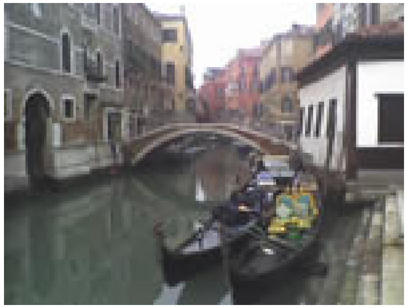
UIE working group
Power Quality

Voltage Dip Immunity of Equipment and Installations



The First International Conference on Smart Grids, Green Communications and IT Energy-aware Technologies

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TUTORIAL

Voltage Dip Economics

(Part 5)

Overview

- The economic issue
- Setting voltage dip immunity requirements
- Financial loss resulting from equipment failure or malfunction
- Cost of increasing equipment immunity to voltage dips
- Selection of mitigating solutions for individual installations
- Setting standards for voltage dip immunity levels
- Summary

The Economic Issue - 1

- There are huge differences in reported financial losses per event, type of interruption, industry, utility and country
- There is no uniformity in reporting the costs
- The annual figures are (sometimes) very large -- easily exceed several millions per utility; the losses on the country/economy level are much higher
- Can we afford to ignore them in the present competitive environment?
- What steps should we take to put them under control and ultimately reduce them?

The Economic Issue - 2

- From a technical point of view, all equipment can be designed so that it is completely immune to voltage dips.
- Complete immunity would come at substantial cost, and most equipment might become ”too immune” for typical disturbances/environments and common areas of application
- The end-user should balance the higher price that needs to be paid for higher immunity against the potential financial loss incurred due to a failure of less resilient equipment/process

The Economic Issue - 3

- Mandatory voltage dip immunity standards?
  - The decision is essentially how much more should all end-users who buy particular equipment be required to pay for the increased immunity of that equipment, keeping in mind that, for large number of applications, voltage dips might not be an issue in the first place

Setting Voltage Dip Immunity Requirements

- Optimal decisions are influenced by the following factors:
  - the number and characteristics of voltage dips experienced at the equipment terminals;
  - the link between characteristics of experienced dips and the industrial process or service interruption, or other adverse impact on the end-user;
  - the financial loss resulting from industrial process or service interruption, or other adverse impact on the end-user;
  - the costs of increasing equipment immunity to voltage dips.

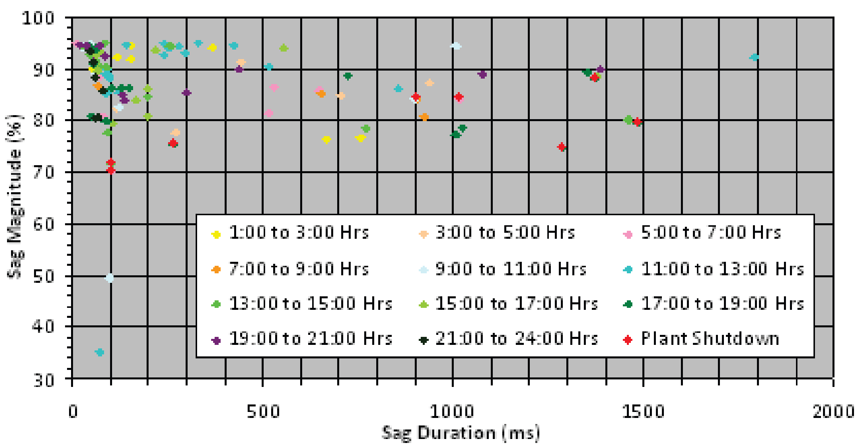
Financial Loss due to Equipment Malfunction - 1

- **Direct costs** - refer to production cost accrual at a given instance of disturbance, and are, therefore, a function of time and process activity.
  - Raw Material
  - Energy
  - Labour
  - Overhead
  - Lost Opportunity
  - Penalties
- **Restart Costs**
  - Expert Damage Assessment
  - Loss, Damage, Repair and Replace
  - Restart Energy
  - Idle and Restart Labour

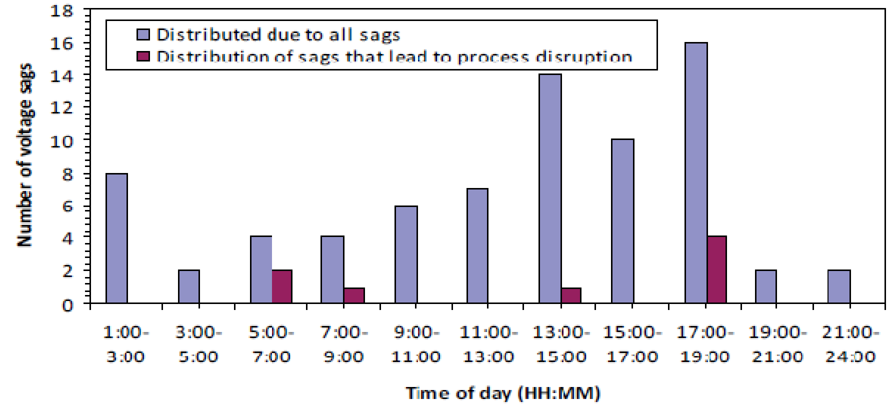
Financial Loss due to Equipment Malfunction - 2

- Hidden Costs
  - Decreased Competitiveness, Reputation and Customer Dissatisfaction
  - Employee Annoyance as a Result of Process Disruption
- Other Factors
  - "Hit Rate and Miss Rate"
  - "Pass Rate and Fail Rate"
  - Plant Voltage Disturbance Trend with Time
  - COD Dependence on Time, Power Consumption and Business Type

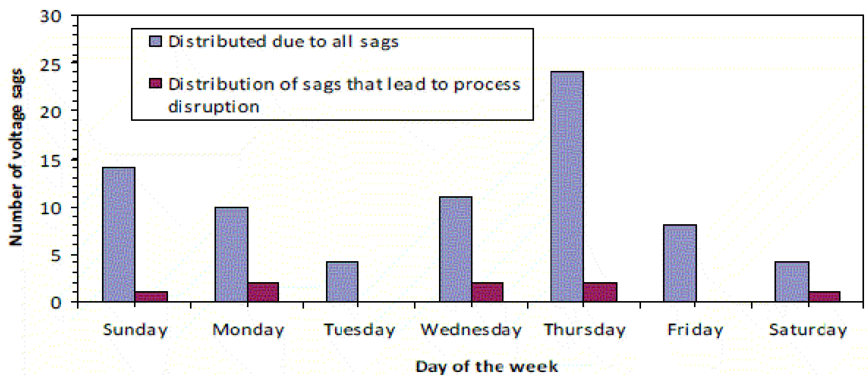
Examples of Plant Voltage Disturbance Trend with Time



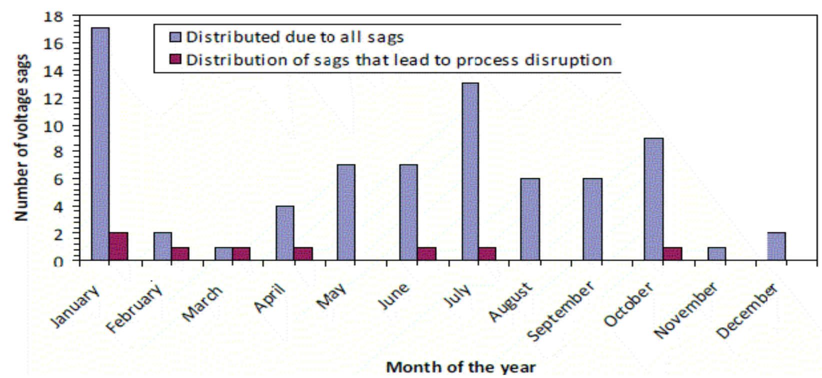
Voltage dip pattern with time of the day.



Hourly variation in number of voltage dips at the primary side of facility transformer.



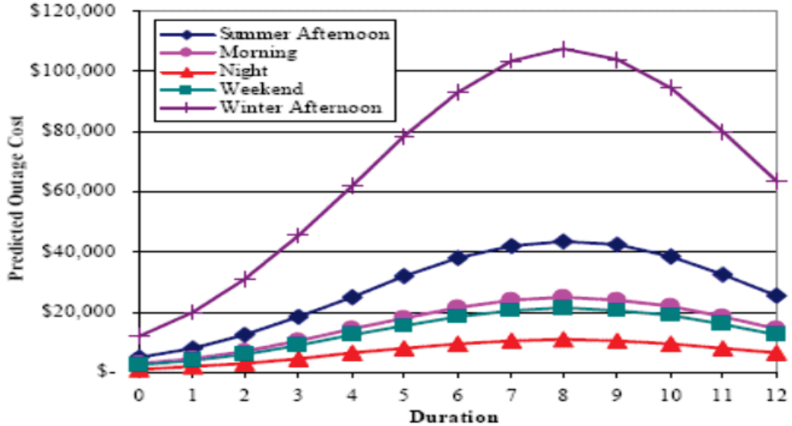
Daily variation in number of voltage dips at the primary side of facility transformer.



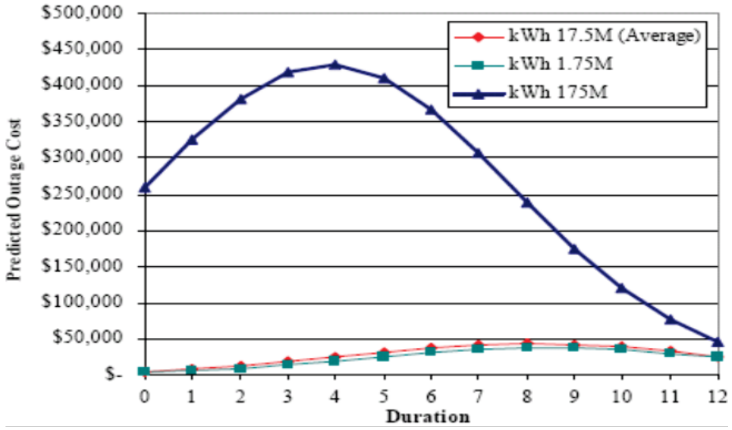
Monthly variation in number of voltage dips at the primary side of facility transformer.

Examples of COD Dependence

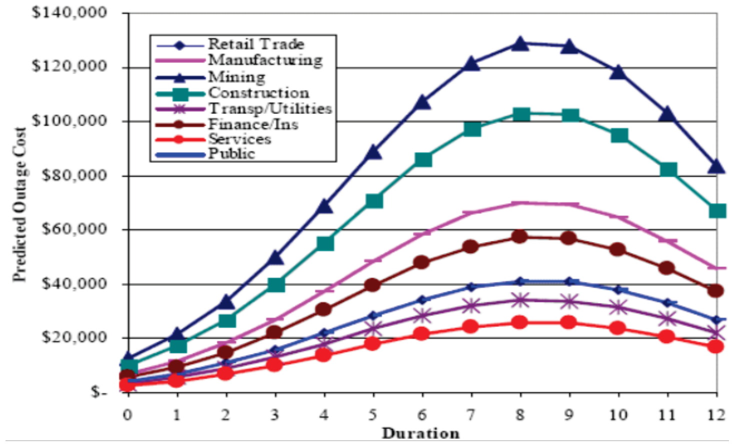
❑ COD Dependence



Varying season and time of day



Varying customer size in annual kWh consumption,summer afternoon outage



Varying business type

Cost of Increasing Equipment Immunity - 1

- The final component affecting optimal decision regarding investment in increased equipment immunity
  - recurring costs (e.g., costs of increased capacitor size recur every time a power supply is made with the larger and more expensive dc link capacitor) roughly proportional to the amount of (stored) energy required by the equipment to ride-through particular dip events
  - non-recurring costs (e.g., the engineering/design costs and testing costs for the increased capacitor occur only once).

Cost of Increasing Equipment Immunity - 2

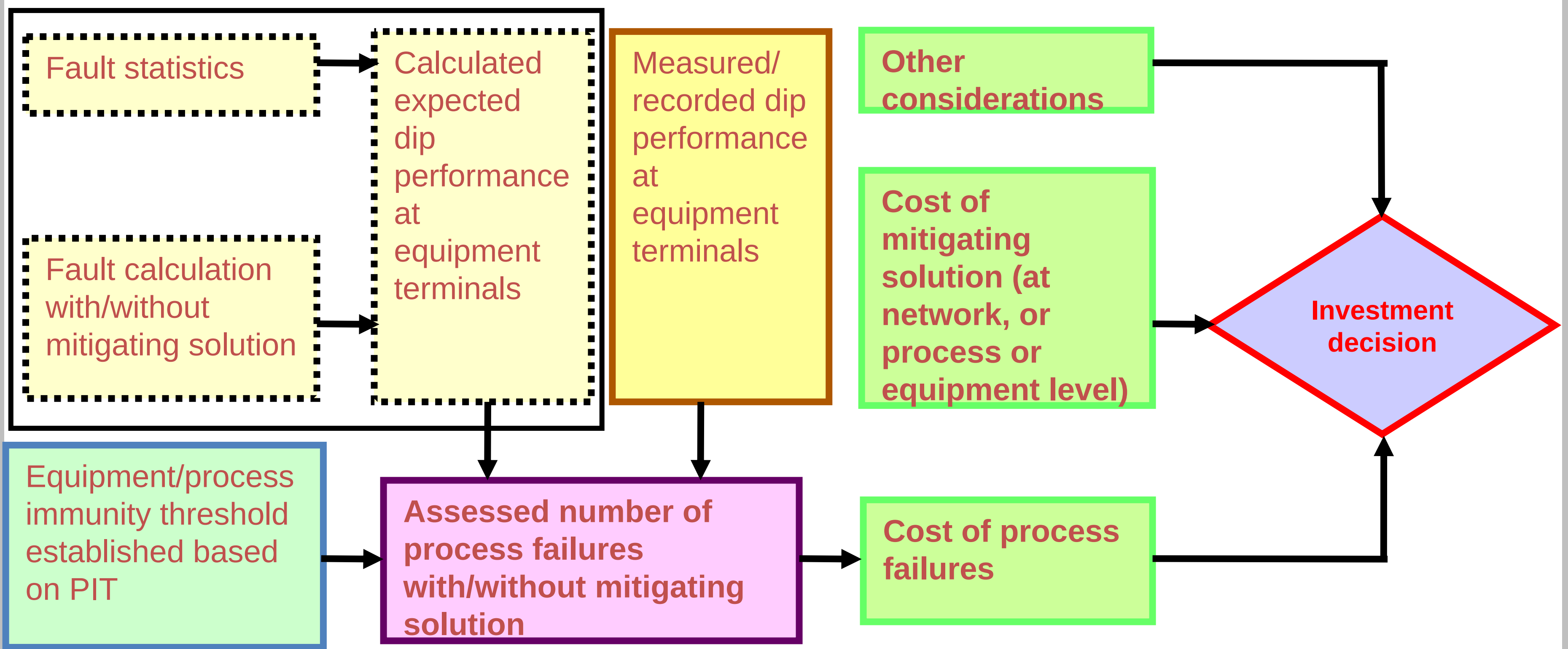
- Increased equipment costs
  - cost of additional component(s) and construction costs,
  - final product reliability costs,
  - space and size related costs due to the redesign of the final product
- Increased engineering costs
  - direct equipment engineering costs,
  - training and knowledge costs,
  - (internal) testing and re-prototyping costs

Cost of Increasing Equipment Immunity - 3

– Testing and certification costs

- test equipment costs (e.g. equipment-under-test with higher rated power/current is usually heavy and less mobile, what requires high-specification and portable test equipment)
- third-party costs (external consultants involved in testing and certification)

Selection of Mitigating Solutions



Setting Standards for Voltage Dip Immunity Levels - 1

- There is presently a relatively limited range of standards for equipment voltage dip immunity
  - IEC 61000-4-11 (≤16 A) and IEC 61000-4-34 (>16 A) give methods for testing equipment immunity to voltage dips and short interruptions
  - SEMI F47-0706, sets dip immunity requirements for equipment used in semiconductor processing factories. The requirements are very close to the requirements in IEC 61000-4-34, and both use the same method for testing equipment dip immunity

The immunity of key assessed items of plant will not necessarily result in a complete process immunity to voltage dips

Setting Standards for Voltage Dip Immunity Levels - 2

- Economic trade-offs
  - The economic impact of a general dip immunity standard (applied to a broad range of equipment, some of which may not actually require any level of dip immunity) cannot be readily evaluated
  - The costs of (required or increased) dip immunity are distributed among all purchasers of equipment, regardless whether or not they need this level of immunity, while the benefits are distributed only among those end-users (both direct and indirect) that happen to need that level of voltage dip immunity

Setting Standards for Voltage Dip Immunity Levels - 3

– The overall cost of equipment compliance with mandatory dip immunity required by a general dip immunity standard should generally be less than the economic benefit to society that this dip immunity delivers

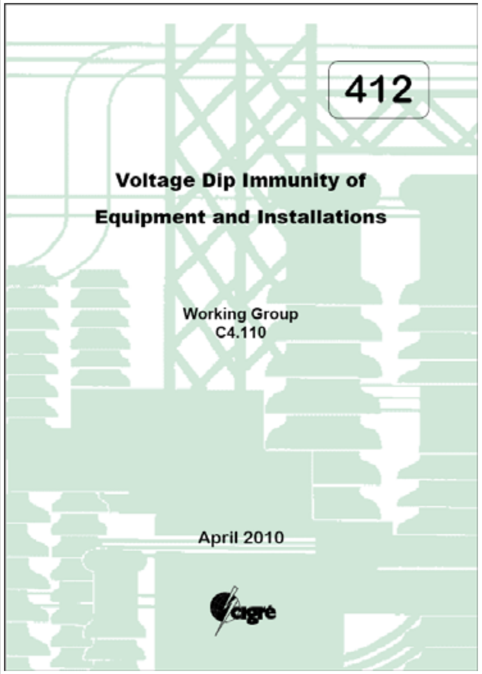
The true economic benefits of the dip immunity levels are uncertain (they do exist, but they are difficult to measure), but related to the number of avoided equipment trips, which in turn is determined by the number of dips that exceed the dip immunity levels

Setting Standards for Voltage Dip Immunity Levels - 4

- Standards should set and select such dip immunity requirements that:
  - include large numbers of dips
  - have relatively inexpensive or highly beneficial immunity requirements
- In order to minimise the cost to society, standards should always set minimum dip immunity requirements

Summary

Close collaboration between a range of specialists within an industrial facility is necessary for selecting an adequate level of equipment/process dip immunity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Voltage Dip Immunity of

Equipment and Installations

Working Group
C4.110

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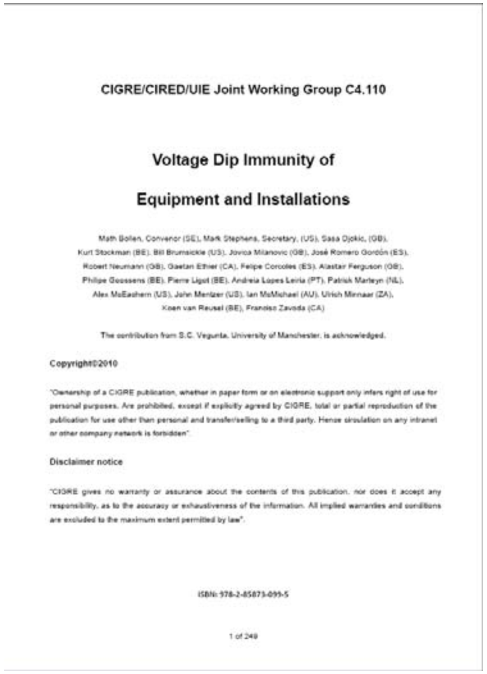
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Equipment and Installations

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