

# Transformer Tap Changer Case Study

ANALYZING PERFORMANCE AND APPLICATIONS OF TAP CHANGERS

# Transformer Voltage Challenges

# Transformer Overvoltage Issues

## Types of Overvoltage

Transformers face overvoltages from lightning surges, switching transients, harmonics, and system voltage fluctuations.

## Impact on Transformer Insulation

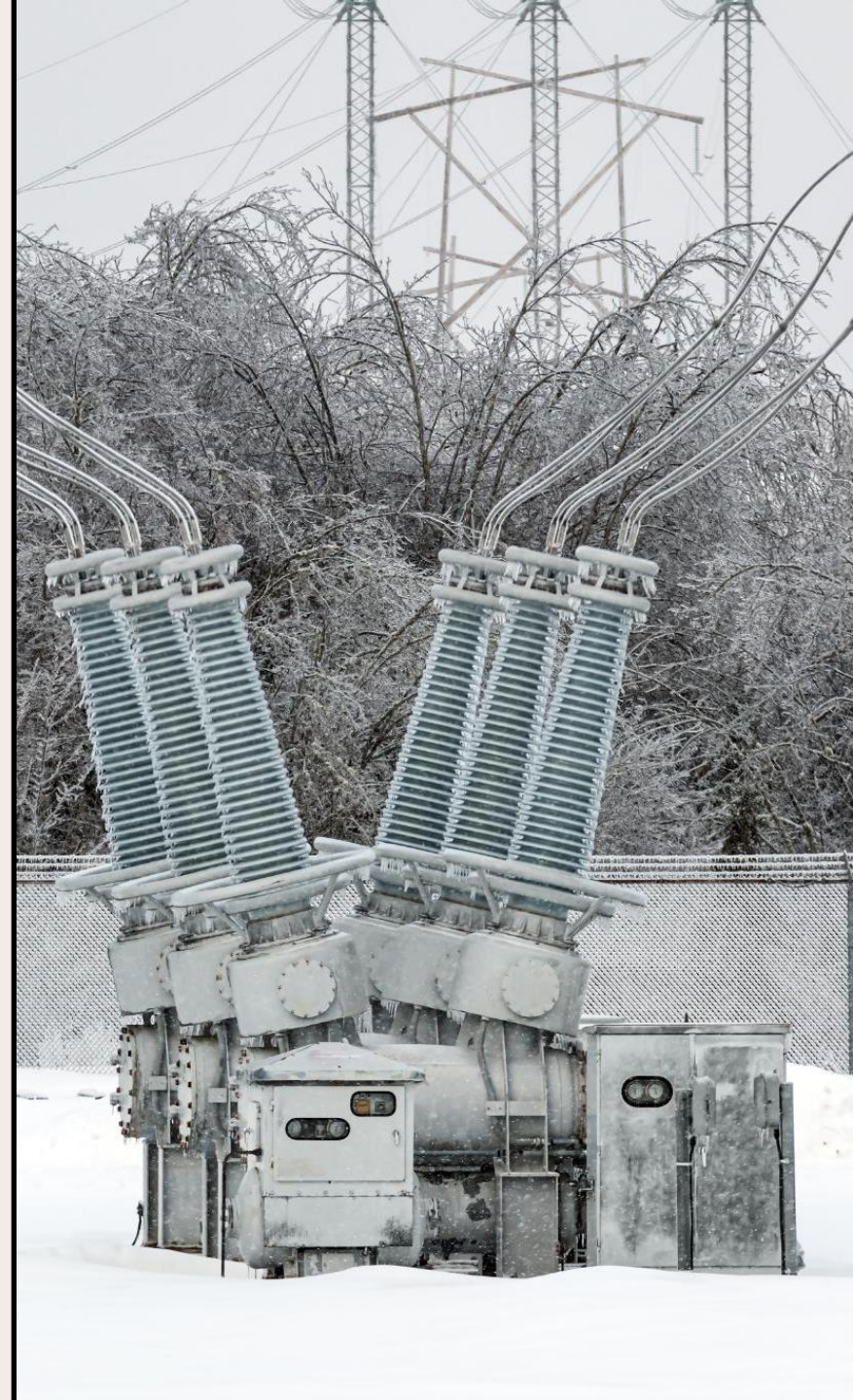
Overvoltage stresses insulation systems, accelerating thermal aging and increasing iron losses in the core.

## Consequences of Sustained Overvoltage

Prolonged overvoltage raises temperature, degrades insulation, shortens transformer life, and risks failure.

## Mitigation Strategies

Effective voltage regulation is critical to prevent overvoltage damage and ensure reliable transformer operation.



# Tap Changer Technology

# Purpose of Automatic Tap Changers

## Voltage Stabilization

Automatic tap changers adjust transformer turns ratio to stabilize voltage during load or input fluctuations.

## Continuous Operation

OLTCs operate while energized, ensuring uninterrupted power delivery during voltage adjustments.

## Real-Time Control

Sensors and controls detect voltage deviations and initiate tap changes instantly for grid reliability.

## Applications

Widely used in industries, substations, and renewable energy setups for dynamic voltage regulation.



# Benefits of OLTC

## Precise Voltage Regulation

OLTCs provide accurate voltage control, improving motor efficiency and minimizing reactive power penalties.

## Enhanced Grid Stability

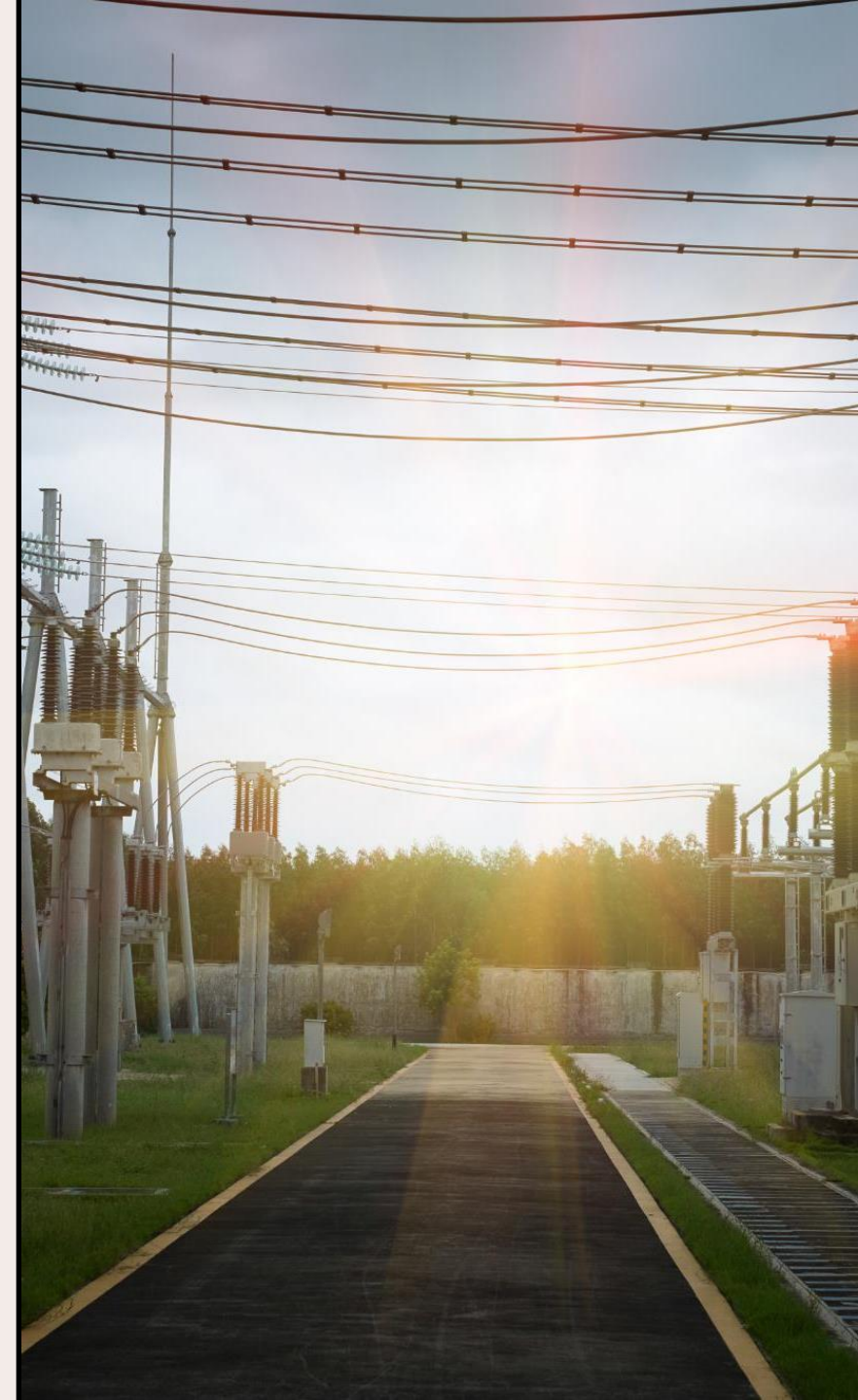
OLTCs prevent voltage sags and swells, reducing outage risks and enhancing grid reliability.

## Operational Flexibility

Dynamic voltage adjustment supports peak load management and integration of renewable energy sources.

## Reduced Transmission Losses

OLTCs decrease transmission losses and extend transformer and equipment lifespan.



# Financial Impact

# Cost Savings & ROI

## Energy Loss Reduction

OLTCs reduce energy losses by up to 39% through voltage optimization and Volt/VAR control integration.

## Conservation Voltage Reduction

CVR enabled by OLTCs lowers energy consumption by 2 to 4%, resulting in notable cost savings.

## Extended Maintenance & Cost Savings

Modern OLTC designs extend maintenance intervals from 3 to 7 years, cutting lifecycle costs by up to 40%.

## Financial Benefits & ROI

Industrial studies show payback under 12 months and NPV exceeding £2M–£5M over 10 years.



# Applications and Case Examples

# Real-World Applications

## Industrial Voltage Regulation

OLTC retrofits in manufacturing plants improve power quality and reduce energy costs for large motor loads.

## Utility Grid Management

Utilities deploy OLTCs to reduce voltage variability, manage peak demand, and support energy conservation.

## Renewable Energy Stability

OLTCs help maintain voltage stability in renewable installations despite fluctuating power generation.

## Enhanced Grid Resilience

Case studies show OLTC use improves equipment reliability, reduces maintenance, and strengthens grid resilience.



# Visual Analysis

# Energy Loss Reduction

| CATEGORY       | PERCENTAGE |
|----------------|------------|
| Base Losses    | 61%        |
| Loss Reduction | 39%        |

# ROI Over 10 Years

| YEAR    | CUMULATIVE SAVINGS (£) | INVESTMENT (£) |
|---------|------------------------|----------------|
| Year 1  | 300,000                | 240,000        |
| Year 2  | 600,000                | 240,000        |
| Year 3  | 900,000                | 240,000        |
| Year 4  | 1,200,000              | 240,000        |
| Year 5  | 1,500,000              | 240,000        |
| Year 6  | 1,800,000              | 240,000        |
| Year 7  | 2,100,000              | 240,000        |
| Year 8  | 2,400,000              | 240,000        |
| Year 9  | 2,700,000              | 240,000        |
| Year 10 | 3,000,000              | 240,000        |

# Conclusion

# Summary and Future Outlook



## Benefits of OLTCs

OLTCs ensure voltage stability, reduce energy losses, and extend transformer lifespan, improving overall power system efficiency.



## Operational and Financial Impact

Integration of OLTCs supports network resilience and sustainability while delivering rapid financial returns in industrial and utility sectors.



## Future Developments

Emerging AI-driven tap control and predictive maintenance will further enhance OLTC performance and value in evolving power grids.