



# Life Cycle Carbon Footprint of Distribution Power Poles

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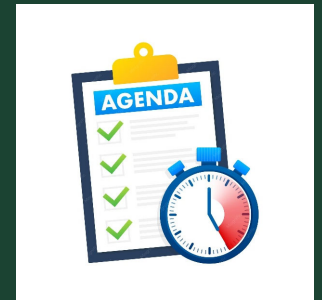
A Comprehensive Environmental Assessment

Based on EPRI/Battelle Environmental Impact Screening Tool

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# | Introduction & Purpose

This presentation examines the life cycle carbon footprint of distribution power poles using the Environmental Impact Screening Tool developed by Battelle for EPRI.

Key Objectives:

- Compare environmental impacts across wood, steel, concrete, and composite poles
- Identify carbon footprint hotspots across life cycle stages
- Provide a decision-making framework for utilities
- Evaluate 5 pole types using 16 environmental impact criteria

This is a screening-level assessment designed to guide material selection and inform sustainability strategies for electric utilities.



# | Pole Types Analyzed

**5 pole types** evaluated across 4 material categories:

Preservative-Treated Wood (Hardwood & Softwood):

- CCA (Chromated Copper Arsenate)

Untreated Natural Wood :

No longer used in New Zealand)

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Non-Wood Materials (3 types):

- Concrete
- Steel
- Fiberglass-Reinforced Composite (FRC)



# | Life Cycle Stages

The carbon footprint assessment covers five key life cycle stages:

## 1. Raw Material Acquisition

Harvesting timber, mining ore, quarrying aggregate, producing resin

## 2. Manufacturing & Processing

Sawing, treating, galvanizing, casting, pultrusion

## 3. Transportation & Installation

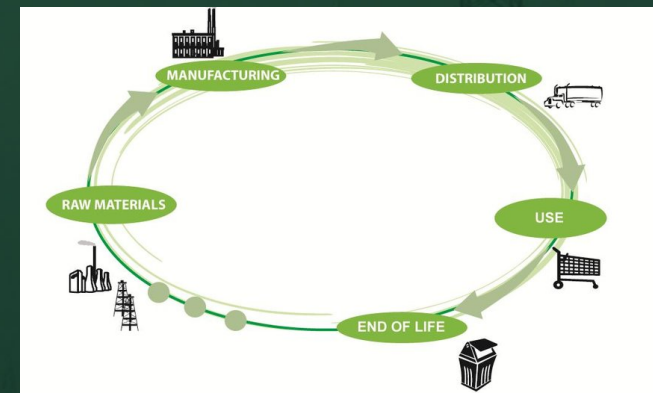
Shipping to site, equipment for installation

## 4. Use & Maintenance

Inspections, retreatment, repairs over service life

## 5. End-of-Life & Disposal

Landfill, incineration, recycling, reuse



# Methodology Overview

## Analytic Hierarchy Process (AHP)

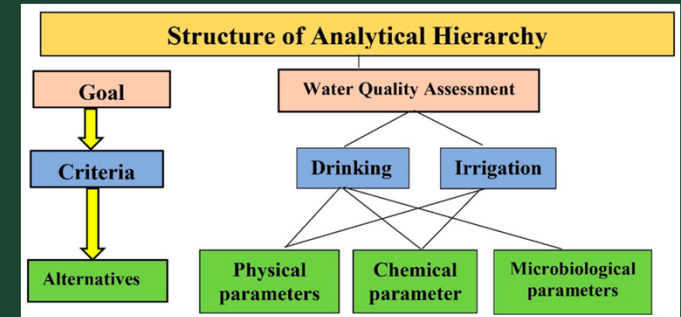
The screening tool uses a semi-quantitative scoring system:

- Each pole type scored on a **1-9 scale** for each of 16 criteria
- Scores weighted using AHP based on expert input
- Two weighting perspectives applied (Utility & Policy)
- Toxicity modifiers adjust scores for aquatic toxicity and carcinogenicity

### Data Sources:

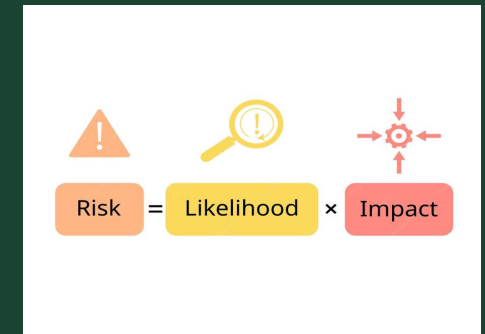
- EPA Toxics Release Inventory (TRI)
- Aerometric Information Retrieval System (AIRS)
- Published LCA literature
- Hazardous materials databases

Results are **comparative**, not absolute - designed to identify hotspots and rank alternatives.



# | 16 Impact Criteria

1. Acidification Potential
2. Aquatic Toxicity
3. Carcinogenicity
4. Energy Use (Embodied)
5. Global Warming Potential
6. Habitat Alteration
7. Human Health (Non-cancer)
8. Ozone Depletion
9. Recyclability
10. Recycled Content
11. Resource Depletion
12. Smog Formation
13. Solid Waste Generation
14. Terrestrial Toxicity
15. Water Use
16. Durability / Service Life



**Carbon-related criteria** (Energy Use, GWP, Resource Depletion) are central to this assessment and receive high weighting in both perspectives.

# | Weighting Perspectives

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## Electric Utility Perspective

Prioritizes:

- Durability and service life
- Downstream environmental impacts
- Maintenance requirements
- Total cost of ownership

Favors long-lived materials that minimize replacement cycles.

## National Policy Perspective

Prioritizes:

- Resource conservation
- Toxicity reduction
- Renewable material use
- Public health protection

Favors materials with lower toxicity and renewable sourcing.

These two perspectives can yield different rankings - demonstrating that material choice depends on stakeholder priorities.

# | Wood Poles: Treated

Four preservative treatments evaluated:

## **CCA (Chromated Copper Arsenate)**

- Contains arsenic and chromium - highest toxicity concerns
- Service life: 45-55 years
- Restricted for residential use since 2004

Used in New Zealand

## **Pentachlorophenol (Penta)**

- Petroleum-based preservative, potential dioxin contamination
- Service life: 45-55 years

Not used in New Zealand

## **Copper Naphthenate (CuNap)**

- Lower toxicity profile than CCA/Penta
- Service life: 40-50 years

Not used in New Zealand

## **ACQ (Alkaline Copper Quaternary)**

- Lowest toxicity among treated options
- Lower ammonia emissions
- Service life: 40-50 years

Not used in New Zealand



# | Wood Poles: Natural (Untreated)

Naturally durable Australian & Tropical hardwoods:  
New Zealand utility poles are now all CCA treated

## **Advantages:**

- No chemical treatment required - zero preservative toxicity
- Low manufacturing energy (no treatment process)
- Renewable resource base
- Minimal habitat impact from harvesting

## **Disadvantages:**

- Very short service life: maybe less than 7 years in some climates
- Limited geographic availability (sub-tropical regions)
- Slow growth rates limit sustainable supply
- High transportation carbon due to distant sourcing

Low toxicity scores but impractical for widespread deployment due to durability limitations.



# Steel Poles

## Carbon Footprint Profile:

### Manufacturing Phase (Highest Impact):

- High embodied energy from steel production
- Significant CO2 emissions from smelting and galvanizing
- Hot-dip galvanization adds energy demand

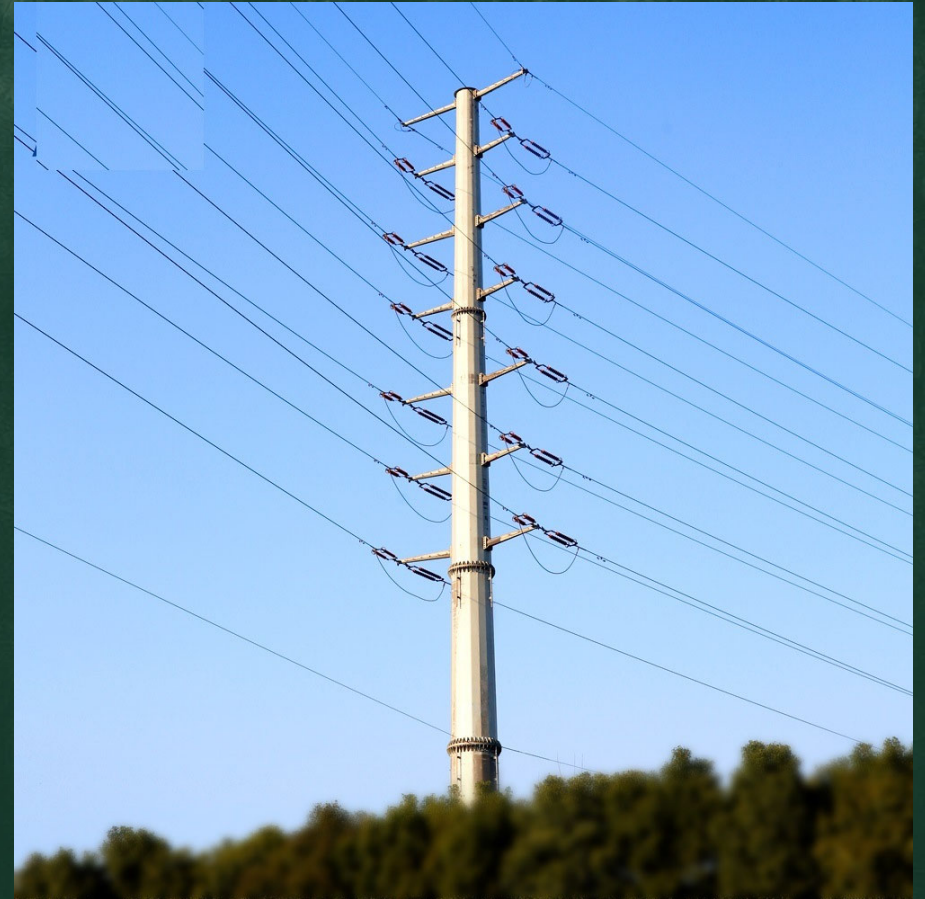
### Use Phase:

- Service life: 80+ years (longest among all types)
- Minimal maintenance requirements
- No chemical retreatment needed

### End-of-Life (Strongest Advantage):

- Highest recyclability of all pole types
- Highest recycled content potential
- Established recycling infrastructure
- Significant carbon credit from avoided virgin production

High upfront carbon offset by longevity and recyclability.



# | Concrete Poles

## Carbon Footprint Profile:

### Manufacturing Phase:

- Cement production is highly carbon-intensive (calcination + kiln energy)
- Heavy aggregate and water use
- Steel reinforcement adds embodied carbon

### Use Phase:

- Service life: 80+ years
- Excellent durability in harsh environments
- No chemical leaching concerns
- Minimal maintenance

### End-of-Life:

- Moderate recyclability (crushed for aggregate)
- Heavy weight increases transportation emissions
- Steel rebar can be recovered and recycled

High manufacturing carbon but excellent durability reduces per-year impact.



# Composite (FRC) Poles

## Fiberglass-Reinforced Composite

### Manufacturing Phase:

- Petroleum-based resins (polyester/vinyl ester)
- Energy-intensive pultrusion process
- Fiberglass production requires high temperatures

### Use Phase:

- Excellent corrosion and rot resistance
- Lightweight - lower transportation emissions
- No chemical leaching
- Good durability in coastal/wet environments

### End-of-Life:

- Moderate recyclability
- Thermoset resins difficult to reprocess
- Emerging mechanical recycling options
- Non-toxic in landfill

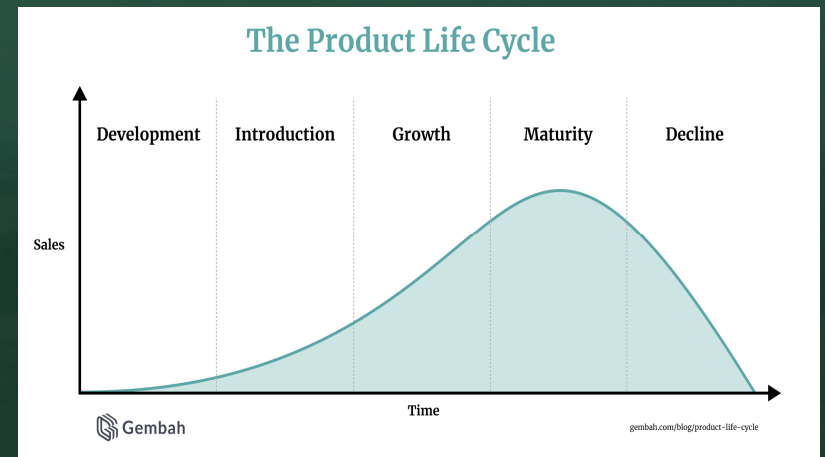
Newer technology with growing market share; carbon profile improving with manufacturing advances.



## | Service Life Comparison

Service life is a critical factor in annualized carbon footprint:

Steel Poles:	80+ years
Concrete Poles:	80+ years
CCA-Treated Wood:	45-55 years
Composite (FRC):	50-80 years
Untreated Natural SoftWood:	Less than 7 years



Longer service life dramatically reduces per-year carbon impact, even when manufacturing emissions are higher. A pole lasting 80 years has half the annualized footprint of one lasting 40 years

# | Energy Use & Global Warming Potential

## Embodied Energy (Manufacturing):

- Steel: Highest embodied energy due to smelting and galvanizing
- Concrete: High energy from cement calcination and kiln operation
- FRC: Moderate-high from resin production and pultrusion
- Treated Wood: Lowest - primarily sawing and chemical treatment
- Natural Wood: Minimal - harvesting and transport only

## Global Warming Potential (CO2 equivalent):

- Steel production: ~1.8 tonnes CO2e per tonne of steel
- Cement production: ~0.9 tonnes CO2e per tonne of cement
- Wood poles store carbon during service life (biogenic carbon)
- End-of-life treatment significantly affects net GWP



When annualized over service life, the gap between materials narrows considerably.

# Recyclability & End-of-Life

## Steel (Highest Recyclability):

- Fully recyclable with established infrastructure
- Highest recycled content of any pole material
- Significant carbon credit from avoided virgin production

## Concrete (Moderate):

- Can be crushed for road base aggregate
- Steel rebar recovered and recycled
- Heavy weight increases disposal transportation emissions

## Composite FRC (Moderate):

- Thermoset resins difficult to reprocess
- Emerging mechanical recycling technologies
- Non-toxic in landfill disposal

## Treated Wood (Limited):

- Limited recycling infrastructure
- Chemical leaching risks in landfills
- Some energy recovery through controlled incineration (unable to confirm any incinerators in New Zealand)
- Toxic material mobility concerns at end-of-life



# | Toxicity Considerations

Toxicity impacts are assessed through aquatic toxicity, carcinogenicity, and human health criteria:

## Highest Concern:

- CCA: arsenic and chromium - known carcinogens

## Moderate Concern:

- CuNap: copper compounds in aquatic environments
- ACQ: lower toxicity but still contains copper

## Lowest Concern:

- Steel, Concrete, FRC: no chemical leaching during use
- Natural woods: no preservative chemicals



Chemical persistence and mobility in soil/water are key differentiators. Toxicity modifiers in the scoring system adjust rankings based on NOAEL, PEL, and NAAQS standards.

# Comparative Results

## Key Findings from the Screening Assessment:

### Wood Poles:

- Lower manufacturing energy and renewable resource base
- Shorter lifespan increases replacement frequency and cumulative impact
- Toxicity from preservatives is a significant differentiator

### Steel & Concrete Poles:

- Higher manufacturing emissions but longest service life
- Superior recyclability offsets upfront carbon
- Zero chemical leaching during use phase

### Natural Tropical Woods: (not utilized in New Zealand)

- Lowest toxicity scores but impractical due to very short service life



# Recommendations

Based on the screening assessment findings:

## 1. Prioritize Annualized Carbon Metrics

- Evaluate poles on carbon per year of service, not just manufacturing emissions
- Longer-lived materials often have lower lifetime carbon intensity

## 2. Consider Full Life Cycle

- Include end-of-life recycling credits in carbon calculations
- Account for replacement cycles and cumulative impacts

## 3. Transition Away from High-Toxicity Treatments

- Consider steel or concrete for long-service applications

## 4. Invest in Detailed LCAs (Life Cycle Assessment)

- This screening tool identifies hotspots - full LCAs needed for precise quantification
- Region-specific data will improve accuracy

## 5. Develop Recycling Infrastructure

- Expand treated wood recycling programs
- Maximize steel recovery at end-of-life



## Conclusion & Next Steps

The life cycle carbon footprint of distribution poles varies significantly by material. No single option is universally superior - the optimal choice depends on utility priorities, regional context, and stakeholder values.

**Key Takeaway:** Steel and concrete poles offer the lowest annualized carbon footprint due to exceptional longevity and recyclability, despite higher manufacturing emissions.

Further detailed LCA studies are recommended to quantify absolute carbon values for specific utility contexts.

Credit to: Environmental Profile of Utility Distribution Poles: EPRI – December 6, 2006

Questions

