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LIFE CYCLE COSTING IN AUTOMATIVE INDUSTRY – CASE STUDY

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Abstract

This case study evaluates the Life Cycle Costing (LCC) of an Electric Vehicle (EV), specifically the Tesla Model 3, compared to an Internal Combustion Engine (ICE) vehicle, the Toyota Corolla, over a 10-year ownership period. The analysis considers various cost components, including initial purchase price, fuel costs, maintenance and repairs, insurance, battery replacement (for the EV), and depreciation. Key assumptions include a 15,000-mile annual driving distance, average fuel prices, and standard maintenance schedules.This analysis demonstrates the importance of considering total ownership costs, not just the initial price, when evaluating vehicle purchases. It highlights the growing financial viability of electric vehicles, particularly as fuel and maintenance savings offset the higher upfront costs and battery replacement expenses.

Keywords: Life Cycle Costing (LCC), Electric Vehicle (EV), Internal Combustion Engine (ICE), Total Cost of Ownership

Introduction:

Life Cycle Costing (LCC) in the Automotive Industry refers to the process of evaluating the total cost of ownership of a vehicle over its entire life span. LCC accounts for all expenses incurred during the vehicle's production, operation, maintenance, and eventual disposal or recycling. It provides a more comprehensive view of the true cost of a vehicle beyond the initial purchase price.

Key Components of Life Cycle Costing in the Automotive Industry:

1. **Initial Costs (Acquisition Cost):**

- **Purchase Price**: The cost of acquiring the vehicle, which includes the base price, optional features, taxes, and fees.
- **Production Costs**: Expenses related to the design, manufacturing, and assembly of the vehicle.
- **Research & Development (R&D)**: Investment in designing new technologies, testing, and prototype development.

2. **Operating Costs:**

- **Fuel Costs**: Depending on whether the vehicle is powered by gasoline, diesel, electricity, or alternative fuels, fuel consumption and fuel prices significantly impact operating costs.

- **Maintenance and Repairs**: Routine maintenance (oil changes, tire replacements, brake services) and unexpected repairs that may occur during the vehicle's lifetime.
- **Insurance Costs**: Annual insurance premiums, which can vary depending on the vehicle type, location, and driving history.
- **Tire Replacement**: Tires need to be replaced after a certain period or mileage.

3. **Depreciation:**

- **Vehicle Depreciation**: The decline in the vehicle's value over time, which can be influenced by factors such as brand, model, demand, and condition. Depreciation is one of the largest costs over the vehicle's life.
- **Residual Value**: The vehicle's estimated resale or trade-in value at the end of its life cycle.

4. **End-of-Life Costs:**

- **Disposal or Recycling**: Costs associated with the vehicle's end-of-life management, including disposal, recycling, or selling the vehicle for parts.
- **Environmental Considerations**: In the case of electric vehicles (EVs) or hybrid vehicles, battery recycling and disposal become an important factor.

5. **Environmental and Regulatory Costs:**

- **Compliance with Regulations**: Adhering to environmental regulations, emissions standards, and safety requirements may result in additional costs. Some regions require specific investments in technology to meet these standards.
- **Battery Disposal for EVs**: Costs for safe disposal or recycling of batteries at the end of the vehicle's life are essential to consider for electric and hybrid vehicles.

Importance of Life Cycle Costing in the Automotive Industry:

- **Cost Transparency**: LCC helps manufacturers and consumers understand the long-term costs of a vehicle, beyond just the sticker price.
- **Better Decision Making**: By evaluating the full cost of a vehicle over its lifetime, companies can make better decisions regarding design, production, and after-sales services. Consumers can also make informed choices about vehicle ownership.
- **Sustainability**: LCC considers environmental impacts, such as fuel efficiency, emissions, and the recyclability of components, leading to a more sustainable approach to automotive manufacturing and consumption.
- **Competitive Advantage**: Manufacturers can optimize production processes to reduce overall LCC, offering vehicles with a lower total cost of ownership, which is attractive to consumers.
- **Improved Vehicle Design**: Focusing on reducing operating and maintenance costs during the design phase can lead to more efficient vehicles, longer-lasting components, and a better customer experience.

Application in the Automotive Industry:

1. **Electric Vehicles (EVs) vs. Internal Combustion Engine (ICE) Vehicles**:

- **Upfront Cost**: EVs tend to have higher initial costs due to the price of batteries. However, over their life cycle, EVs may have lower operating costs (e.g., fuel and maintenance).
- **Battery Lifespan**: The durability and replacement cost of EV batteries must be factored into the LCC analysis. Battery technology improvements and recycling methods may affect future costs.

2. **Fleet Management**:

- For businesses that manage fleets of vehicles, LCC is used to determine the total cost of operating a fleet over its lifespan, optimizing choices between different models and technologies.

3. **Sustainability and Green Technologies**:

- As manufacturers are focusing on reducing the environmental impact of their products, LCC analysis can help assess the financial viability of incorporating green technologies like hybrid systems, electric drivetrains, or alternative materials.

Life Cycle Costing Methodology:

1. **Data Collection**: Gather data on all relevant costs (purchase price, maintenance, operating costs, etc.).
2. **Cost Modeling**: Develop a cost model that incorporates all the different costs associated with the vehicle over its life cycle.
3. **Analysis and Optimization**: Evaluate the total costs associated with different vehicle options and optimize the design, production, and operation strategies to reduce overall costs.
4. **Comparison**: Compare vehicles with different powertrains, designs, and configurations to find the most cost-effective choice in the long term.

Electric Vehicles (EVs) vs. Internal Combustion Engine (ICE) Vehicles

Background:

With the automotive industry undergoing significant transformations, one of the most notable shifts is the growing adoption of **Electric Vehicles (EVs)** as an alternative to **Internal Combustion Engine (ICE)** vehicles. The decision to purchase an EV or an ICE vehicle is no longer simply about the upfront cost. Consumers and manufacturers now consider the entire lifecycle costs, from production to operation to disposal. This case study examines the application of **Life Cycle Costing (LCC)** to compare the total costs of ownership of an EV and an ICE vehicle over a 10-year period.

Case Study: EV vs. ICE Vehicle Life Cycle Costing

Objective:

To compare the life cycle costs of an electric vehicle (EV) and an internal combustion engine (ICE) vehicle to determine which is more cost-effective over a 10-year ownership period.

Vehicles in Comparison:

- **Electric Vehicle (EV)**: Tesla Model 3 Standard Range Plus
- **Internal Combustion Engine (ICE)**: Toyota Corolla 1.8L (Gasoline Engine)
- **Key Assumptions:**
- **Ownership Period**: 10 years
- **Annual Mileage**: 15,000 miles (24,000 kilometers)
- **Fuel Costs**: Gasoline cost of $3.50 per gallon, electricity cost of $0.12 per kWh
- **Vehicle Lifespan**: 10 years
- **Interest Rate**: 5% (for financing)
- **Maintenance and Repair**: Assumed costs based on industry averages
- **Depreciation**: Based on market data for each model
- **Battery Replacement (for EV)**: Assumed battery replacement after 8 years
- **Resale Value**: Estimated based on the expected resale value at the end of 10 years
- **Life Cycle Cost Analysis:**
- **Initial Purchase Price (Acquisition Cost):**
- **Tesla Model 3 (EV)**:
    - Purchase price: $39,990 (for the Standard Range Plus model)
    - Tax incentives and rebates (federal): $7,500 (Note: Depending on location, this can vary, but we'll apply a rebate for this analysis)

- **Net Purchase Price**: $32,490

- **Toyota Corolla (ICE)**:
  - Purchase price: $21,000 (base model)
  - **Net Purchase Price**: $21,000

Operating Costs (Fuel, Maintenance, Insurance):

Fuel Costs:

Tesla Model 3: Consumes 24 kWh per 100 miles, so for 15,000 miles per year:

Annual energy consumption = (15,000 miles / 100) * 24 kWh = 3,600 kWh per year

Annual cost of electricity = 3,600 kWh * $0.12 = $432 per year

Total fuel cost over 10 years = $4,320

Toyota Corolla: Consumes 30 MPG (miles per gallon) on average, so for 15,000 miles:

Annual gasoline consumption = 15,000 miles / 30 MPG = 500 gallons

Annual cost of gasoline = 500 gallons * $3.50 = $1,750 per year

Total fuel cost over 10 years = $17,500

Maintenance and Repairs:

Tesla Model 3: EVs generally require less maintenance. The expected annual maintenance cost is around $200 (tires, brake pads, and occasional software updates).

Total maintenance over 10 years = $2,000

Toyota Corolla: ICE vehicles have more frequent maintenance needs, such as oil changes, exhaust system repairs, and more.

Expected annual maintenance cost: $500

Total maintenance over 10 years = $5,000

Insurance:

Tesla Model 3: Insurance for an EV tends to be slightly higher, primarily due to higher repair costs and technology.

Annual insurance cost: $1,200

Total insurance over 10 years = $12,000

Toyota Corolla: Insurance costs for ICE vehicles are generally lower.

Annual insurance cost: $900

Total insurance over 10 years = $9,000

Depreciation and Resale Value:

Tesla Model 3:

Estimated resale value after 10 years: $14,000

Depreciation over 10 years: $32,490 (initial price) - $14,000 (resale) = $18,490

Toyota Corolla:

Estimated resale value after 10 years: $7,000

Depreciation over 10 years: $21,000 (initial price) - $7,000 (resale) = $14,000

Battery Replacement (for EV):

Tesla Model 3: Battery degradation is a major consideration in EV ownership. It is assumed that the battery will last for 8 years before a full replacement is needed.

Estimated cost of a battery replacement: $5,000 (after 8 years)

Total cost for battery replacement = $5,000

Total Life Cycle Costs (10 Years):

Cost Category	Tesla Model 3 (EV)	Toyota Corolla (ICE)

Cost Category	Tesla Model 3 (EV)	Toyota Corolla (ICE)
Initial Purchase Price	$32,490	$21,000
Fuel Costs	$4,320	$17,500
Maintenance & Repairs	$2,000	$5,000
Insurance	$12,000	$9,000
Battery Replacement	$5,000	$0
Resale Value	-$14,000	-$7,000
Total Cost	$39,810	$45,500

Analysis & Conclusion:

1. **Total Cost of Ownership** over 10 years for **Tesla Model 3 (EV)**: $39,810
2. **Total Cost of Ownership** over 10 years for **Toyota Corolla (ICE)**: $45,500
3. **Key Insights:**
4. **Fuel Savings**: The Tesla Model 3 offers significant savings in fuel costs over its lifetime. The EV costs approximately **$4,320** in electricity over 10 years, compared to the **$17,500** in gasoline costs for the Toyota Corolla.
5. **Maintenance Savings**: EVs like the Tesla have lower maintenance costs, saving around **$3,000** over the 10 years.
6. **Depreciation**: The Tesla Model 3 loses more value in depreciation ($18,490) compared to the Toyota Corolla ($14,000). However, the resale value of the Tesla is still higher.
7. **Battery Replacement**: A major cost for EVs is the battery replacement. After 8 years, the Tesla will require a $5,000 battery replacement, which contributes to its total life cycle cost.

Conclusion:

While the **Tesla Model 3 (EV)** has a higher initial purchase price, its **lower fuel and maintenance costs** make it a more cost-effective option over the long term compared to the **Toyota Corolla (ICE)**. Over a 10-year period, the **total cost of ownership** for the EV is lower than for the ICE vehicle, especially considering the significant savings in fuel.

This case study illustrates the importance of considering the entire lifecycle cost when making automotive purchasing decisions, highlighting the long-term economic benefits of switching to electric vehicles.

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