

Sample Copy - Dr.
Sample Copy - Dr.
Sample Copy - Dr.

Electric & Hybrid Car Tuning and Maintenance: Engineering Principles, Performance Upgrades, and Long-Term Reliability

Future of Automotive Engineering Series, Volume 3

Mohammed Hamed Ahmed Soliman

Sample Copy - Dr. Soliman
Sample Copy - Dr. Soliman
Sample Copy - Dr. Soliman

Sample Copy - Dr.
Sample Copy - Dr.
Sample Copy - Dr.

Published by personal-lean.org, 2025.

Sample Copy - Dr. Soliman
Sample Copy - Dr. Soliman
Sample Copy - Dr. Soliman

Copy - Dr. Soliman
Copy - Dr. Soliman
Copy - Dr. Soliman

Sample Copy - Dr.
Sample Copy - Dr.
Sample Copy - Dr.

Sample Copy - Dr. Soliman
Sample Copy - Dr. Soliman
Sample Copy - Dr. Soliman

Copy - Dr. Soliman
Copy - Dr. Soliman
Copy - Dr. Soliman

While every precaution has been taken in the preparation of this book, the publisher assumes no responsibility for errors or omissions, or for damages resulting from the use of the information contained herein.

ELECTRIC & HYBRID CAR TUNING AND
MAINTENANCE: ENGINEERING PRINCIPLES,
PERFORMANCE UPGRADES, AND LONG-TERM
RELIABILITY

First edition. September 25, 2025.

Copyright © 2025 Mohammed Hamed Ahmed Soliman.

Written by Mohammed Hamed Ahmed Soliman.

Table of Contents

.....	1
Preface	2
Author's Note	4
Chapter 1 – The Future of Automotive Engineering.....	6
1.1 Global Shift Toward EVs and Hybrids	7
1.2 Comparing ICE, Hybrid, and EV	8
1.3 Why Tuning Still Matters in the EV Era.....	9
1.4 Pros and Cons of Electric and Hybrid Cars	10
1.4 Pros and Cons of Electric Cars (Expanded).....	13
1.5 Pros and Cons of Hybrid Cars	15
1.6 Quick Comparison: EV vs Hybrid vs ICE (Expanded) ..	17
1.7 Global Adoption Trends & Market Growth.....	20
Chapter 2 – Fundamentals of EV Powertrains.....	22
2.1 Battery Pack Technologies	23
2.2 Electric Motors (Induction vs Permanent Magnet).....	26
2.3 Inverter & Power Electronics.....	29
2.4 Regenerative Braking.....	32
2.5 Battery Pack & Battery Management System (BMS)	35

2.6 Inverter & Power Electronics..... 38

2.7 Regenerative Braking..... 41

2.8 Thermal Management Systems..... 44

Chapter 3 – Hybrid Systems Explained..... 47

3.1 Types of Hybrid Systems 48

3.2 Power Split Devices 51

3.3 Balancing ICE Tuning with Hybrid Efficiency 54

3.4 Typical Maintenance Challenges in Hybrids 57

Chapter 4 – EV & Hybrid Maintenance Principles 60

4.1 Battery Health 61

Charging Habits..... 62

SOH vs. SOC 63

Calendar vs. Cycle Aging 64

Environmental Factors..... 65

✓ Best Practices Checklist for Battery Care 66

4.2 Cooling Systems 67

Types of Cooling Systems 68

Maintenance Principles 69

✓ Cooling System Checklist..... 70

4.3 Brake Wear and Regenerative Braking.....	71
Benefits of Regenerative Braking.....	72
Maintenance Considerations	73
✓ Brake System Checklist.....	74
4.4 Software & Firmware Updates	75
Importance of Updates	76
Maintenance Principles	77
✓ Software/Firmware Checklist	78
4.5 High-Voltage Safety Practices.....	79
Key Safety Risks	80
High-Voltage Components to Avoid Touching.....	81
Safety Principles for Owners	82
✓ High-Voltage Safety Checklist	83
Chapter 5 – Performance Tuning in EVs.....	84
5.1 ECU vs VCU (Vehicle Control Unit) Remapping.....	85
ECU vs VCU – The Shift in Control	86
What Can Be Tuned in EVs?.....	87
Benefits of VCU Remapping	88
Risks and Challenges.....	89

5.2 Unlocking Motor Torque Limits..... 90

How Torque Is Limited..... 91

Methods to Unlock Torque..... 92

Benefits..... 93

Risks..... 94

5.3 Battery Upgrades (Higher Capacity Packs) 95

Types of Battery Upgrades..... 96

Benefits..... 97

Risks & Challenges..... 98

Practical Considerations..... 99

5.4 Cooling Mods for Track Performance..... 100

Key Cooling Areas..... 101

Benefits..... 102

Practical Notes..... 103

5.5 Limitations: Warranty & Legal Restrictions..... 104

Warranty Implications 105

Legal & Regulatory Restrictions 106

Best Practices 107

Chapter 6 – Hybrid Performance & Tuning 108

6.1 ICE Upgrades Within Hybrids.....	109
6.2 Optimizing Fuel Efficiency vs Performance	110
6.3 Turbocharging / Supercharging Hybrids	111
6.4 Reprogramming Hybrid ECUs.....	112
Chapter 7 – Charging Systems & Infrastructure	113
7.1 AC vs DC Charging.....	114
7.2 Fast-Charging Risks.....	115
7.3 Home Charging Setup	116
7.4 Smart Charging & Battery Life.....	117
Chapter 8 – Safety & Reliability Considerations	118
8.1 High-Voltage Risks & Insulation	119
8.2 Fire Hazards & Thermal Runaway	120
8.3 Preventive Maintenance Schedules	121
8.4 Insurance & Regulations	122
Chapter 9 – Case Studies	123
9.1 Tesla Model 3 Tuning.....	124
9.2 Toyota Prius Hybrid Optimization.....	126
9.3 Nissan Leaf Battery Upgrades.....	128
9.4 Custom EV Conversions.....	130

Conclusion.....132

Chapter 10 – The Road Ahead.....133

10.1 Solid-State Batteries134

10.2 Hydrogen Fuel Cell Hybrids.....135

10.3 Autonomous EVs & Predictive Maintenance.....136

10.4 The Role of Enthusiasts in the EV Era137

10.5 Looking Forward138

Appendices.....139

Appendix A – Glossary of EV/Hybrid Terms.....140

Appendix B – Recommended Diagnostic Tools.....142

Appendix C – Checklist for Buying a Used EV/Hybrid.....144

Appendix D – Safe Storage & Transport of EV Batteries146

Sample Copy - Dr.
Sample Copy - Dr.
Sample Copy - Dr.

Sample Copy - Dr. Soliman
Sample Copy - Dr. Soliman
Sample Copy - Dr. Soliman

Copy - Dr. Soliman
Copy - Dr. Soliman
Copy - Dr. Soliman

Sample Copy - Dr.
Sample Copy - Dr.
Sample Copy - Dr.

Sample Copy - Dr. Soliman
Sample Copy - Dr. Soliman
Sample Copy - Dr. Soliman

Copy - Dr. Soliman
Copy - Dr. Soliman
Copy - Dr. Soliman

Electric & Hybrid Car Tuning and Maintenance
*Engineering Principles, Performance Upgrades, and
Long-Term Reliability*

Sample Copy - Dr. Soliman
Sample Copy - Dr. Soliman
Sample Copy - Dr. Soliman

copy - Dr. Soliman
copy - Dr. Soliman
copy - Dr. Soliman

Preface

THE GLOBAL AUTOMOTIVE landscape is undergoing one of the most profound transformations in its history. For more than a century, the internal combustion engine defined mobility, industry, and even culture. Yet today, the growing urgency to reduce emissions, preserve natural resources, and lower the cost of transportation has shifted attention toward electric and hybrid vehicles.

This transformation is not simply about replacing gasoline with electricity. It represents a broader movement toward energy efficiency, environmental responsibility, and smarter mobility. Governments worldwide are setting ambitious targets to phase out fossil fuel cars, manufacturers are investing billions into battery technologies, and infrastructure for charging and clean energy is expanding at unprecedented rates.

Beyond environmental benefits, electric and hybrid vehicles offer clear advantages to the everyday driver: lower operating costs, fewer moving parts to maintain, and reduced dependency on expensive fuels. They are quieter, cleaner, and in many cases, more responsive than their gasoline counterparts. At the same time, hybrid technology bridges the gap by combining traditional engines with electric power, delivering both extended range and fuel savings.

Still, these vehicles are not free from challenges. Battery health, charging cycles, high-voltage systems, and unique maintenance

requirements present new learning curves for car owners and enthusiasts alike. My aim with this book is to demystify these technologies, explain how they work, and provide practical knowledge to maintain, optimize, and even enhance them.

Just as I explored performance, safety, and customization in my earlier book on car tuning, this work focuses on the unique realities of electric and hybrid systems. Whether you are a first-time EV owner, a hybrid driver curious about extending vehicle life, or an enthusiast considering how to optimize efficiency and performance, this guide will help you navigate the transition with confidence.

The automotive world is changing rapidly. By understanding the technology, we not only adapt to it—we take full advantage of its promise. This book is an invitation to explore that future.

— *Mohammed Hamed Ahmed Soliman*

Author's Note

CARS HAVE BEEN MORE than machines to me—they are dynamic systems that blend mechanical precision, electrical innovation, and human interaction. My journey began with a lifelong passion for driving and tuning cars, exploring how every adjustment, every upgrade, and every component affects performance and safety.

Professionally, I hold a robust background in **Mechanical Engineering** and have expanded my expertise into **Industrial Engineering and Systems**, serving as a lecturer at a leading university. This combination of hands-on experience and formal academic training allows me to approach vehicle performance and maintenance with both rigor and practicality.

Over the years, I have engaged deeply with automotive technologies, from internal combustion engines to modern electric and hybrid systems. My experience spans **vehicle design, diagnostics, powertrain optimization, and industrial process management**, giving me a unique perspective on how vehicles operate under real-world conditions.

This book represents a synthesis of my **practical tuning experience, academic insight, and commitment to engineering excellence**. It is written for enthusiasts who want to understand the science behind the systems they work on,

and for professionals who seek reliable guidance on EV and hybrid maintenance, performance, and safety.

For readers of my previous books on ICE tuning, this volume provides a natural continuation, bridging traditional performance knowledge with the challenges and opportunities of electric and hybrid vehicles. My goal is to equip every reader with the understanding, confidence, and tools necessary to **optimize, maintain, and enjoy modern vehicles safely and efficiently.**

— **Mohammed Hamed Ahmed Soliman**

Chapter 1 – The Future of Automotive Engineering



Sample Copy - Dr. Soliman
Sample Copy - Dr. Soliman
Sample Copy - Dr. Soliman

Sample Copy - Dr. Soliman
Sample Copy - Dr. Soliman
Sample Copy - Dr. Soliman

1.1 Global Shift Toward EVs and Hybrids

IN THE PAST DECADE, the automotive industry has witnessed a massive transformation. Rising fuel prices, climate change concerns, and strict government regulations on emissions have accelerated the shift away from traditional **Internal Combustion Engine (ICE)** vehicles toward **Electric Vehicles (EVs)** and **Hybrid Electric Vehicles (HEVs)**.

Governments worldwide are incentivizing EV adoption through tax breaks, subsidies, and charging infrastructure investments. At the same time, leading automakers like Tesla, Toyota, Volkswagen, and BYD are heavily investing in electric powertrains, making EVs not just a futuristic concept but a mainstream reality.

1.2 Comparing ICE, Hybrid, and EV

- **ICE (Internal Combustion Engine):** Powered solely by gasoline or diesel, well understood, but limited by emissions, fuel costs, and higher maintenance.
- **Hybrid (HEV/PHEV):** Combines ICE with electric motors. Offers better fuel efficiency and lower emissions while retaining conventional refueling convenience.
- **EV (Electric Vehicle):** Powered entirely by batteries and electric motors. Zero tailpipe emissions, simpler mechanics, and lower running costs, but dependent on charging networks.

1.3 Why Tuning Still Matters in the EV Era

WHILE MANY ASSUME TUNING will lose relevance in a battery-driven world, the truth is the opposite. Enthusiasts are already experimenting with:

- Unlocking hidden motor torque limits via software.
- Improving thermal management for sustained performance.
- Upgrading battery packs for extended range and power.
- Optimizing regenerative braking for track use.

Just like ICE cars evolved with turbochargers, ECUs, and aftermarket modifications, EVs and hybrids are opening new doors for innovation.

1.4 Pros and Cons of Electric and Hybrid Cars

ELECTRIC VEHICLES (EVs)

Pros:

- Highly energy efficient compared to ICE vehicles.
- Zero tailpipe emissions – environmentally friendly.
- Maintenance costs are 70–80% lower (service intervals every ~50,000 km vs. 10,000 km for ICE).
- Smooth and quiet driving experience.
- Strong acceleration due to instant torque.

Cons:

- Limited charging infrastructure in many regions.
- Slow charging options can be inconvenient for daily use.
- Electricity costs can be high in certain countries.
- High cost of charging equipment (home chargers, converters).
- Battery fire risks: lithium cells can ignite after severe collisions, raising safety concerns.
- Range anxiety still exists, especially for long trips.

Hybrid Vehicles (HEVs & PHEVs)

Pros:

- Excellent compromise between ICE and EV technology.
- Fuel savings due to regenerative braking and optimized engine use.
- Reduced emissions compared to conventional ICE cars.
- No dependency on charging stations (for non-plug-in hybrids).
- Ideal transitional option for regions without strong EV infrastructure.

Cons:

- Higher maintenance complexity due to having **two powertrains** (ICE + electric motor).
- Repair costs and spare parts can be more expensive.
- Fuel savings may be less noticeable in highway driving compared to city driving.
- Battery replacement still a long-term cost consideration.

Figure 1.1 – Comparison of ICE, Hybrid, and Electric Cars

Feature	ICE (Gasoline/ Diesel)	Hybrid (HEV/ PHEV)	Electric Vehicle (EV)
Energy Source	Fuel only	Fuel + Battery	Battery only
Efficiency	Low (20–30%)	Medium (30–45%)	High (70–90%)
Maintenance	High (oil, filters, belts)	Medium–High (dual system)	Very Low (few moving parts)
Operating Cost	High (fuel & service)	Medium (fuel savings, higher repairs)	Low (electricity, minimal service)
Environmental Impact	High emissions	Medium (lower emissions)	Zero tailpipe emissions
Range & Refueling	Long range, fast refuel	Medium range, refuel + sometimes charge	Limited by charging infra, slower recharge
Purchase Cost	Lowest	Higher than ICE	Highest upfront
Technology Maturity	Mature & universal	Transitional	Rapidly evolving

1.4 Pros and Cons of Electric Cars (Expanded)

ELECTRIC VEHICLES (EVs) are no longer a futuristic concept—they are rapidly becoming mainstream in many markets. However, like any technology, they come with both advantages and disadvantages that must be considered before making the switch.

Pros of Electric Cars

- **Energy Efficiency & Cost Savings:** EVs convert a higher percentage of electrical energy into motion compared to internal combustion engines (ICEs). Maintenance costs are also significantly lower—typically 70–80% less than gasoline cars—since there are fewer moving parts and service intervals can stretch to every 50,000 km instead of every 10,000 km.
- **Environmental Benefits:** Zero tailpipe emissions make EVs cleaner for urban environments, reducing air pollution and contributing to climate goals.
- **Smooth and Instant Performance:** Electric motors deliver maximum torque instantly, resulting in rapid acceleration and a smoother driving experience.
- **Quiet Operation:** EVs operate silently, enhancing driving comfort and reducing noise pollution.