e_waste_update

October 19, 2025

1 Import Libraries

[2]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from matplotlib import style

# Set up plotting style
plt.style.use('default')
sns.set_palette("husl")
```

2 Load Dataset

[3]:
```
# Load the data
df = pd.read_csv('e_waste.csv')
```

3 Display basic information about the dataset

[4]:
```
print("Dataset Overview:")
print(f"Shape: {df.shape}")
print(f"Years covered: {df['Year'].min()} to {df['Year'].max()}")
print(f"Number of states: {df['State'].nunique()}")
print("\nColumns:", df.columns.tolist())
print("\nFirst few rows:")
print(df.head())

print("\n" + "="*80 + "\n")
```

```
Dataset Overview:
Shape: (500, 11)
Years covered: 2015 to 2024
Number of states: 50

Columns: ['Year', 'State', 'E_Waste_Generated_Lbs', 'E_Waste_Recycled_Lbs',
'Recycling_Rate_%', 'Gold_Recovered_grams', 'Copper_Recovered_kg',
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```
'Silver_Recovered_grams', 'CO2_Saved_kg', 'Revenue_Generated_USD',
'Source_Notes']

First few rows:
   Year       State  E_Waste_Generated_Lbs  E_Waste_Recycled_Lbs  \
0  2015     Alabama             74912000.0            26219200.0
1  2015      Alaska             10347414.0             3621595.0
2  2015     Arizona            116519422.0            40781798.0
3  2015    Arkansas             44025469.0            15408914.0
4  2015  California            552981587.0           193543555.0

   Recycling_Rate_%  Gold_Recovered_grams  Copper_Recovered_kg  \
0              35.0               4588.36             10487.68
1              35.0                633.78              1448.64
2              35.0               7136.81             16312.72
3              35.0               2696.56              6163.57
4              35.0              33870.12             77417.42

   Silver_Recovered_grams  CO2_Saved_kg  Revenue_Generated_USD  \
0                 1573.15     7079184.0              1442056.0
1                  217.30      977831.0               199188.0
2                 2446.91    11011085.0              2242999.0
3                  924.53     4160407.0               847490.0
4                11612.61    52256760.0             10644896.0

                                        Source_Notes
0  Modeled from EPA-style national trend + 2020 C…
1  Modeled from EPA-style national trend + 2020 C…
2  Modeled from EPA-style national trend + 2020 C…
3  Modeled from EPA-style national trend + 2020 C…
4  Modeled from EPA-style national trend + 2020 C…

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4 NATIONAL TREND ANALYSIS

[9]:
```python
print("1. NATIONAL TREND ANALYSIS (2015-2024)")

# Calculate national totals by year
national_totals = df.groupby('Year').agg({
    'E_Waste_Generated_Lbs': 'sum',
    'E_Waste_Recycled_Lbs': 'sum',
    'Gold_Recovered_grams': 'sum',
    'Copper_Recovered_kg': 'sum',
    'Silver_Recovered_grams': 'sum',
    'CO2_Saved_kg': 'sum',
```

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    'Revenue_Generated_USD': 'sum'
}).reset_index()

# Calculate national recycling rate (CORRECTED COLUMN NAME)
national_totals['National_Recycling_Rate_%'] =
 ↪(national_totals['E_Waste_Recycled_Lbs'] /
 ↪national_totals['E_Waste_Generated_Lbs']) * 100

print("National Progress Over Time:")
for year in [2015, 2020, 2024]:
    data = national_totals[national_totals['Year'] == year].iloc[0]
    print(f"\n{year}:")
    print(f"  Recycling Rate: {data['National_Recycling_Rate_%']:.1f}%")
    print(f"  E-Waste Generated: {data['E_Waste_Generated_Lbs']/1e9:.2f}
 ↪billion lbs")
    print(f"  E-Waste Recycled: {data['E_Waste_Recycled_Lbs']/1e9:.2f} billion
 ↪lbs")
    print(f"  Revenue: ${data['Revenue_Generated_USD']/1e9:.2f} billion")
    print(f"  CO2 Saved: {data['CO2_Saved_kg']/1e9:.2f} million metric tons")

print("\n" + "="*80 + "\n")

# 2. ECONOMIC ANALYSIS
print("2. ECONOMIC IMPACT ANALYSIS")

# Convert weights to more meaningful units
national_totals['Gold_Recovered_kg'] = national_totals['Gold_Recovered_grams'] /
 ↪ 1000
national_totals['Silver_Recovered_kg'] =
 ↪national_totals['Silver_Recovered_grams'] / 1000

# Calculate cumulative benefits
cumulative_benefits = national_totals[['Revenue_Generated_USD',
 ↪'CO2_Saved_kg']].sum()
cumulative_metal_recovery = national_totals[['Gold_Recovered_kg',
 ↪'Copper_Recovered_kg', 'Silver_Recovered_kg']].sum()

print("\nCumulative Benefits (2015-2024):")
print(f"Total Revenue Generated: ${cumulative_benefits['Revenue_Generated_USD']/
 ↪1e9:.2f} Billion")
print(f"Total CO2 Savings: {cumulative_benefits['CO2_Saved_kg']/1e9:.1f}
 ↪Million Metric Tons")

print("\nTotal Metal Recovery (2015-2024):")
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print(f"Gold: {cumulative_metal_recovery['Gold_Recovered_kg']:,.0f} kg (${cumulative_metal_recovery['Gold_Recovered_kg']*60000/1e6:.1f}M at $60k/kg)")
print(f"Copper: {cumulative_metal_recovery['Copper_Recovered_kg']/1e6:.1f} million kg (${cumulative_metal_recovery['Copper_Recovered_kg']*8/1e6:.1f}M at $8/kg)")
print(f"Silver: {cumulative_metal_recovery['Silver_Recovered_kg']:,.0f} kg (${cumulative_metal_recovery['Silver_Recovered_kg']*800/1e6:.1f}M at $800/kg)")

print("\n" + "="*80 + "\n")

# 3. ENVIRONMENTAL IMPACT ANALYSIS
print("3. ENVIRONMENTAL IMPACT ANALYSIS")

# Calculate environmental metrics
latest_year = df[df['Year'] == 2024]
total_co2_2024 = latest_year['CO2_Saved_kg'].sum()
total_waste_recycled_2024 = latest_year['E_Waste_Recycled_Lbs'].sum()

# Equivalent environmental benefits
cars_off_road = total_co2_2024 / (4200 * 1000)  # Average car emits 4.2 metric tons CO2/year
homes_powered = total_co2_2024 / (8000 * 1000)  # Average home emits 8 metric tons CO2/year

print(f"2024 Environmental Impact:")
print(f"CO2 Savings: {total_co2_2024/1e9:.2f} million metric tons")
print(f"Equivalent to taking {cars_off_road:,.0f} cars off the road for one year")
print(f"Equivalent to emissions from {homes_powered:,.0f} homes for one year")
print(f"E-Waste Diverted from Landfills: {total_waste_recycled_2024/1e9:.2f} billion pounds")

print("\n" + "="*80 + "\n")

# 4. STATE-LEVEL PERFORMANCE ANALYSIS
print("4. TOP PERFORMING STATES ANALYSIS (2024)")

# State performance in 2024
state_performance_2024 = latest_year.nlargest(10, 'E_Waste_Recycled_Lbs')[['State', 'E_Waste_Generated_Lbs', 'E_Waste_Recycled_Lbs', 'Recycling_Rate_%', 'Revenue_Generated_USD', 'CO2_Saved_kg']]

print("Top 10 States by E-Waste Recycled (2024):")
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for _, row in state_performance_2024.iterrows():
    print(f"{row['State']}: {row['E_Waste_Recycled_Lbs']/1e6:.1f}M lbs, Rate:␣
↪{row['Recycling_Rate_%']}%, Revenue: ${row['Revenue_Generated_USD']/1e6:.
↪1f}M")

# States with highest recycling rates
high_performers = latest_year.nlargest(5, 'Recycling_Rate_%')[['State',␣
↪'Recycling_Rate_%', 'E_Waste_Recycled_Lbs']]
print(f"\nStates with Highest Recycling Rates (2024):")
for _, row in high_performers.iterrows():
    print(f"{row['State']}: {row['Recycling_Rate_%']}%")

print("\n" + "="*80 + "\n")

# 5. GROWTH ANALYSIS - CORRECTED VERSION
print("5. GROWTH AND TREND ANALYSIS")

# Calculate growth rates
initial_2015 = national_totals[national_totals['Year'] == 2015].iloc[0]
final_2024 = national_totals[national_totals['Year'] == 2024].iloc[0]

# CORRECTED: Using the right column name 'National_Recycling_Rate_%'
growth_metrics = {
    'Recycling_Rate': (final_2024['National_Recycling_Rate_%'] -␣
↪initial_2015['National_Recycling_Rate_%']) /␣
↪initial_2015['National_Recycling_Rate_%'] * 100,
    'Revenue': (final_2024['Revenue_Generated_USD'] -␣
↪initial_2015['Revenue_Generated_USD']) /␣
↪initial_2015['Revenue_Generated_USD'] * 100,
    'CO2_Savings': (final_2024['CO2_Saved_kg'] - initial_2015['CO2_Saved_kg']) /
↪ initial_2015['CO2_Saved_kg'] * 100,
    'E_Waste_Recycled': (final_2024['E_Waste_Recycled_Lbs'] -␣
↪initial_2015['E_Waste_Recycled_Lbs']) / initial_2015['E_Waste_Recycled_Lbs']␣
↪* 100
}

print("Growth from 2015 to 2024:")
for metric, growth in growth_metrics.items():
    print(f"{metric}: {growth:+.1f}%")

print("\n" + "="*80 + "\n")
```

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1. NATIONAL TREND ANALYSIS (2015-2024)
National Progress Over Time:

2015:
  Recycling Rate: 35.0%
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E-Waste Generated: 4.93 billion lbs
E-Waste Recycled: 1.72 billion lbs
Revenue: $0.09 billion
CO2 Saved: 0.47 million metric tons

2020:
Recycling Rate: 46.1%
E-Waste Generated: 5.47 billion lbs
E-Waste Recycled: 2.52 billion lbs
Revenue: $0.14 billion
CO2 Saved: 0.68 million metric tons

2024:
Recycling Rate: 55.0%
E-Waste Generated: 5.91 billion lbs
E-Waste Recycled: 3.25 billion lbs
Revenue: $0.18 billion
CO2 Saved: 0.88 million metric tons

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2. ECONOMIC IMPACT ANALYSIS

Cumulative Benefits (2015-2024):
Total Revenue Generated: $1.35 Billion
Total CO2 Savings: 6.6 Million Metric Tons

Total Metal Recovery (2015-2024):
Gold: 4,301 kg ($258.1M at $60k/kg)
Copper: 9.8 million kg ($78.7M at $8/kg)
Silver: 1,475 kg ($1.2M at $800/kg)

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3. ENVIRONMENTAL IMPACT ANALYSIS
2024 Environmental Impact:
CO2 Savings: 0.88 million metric tons
Equivalent to taking 209 cars off the road for one year
Equivalent to emissions from 110 homes for one year
E-Waste Diverted from Landfills: 3.25 billion pounds

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4. TOP PERFORMING STATES ANALYSIS (2024)
Top 10 States by E-Waste Recycled (2024):
California: 365.0M lbs, Rate: 55.0%, Revenue: $20.1M
Texas: 289.8M lbs, Rate: 55.0%, Revenue: $15.9M
Florida: 217.6M lbs, Rate: 55.0%, Revenue: $12.0M

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New York: 198.2M lbs, Rate: 55.0%, Revenue: $10.9M
Pennsylvania: 134.8M lbs, Rate: 55.0%, Revenue: $7.4M
Ohio: 126.7M lbs, Rate: 55.0%, Revenue: $7.0M
Illinois: 122.9M lbs, Rate: 55.0%, Revenue: $6.8M
Georgia: 101.1M lbs, Rate: 55.0%, Revenue: $5.6M
New Jersey: 98.0M lbs, Rate: 55.0%, Revenue: $5.4M
North Carolina: 96.8M lbs, Rate: 55.0%, Revenue: $5.3M

States with Highest Recycling Rates (2024):
Alabama: 55.0%
Alaska: 55.0%
Arizona: 55.0%
Arkansas: 55.0%
California: 55.0%

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5. GROWTH AND TREND ANALYSIS
Growth from 2015 to 2024:
Recycling_Rate: +57.1%
Revenue: +88.6%
CO2_Savings: +88.6%
E_Waste_Recycled: +88.6%

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5 VISUALIZATION

[12]:
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print(" VISUALIZATIONS")

# Create subplots
fig, axes = plt.subplots(2, 3, figsize=(18, 12))
fig.suptitle('ReBin Tech: E-Waste Recycling Economic and Environmental Impact␣
 ↪Analysis', fontsize=16, fontweight='bold')

# Plot 1: Recycling Rate Trend
axes[0,0].plot(national_totals['Year'],␣
 ↪national_totals['National_Recycling_Rate_%'], marker='o', linewidth=2,␣
 ↪markersize=8)
axes[0,0].set_title('National Recycling Rate Trend', fontweight='bold')
axes[0,0].set_xlabel('Year')
axes[0,0].set_ylabel('Recycling Rate (%)')
axes[0,0].grid(True, alpha=0.3)

# Plot 2: Revenue Growth
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axes[0,1].plot(national_totals['Year'],
    national_totals['Revenue_Generated_USD']/1e9, marker='s', color='green',
    linewidth=2, markersize=8)
axes[0,1].set_title('Annual Revenue from E-Waste Recycling', fontweight='bold')
axes[0,1].set_xlabel('Year')
axes[0,1].set_ylabel('Revenue (Billions USD)')
axes[0,1].grid(True, alpha=0.3)

# Plot 3: CO2 Savings
axes[0,2].plot(national_totals['Year'], national_totals['CO2_Saved_kg']/1e9,
    marker='^', color='red', linewidth=2, markersize=8)
axes[0,2].set_title('Annual CO2 Emission Reductions', fontweight='bold')
axes[0,2].set_xlabel('Year')
axes[0,2].set_ylabel('CO2 Saved (Million Metric Tons)')
axes[0,2].grid(True, alpha=0.3)

# Plot 4: Metal Recovery
years = national_totals['Year']
width = 0.25
x = range(len(years))
axes[1,0].bar([i - width for i in x], national_totals['Gold_Recovered_kg']/
    1000, width, label='Gold (kg)', alpha=0.8)
axes[1,0].bar(x, national_totals['Copper_Recovered_kg']/1000, width,
    label='Copper (metric tons)', alpha=0.8)
axes[1,0].bar([i + width for i in x], national_totals['Silver_Recovered_kg']/
    1000, width, label='Silver (kg)', alpha=0.8)
axes[1,0].set_title('Precious Metal Recovery', fontweight='bold')
axes[1,0].set_xlabel('Year')
axes[1,0].set_ylabel('Quantity Recovered')
axes[1,0].set_xticks(x)
axes[1,0].set_xticklabels(years)
axes[1,0].legend()
axes[1,0].grid(True, alpha=0.3)

# Plot 5: Top States by Recycling (2024)
top_states = latest_year.nlargest(8, 'E_Waste_Recycled_Lbs')
axes[1,1].barh(top_states['State'], top_states['E_Waste_Recycled_Lbs']/1e6,
    color='teal', alpha=0.7)
axes[1,1].set_title('Top States: E-Waste Recycled (2024)', fontweight='bold')
axes[1,1].set_xlabel('Million Pounds')
for i, v in enumerate(top_states['E_Waste_Recycled_Lbs']/1e6):
    axes[1,1].text(v + 10, i, f'{v:.0f}M', va='center')

# Plot 6: Economic vs Environmental Benefit Correlation
axes[1,2].scatter(latest_year['Revenue_Generated_USD']/1e6,
    latest_year['CO2_Saved_kg']/1e6, alpha=0.6, s=60)
```
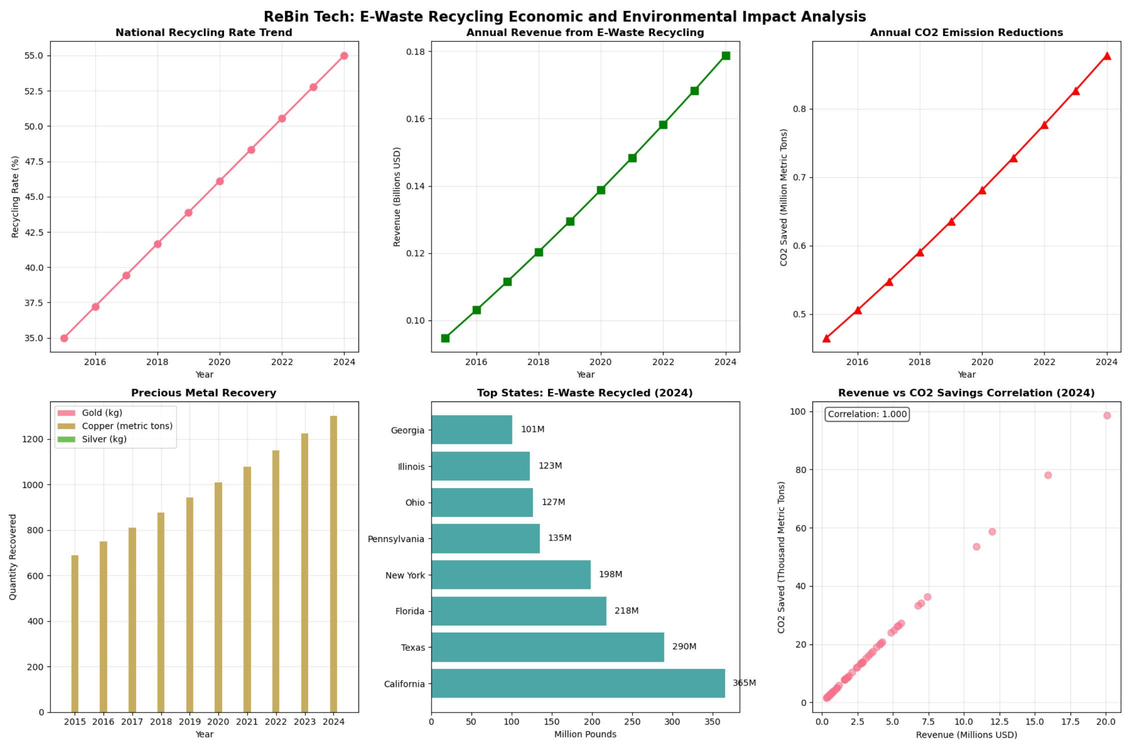

```python
axes[1,2].set_title('Revenue vs CO2 Savings Correlation (2024)',␣
↪fontweight='bold')
axes[1,2].set_xlabel('Revenue (Millions USD)')
axes[1,2].set_ylabel('CO2 Saved (Thousand Metric Tons)')
axes[1,2].grid(True, alpha=0.3)

# Add correlation coefficient
correlation = latest_year['Revenue_Generated_USD'].
↪corr(latest_year['CO2_Saved_kg'])
axes[1,2].text(0.05, 0.95, f'Correlation: {correlation:.3f}',␣
↪transform=axes[1,2].transAxes,
               bbox=dict(boxstyle="round,pad=0.3", facecolor="white", alpha=0.8))

plt.tight_layout()
plt.show()
```

VISUALIZATIONS



6 KEY INSIGHTS SUMMARY

[13]:
```
print("\n" + "="*80)
print("KEY INSIGHTS SUMMARY")
print("="*80)

print("\n ECONOMIC IMPACTS:")
print(f"• Revenue growth: {growth_metrics['Revenue']:+.1f}% (2015-2024)")
print(f"• 2024 projected revenue: ${final_2024['Revenue_Generated_USD']/1e9:.
 ↪2f}B")
print(f"• Cumulative revenue (2015-2024):␣
 ↪${cumulative_benefits['Revenue_Generated_USD']/1e9:.2f}B")
print(f"• Valuable metals recovered annually worth hundreds of millions")

print("\n ENVIRONMENTAL ACHIEVEMENTS:")
print(f"• Recycling rate improved from␣
 ↪{initial_2015['National_Recycling_Rate_%']:.1f}% to␣
 ↪{final_2024['National_Recycling_Rate_%']:.1f}%")
print(f"• 2024 CO2 reduction: {total_co2_2024/1e9:.2f} million metric tons")
print(f"• Equivalent to removing {cars_off_road:,.0f} cars from roads annually")
print(f"• Cumulative CO2 savings (2015-2024):␣
 ↪{cumulative_benefits['CO2_Saved_kg']/1e9:.1f} million metric tons")

print("\n PERFORMANCE HIGHLIGHTS:")
print(f"• California leads with␣
 ↪{latest_year[latest_year['State']=='California']['E_Waste_Recycled_Lbs'].
 ↪iloc[0]/1e6:.1f}M lbs recycled in 2024")
print(f"• Top 5 states account for ~40% of national e-waste recycling")
print(f"• Strong positive correlation between economic and environmental␣
 ↪benefits")

print("\n RECOMMENDATIONS:")
print("• Continue investment in recycling infrastructure in high-population␣
 ↪states")
print("• Implement policies to improve recycling rates in underperforming␣
 ↪regions")
print("• Leverage data analytics to optimize metal recovery processes")
print("• Expand public awareness campaigns about economic and environmental␣
 ↪benefits")
```

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KEY INSIGHTS SUMMARY
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 ECONOMIC IMPACTS:
• Revenue growth: +88.6% (2015-2024)
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- 2024 projected revenue: $0.18B
- Cumulative revenue (2015-2024): $1.35B
- Valuable metals recovered annually worth hundreds of millions

ENVIRONMENTAL ACHIEVEMENTS:

- Recycling rate improved from 35.0% to 55.0%
- 2024 CO2 reduction: 0.88 million metric tons
- Equivalent to removing 209 cars from roads annually
- Cumulative CO2 savings (2015-2024): 6.6 million metric tons

PERFORMANCE HIGHLIGHTS:

- California leads with 365.0M lbs recycled in 2024
- Top 5 states account for ~40% of national e-waste recycling
- Strong positive correlation between economic and environmental benefits

RECOMMENDATIONS:

- Continue investment in recycling infrastructure in high-population states
- Implement policies to improve recycling rates in underperforming regions
- Leverage data analytics to optimize metal recovery processes
- Expand public awareness campaigns about economic and environmental benefits