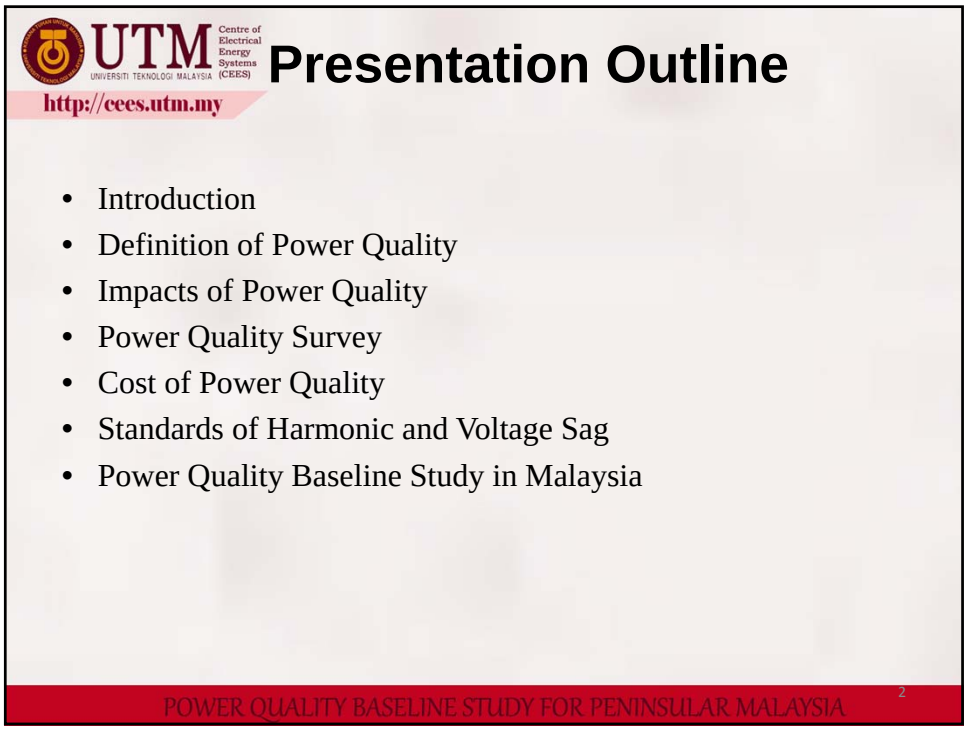

UTM
UNIVERSITI TEKNOLOGI MALAYSIA
Centre of Electrical Energy Systems (CEES)
http://cees.utm.my
STAKEHOLDER WORKSHOP
PWTC
(19th OCTOBER 2011)
-:PROJECT OVERVIEW:-
POWER QUALITY BASELINE STUDY
FOR
PENINSULAR MALAYSIA
Suruhanjaya Tenaga
KeTTHA
KEMENTERIAN TENAGA, TEKNOLOGI HIJAU DAN AIR
GTIM
1


UTM
UNIVERSITI TEKNOLOGI MALAYSIA
Centre of Electrical Energy Systems (CEES)
http://cees.utm.my
Presentation Outline
• Introduction
• Definition of Power Quality
• Impacts of Power Quality
• Power Quality Survey
• Cost of Power Quality
• Standards of Harmonic and Voltage Sag
• Power Quality Baseline Study in Malaysia
POWER QUALITY BASELINE STUDY FOR PENINSULAR MALAYSIA
2

UTM Centre of Electrical Energy Systems (CEES)
UNIVERSITI TEKNOLOGI MALAYSIA
http://cees.utm.my

INTRODUCTION

- Power Quality has been recognized as one of the main issues in electricity supply, worldwide.
- Studies done in many countries have shown that the impacts of Power Quality problems to customers and the national economy are tremendous.

UTM Centre of Electrical Energy Systems (CEES)
UNIVERSITI TEKNOLOGI MALAYSIA
http://cees.utm.my

Power Quality Definition

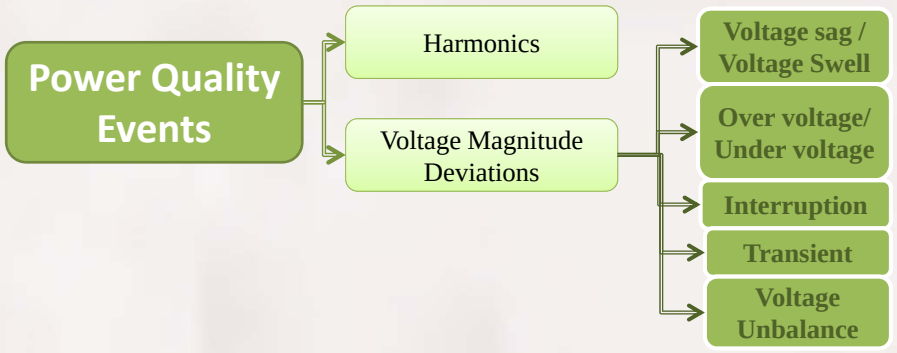
- Power quality or conducted Electromagnetic Compatibility (EMC) is defined by IEC as *"the ability of a device, equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment*." [IEC 61000-1-1]
- In IEC there are two sides to the EMC equation:

  i. Source equipment whose emissions must be limited; and

  ii. Equipment that needs to have sufficient immunity to those disturbances in its environment within which it operates.

UTM Centre of Electrical Energy Systems (CEES)
UNIVERSITI TEKNOLOGI MALAYSIA
http://cees.utm.my

PQ Major Events



UTM Centre of Electrical Energy Systems (CEES)
UNIVERSITI TEKNOLOGI MALAYSIA
http://cees.utm.my

Impacts of Power Quality

- Voltage sags disrupt continuous process especially manufacturing facilities – causing economic loss.
- Stopped computer or digital equipment operation – affecting commercial and industrial customers
- Harmonics can cause damages to installation due to heating effects – may lead to fires, which is a safety issue.
- Harmonics can cause equipment to malfunction
- Equipment may inject harmonics into the grid or distribution system and interfere with other customers installation and

UTM Centre of Electrical Energy Systems (CEES) UNIVERSITI TEKNOLOGI MALAYSIA
http://cees.utm.my

Power Quality Study

- Due to the importance and significance of power quality, tremendous amount of efforts have been invested worldwide to study the PQ problem.

- The study can be broadly categorize into
  - Statistical study of PQ events in the industry
  - Cause of PQ disturbances
  - Analysis and simulation
  - Cost benefit of mitigation approaches
  - Power Quality Standards

UTM Centre of Electrical Energy Systems (CEES) UNIVERSITI TEKNOLOGI MALAYSIA
http://cees.utm.my

Previous Power Quality Monitoring and Surveys

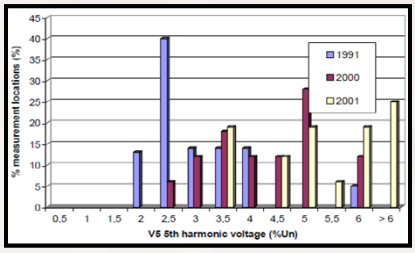
There have been many efforts to carry out system wide monitoring and survey. Table below illustrates the breadth and depth of the data managed from several countries.

Country	Voltage level	Phase to phase [p2p] or phase to neutral [p2n]	Minimum monitoring period	Maximum monitoring period	Number of sites
Canada	LV /HV /MV	p2n	607 days	730 days	11
Portugal	LV /HV /MV	p2p	30 days	303 days	261
UK	MV	p2n	28 days	2222 days	273
South Africa	HV	p2p	31 days	2557 days	234
USA	HV /MV	p2p	4475 days	4475 days	17
Australia	LV /MV	p2p	28 days	28 days	56
Spain	LV /HV /MV	p2p	88 days	1656 days	349
				Total	1175

UTM Centre of Electrical Energy Systems (CEES)
UNIVERSITI TEKNOLOGI MALAYSIA
http://cees.utm.my

Harmonics Monitoring and Survey Statistics

France: Survey on 20 Public LV Systems 1991, 2000



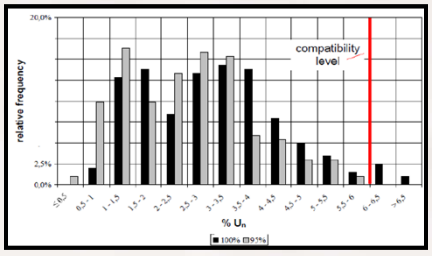
Over the years it is noted that the 5th harmonic voltages has moved to higher occurrence of higher levels.

Measured values:	5th harmonic
Location of measurement:	20 public LV systems, 16 out of them supplying only one type of customer each (residential, industrial or tertiary) 4 out of them chosen with a high THD value.
Measurement campaign:	1991,2000,2001
Time of measurement	All the year
Duration	1 week (1991) per measurement point

UTM Centre of Electrical Energy Systems (CEES)
UNIVERSITI TEKNOLOGI MALAYSIA
http://cees.utm.my

Harmonics Monitoring and Survey Statistics

Austria LV Networks in year 2000 until 2003



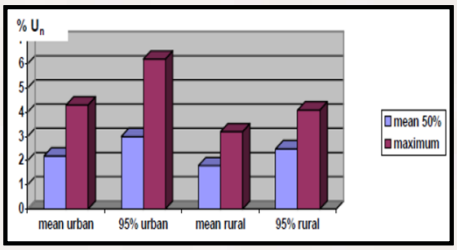
In LV and MV networks, the measurement results are within the compatibility levels are between the average, but 7 out 202 measurements are exceeding the compatibility limits.

Measured values:	5th Harmonics
Location of measurement:	30-40 measurement points in LV networks (65% residential, 10% industrial, 25% mixed environment)
Measurement campaign:	2000-2003(6series)
Time of measurement	June 2000, January 2001, June 2001, January 2002, June 2002, January 2003
Duration	1 week each
Level type:	95% and 100% value of the 5th harmonic

UTM Centre of Electrical Energy Systems (CEES) UNIVERSITI TEKNOLOGI MALAYSIA
http://cees.utm.my

Harmonics Monitoring and Survey Statistics

Denmark LV Networks in year 1996 until 1998



Generally, the harmonic level is higher in urban than in rural areas. With respect to the 5th harmonic, in urban areas, higher values exceeding the compatibility level of 6 % were found during some weakly periods.

Measured values:	THD, odd harmonics up to 15th order
Location of measurement:	200 delivery points in the LV network in rural and urban areas
Measurement campaign:	November 1996 – May 1998
Time of measurement	5 week with a time difference of 3 months each per measuring point (check for seasonal variations)
Duration of	1 week

UTM Centre of Electrical Energy Systems (CEES) UNIVERSITI TEKNOLOGI MALAYSIA
http://cees.utm.my

On-going System-Wide Power Quality Projects

- The Power Quality monitoring project in Australia started in 2004 as a pilot project from the University of Wollongong.
- Later, the Integral Energy, which is major distributor in New South Wales, NSW, and a retailer in NSW and Queensland, contracted the project to its utility wide monitoring system.
- The monitoring project will continue till 2011.
- Much has been learned about power quality by the utility and use to guide Australia in its decision.

UTM Centre of Electrical Energy Systems (CEES) UNIVERSITI TEKNOLOGI MALAYSIA

http://cees.utm.my

Power Quality Project in New Zealand

- The New Zealand project regards that there are two important sides that need to be analyzed which are:

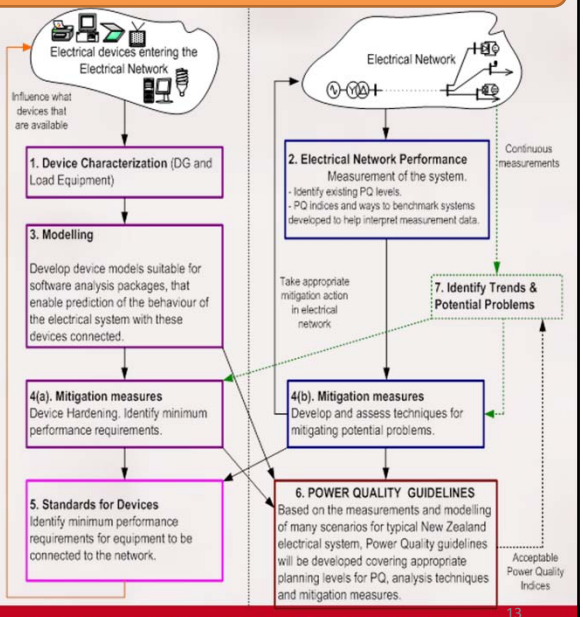
Electrical Device side

The characteristics of the emission and immunity levels of electrical devices.

Electrical Network side

The characteristics of the electrical network need to be determined on the electrical network side.

- After analyzing these two sides, the mitigation techniques can be applied due to the systems compatibility.



UTM Centre of Electrical Energy Systems (CEES) UNIVERSITI TEKNOLOGI MALAYSIA

http://cees.utm.my

POWER QUALITY COST

- The cost of wastage caused by poor PQ for EU-25 according to the cost analysis in European study 2008, exceeds €150bn.
- "Industry" accounts for over 90% of this wastage. The proportion due to "Services" is relatively small. This is possibly because of cost under-estimations by service sector organizations that often experience PQ problems but finding it difficult to distinguish with other causes of disruption. Some services sectors like data centers, which probably experience high PQ costs, have no representation in the survey.
- Dips and short interruptions account for almost 60% of the overall cost to industry and 57% for the total sample.
- This extrapolation corresponds well with those levels indicated by EPRI CEIDS PQ survey (2000) in the US which reports costs of between $119-188bn, with 4% of companies reporting annual costs of 10% or more of annual revenue and 9% reporting costs between 1 and 9,99%.

UTM Centre of Electrical Energy Systems (CEES) UNIVERSITI TEKNOLOGI MALAYSIA
http://cees.utm.my

Power Quality Baseline Study: The Malaysian Energy Commission

- The Malaysian Power Quality Baseline Study is almost similar to the Power Quality Project being undertaken in New Zealand.
- One of the deliverables that is not addressed in New Zealand is the regulatory framework, in other words standards that need to be enforced.
- There is also more emphasis on the economic aspects, in terms of economic losses.
- In Malaysia, the project consultant is tasked to focus on the following tasks:
  - Analysis of power quality events (ie: voltage sag, harmonics)
  - Power quality survey to analyze the economic losses due to power quality events
  - Determine and suggest suitable mitigations
  - Validation of standards of power quality

UTM Centre of Electrical Energy Systems (CEES) UNIVERSITI TEKNOLOGI MALAYSIA
http://cees.utm.my

Economic Losses due to Power Quality Events

- According to a study sponsored by EPRI's Consortium for Electric Infrastructure to Support a Digital Society (CEIDS), U.S. economy is losing between $104 billion and $164 billion a year to outages and another $15 billion to $24 billion to PQ phenomena.
- In EU, it is estimated that power quality problems cost industry and commerce about €10 billion per annum while expenditure on preventative measures is less than 5 % of this.

Losses due to Power Quality Events in EU

Industry Typical financial loss per event	Losses (€)
Semiconductor production	3 800 000
Financial trading	6 000 000 per hour
Computer centre	750 000
Telecommunications	30 000 per minute
Steel works	350 000
Glass industry	250 000

UTM Centre of Electrical Energy Systems (CEES) UNIVERSITI TEKNOLOGI MALAYSIA
http://cees.utm.my

Economic Losses in Malaysia due to Power Quality Events

- Since KHTP inception, reported 73 cases of impact over 244 incidences of power disturbances to the tenants, accounted average of 30% over 10 years
- Substantial losses in revenue incurred depending on various degree of severity for the sag magnitude and duration. The typical losses for last 3 years are:
  - ❖ 2007, RM9.65 million for dip 54% at 4 s
  - ❖ 2008, RM10.5 million for dip 46% at 109 ms
  - ❖ 2009, RM2.0 million for dip 72% at 106 ms

UTM Centre of Electrical Energy Systems (CEES) UNIVERSITI TEKNOLOGI MALAYSIA
http://cees.utm.my

Economic Losses in Malaysia due to Power Quality Events

Losses at KHTP in 2007 due to Voltage Sag

No	Company	Affected	Products	Total Loss (RM)	Remarks
1	A	Yes	Semiconductor Wafers	6,361,816	Impact due to wafer scrapped
2	B	Yes	CPU	4,440	
3	C	Yes	Magnetic Disk	750,000	Material & Parts Damage
4	D	Yes	Semiconductor Wafers	2,500,00	Material & Parts Damage
5	H	Yes	Semiconductor	35,000	
6	I	Yes	Magnetic Disk	0	Production Downtime = 2 hours

UTM Centre of Electrical Energy Systems (CEES) UNIVERSITI TEKNOLOGI MALAYSIA
http://cees.utm.my

Losses at KHTP in 2008 due to Voltage Sag

No	Company	Affected	Products	Losses (RM)	Remarks
1	A	Yes	Semiconductor Wafers	3,400,000	Impact due to wafer scrapped
2	B	Yes	CPU	3,960,000	24K Prod Opportunities Lost
3	C	Yes	Magnetic Disk/Wafers	453,700	Material & Parts Damage
4	D	Yes	Semiconductor Wafers	500,00	Material & Parts Damage
5	H	Yes	Semiconductor	2,160,000	
6	I	Yes	Magnetic Disk	0	Product has to be recycled again. Time loss. No exact value
7	G	Yes	SMT/PCB Assembly	0	2 circuit board for battery charger – generator & HT switch

UTM Centre of Electrical Energy Systems (CEES) UNIVERSITI TEKNOLOGI MALAYSIA
http://cees.utm.my

Economic Losses due to Power Quality Events

Losses at one semiconductor company in June 2009

Date	Losses (USD)	Sag level (%) and Duration	Cause
June 3, 2009	488.79k	Yellow phase 40% (1 s) Red phase 27% (1 s)	Interruption to 132kV transmission line at Pandan Maju substation caused by kite (copper wire was used as kite string - 4 person were electrocuted)
June 20, 2009	510.26k	RYB phase 97 % (89 ms)	33kV Termination fault (flashover) at PandanMaju substation (Feeder to TAMAN KOSAS substation)
June 21, 2009	91.75k	Yellow phase 16.7% (380ms)	11kV Cable fault at MPAJ substation (Same main intake as TIM - from PandanMaju)
June 27, 2009	647.98k	Red phase 50% (1.14s). Blue phase 36% (1.14s)	33kV from Selangor to Kuari Ampang Overhead line fault caused the Taman Kosas substation circuit breaker tripped

UTM Centre of Electrical Energy Systems (CEES)
UNIVERSITI TEKNOLOGI MALAYSIA
http://cees.utm.my

Losses at another semiconductors company from 2007 until 2010

Year	2007	2008	2009	2010
Equipment Malfunction (RM)	2,200,000	1,500,000	150,000	32,000
Equipment Damage (RM)	930,000	590,000	150,000	2,000
Equipment Additional Maintenance (RM)	310,000	55,000	285,000	10,000
Total Losses (RM)	3,440,000	2,145,000	585,000	44,000

UTM Centre of Electrical Energy Systems (CEES)
UNIVERSITI TEKNOLOGI MALAYSIA
http://cees.utm.my

Economic Losses due to Power Quality Events

Losses at one petrochemical company

Type of Losses	Amount (RM)
Costs of raw materials involved in the production	70,000
Labor involved the production or services which was inevitably lost	1,500
Costs of labour needed to make up for lost production, sales, or services such as overtime pay, extra shifts, etc	1,500
Annual value of products running out of specification and / or value of insufficient quality of products	43,000
The cost of the raw material for equipment damage	15,000
Total Losses	131,000

Losses at another petrochemical company

Type of Losses	Amount (RM)
Annual value of products running out of specification and / or value of insufficient quality of products	8,000,000
Average cost for equipment additional maintenance	1,200,000
Total losses	9,200,000

UTM Centre of Electrical Energy Systems (CEES)
UNIVERSITI TEKNOLOGI MALAYSIA
http://cees.utm.my

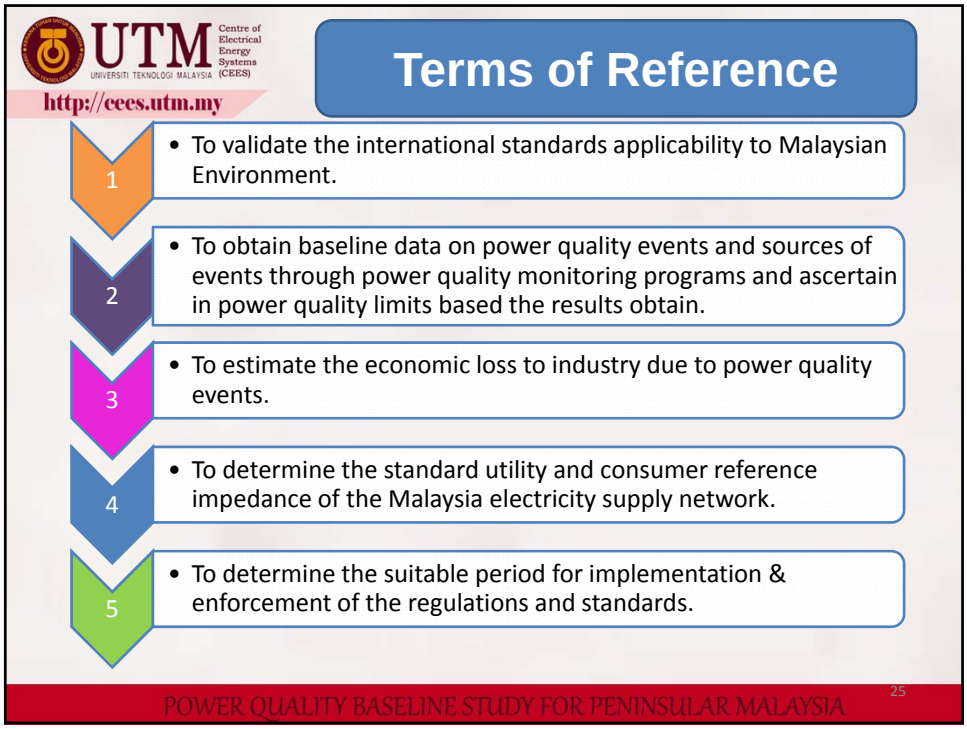
Benefits by Participating in this Project

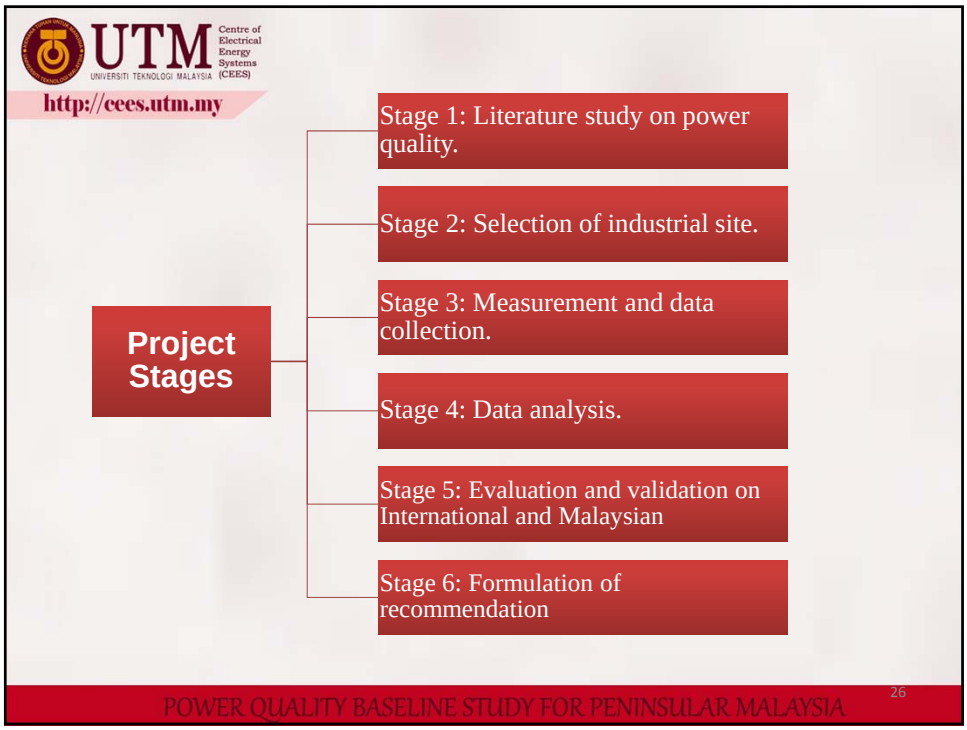
- Customers will be given a copy of data where they can use the data to analyze the power quality events.
- Customers may know the severity of power quality events in their premise.
- By knowing the level of power quality problems, customers may find the suitable mitigation options to improve the power quality.
- Reduce the economical losses due to power quality.
- Increase the profits (reducing the risk of plant shutdown, equipment malfunction, etc).

UTM Centre of Electrical Energy Systems (CEES)
UNIVERSITI TEKNOLOGI MALAYSIA
http://cees.utm.my

What does Malaysian PQ Baseline study do?

- Energy Commission has appointed Global Technology Innovation Management Sdn Bhd (GTIM, a UTM subsidiary) to carry out a Power Quality Baseline Study for Peninsular Malaysia.
- The duration of the project is 2 1/2 years, starting from April 2010 and expected to be completed on December 2012.
- The consultant has collected data from commercial, residential and industrial sites for power quality event analysis.
- Apart from that, the consultant already distributed power quality survey to the selected customers in order to analyze the economic losses due to power quality.


UTM
Centre of Electrical Energy Systems (CEES)
UNIVERSITI TEKNOLOGI MALAYSIA
http://cees.utm.my
Terms of Reference
1
• To validate the international standards applicability to Malaysian Environment.
2
• To obtain baseline data on power quality events and sources of events through power quality monitoring programs and ascertain in power quality limits based the results obtain.
3
• To estimate the economic loss to industry due to power quality events.
4
• To determine the standard utility and consumer reference impedance of the Malaysia electricity supply network.
5
• To determine the suitable period for implementation & enforcement of the regulations and standards.
POWER QUALITY BASELINE STUDY FOR PENINSULAR MALAYSIA
25


UTM
Centre of Electrical Energy Systems (CEES)
UNIVERSITI TEKNOLOGI MALAYSIA
http://cees.utm.my
Project Stages
Stage 1: Literature study on power quality.
Stage 2: Selection of industrial site.
Stage 3: Measurement and data collection.
Stage 4: Data analysis.
Stage 5: Evaluation and validation on International and Malaysian
Stage 6: Formulation of recommendation
POWER QUALITY BASELINE STUDY FOR PENINSULAR MALAYSIA
26

UTM Centre of Electrical Energy Systems (CEES)
UNIVERSITI TEKNOLOGI MALAYSIA
http://cees.utm.my

Harmonics

- Customer is responsible for limiting the amount of harmonic currents injected into the power system.
- Utility is responsible for not injecting harmonic voltage from their transmission systems.

Customer → **Harmonic Current Limits**

Utility → **Voltage Distortion Limits**

UTM Centre of Electrical Energy Systems (CEES)
UNIVERSITI TEKNOLOGI MALAYSIA
http://cees.utm.my

Harmonics

Costs due to harmonics

- Supplementary losses and heating
- Iron losses (Eddy current losses)
- Insulation ageing
- Resonance Phenomena
- Derating of equipment (ie: Transformer)
- Equipment malfunction

UTM Centre of Electrical Energy Systems (CEES) UNIVERSITI TEKNOLOGI MALAYSIA
http://cees.utm.my

Standards on Harmonics

Standard	IEC 61000-3-2, IEC 61000-3-4
Title of document	61000-3-2: Limit for harmonic current emissions (equipment input current <16A) 61000-3-4: Limitation of emission of harmonic currents in low voltage power supply systems for equipment with rated current >16A
Scope	Define harmonic current emission limits for equipment only
Limit	Equipment are classified into four categories (61000-3-2): Class A: Balanced Three-phase Class B: Portable tools Class C: Lighting equipment Class D: with special wave shape For equipment > 16 A (61000-3-4): 3 assessment categories – depends on short circuit ratio and connection. Individual harmonic current and THD limits are given.

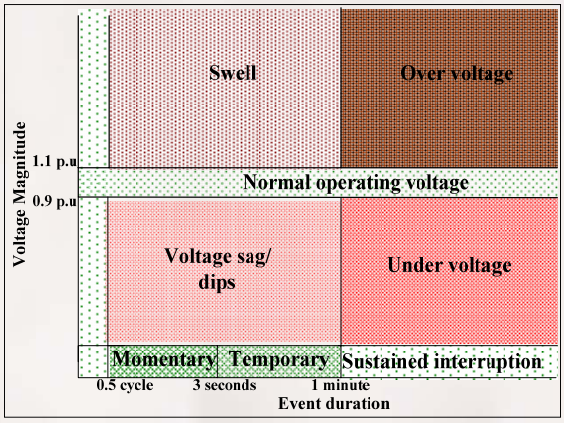
UTM Centre of Electrical Energy Systems (CEES) UNIVERSITI TEKNOLOGI MALAYSIA
http://cees.utm.my

Standards on Harmonics

Standard	IEEE 519-1992	
Title of document	IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.	
Scope	Gives guidelines and recommended practices dealing with harmonics. It explains several topics: 1. Harmonic generation 2. System Response characteristics 3. Effects of harmonics 4. Reactive Power compensation and Harmonic control	
Limit	For individual customers - Current limits are imposed on individual customers at PCC or point of metering. - Depends on customer size and short circuit duration. - The objective is to limit individual voltage harmonic to 3% and THD of 5%.	For utilities - <60 kV, THD 5%, individual 3% - 60 kV to 161 kV – THD 2.5%, individual 1.5% - 161 kV and above – THD 1.5%, individual 1%

UTM Centre of Electrical Energy Systems (CEES)
UNIVERSITI TEKNOLOGI MALAYSIA
http://cees.utm.my

Voltage Distortion



Voltage Sag

A reduction in voltage (below than 90% of the nominal voltage) for the duration of half cycle until 1 minute.

Voltage Swell

An increases in voltage for the duration of half cycle until 1 minute.

Over Voltage

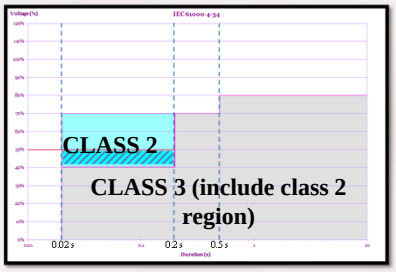
An increases in voltage (110% above rated RMS voltage) for one or more cycles.

Under Voltage

A decreases in voltage (90% above rated RMS voltage) for one or more cycles

UTM Centre of Electrical Energy Systems (CEES)
UNIVERSITI TEKNOLOGI MALAYSIA
http://cees.utm.my

Standards on Voltage Sag



IEC 61000-4-34

Class a	Test level and durations for voltage sags (ts)				(50Hz/60Hz)
Class 1	Case-by-case according to equipment requirements				
Class 2	0% during 1/2 cycle	0% during 1 cycle	70% during 225/30 cycles		
Class 3	0% during 1/2 cycle	0% during 1 cycle	400% during 10/1 cycles 2	70% during 25/30 cycles	80% during 50/300 cycles
Class Xb	X	X	X	X	X
A	Classes per IEC 610000-2-4				
B	To be identified by product committee. For equipment connected directly or indirectly to the public network, the level must be less than level 2.				
C	25/30' cycles means '25 cycles for 50 Hz test' and '300 cycles for 600Hz test'				

UTM Centre of Electrical Energy Systems (CEES)
UNIVERSITI TEKNOLOGI MALAYSIA
http://cees.utm.my

Power Quality Logging

PQ Logging Process → Identify logging sites → Request the permission to install PQ Logger. → Install PQ Logger for the duration of 24 hours → Download data → Data analysis

Number of Sites for Every State

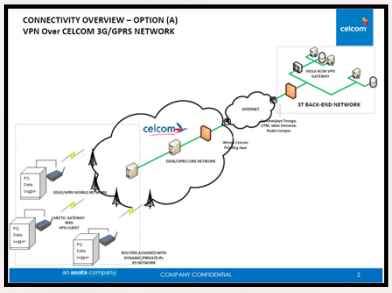
Region	State	Industry	Commercial	Residential	Total
Northern Region	Perak	36	18	6	60
	Penang	42	21	7	70
	Kedah	24	12	4	40
	Perlis	1	1	1	3
Eastern Region	Kelantan	4	3	1	8
	Terengganu	20	11	3	34
	Pahang	23	9	3	35
Central Region	Selangor	50	20	5	78
	Kuala Lumpur	7	18	14	72
Southern Region	Johor	41	17	3	80
	Melaka	23	10	1	10
	N. Sembilan	29	10	2	10
Total		300	150	50	500

POWER QUALITY BASELINE STUDY FOR PENINSULAR MALAYSIA 33

UTM Centre of Electrical Energy Systems (CEES)
UNIVERSITI TEKNOLOGI MALAYSIA
http://cees.utm.my

Power Quality Monitoring

Identify monitoring sites → Request the permission to install PQ Monitoring. → Install PQ Monitoring for the duration of 1 year → Download data (online & manual download) → Data analysis



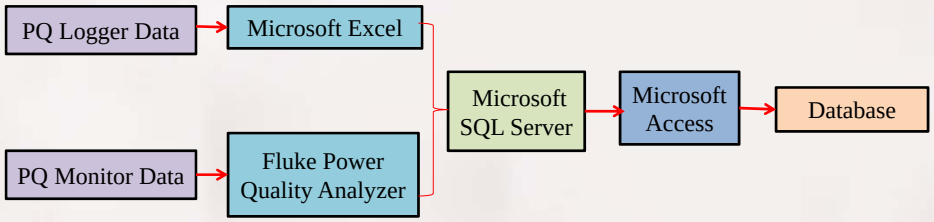
Power Quality Monitoring System

POWER QUALITY BASELINE STUDY FOR PENINSULAR MALAYSIA 34

UTM Centre of Electrical Energy Systems (CEES)
UNIVERSITI TEKNOLOGI MALAYSIA
http://cees.utm.my

Power Quality Database

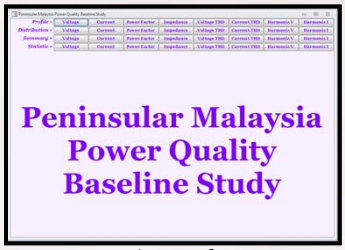
- The consultant has currently develops the automated power quality analysis and reporting systems.
- The system has been developed by using Microsoft SQL server software and Microsoft Access.
- The data recorded from the PQ loggers and monitors will be transferred into the Microsoft SQL database server.



UTM Centre of Electrical Energy Systems (CEES)
UNIVERSITI TEKNOLOGI MALAYSIA
http://cees.utm.my

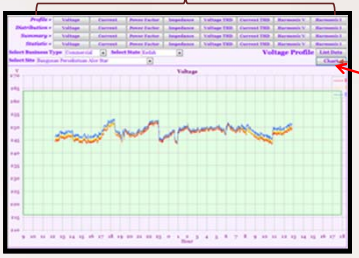
Automated PQ Analysis

Global User Interface (GUI)

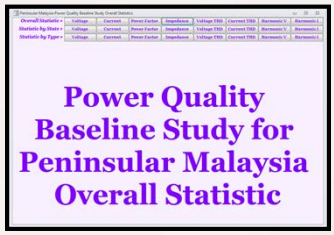


Main Interface

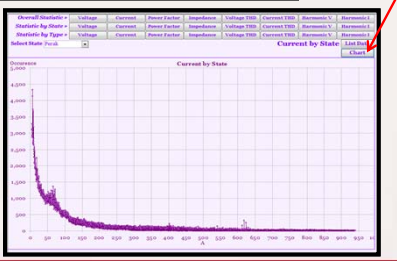
Analysis Menu Button



Button to select analysis results in graph view.



Interface for Overall Statistic



UTM Centre of Electrical Energy Systems (CEES)
UNIVERSITI TEKNOLOGI MALAYSIA
http://cees.utm.my

Power Quality Survey

- The consultant has already prepared the Power Quality Questionnaire to be distributed to the industrial and commercial sites that participate in this project.
- The purpose of the questionnaire is to help identify the costs of power quality events and thereby assist in estimating economic impacts of power quality events.
- We have distributed the questionnaire to all monitored sites and other selected companies for feedback.
- From the feedbacks, wherever suitable, we will amend the questions for improvements.
- Apart from that, we can also estimate the economic losses due to power quality events.
- PQ Questionnaire has been made available online at http://cees.utm.my

UTM Centre of Electrical Energy Systems (CEES)
UNIVERSITI TEKNOLOGI MALAYSIA
http://cees.utm.my

THANK YOU