Ir YT Chan

Senior Engineering Consultant & Professional Trainer

Remarkable Condition Monitoring and

Assessment of Power Transformers in Asset Life Cycle Management
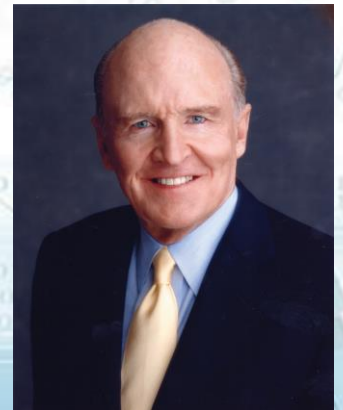
HKIE Technical Seminar
Young Members Committee
The Hong Kong Institution of Engineers

Date : 11 Sep 2018

Landscape of the Energy Business is Reshaping

"If the rate of change outside your organization is greater than the rate of change inside your organization, the end is in sight."

Jack Welch ex-CEO General Electric

Challenging Project

in Comprehensive Asset Life Cycle Management ?

Challenging Project :

Zero Power Equipment Failure

Improve Power Supply Reliability

4

INDUSTRIAL INTERNET OF THINGS

IIoT

of Big Data Applications
is the best solution in
Condition Monitoring & Assessment System

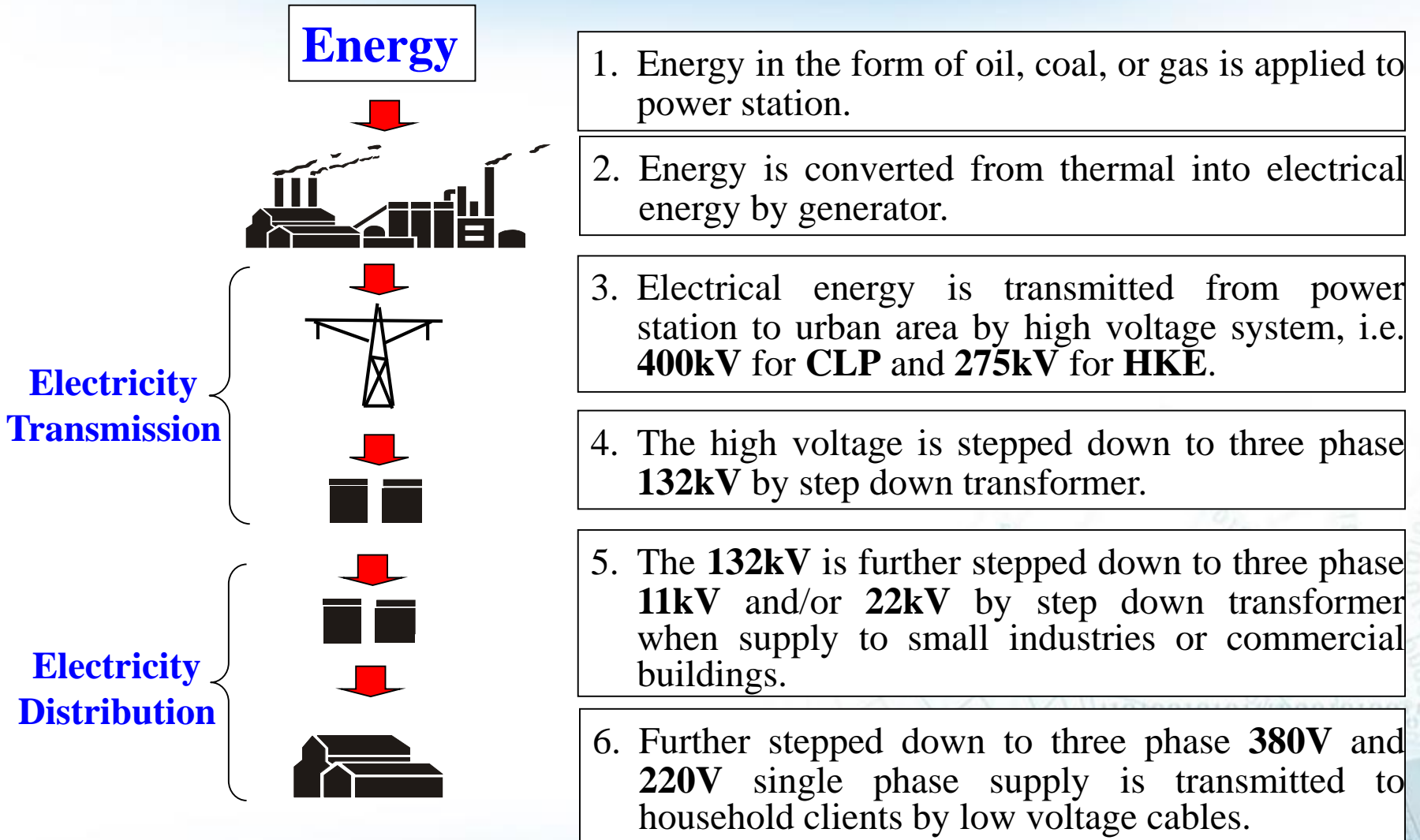# Transmission & Distribution Power Systems in Hong Kong

Source: YT Chan's Information Management System

Typical Electrical Power Transmission & Distribution Systems

Generation

Transmission Line

400kV S/S

132/ 11kV S/S

Transmission Network

Distribution Network (11kV Ring System)

Industrial Building

Commercial Buildings

Residential Building

Remote Customers

Typical Electrical Power Transmission & Distribution Systems

Energy

Electricity Transmission

Electricity Distribution

1. Energy in the form of oil, coal, or gas is applied to power station.

2. Energy is converted from thermal into electrical energy by generator.

3. Electrical energy is transmitted from power station to urban area by high voltage system, i.e. **400kV** for **CLP** and **275kV** for **HKE**.

4. The high voltage is stepped down to three phase **132kV** by step down transformer.

5. The **132kV** is further stepped down to three phase **11kV** and/or **22kV** by step down transformer when supply to small industries or commercial buildings.

6. Further stepped down to three phase **380V** and **220V** single phase supply is transmitted to household clients by low voltage cables.

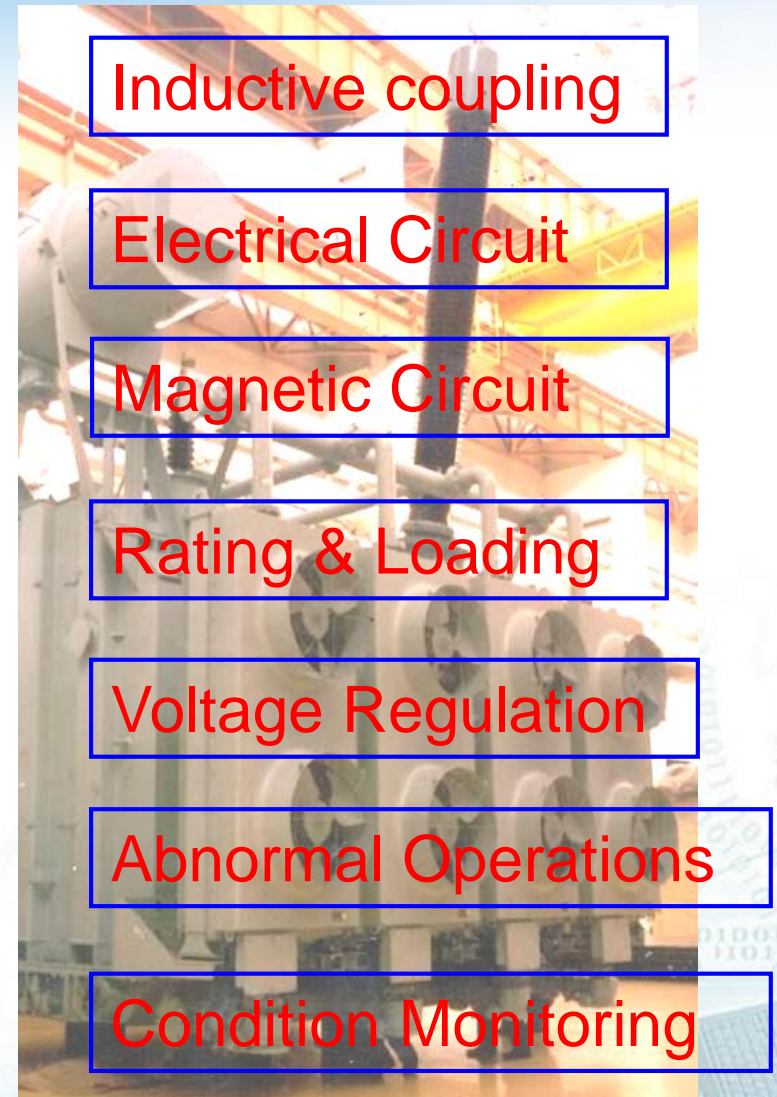# What is a Power Transformer ?

A Power Transformer is :

o a static device

o Transfers electrical energy

o from one circuit to another circuit

o varying voltage *from primary* winding to *secondary* winding.

o varying current *from primary* winding to *secondary* winding.

o Operating in safe manner under various conditions in power network.

Source: YT Chan's Information Management System

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Inductive coupling

Electrical Circuit

Magnetic Circuit

Rating & Loading

Voltage Regulation

Abnormal Operations

Condition Monitoring

Operations of Power Transformer

- **Main Parts**
    - Steel
    - Copper
    - Insulating Oil
    - Insulating Paper

- **Operational Stress**
    - Electrical
    - Thermal
    - Mechanical
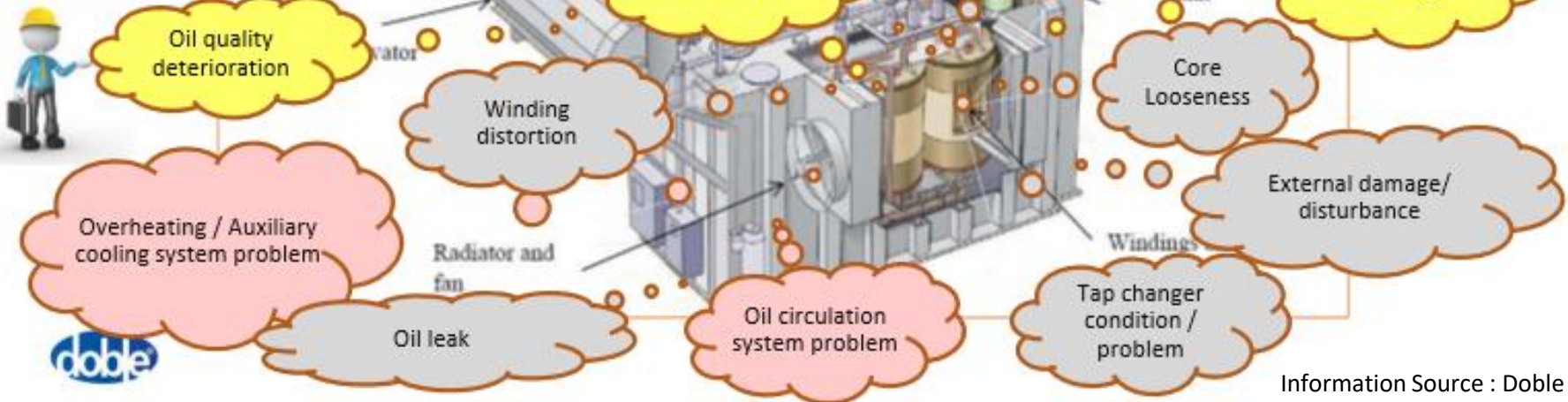   - Chemical
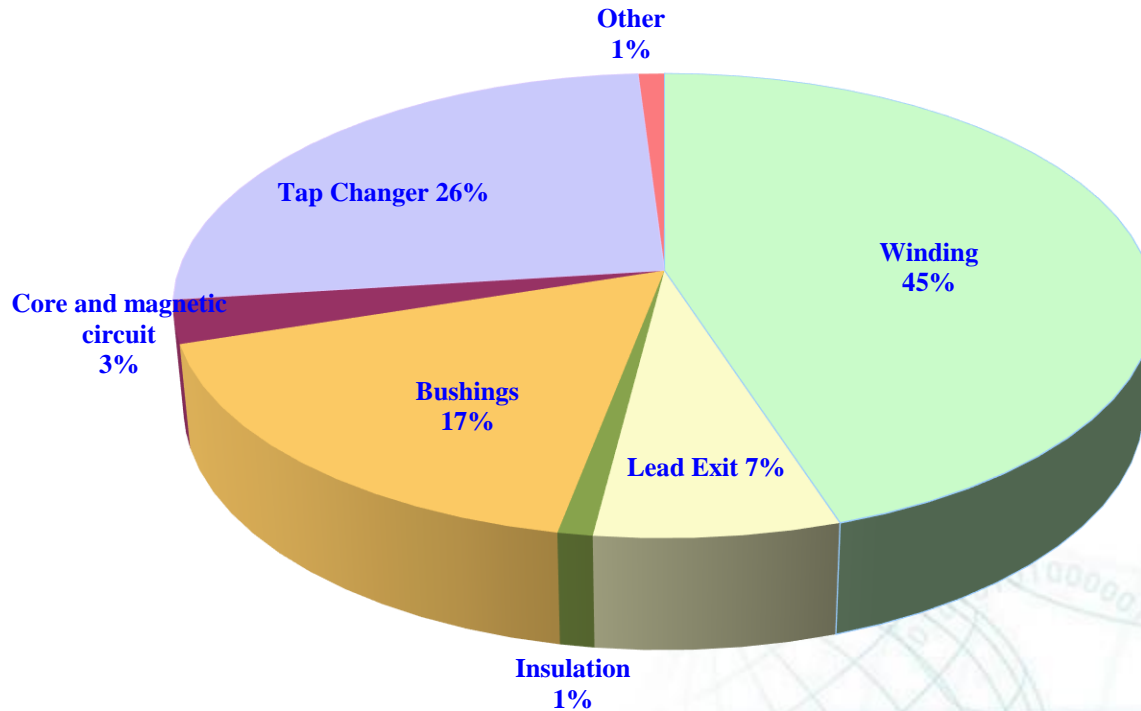
240MVA 400/132kV Transformer

Asset of Power Transformer and Failure Mode

Information Source : Doble

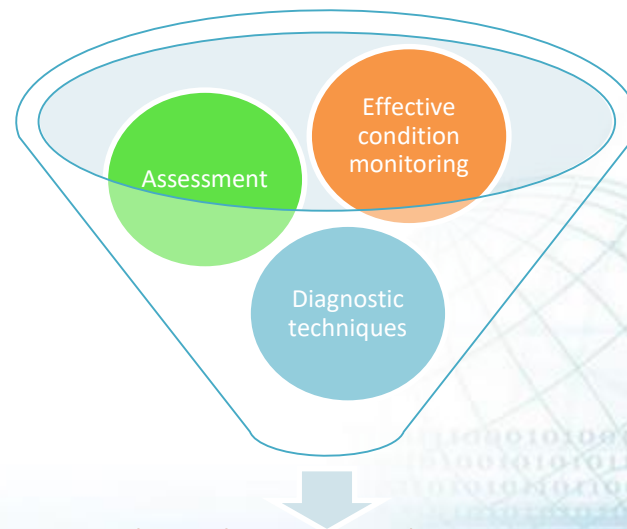# Fault Analysis – Cigre WG A2.27 , No. 261

Transmission Power Transformers

Power Transformer : Condition Monitoring & Assessment Systems under Smart Grid Operations

- Service life of 50 years is required for Power transformers operating in power system.

- Power transformers are subjected to different levels of dielectric, thermal, mechanical and chemical impacts

- Failure of power transformer hamper the power system performance and post hazards to the working personnel.

- Effective condition monitoring, assessment and diagnostic techniques under smart grid operations are required to identify these problems at an early stage for just-in-time maintenance.


Just-in-time maintenance

Power Transformer : Condition Monitoring & Assessment Systems under Smart Grid Operations

➤ **Power transformer condition assessment under smart grid operations requires a great variety of state-of-art technologies to be applied.**

➤ **embark on a number of advanced condition monitoring systems under smart grid operations for power transformers including**

- ❖ **partial discharge detection and location,**
- ❖ **dissolved gas analysis,**
- ❖ **winding movement and deformation detection,**
- ❖ **furfural concentration measurement, etc.**
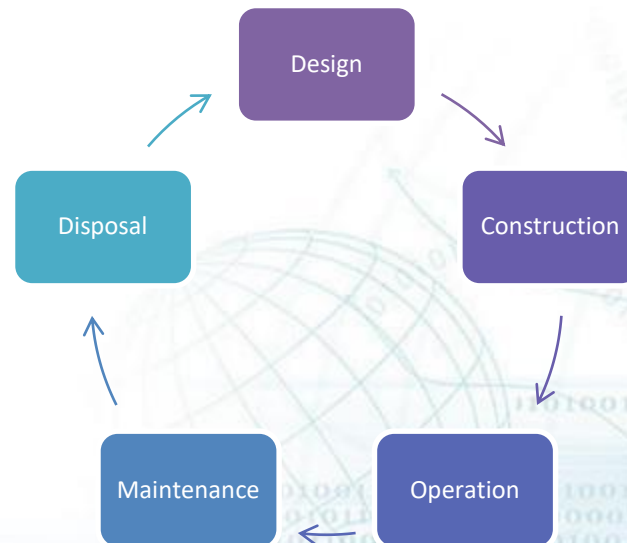
Design → Construction → Operation → Maintenance → Disposal → Design

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Remarkable Condition Monitoring and Assessment of Power Transformers in Asset Life Cycle Management
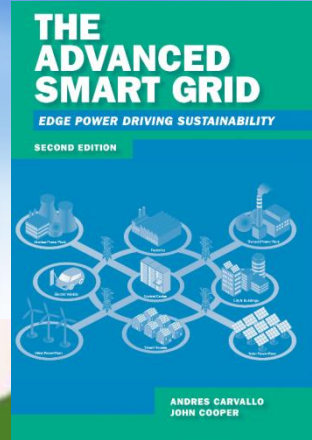
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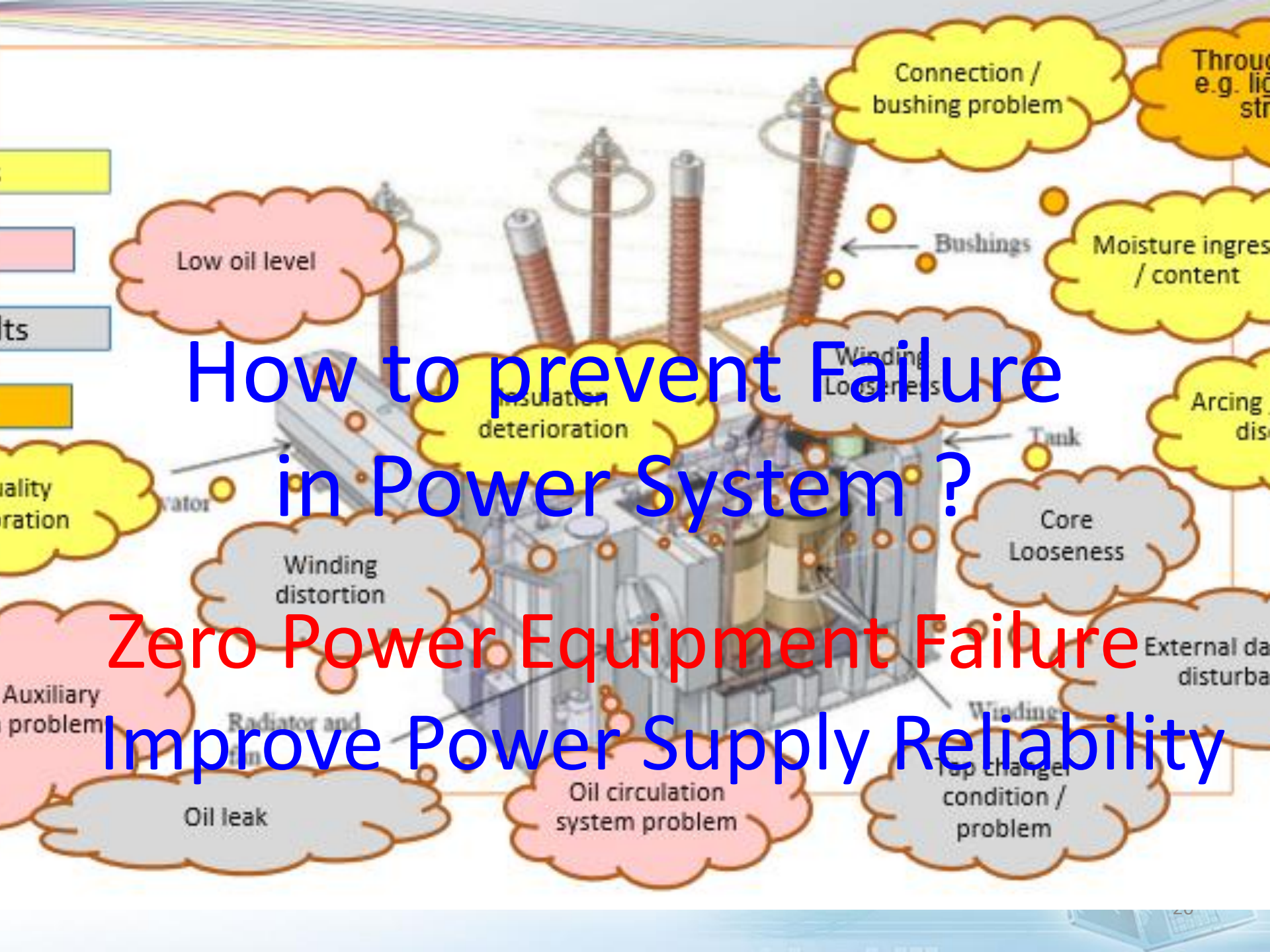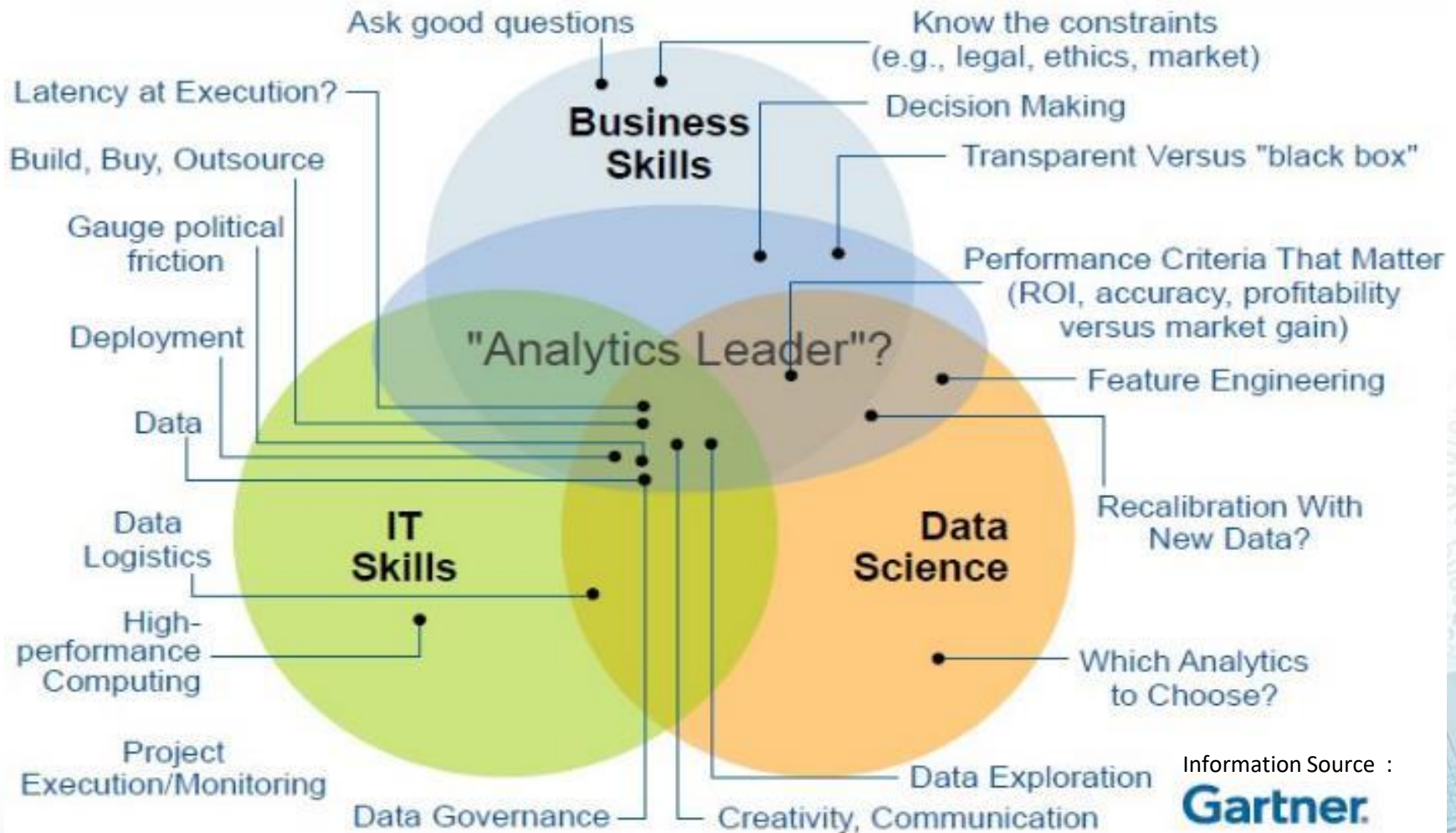Condition Monitoring & Assessment System

Smart Convergence 智慧滙萃

How to prevent Failure in Power System ?

Zero Power Equipment Failure

Improve Power Supply Reliability

Specialist Skills to Lead Smart Convergence

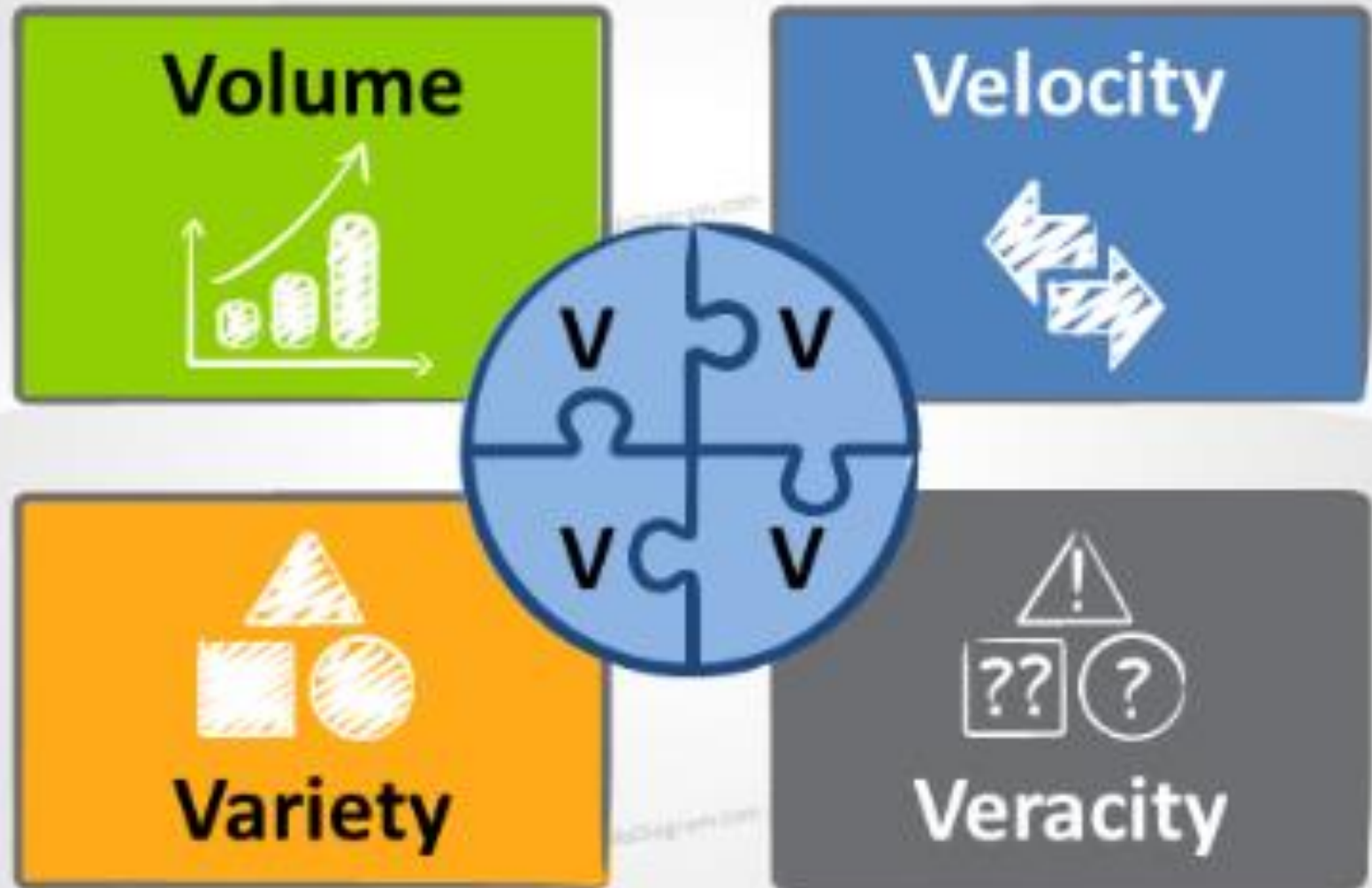**Driving the Success of Data Science Solutions: Skills, Roles and Responsibilities ...**

- Ask good questions
- Know the constraints (e.g., legal, ethics, market)
- Latency at Execution?
- Decision Making
- **Business Skills**
- Transparent Versus "black box"
- Build, Buy, Outsource
- Gauge political friction
- Performance Criteria That Matter (ROI, accuracy, profitability versus market gain)
- Deployment
- "Analytics Leader"?
- Feature Engineering
- Data
- Data Logistics
- **IT Skills**
- **Data Science**
- Recalibration With New Data?
- High-performance Computing
- Which Analytics to Choose?
- Project Execution/Monitoring
- Data Governance
- Creativity, Communication
- Data Exploration

Information Source :
Gartner.

The network of a multitude of devices connected by communications technologies.

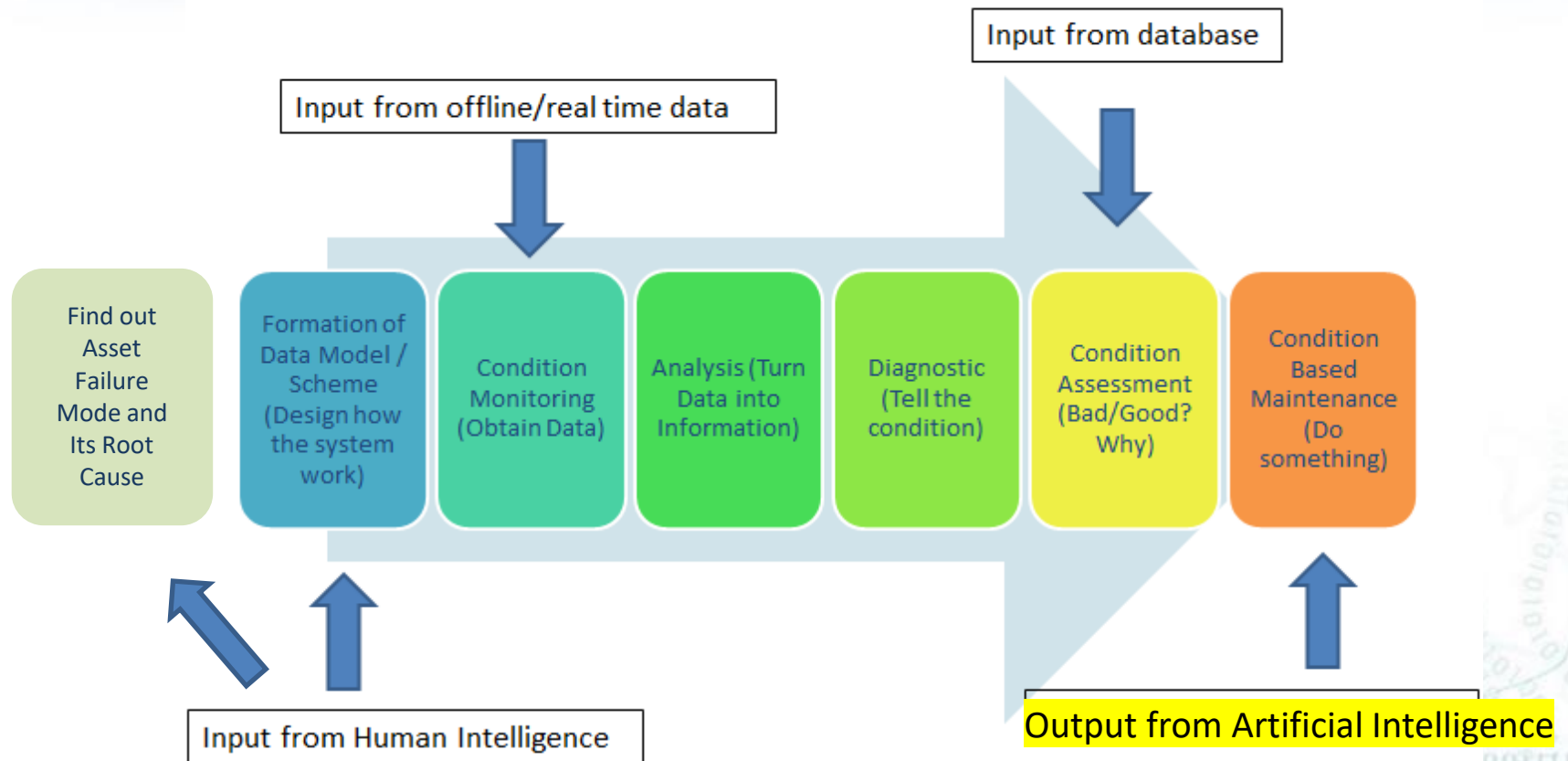Can monitor, collect, exchange, analyze.

Help drive smarter, faster business decisions for industrial companies.

Deliver valuable new insights

Industrial IoT

Brings together brilliant machines, advanced analytics, and people at work.

Condition Monitoring(CM) to Condition Based Maintenance(CBM)

Input from offline/real time data

Input from database

| Find out Asset Failure Mode and Its Root Cause | Formation of Data Model / Scheme (Design how the system work) | Condition Monitoring (Obtain Data) | Analysis (Turn Data into Information) | Diagnostic (Tell the condition) | Condition Assessment (Bad/Good? Why) | Condition Based Maintenance (Do something) |

Input from Human Intelligence

Output from Artificial Intelligence

Conditional Based Maintenance (CBM)

- Maintenance man hours
- Days in maintenance
- Time between overhaul
- Days pending repair

Time savings

Direct cost benefits
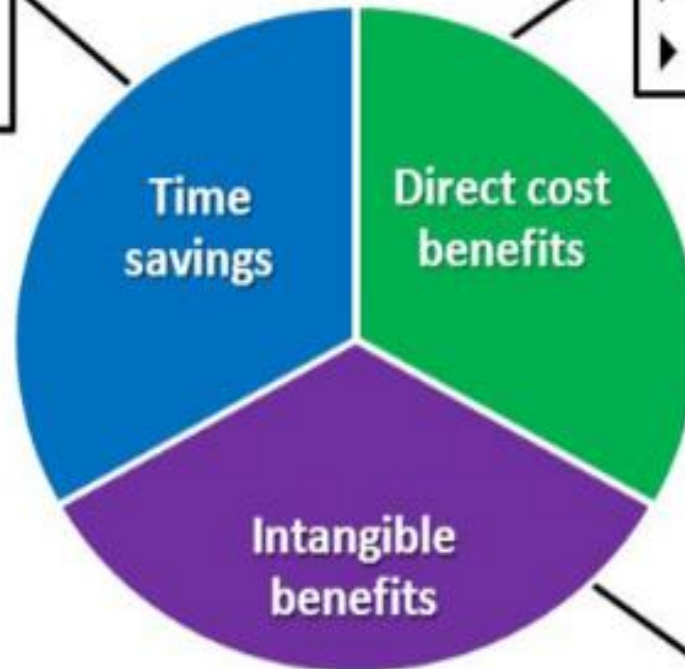
- Total parts cost
- Premature part failure
- Material cost avoidance
- Operational cost avoidance

Intangible benefits

- Performance
- Morale
- Sense of safety
- Sense of time savings
- Confidence

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Remarkable Condition Monitoring and Assessment of Power Transformers in Asset Life Cycle Management

Two Excellent Projects :

o **Extra High Voltage 400kV Transformers**

o **Distribution Supply 11kV Transformers**

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Remarkable Condition Monitoring and

Assessment of Power Transformers in Asset Life Cycle Management

by Excellent Projects of

Realization by Value

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"I conceive that the great part of the miseries of mankind are brought upon them by false estimates they have made of the value of things" - Benjamin Franklin

"Price is what you pay; value is what you get" - Warren Buffett.
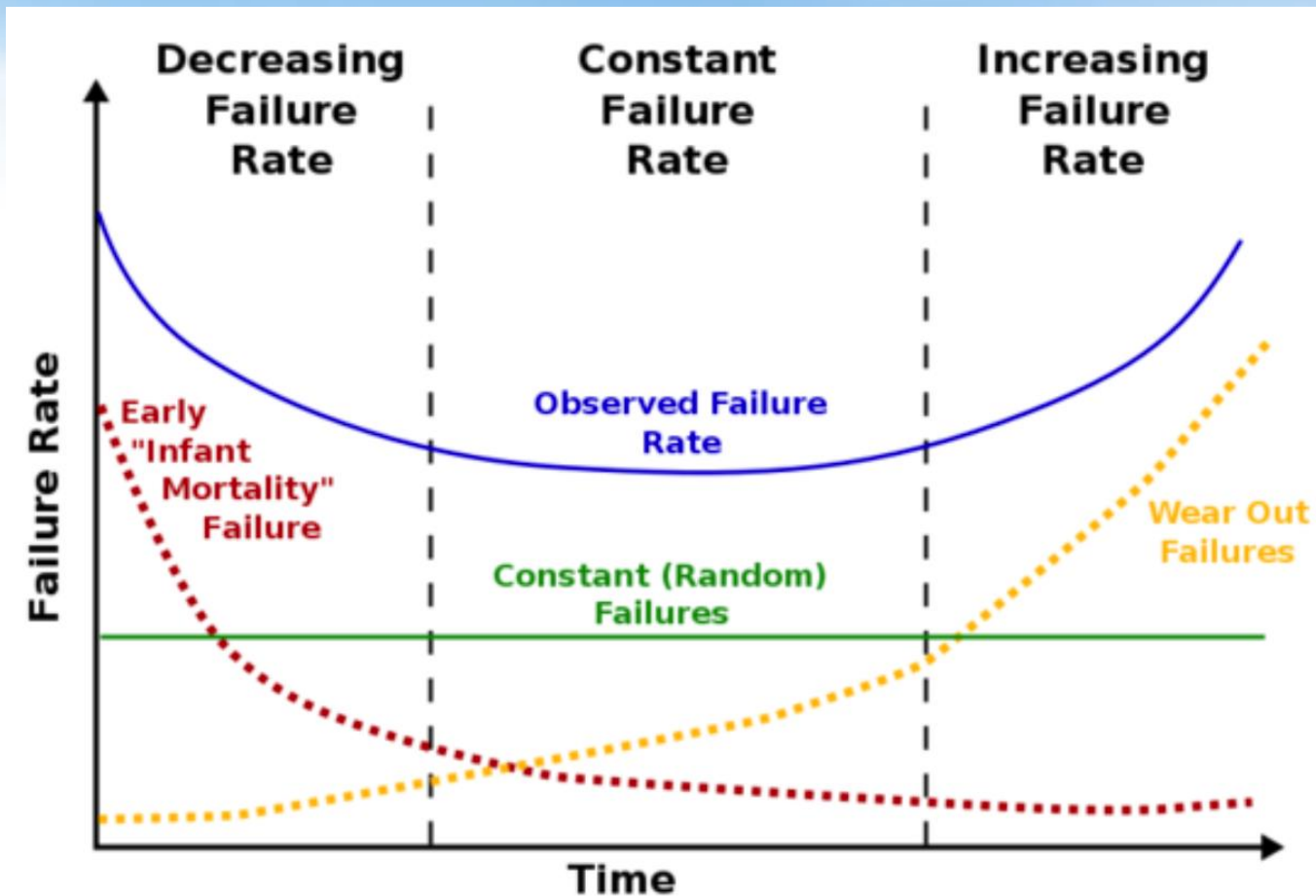
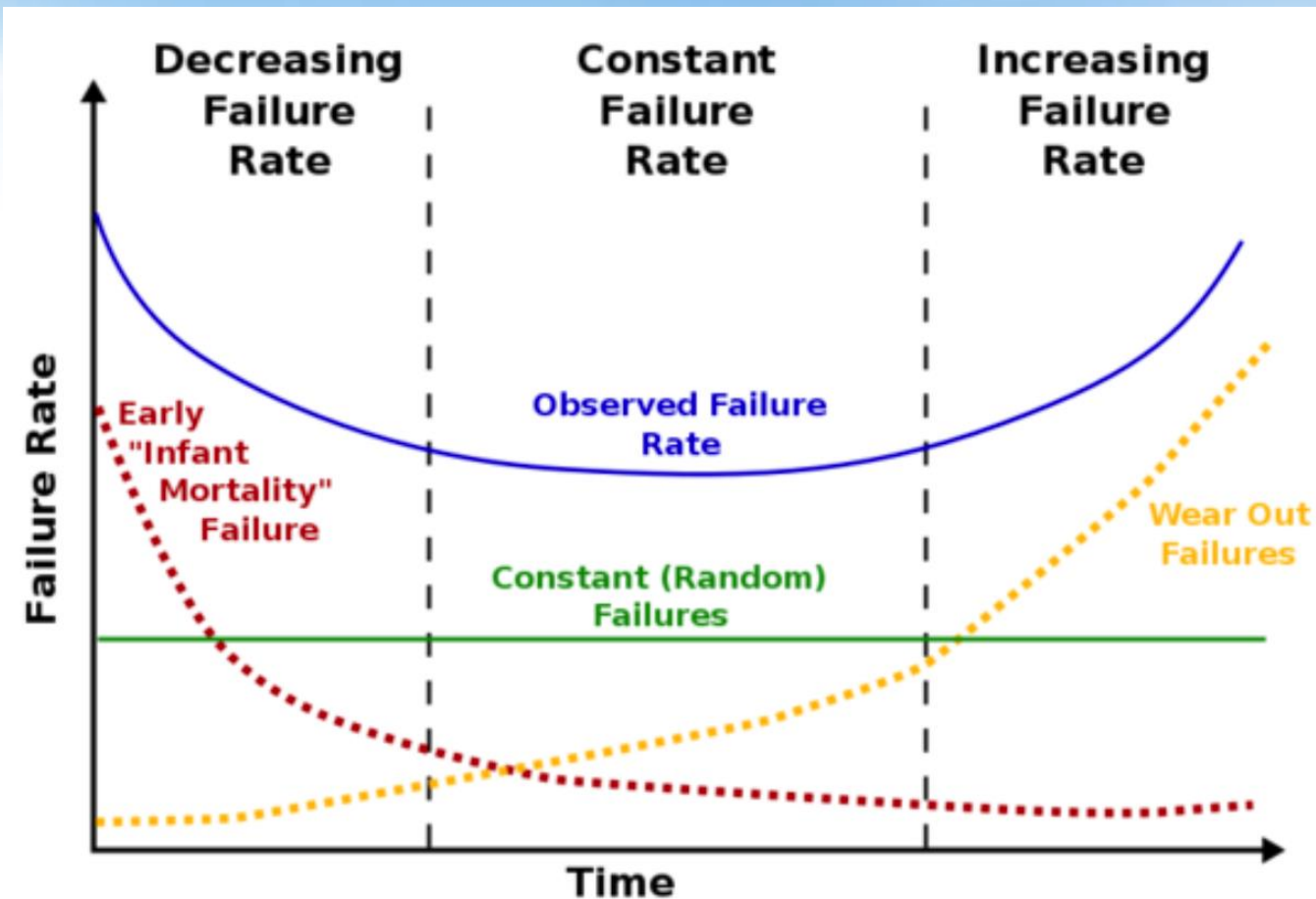# Failure Modes : Some basic concepts

Failure Modes

Bathtub Failure Curve is assumed:

- ✓ Time based maintenance
- ✓ Periodic Monitoring

Failure Modes

68% of Equipment - infant mortality and random failure:

✓ Detective monitoring

✓ Online continuous monitoring, especially early years

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Realization by Value
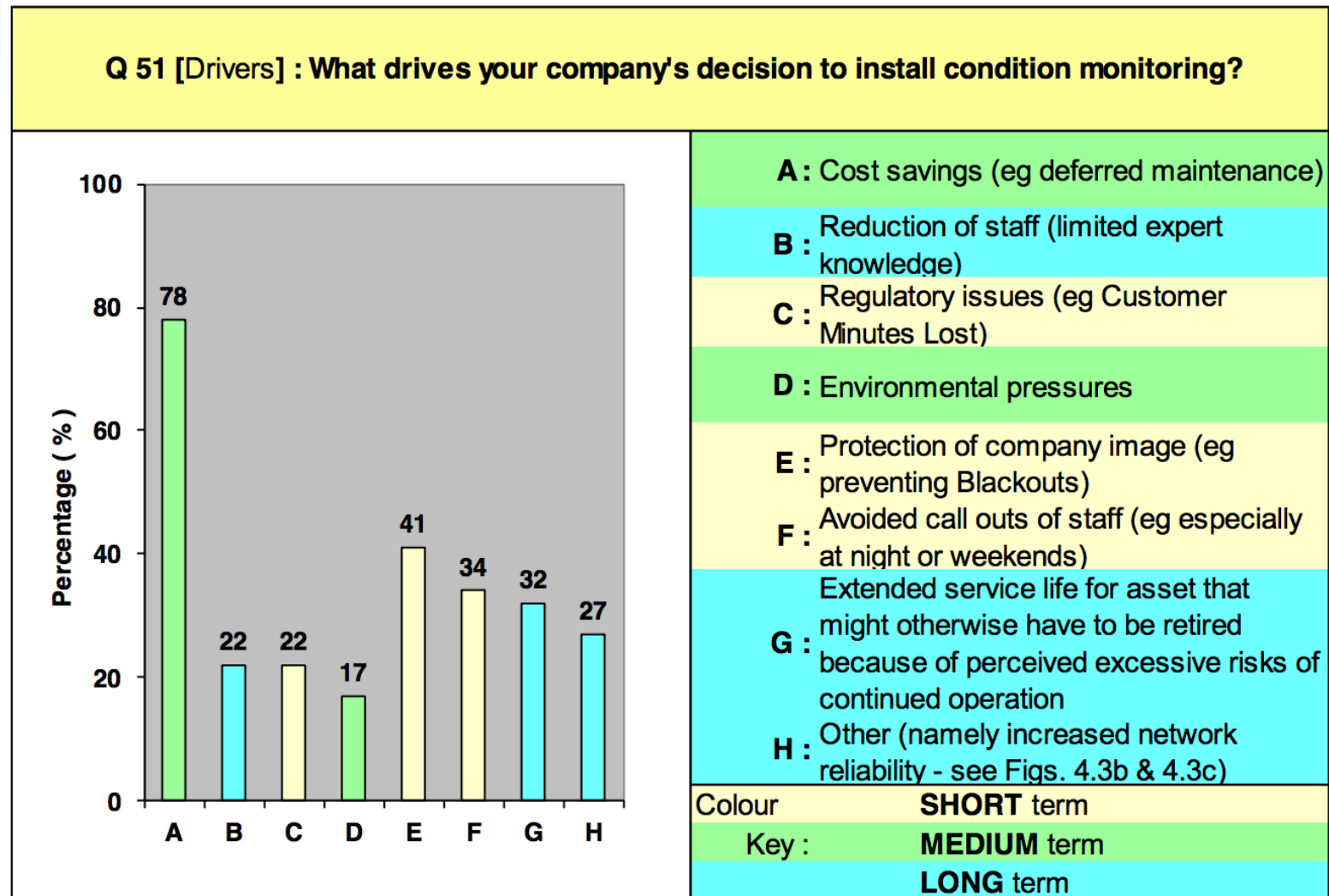
in Advanced Condition Monitoring Systems

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Realization by Value in
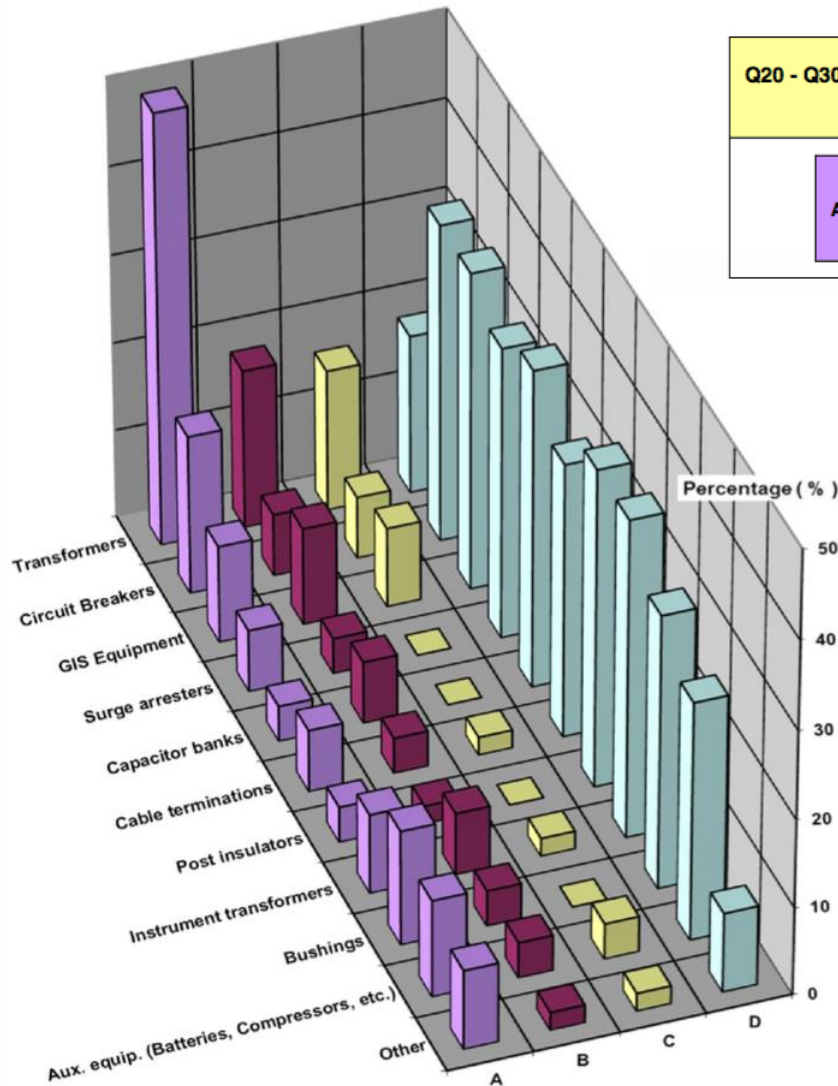## Advanced Condition Monitoring Systems under IIoT

- Early warning of potential failure

- Auto data collection & expert systems

- Better use of skilled resources

- Increased asset utilisation – we can get more from it

- Better asset decision making

- Lower maintenance costs

- Higher reliability

- Condition Based Maintenance

Drivers for Online Condition Monitoring

Q 51 [Drivers] : What drives your company's decision to install condition monitoring?

A : Cost savings (eg deferred maintenance)
B : Reduction of staff (limited expert knowledge)
C : Regulatory issues (eg Customer Minutes Lost)
D : Environmental pressures
E : Protection of company image (eg preventing Blackouts)
F : Avoided call outs of staff (eg especially at night or weekends)
G : Extended service life for asset that might otherwise have to be retired because of perceived excessive risks of continued operation
H : Other (namely increased network reliability - see Figs. 4.3b & 4.3c)

Colour Key : SHORT term / MEDIUM term / LONG term

Information sources of Cigre Survey
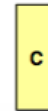
Industry Practices for Online Condition Monitoring

Q20 - Q30 [Application of condition monitoring (CM)] : Does your company install CM systems on EXISTING equipment in any of the following categories;
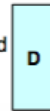
A : Before end of life to avoid faults, or gain knowledge
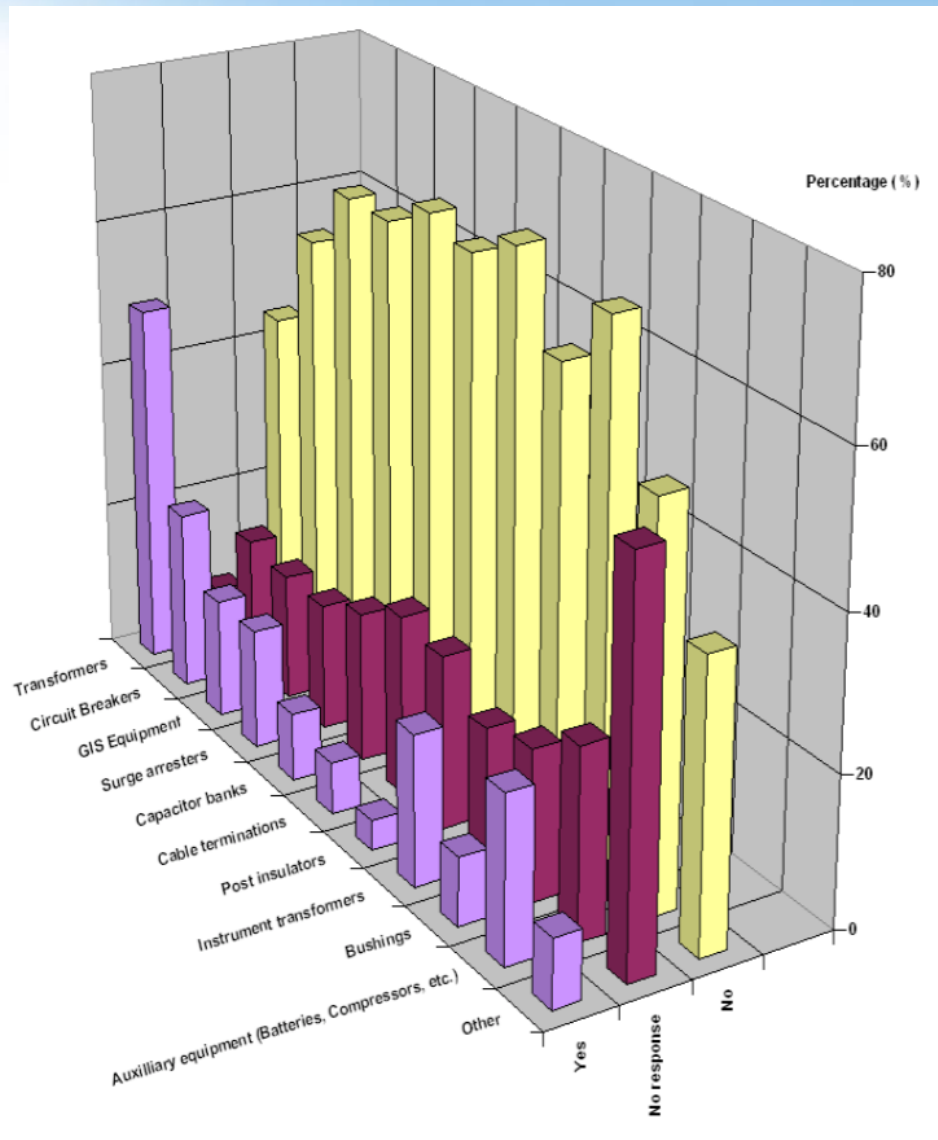B : After faults on the unit, or similar units
C : After repeated alarms
D : Other

Information sources of Cigre Survey

The outcome for Online Condition Monitoring

Q37 - Q47 [Benefits of condition monitoring] : Has your company avoided failures through the use of condition monitoring for the following equipment?

: Yes   : No reponse   : No

Information sources of Cigre Survey

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Thank You

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