

COURSE NAME| Session No.5

## MAINTENANCE OF ENERGY SYSTEMS



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### Overview

- Maintenance plays a crucial role in achieving energy savings across various sectors by ensuring the efficient operation of equipment, systems, and facilities.
- According to industry reports, a well-maintained energy-efficient building can achieve energy savings of up to 30%, resulting in considerable monetary benefits.
- When “things are difficult,” however, maintenance budget or expenditures are often cut before other costs.



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### Learning Objectives:

Familiarize with:

- Maintenance in Energy & Building Systems
- Different Types of Maintenance Strategies
- Maintenance Terminologies & Methodologies
- Recent Technologies/Trends in Maintenance
- Maintenance Tools for Energy Management & Audit



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## Maintenance of Energy Systems

Refers to the practices and procedures implemented to ensure the **proper functioning, reliability, and longevity of systems** that **produce, distribute, or utilize energy**.



These systems encompass a wide range of technologies, including power plants, electrical grids, renewable energy installations, heating, ventilation, and air conditioning (HVAC) systems, compressed air systems, among others.



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## Key Aspects of Maintenance of Energy Systems

**1. Scheduled Maintenance:** Regularly scheduled inspections, servicing, and replacements of components according to manufacturer recommendations or industry standards.

**2. Predictive Maintenance:** Utilizing data and monitoring systems to predict potential failures that is likely to occur.



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## Key Aspects of Maintenance of Energy Systems

**3. Preventive Maintenance:** Performing routine maintenance tasks at predetermined intervals, regardless of the current condition of the equipment.

**4. Corrective Maintenance:** Addressing issues as they arise through repairs or replacements of malfunctioning components.



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## Key Aspects of Maintenance of Energy Systems

**5. Safety Inspections:** Conducting regular safety inspections to identify hazards, ensure compliance with regulations, and mitigate risks associated with energy systems operation.

**6. Training and Education:** Providing training programs and resources for personnel responsible for operating and maintaining energy systems.



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## Key Aspects of Maintenance of Energy Systems

**7. Asset Management:** Implementing strategies for effective asset management, including inventory tracking, lifecycle analysis, and prioritization of maintenance activities based on criticality and cost-effectiveness.

**8. Performance Monitoring and Optimization:** Continuously monitoring system performance and efficiency to identify opportunities for optimization and energy conservation.



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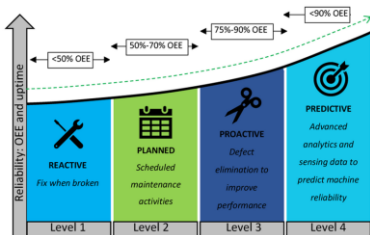
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## Maintenance of Energy Systems

**Advantages:**

- maintenance cost reduction
- repair stop reduction
- machine fault reduction
- spare-part life increases
- inventory reduction
- operator safety
- increased production
- repair verification
- increase in overall profit



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## Preventive Maintenance vs Predictive Maintenance

The difference between

### Preventive Maintenance

Scheduled maintenance action to prevent an unexpected breakdown or malfunction.

### Predictive Maintenance

Data-driven maintenance strategy used to foresee when equipment is likely to fail.



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## Computerized Maintenance Management System



CMMS are made to hold all your maintenance information:

- Work orders
- Preventive maintenance schedules
- Asset information
- Maintenance logs
- Work histories
- Parts inventory
- Vendors



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## Energy Management Significance

Maintaining energy systems is crucial for enhancing energy efficiency, performance, safety, and environmental sustainability. Proper maintenance not only reduces energy consumption and operational costs but also minimizes the likelihood of downtime due to unforeseen breakdowns.

The maintenance of energy systems is essential to optimize energy efficiency, prevent breakdowns, minimize downtime, and ensure safety.



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## Maintenance Program

A maintenance program, also known as a maintenance management program or maintenance plan, is a structured approach designed to ensure the ongoing reliability, safety, and performance of equipment, machinery, facilities, or infrastructure. The primary goal of a maintenance program is to minimize downtime, prevent failures, extend asset lifespan, and optimize maintenance costs.




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## Developing The Maintenance Program




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## Developing The Maintenance Program

**Create a Baseline**  
 If you want to carry out preventive maintenance effectively, you need to first create a baseline. This is a record of all the maintenance that has been carried out on your equipment and systems, and it provides a reference point for future work.

**Implement**  
 When it comes to your PM plan, consistency is key for accurate results. Document everything you do during each maintenance activity to track your progress and ensure that all PM tasks are being completed as scheduled.

**Assess**  
 The best way to assess your preventive maintenance is to look at the failure metrics for each asset. They provide a good indication of whether your plan is working.

**Improve**  
 Review your current PM schedule and make sure it makes sense for your specific operations. Stay up-to-date on new technology and trends in preventive maintenance.




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APPENDIX B  
Frequency of Maintenance Tests

ANSI/NETA MTS-2015

Inspections and Tests Frequency in Months (Multiply These Values by the Factor in the Maintenance Frequency Matrix)			
Section	Description	Visual	Visual & Mechanical & Electrical
7.1	Switchgear & Switchboard Assemblies	12	24
7.2	Transformers		
7.2.1.1	Small Dry-Type Transformers	2	36
7.2.1.2	Large Dry-Type Transformers	1	24
7.2.2	Liquid-Filled Transformers	1	24
	Sampling	-	12
7.18.1	AC Induction Motors and Generators	1	24
7.18.2	Synchronous Motors and Generators	1	24
7.18.3	DC Motors and Generators	1	24
7.22.2	Uninterruptible Power Systems	1	12
	Functional Testing	-	2
7.22.3	Automatic Transfer Switches	1	12
	Functional Testing	-	2

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Table 14.9 Table of preventive maintenance actions.

	Frequency
Chillers (Ref. 5)	Annually
1. Clean condenser and oil cooler	
2. Calibrate controls	
3. Check electrical connections	
4. Inspect valves and bearings	
Condensate return system	
1. Check valves, pumps, and lines	Annually
Cooling coils	
1. Brush and wash with soap	Quarterly or when needed
2. Clean drip pan drain	When needed
Compressors	
1. Check oil levels	Monthly
2. Check wiring	Annually
3. Visual check for leaks	Monthly
4. Log oil temperature and pressure	Monthly
5. Remove rust with wire brush	Annually
6. Replace all drive belts	Annually
Condensate	
1. Clean fan	Annually
2. Brush off coil	Monthly
Controls	
1. Calibrate thermostats	Semiannually (Ref. 4)
2. Get professional inspection of control system	According to equipment specifications
3. Check gauges to see that readings are in correct range	Monthly
4. Examine control tubing for leaks	Monthly

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Table 14.9 Table of preventive maintenance actions.

	Frequency
Blowers	Annually
1. Inspect belts for tension and alignment	
2. Inspect pulley wheels	
3. Inspect for dirt and grease	
Boilers (see Section 14.2.1)	
1. Check temperature and pressure	Daily
2. Clean tubes and other heating surfaces	As needed
3. Check water gauge glass	Daily
4. Remove scale	Annually
5. Perform flue-gas analysis	Monthly
6. Calibrate controls	Annually
Lights, inside	
1. Perform group relamping	See Chapter 13
2. Perform survey of lighting in actual use	Semiannually
3. Clean luminaires	Office area: every 6 months; laboratories: every 2 months; maintenance shops: every 6 months; heavy manufacturing areas: every 3 months; warehouses: every 12 months
4. Replace flickering lights	Immediately
Motors	
1. Lubricate bearings	When needed
2. Check alignment	Semiannually
3. Check mountings	Semiannually

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### Maintenance Tools to Use In Energy Management & Audit

- IRT Camera
- Vibration Analyzer
- Power Quality Analyzer
- Gas Leak Detector
- Lubricant (Oil) Analysis



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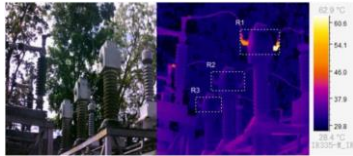
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### Thermal Inspection using IRT Camera on Electrical Infrastructure

*Thermal anomaly maybe caused by:*

- Sloppy connection
- Contact (dust)
- Faulty components
- Unbalanced load



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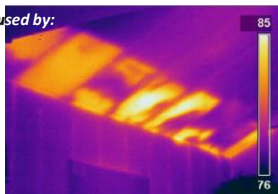
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### Thermal Inspection using IRT Camera on Building Envelope

*Thermal anomaly maybe caused by:*

- Poor insulation
- Damage insulation
- Missing insulation



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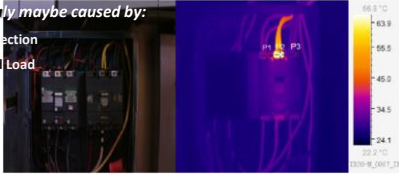
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## Thermal Inspection using IRT Camera on Electrical Eqpt. & Devices

Thermal anomaly may be caused by:

- Loose Connection
- Unbalanced Load



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## Maintenance of Lighting System

Lighting loss occur over time in:

- Quantity (lumen depreciation)
- Quality (color shift, visual stability) of illumination

Light loss factor	Maintenance activity
Lamp lumen depreciation (LLD)	Relamping
Lamp burnout	Relamping
Lumen dirt depreciation (LDD)	Luminaire cleaning
Room surface dirt depreciation (RSDD)	Room cleaning

"Recommended Practices for Lighting Maintenance" RP-36-15 (2015) Illuminating Engineering Society ies.org

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## Electrical System Maintenance



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## Chiller Maintenance



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## Air Compressor Maintenance



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## Analysis of Vibration using Vibration Analyzer

Measures the vibration characteristics of the equipment (typically spinning) in order to determine:

- Bearing and/or gears that have failed
- Inadequate alignment/balance
- Machine mounting that are loose

There are two primary diagnostic methods:

1. Signatures of vibration (snap-shot)
2. Trending (observations over time)



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## Lubricant (Oil) Analysis

Lubricant oil analysis is a crucial aspect of equipment maintenance across various industries to ensure the smooth operation and longevity of the equipment. Here's an overview of how it's typically conducted and its importance:

**Sampling:** The process begins with collecting samples of the lubricant oil from the equipment.

**Testing:** Once the oil samples are collected, they undergo various tests

**Interpretation:** The results of the oil analysis are interpreted by trained professionals

**Maintenance Recommendations:** This may include actions such as changing the oil, replacing filters, addressing component wear, adjusting lubrication schedules, or investigating potential sources of contamination.

**Preventive Maintenance:** Monitoring the condition of the oil, potential problems can be identified early, allowing for timely maintenance interventions to prevent costly downtime, repairs, and premature equipment failure.



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## Oil Analysis

Overall, lubricant oil analysis helps organizations optimize their maintenance practices, extend equipment lifespan, improve reliability, and reduce operational risks and costs. It enables informed decision-making and facilitates the implementation of effective maintenance strategies tailored to the specific needs of each piece of equipment.



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## Opportunities for Energy Savings through Maintenance Activities



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## Maintenance of Energy System

### Steam Leaks:

Steam leaks can often be detected by listening for a hissing sound. When the environment is too noisy to be able to detect leaks audibly, then an ultrasonic leak detector can be used. If the amount of steam leaking from a system (in pounds per hour) cannot be measured directly, it can be estimated using Grashof's formula:

$$\text{Steam Loss } \left(\frac{\text{lb}}{\text{h}}\right) = 0.70 \times 0.0165 \times 3600 \times A \times P^{0.97}$$




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## Maintenance of Energy System

### Steam Leaks:

In this equation 0.70 is a coefficient for hole shape, 0.0165 is a constant, 3600 is the number of seconds in an hour, A is the area of the hole in square inches, and P is the steam pressure in pounds per square inch. Once the steam loss has been calculated, the annual cost of the leak can be calculated using the following equation:

$$\text{Cost of Steam Leak } \left(\frac{\$}{\text{yr}}\right) = \text{Cost of Steam } \left(\frac{\$}{\text{Btu}}\right) \times \text{Steam Loss } \frac{\text{lb}}{\text{h}} \times \text{Enthalpy } \left(\frac{\text{Btu}}{\text{lb}}\right) \times \text{Operating Hours } \left(\frac{\text{h}}{\text{yr}}\right)$$




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## Maintenance of Energy System

### Boiler Water Treatment & Scale Deposit

Scale Thickness (mm)	Fuel Loss % of Total Use		
	Normal Scale	High Iron	Iron plus Silica
0.4	1	1.6	3.5
0.8	2	3.1	7
1.2	3	4.7	
1.6	3.9	6.2	

U.S. DOE Advanced Manufacturing Office Steam Tip Sheet #7  
[energy.gov/sites/prod/files/2014/05/16/steam7\\_surfaces.pdf](https://energy.gov/sites/prod/files/2014/05/16/steam7_surfaces.pdf)




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## Maintenance of Energy System

### Boiler Water Treatment & Scale Deposit

A boiler's tube have a scale thickness of 1.2mm (3/64 inches). If the boiler consumes 15GJ/hour and operates 2,500 hours per year, what are the annual savings if it is to clean the tubes and get the scale reduced to 0.4mm (1/64 inches). Assume, "normal scale" & fuel costs Php155/GJ.




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## Maintenance of Energy System

A boiler's tube have a scale thickness of 1.2mm (3/64 inches). If the boiler consumes 15GJ/hour and operates 2,500 hours per year, what are the annual savings if it is to clean the tubes and get the scale reduced to 0.4mm (1/64 inches). Assume, "normal scale" & fuel costs Php155/GJ.

Scale Thickness (mm)	Fuel Loss % of Total Use		
	Normal Scale	High Iron	Iron plus Sulfide
0.4	0	0.8	3.5
0.8	2	3.1	7
1.2	3	4.7	9
1.6	3.9	6.2	10

Answer:

Savings are approx. 3% - 1% = 2%

Annual Savings = (0.02)\*(15 GJ/hr)\*(2500 hr/year)\*(Php155/GJ)

**Annual Savings = Php116,250 / year**




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## Commissioning in New & Existing Building

**Commissioning** a systematic process that ensures building systems are documented, are properly installed and tested, and their operational performance is validated as meeting the intended original building design.

**ASHRAE Standard 202: Commissioning Process for Buildings and Systems.** Its purpose is to ensure the proper procedures, protocols, and documentation are used in the completion of all building and systems commissioning.




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## Commissioning in New & Existing Building

**Cost savings** are the primary benefit of building commissioning. Other benefits of proper building commissioning include the following:

1. Lower energy consumption
2. Improved environmental conditions
3. Better building operation and maintenance
4. Longer equipment life
5. Increased occupant satisfaction
6. Better system documentation




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## Types of Commissioning in New & Existing Building

### *Commissioning*

The process of ensuring the systems in a new building operate as intended is called commissioning. It is a systematic process to verify equipment is installed, tested, and operating as intended in the planning and design phase.

### *Re-commissioning*

The performance of buildings that were commissioned during the construction and handover phase will gradually decline as changes are made to meet new operational needs and equipment gets older.




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## Types of Commissioning in New & Existing Building

### *Retro-commissioning*

A commissioning process for existing buildings that were not commissioned when they were built and handed over to the occupants is called retro-commissioning.

### *Continuous commissioning (monitoring base Cx)*

Also called real-time commissioning, continuous commissioning is an ongoing process throughout the life of a building to make sure that all systems are operating optimally to meet current conditions rather than just the original design intent.




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## Phases, Participants & Documentation

### Planning phase

Commissioning should begin in the pre-design phase. A preliminary commissioning plan and budget are prepared at this stage.

### Design phase

A commissioning agent, who should ideally be an independent third-party contracted by the building owner, should lead the commissioning process.

### Construction phase

The commissioning team's goals during construction are to ensure the system requirements are met and the quality of the installation meets the necessary standards. Installation, start-up, functional tests, documentation, and operator training are carried out.

### Occupancy phase

The performance of systems gradually alters over time, and the needs of occupants can change, so the commissioning team will resolve any issues that arise, carry out seasonal testing and a post-occupancy review, and prepare a final commissioning report.



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## Key Points

- Proper maintenance should be systematically implemented to ensure the proper functioning, reliability, and longevity of energy & energy consuming systems.
- In addition to lowering energy usage and operating expenses brought on by equipment failure, preventive maintenance also lessens the chance of downtime, which boosts productivity and profitability.
- Commissioning plays a crucial role in delivering high-performance buildings that are energy-efficient, environmentally sustainable, and conducive to occupant health and well-being. It also benefits the building owners, occupants, and society as a whole by optimizing building performance and reducing environmental impact.



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# THANK YOU!



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