

INEOS INsights

**For Industrial Electrolysis Applications,
When Should Electrodes Be Recoated?**

When Should Electrodes Be Recoated? A Practical Guide for Chlor-Alkali and Green Hydrogen Plant Operators



Fig 1: BICHLOR™ Electrolysers

Electrode coatings are the heart of industrial electrolysis. Whether producing chlorine and caustic soda in chlor-alkali plants or generating green hydrogen through water electrolysis, the electrocatalytic coating applied to an electrode directly influences energy consumption, production capacity, operating costs and plant reliability.

Over time, these coatings gradually degrade through electrochemical, mechanical and chemical mechanisms. The critical question for plant operators is not whether electrodes need recoating, but when.

Understanding the right timing for recoating can significantly reduce energy costs, avoid unplanned outages and maximise return on investment

Why Electrode Coatings Matter

Modern industrial electrolyzers use catalytic coatings based on precious metals and mixed metal oxides (MMO), and other catalytic materials. These coatings lower the overpotential required for electrochemical reactions and help maintain efficient operation over many years.

As coatings age, catalytic activity decreases, resulting in :

- Higher cell voltage
- Increased electricity consumption
- Reduced production efficiency
- Greater risk of coating failure
- Potential damage to underlying electrode substrates

Given that electricity typically represents 60 - 80% of operating costs in electrolysis, even small increases in cell voltage can have a significant economic impact.

Signs That Recoating Is Required

Increasing Cell Voltage

The most reliable indicator that electrode recoating is approaching is a sustained increase in cell voltage under normal operating conditions. As catalytic activity declines:

- Higher voltage is required to maintain the same current density
- Energy consumption rises proportionally
- Production economics deteriorate

For most industrial electrolyzers, coating degradation occurs gradually and can be tracked through routine operational data. However, at end of life, once a minimum loading is reached, (particularly with anodes), an exponential rise in overvoltage may be observed, making it especially important to recoat before this limit is reached.

Typical Rule of Thumb

Many operators begin evaluating recoating when cell voltage has increased by:

- 200 to 300 mV above baseline performance for chlor-alkali cells (in second membrane cycle)
- Similar voltage increases in alkaline water electrolyser systems

The precise threshold depends on electricity costs and plant economics, but waiting until severe voltage deterioration occurs often proves more expensive than undertaking timely and planned refurbishment.

Electrode Age Approaching Design Life

Most coated electrodes are supplied with an expected catalytic lifetime expressed as operating years. While operating conditions vary, typical lifetimes often range between:

Application	Typical recoating interval
Chlor-alkali anodes	8 to 10 years
Chlor-alkali cathodes	8 to 10 years
Alkaline water electrolysis (hydrogen) electrodes	8 to 10 years
Harsh operating environments	Shorter intervals

Actual performance depends heavily on:

- Current density
- Temperature
- Start-stop frequency
- Water quality
- Process upsets
- Mechanical handling

Plants should therefore treat design life as guidance rather than a fixed replacement schedule.

Rising Energy Consumption

Increasing power consumption frequently provides an earlier economic warning than voltage alone.

Consider an electrolyser operating continuously:

- A 200 mV increase across a large industrial cell can translate into substantial additional electricity costs over a year
- Across an entire electrolyser plant, this can amount to hundreds of thousands of pounds annually

In many cases, the cost of excess energy and CO₂ costs exceeds the cost of recoating long before the electrode reaches end-of-life.

Forward-looking operators therefore evaluate recoating based on energy economics rather than purely technical limits.

Failure To Meet Production Targets

Degraded electrodes can restrict plant output. Common symptoms include:

- Inability to achieve design current density
- Reduced hydrogen production rates
- Reduced chlorine production rates
- Increased process instability
- Hot spots within cells

When plants need to increase production but encounter electrical or voltage limitations, electrode condition should be investigated as a potential root cause.

Visible Coating Loss During Inspection

Periodic visual inspections can reveal clear signs of degradation. Warning indicators include:

- Discolouration
- Patchy coating appearance
- Exposed substrate material
- Localised wear patterns
- Mechanical damage
- Corrosion initiation points

By the time significant coating loss becomes visible, catalytic performance has often already deteriorated substantially.

Visual inspection should therefore complement, not replace, electrical performance monitoring.

Chlor-alkali Specific Considerations

For chlor-alkali operators, anode recoating is particularly important because chlorine evolution represents a highly demanding electrochemical environment. Operators should pay particular attention to:

Anode Wear

Dimensionally Stable Anodes (DSA's) gradually lose active catalyst over time, and are susceptible to alkali wear, strongly linked to membrane current efficiency and so it is critical to ensure operation within the design envelope of the electrolyser.

Key indicators include rising anode overpotential / increased cell voltage



Fig. 2: BICHLOR Electrolysers

Cathode Performance

Modern activated cathodes provide significant energy savings through reduced hydrogen evolution overpotential. As cathode coatings age, hydrogen overpotential increases / cell voltage rises / energy efficiency declines.

Performance decline of certain cathode coatings can be accelerated through frequent shutdowns if not appropriately mitigated; a topic to be covered in more detail in the next edition of INEOS INsights

Many plants find that cathode recoating projects deliver attractive payback periods through reduced power costs alone.

Water Electrolysis Considerations

Green hydrogen production introduces different operating challenges, many electrolyser systems experience:

- Frequent load cycling
- Variable renewable power input
- Increased start-stop operation

These conditions can accelerate coating deterioration compared with traditional baseload chlor-alkali service. Operators should therefore monitor:

- Stack voltage trends
- Individual cell performance
- Catalyst degradation rates
- Production efficiency metrics

Rather than relying solely on elapsed years, many hydrogen plants are increasingly adopting condition-based maintenance strategies.

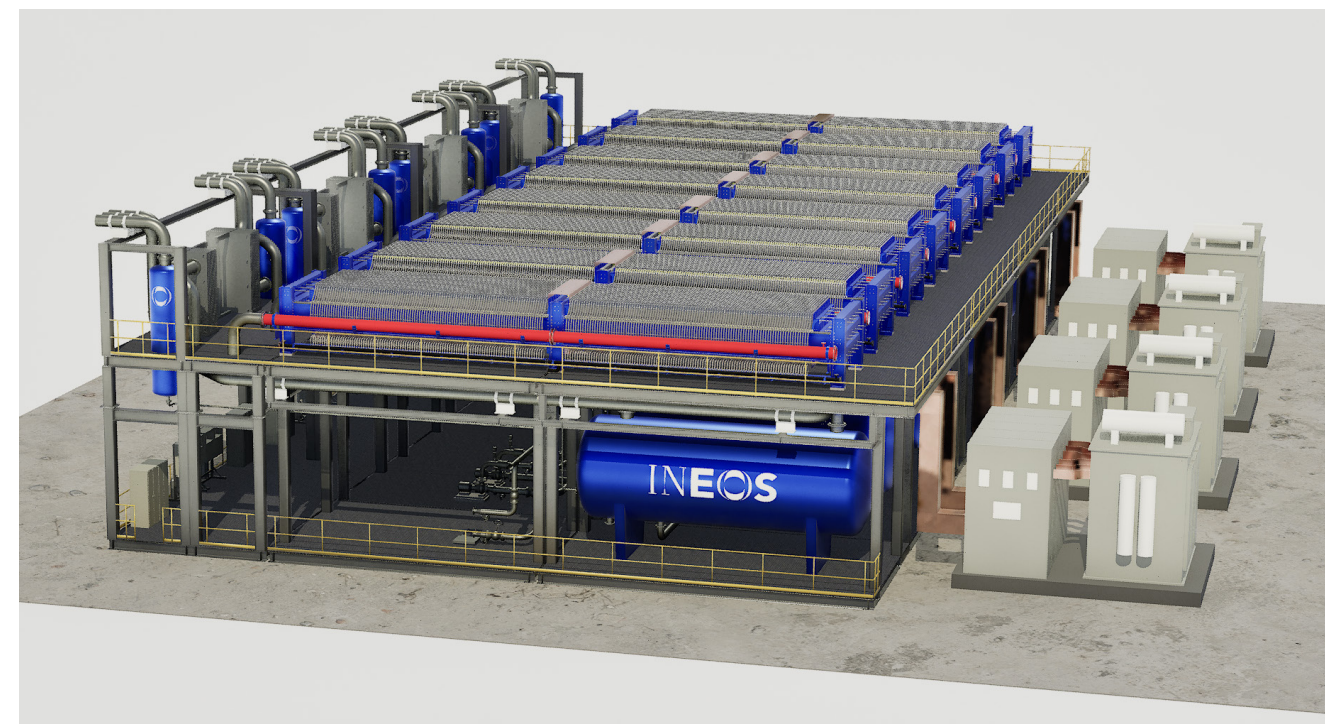


Fig. 3: Hydraeon™ Alkaline Water Electrolyser

Why Early Recoating Can be Economically Attractive

A common mistake is to delay recoating until electrodes are close to failure. In practice, the economic optimum often occurs much earlier.

Consider:

- Recoating restores original catalytic activity
- Energy consumption immediately decreases
- Production efficiency improves
- Asset life is extended
- Risk of unplanned outages is reduced

For plants facing high electricity and CO₂ prices, the energy savings generated after recoating can often justify the refurbishment investment within a relatively short period.

The question therefore becomes: “At what point does the additional electricity cost exceed the cost of recoating?”. For many operators, this is the most important calculation.

Best Practice: A Condition-Based Recoating Strategy

The most effective approach combines multiple indicators rather than relying on a single criterion.

A robust recoating strategy should include:

- Routine cell voltage monitoring
- Energy consumption trend analysis
- Periodic electrode inspections
- Performance benchmarking against original values
- Scheduled technical assessments by coating specialists
- Economic analysis comparing total cost of ownership versus refurbishment costs

This approach allows operators to maximise coating life while avoiding the significant costs associated with excessive degradation.

Case Study Example:

Using Electrode Recoating to Reduce Energy Costs and Restore Electrolyser Performance

A chlor-alkali producer operating membrane cell technology had been tracking a gradual increase in average cell voltage over several years. Although the electrolyser continued to operate reliably and production targets were being met, plant engineers identified a sustained voltage increase compared with start of life performance.

Visual inspection revealed no significant mechanical damage and the electrodes remained serviceable. Under a traditional time-based maintenance philosophy, recoating would likely have been deferred until a later scheduled outage.

Instead, the operator adopted a condition-based approach, reviewing:

- Historical cell voltage trends
- Power consumption data
- Operating hours
- Production rates
- Electrode coating age

Working with INEOS Electrochemical Solutions, the plant assessed the cost of ongoing energy losses against the cost of refurbishment. The analysis demonstrated that the additional electricity consumption associated with the increased cell voltage was significantly greater than the annualised cost of recoating.

A planned electrode refurbishment programme was subsequently implemented.

Results Achieved Included:

- Restoration of electrode performance close to original operating levels
- Lower electricity consumption across the electrolyser
- Improved operating margin during periods of high-power prices
- Extension of overall electrode asset life through refurbishment rather than replacement
- Turnaround time was minimised by using INEOS Exchange Module pool system structures

Most importantly, the project was undertaken during a planned outage, avoiding the operational disruptions and costs associated with unexpected premature electrode failure.

Key Takeaways

Electrodes should be recoated when performance degradation begins to create a measurable economic penalty, and not when catastrophic failure occurs. In fact, the most successful electrolysis operators treat electrode recoating as an optimisation exercise rather than a maintenance event.

In both chlor-alkali and green hydrogen electrolysis, the strongest indicators are:

1. Sustained increases in cell voltage
2. Rising electricity consumption
3. Approaching design coating life
4. Visible coating deterioration
5. Reduced production capability

By adopting a condition-based maintenance philosophy and monitoring electrode performance closely, operators can minimise energy costs, maximise production efficiency and extend the lifetime of their electrolyser assets.

Ultimately, the best time to recoat an electrode is usually several years before it fails, when the value of recovered efficiency exceeds the cost of refurbishment. This transforms electrode recoating from a maintenance expense into a strategic energy-saving investment.

Through electrode inspections, performance reviews and refurbishment expertise, INEOS Electrochemical Solutions helps operators make these decisions with confidence, ensuring that maintenance investments deliver the greatest possible return.



Fig. 4: BICHLOR Electrolysers

Who we are and how we help you

At INEOS Electrochemical Solutions, we understand chlor-alkali from an operator's point of view because we've spent many decades operating electrolyser plants of our own. As Europe's largest operator of electrolysis and first-hand experience of the challenges you face each day, we create state-of-the-art products designed with safety, low-power consumption and ease of maintenance in mind.

Supported by our robust, world-leading technology and our outstanding in-house expertise, you're able to maximise your operational uptime and cut overall life-cycle costs. And with direct access to our specialist teams whenever they're needed – and wherever you are in the world – you enjoy the outstanding service you deserve.

We're operators designing for operators – and we support customers like you for life.

Find out more

For more information about BICHLOR electrolyzers and CHLORCOAT coatings, visit our website at: www.ineos.com/electrochemical

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