following example illustrates the way in which the KPI is calculated:

Suppose Total EnIn = 180 000 000 MWh and Total EnOut = 165 000 000 MWh

Losses (%) = $(180\,000\,000 - 165\,000\,000) / 180\,000\,000 = 8.33\%$

3.8.8 Additional Information

Losses are not directly considered as a performance indicator but rather as one of the results related to both the demand level, the characteristics of the system and the operation of the system. Basically network losses consist in one “copper losses” component proportional to the resistance (r) and the square of the current (I) of each circuit ($r * I^2$) and a component “iron losses” independent of the load. To the extent the dispatching can minimize the losses by an optimal dispatch of the reactive power generated at generators, losses can partly be considered as a performance indicator in transmission networks. In distribution networks, the reactive power cannot be controlled from the dispatching and are therefore only a function of the loading and of the configuration.

4 CUSTOMER SERVICE

4.1 C1: AVERAGE TIME TO SUPPLY – EXISTING CONNECTIONS (ATSE)

4.1.1 Background

The average time to provide supply to customers is an indication of the waiting time that customers experience in obtaining electricity supply. This indicator applies to providing supply to customers where there is already a physical connection in place.

4.1.2 KPI Formula

The indicator ATS-E is defined as follows:

$$ATS_E = \frac{\sum_i d_i}{N_E}$$

Where:

- i : Index of realized supply to existing connections in the given period, but only the connections where no works in the Medium Voltage or higher network are involved
- d_i : Lead time of realizing supply i , defined as the time between the moment that the customer makes a supply request for an existing connection, and the moment where the meter has been installed by the utility, measured in regular working days
- N_E : Total number of supplies realized to existing connections in the given period
- Supply request: The request made by the customer to the utility to obtain a connection from the utility after all necessary payments to the utility have been made

4.1.3 Time Period

The KPI is reported on an annual basis i. e. for all connection requests that were **realized** on or after 1st of January at 0:00 am and up to 31st of December at 11:59 pm of the given year.

4.1.4 Classification

The KPI is reported according to the following classification:

- Per department of the utility

4.1.5 Reporting

The KPI should be reported according to the following schedule:

Key Performance Indicator	UNIT	Total	Department 1	...
C1. Average Time to Supply - Existing Connections	Days			

4.1.6 Records to be maintained

The utility should maintain records in which the data required for the KPI computation and subsequent reporting will be based. A template file will be provided by ECRA for this purpose. The records and underlying data should be made available to ECRA when audits are being performed. These records should be saved by the utility for a period of at least 5 years. Note also that these records prescribe the minimal information that should be registered; the utility is free to register additional information that it considers necessary.

The register should contain the following data fields, as shown in the following Table. The data should be maintained for each each department.

Request ID	Date of Supply Request	Date of Meter Installation
#	dd-mm-yy	dd-mm-yy
1		
2		
...		

4.2 C2: AVERAGE TIME TO SUPPLY – NEW CONNECTIONS (ATSN)

4.2.1 Background

The average time to provide supply to customers is an indication of the waiting time that customers experience in obtaining electricity supply. This indicator applies to providing supply to customers where a physical connection is not yet set in place.

4.2.2 KPI Formula

The indicator ATS-N is defined as follows:

$$ATS_N = \frac{\sum_i d_i}{N_N}$$

Where:

- i : Index of realized supply to new connections in the given period, but only the connections where no works in the Medium Voltage or higher network are involved
- d_i : Lead time of realizing supply i , defined as the time between the moment that the customer makes a supply request for a new connection, and the moment where the meter has been installed by the utility, measured in regular working days
- N_N : Total number of supplies realized to new connections in the given period
- Supply request: The request made by the customer to the utility to obtain a connection from the utility after all necessary payments to the utility have been made

4.2.3 Time Period

The KPI is reported on an annual basis i. e. for all connection requests that were **realized** on or after 1st of January at 0:00 am and up to 31st of December at 11:59 pm of the given year.

4.2.4 Classification

The KPI is reported according to the following classification:

- Per department of the utility

4.2.5 Reporting

The KPI should be reported according to the following schedule:

Key Performance Indicator	KPI	UNIT	Total	Department 1	...
C2. Average Time to Supply - New Connections	ATSN	Days			

4.2.6 Records to be maintained

The utility should maintain records in which the data required for the KPI computation and subsequent reporting will be based. A template file will be provided by ECRA for this purpose. The records and underlying data should be made available to ECRA when audits are being performed. These records should be saved by the utility for a period of at least 5 years. Note also that these records prescribe the minimal information that should be registered; the utility is free to register additional information that it considers necessary.

The register should contain the following data fields, as shown in the following Table. The data should be maintained for each each department.

The register should contain the following data fields, as shown in the following Table:

Request ID	Date of Supply Request	Date of Meter Installation
#	dd-mm-yy	dd-mm-yy
1		
2		
...		

4.3 C3: AVERAGE TIME TO RECONNECT AFTER PAYMENT (ATRAP)

4.3.1 Background

The average time to reconnect after payment measures the speed at which the utility is able to reconnect customers who were disconnected for reasons of non-payment, and now need to be reconnected after having fulfilled their payment obligations.

4.3.2 KPI Formula

The indicator is defined as follows:

$$ATRAP = \frac{\sum d_i}{N_{RAP}}$$

Where:

- i : Index of reconnections of customers after payment in the given period
- d_i : For reconnection case i , the time between the moment that the utility has been notified of the payment by the customer, and the time the customer is again able to receive electricity supply, measured in hours
- N_{RAP} : Total number of cases where the customer was reconnected after payment in the given period

4.3.3 Time Period

The KPI is reported on an annual basis i. e. for all cases where the customer fulfilled its payment obligations on or after 1st of January at 0:00 am and up to 31st of December at 11:59 pm of the given year.

4.3.4 Classification

The KPI is reported according to the following classification:

- Per department of the utility

4.3.5 Reporting

The KPI should be reported according to the following schedule:

Key Performance Indicator	KPI	UNIT	Total	Department 1	...
C3. Average Time to Reconnect after Payment	ATRAP	Hours			

4.3.6 Records to be maintained

The utility should maintain records in which the data required for the KPI computation and subsequent reporting will be based. A template file will be provided by ECRA for this purpose. The records and underlying data should be made available to ECRA when audits are being performed. These records should be saved by the utility for a period of at least 5 years. Note also that these records prescribe the minimal information that should be registered; the utility is free to register additional information that it considers necessary

The register should contain the following data fields, as shown in the following Table. The data should be maintained for each each department.

Account Number	Date of Payment Notification	Time of Payment Notification	Date of Reconnection	Time of Reconnection
#	dd-mm-yy	hh: mm	dd-mm-yy	hh: mm

4.4 C4: NOTIFICATION OF INTERRUPTION OF SUPPLY (NIS)

4.4.1 Background

If customers are aware that an interruption will take place, they can take actions to reduce the adverse impact of that interruption. The utility can provide advance notification of in the case that the interruption is planned. This indicator measures the extent by which the utility notifies its customers of planned interruptions.

4.4.2 KPI Formula

The indicator is defined as follows:

$$ATRC = \frac{N_{Notif}}{N_{Int}} \times 100\%$$

Where:

- N_{Notif} : The total number of planned interruptions where the utility provided advance notification to customers in line with the standard set by ECRA
- N_{Int} : The total number of planned interruptions

4.4.3 Time Period

The KPI is reported on an annual basis i. e. for all interruptions on or after 1st of January at 0:00 am and up to 31st of December at 11:59 pm of the given year.

4.4.4 Classification

The KPI is reported according to the following classification:

- Per department of the utility

4.4.5 Reporting

The KPI should be reported according to the following schedule:

Key Performance Indicator	KPI	UNIT	Total	Department 1	...
C4. Notification of Interruption of Supply	NIS	%			

4.4.6 Records to be maintained

The utility should maintain records in which the data required for the KPI computation and subsequent reporting will be based. A template file will be provided by ECRA for this purpose. The records and underlying data should be made available to ECRA when audits are being performed. These records should be saved by the utility for a period of at least 5 years. Note also that these records prescribe the minimal information that should be registered; the utility is free to register additional information that it considers necessary.

The register should contain the following data fields, as shown in the following Table. The data should be maintained for each each department.

Interruption	Date of Interruption	Date of Notification Provided	Advance Notification	Notification Provided in line with standard
#	dd-mm-yy	dd-mm-yy	Days	Yes/No
1				
2				
...				

4.4.7 Additional Information

In the case that the interruption covers more than one department, the interruption is assumed to be applicable to the region where most of the customers being affected are located.

4.5 C5: FREQUENCY OF COMPLAINTS (FC)

4.5.1 Background

The frequency of complaints indicates how many complaints the utility is receiving per customer. To obtain a meaningful measure the measure is expressed in number of complaints per 100 customers

4.5.2 KPI Formula

The indicator is defined as follows:

$$FC = \frac{N_C}{N_{Cus}} \times 100$$

Where:

- N_C : Total number of complaints that are received through the call centre or customer centre operated by the utility
- N_{Cus} : The total number of customers being served by the utility, defined as the average of the total number of customers on 1 January and 31 December of the relevant year

4.5.3 Time Period

The KPI is reported for all complaints that were received on or after 1st of January at 0:00 am and up to 31st of December at 11:59 pm of the given year.

4.5.4 Classification

The KPI is reported according to the following classification:

- Per operating area:
 - a. For SEC: Central Operational Area (COA), Eastern Operational Area (EOA), Southern Operational Area (SOA), Western Operational Area (WOA)
 - For Marafiq: MYAS (Madinat Yanbu Al Sinaiyah)

4.5.5 Reporting

The KPI should be reported according to the following schedule:

Key Performance Indicator	KPI	UNIT	Total	Central	East	South	West	MYAS
C5. Frequency of Complaints	FC	Nr/100 cust.						

Note that the operating areas Central, East, South and West are applicable to SEC. The area MYAS is applicable to Marafiq.

4.5.6 Records to be maintained

The utility should maintain records in which the data required for the KPI computation and subsequent reporting will be based. A template file will be provided by ECRA for this purpose. The records and underlying data should be made available to ECRA when audits are being performed. These records should be saved by the utility for a period of at least 5 years. Note also that these records prescribe the minimal information that should be registered; the utility is free to register additional information that it considers necessary.

The register should contain the following data fields, as shown in the following Table. The data should be maintained for each each operating area.

Compl aint ID	Type of Complaint	Date Complaint Received	Date Complaint Resolved	Complaint Resolution Time
#	Billing / Other	dd-mm-yy	dd-mm-yy	Days
1				
2				
...				

4.6 C6: FREQUENCY OF BILLING COMPLAINTS (FBC)

4.6.1 Background

This indicator is a refinement of the Frequency of Complaints (FC) indicator and only considers complaints that are related to the billing. This indicator is also expressed in number of complaints per 100 customers.

4.6.2 KPI Formula

The indicator is defined as follows:

$$FBC = \frac{N_{BC}}{N_{Cus}} \times 100$$

Where:

- N_{BC} : Total number of complaints that are received received through the call centre or customer centre operated by the utility, that are related to billing N_C :
- N_{Cus} : The total number of customers being served by the utility, defined as the average of the total number of customers on 1 January and 31 December of the relevant year

4.6.3 Time Period

The KPI is reported for all complaints that were received on or after 1st of January at 0:00 am and up to 31st of December at 11:59 pm of the given year.

4.6.4 Classification

The KPI is reported according to the following classification:

- Per operating area:
 - a. For SEC: Central Operational Area (COA), Eastern Operational Area (EOA), Southern Operational Area (SOA), Western Operational Area (WOA)
 - b. For Marafiq: MYAS (Madinat Yanbu Al Sinaiyah)

4.6.5 Reporting

The KPI should be reported according to the following schedule:

Key Performance Indicator	KPI	UNIT	Total	Central	East	South	West	MYAS
C6. Frequency of Billing Complaints	FBC	Nr/100 cust.						

Note that the operating areas Central, East, South and West are applicable to SEC. The area MYAS is applicable to Marafiq.

4.6.6 Records to be maintained

The records to be kept for this KPI are part of the same register as the KPI Frequency of Billing Complaints (FBC) as described in section 4.5.6.

4.7 C7: AVERAGE TIME TO RESOLVE BILLING COMPLAINTS (ATRBC)

4.7.1 Background

The average time to resolve complaints indicates the speed at which the utility is able to resolve customer complaints.

4.7.2 KPI Formula

The indicator is defined as follows:

$$ATRBC = \frac{\sum_i d_i}{N_{BC}}$$

Where:

- i : Index of complaints that are both received and resolved in the given period, as well as any complaint that was received in previous periods but have been resolved in this period
- d_i : Time between the moment that the complaint i was received by the utility, and the moment the complaint has been resolved, measured in regular working days
- N_{BC} : Total number of complaints that are received by the utility that are related to billing
- A complaint is considered resolved if no unsatisfactory response is received from the customer within 10 working days after issuing a response or implementing a solution by the utility

4.7.3 Time Period

The KPI is reported for all complaints that were received on or after 1st of January at 0:00 am and up to 31st of December at 11:59 pm of the given year, as well as all complaints that were not resolved on 1st of January at 0:00 am of the given year.

4.7.4 Classification

The KPI is reported according to the following classification:

- Per operating area:
 - a. For SEC: Central Operational Area (COA), Eastern Operational Area (EOA), Southern Operational Area (SOA), Western Operational Area (WOA)
 - b. For Marafiq: MYAS (Madinat Yanbu Al Sinaiyah)

4.7.5 Reporting

The KPI should be reported according to the following schedule:

Key Performance Indicator	KPI	UNIT	Total	Central	East	South	West	MYAS
C7. Average Time to Resolve Billing Complaints	ATRBC	Days						

Note that the operating areas Central, East, South and West are applicable to SEC. The area MYAS is applicable to Marafiq.

4.7.6 Records to be maintained

The records to be kept for this KPI are part of the same register as the KPI Frequency of Billing Complaints (FBC) as described in section 4.5.6.

4.7.7 Additional Information

The records need to be maintained for all type of complaints. However, the KPI needs to be reported only for the resolution time of billing complaints.

4.8 C8: AVERAGE WAITING TIME CALL CENTER (AWTCC)

4.8.1 Background

The average waiting time call center is an indication of how long customers have to wait before they can speak to a call center agent.

4.8.2 KPI Formula

The indicator is defined as follows:

$$AWTCC = \frac{\sum_i d_i}{N_{Calls}}$$

Where:

- i : Index of calls received by the call center during its opening hours
- d_i : Time between the moment that the call is received and the moment that the call is being served by a call center agent, measured in seconds
- N_{Calls} : Total number of calls received by the customer center during its opening hours but excluding calls that receive an engaged tone or are terminated before being answered by a call center agent

4.8.3 Time Period

The KPI is reported on an annual basis i. e. for all calls that are received on or after 1st of January at 0:00 am and up to 31st of December at 11:59 pm of the given year.

4.8.4 Classification

The KPI is reported according to the following classification:

- Per operating area:
 - a. For SEC: Central Operational Area (COA), Eastern Operational Area (EOA), Southern Operational Area (SOA), Western Operational Area (WOA)
 - b. For Marafiq: MYAS (Madinat Yanbu Al Sinaiyah)

4.8.5 Reporting

The KPI should be reported according to the following schedule:

Key Performance Indicator	KPI	UNIT	Total	Central	East	South	West	MYAS
C8. Average Waiting Time Call Centre	AWTCC	Seconds						

Note that the operating areas Central, East, South and West are applicable to SEC. The area MYAS is applicable to Marafiq.

4.8.6 Records to be maintained

The utility should maintain records in which the data required for the KPI computation and subsequent reporting will be based. A template file will be provided by ECRA for this purpose. The records and underlying data should be made available to ECRA when audits are being performed. These records should be saved by the utility for a period of at least 5 years. Note also that these records prescribe the minimal information that should be registered; the utility is free to register additional information that it considers necessary.

The register should contain the following data fields, as shown in the following Table. The data should be maintained for each each operating area.

Call ID	Date of Call	Reception Time of Call	Answering Time of Call	Waiting Time of Call
Nr	dd-mm-yy	hh:mm:ss	hh:mm:ss	Seconds
1				
2				
...				