METU EE7566
Electric Drives in Electric and Hybrid Electric Vehicles

Emine Bostancı

Office: C-107

Content

Part I: Course Information

Part II: Brief History of Electrified Powertrains

Part III: Today’s Electrified Vehicles

EE7566 – Course Contents

Introduction to electrified vehicle powertrain systems

- Vehicle Longitudinal Dynamics
- Topologies; electric vehicles, hybrid and fuel-cell hybrid electric vehicles
- Architectures of hybrid electric vehicles
- Drivetrain components
- Specifications, requirements and challenges
- Railway traction

Design, performance analysis and control of electric drive systems

- Fundamental concepts
- Permanent magnet synchronous machine drives
- Induction machine drives
- Switched reluctance machine drives

Course Information

Course Hours: Wednesdays 13:40-16:30 @ EA211

Course and break times will be approx. as below:

1. session: 13:40-14:50

Break: 14:50-15:20

2. session: 15:20-16:30

We will have one long break!

Textbooks

1. Ehsani, M. and Gao, Y. and Emadi, A., “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design”, 2nd Edition, CRC Press LLC, 2009.
2. Chris Mi, M. Abul Masrur, David Wenzhong Gao, “Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives”, John Wiley & Sons, May 23, 2011.
3. Larminie, J. and Lowry J., “Electric Vehicle Technology Explained”, 2nd edition, John Wiley & Sons, 2012.
4. Chau, K.T. “Electric Vehicle, Machines and Drives: Design, Analysis and Application”, John Wiley & Sons, 2015.
5. Emadi, A., “Advanced Electric Drive Vehicles”, CRC Press, 2014.
6. Mohan N., Undeland T., and Robbins W., “Power Electronics: Converters, Applications, and Design”, John Wiley & Sons, 2002.
7. De Doncker R.W., Pulle D.W.J., Veltman A. “Advanced Electrical Drives”, Springer Netherlands, 1st Edition, 2011.

Grading and Course Policies

1 midterm examination, 25%

1 final examination, 30%

Homeworks, 15%

1 term project (report and presentation), 30%

-o-o-o-o-o-o-o-o-o-o-o-o-o-

Class attendance will be taken but will not be graded.

Late assignments are not allowed unless the reason is stated and approved in advance.

Any of the following actions will result in NA grade:

- Not submitting the term project
- Not attending to the final exam

Assignments

Homework 1: Electric vehicle design in Matlab

Homework 2: Permanent Magnet Synchronous Machine Simulation using Ansys/Maxwell

Project:

Electric Drive System in Matlab/Simulink or Ansys/Simplorer

or

Electric Machine Simulation in Ansys/Maxwell

What is the best way of learning?

Lectures are good to get familiar and also learn the most important aspects.

+

Books include consistent content and good to build a complete understanding.

+

Our brains are lazy, **exercises** makes us think deeply and crucial to see what is understood what was assumed to be understood.

+

Projects are means of being totally involved in the content by activing our creativity and problem solving skills.

What is required for the course:

- **Basic Matlab and Matlab/Simulink Knowledge**
- **Power Electronics**

  EE463 + EE 464 or equivalents
- **Electric Machine Theory**

  EE 361 + EE 362 or equivalents
- **Basic Control Theory**

  PID controller

  Feedback control systems

Note: Ansys/Maxwell Tutorials will be offered!

Content

Part I: Course Information

Part II: Brief History of Electrified Powertrains

Part III: Today's Electrified Vehicles

Early Electric Vehicles

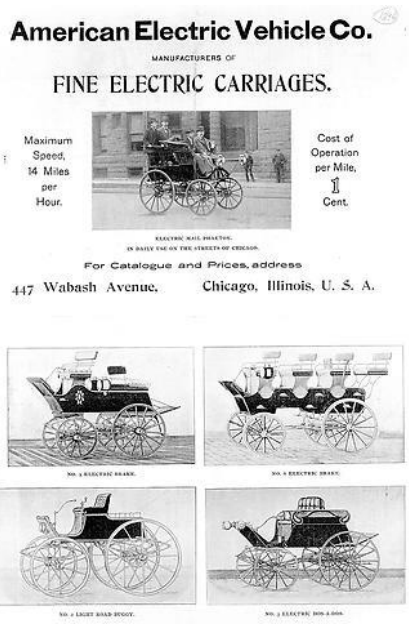
1828 — 1835 | 1889 — 1891 | 1896— 1899 | 1900 — 1912 | 1908 — 1912

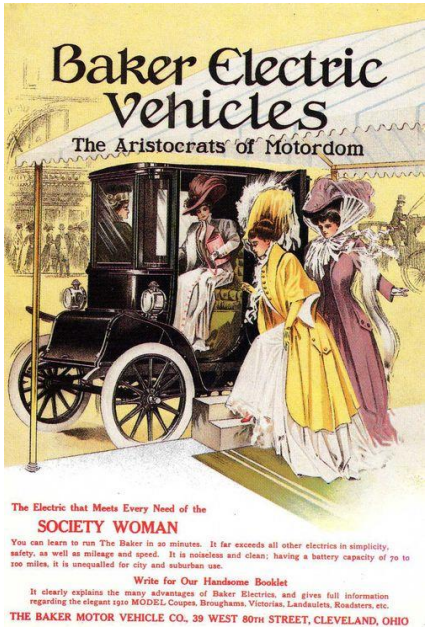
Small scale electric cars

First successful electric cars

Electric cars gain popularity

Electric cars have their heyday

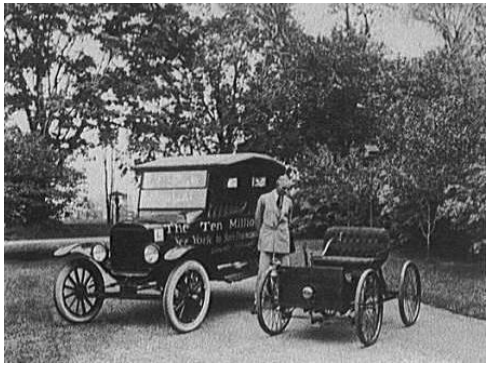




American automobiles: 40% were powered by steam, 38% by electricity, and 22% by gasoline

Thomas Edison and an electric car in 1913

Ford Model T (1908-1927) deals a blow to model electric vehicles



Thanks to series DC motor used as starter.

Source: http://energy.gov/articles/history-electric-car

First Electric Taxis: Morris and Salom's Electroboat in 1897

This vehicle was operated as a taxi in New York City.

The Electroboat proved to be more profitable than horse cabs despite a higher purchase price (around $3000 vs. $1200).

It could be used for three shifts of 4h with 90-min recharging periods in between.

It was powered by two 1.5 hp motors at a maximum speed of 32 km/h and a 40 km range.

Electric Car by Porsche 1900 World Exhibition Paris

Features:

- 2 wheel hub motors
- P_{max} = 2 x 7 hp
- P_{rated} = 2 x 2,5 hp (at 120 rpm)
- 44 cells 300 Ah Accu at 80 V
- **V_{max} = 50 km/h**
- **Range 50 km**
- **Electric front brakes**
- Mechanical rear band brakes
- Total weight 980 Kg
- **Battery weight 410 Kg**
- 1 front wheel 115 Kg
- Ca. **300** cars sold

Early Plug-in Hybrid Electric Cars

1899-1900 Dr. Ferdinand Porsche built the first Hybrid Vehicle

- A petrol engine rotating at **a constant speed** is used to drive a dynamo, which charged a bank of accumulators.
- Electric motors contained within the **hubs of the front wheels**.
- There were no drive shafts, transmission, gears, straps, chains or clutch.
- Very high efficiency.

- Motivation:
- Assist weak internal combustion engine
- Improve range of electric vehicle

- Difficulties:
- Control of electric machine with mechanical switches and resistors

In the beginning I looked around and could not find quite the car I dreamed of. So I decided to build it myself.

Ferry Porsche

Fritchle A Model Victoria: An EV with a 100-mil range in 1908

The 100 Mile
Fritchle Electric

The Only Electric Guaranteed to Go 100 Miles on One Charge.

MODEL "A" VICTORIA PHAETON.

The Victoria Phaeton shown here, is an ideal lady's carriage for city and country use. Its artistic and impressive body design, its superb painting and upholstering make it the most attractive lady's car ever offered to the public.

Harry L. Cort, Sole Agent

Moore Theatre, Phone Main 6103.

Can deliver 10 days after order is placed. Guaranteed against defective parts, material and workmanship for one year from date of delivery.

Newspaper Quote - The New York Times in January 20, 1911

possess. Another great advantage of the electric in years gone by was their quiet operation, as compared with gasoline cars, and this fact alone was responsible for their widespread use by women.

The designers of electric passenger-carrying vehicles have made great advances in the past few years, and these machines have retained all their early popularity and are steadily growing in favor with both men and women. They are very handy for use in cities, and numbers of the best known and most prominent makers of gasoline cars in this country use electrics for driving between their homes and their offices.

The enthusiastic interest recently shown by the electric power companies all over the country in furthering the cause of the electric passenger vehicle assures a still greater use of these machines. In the past it was sometimes difficult to make arrangements to have electrics charged unless the vehicles were stored in a garage where owners of electrics were catered to, but this state of affairs has been changed. Now it is possible for an owner of an electric to install his own charging plant in his stable, and the electric power companies are anxious to connect their feed wires to these individual charging plants.

- Another great advantage of the electric in years gone by was their quiet operation, as compared with gasoline cars…
- The designers of electric passenger-carrying vehicles have made great advances in the past few years, and these machines have retained all their early popularity and are steadily growing in favor with both men and women. They are very handy for use in cities, and numbers of the best known and most prominent makers of gasoline cars in this country use electrics for driving between their homes and their offices…
- Now it is possible for an owner of an electric to install own charging plant in his stable, and the electric power companies are anxious to connect their feed wires to these individual charging plants.

Who/What is responsible? → Electric Starter

Charles Kettering and his original electric starter.

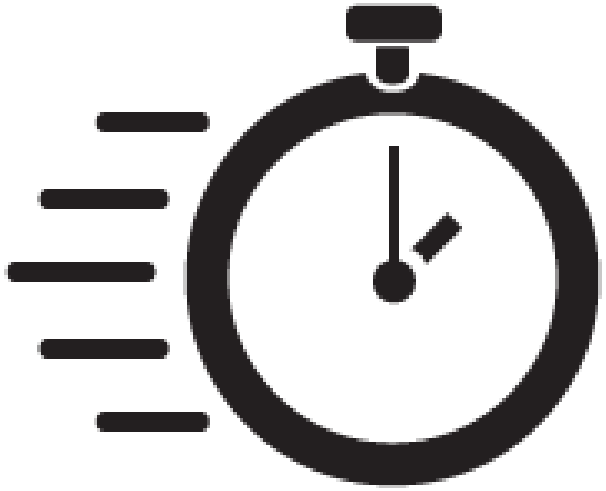
Charles F. Kettering, co-founder of Dayton Engineering Laboratories Company (DELCO) in Dayton, Ohio, is issued U.S. Patent No. 1,150,523 for his "**engine-starting device**"–the first electric ignition device for automobiles– on August 17, 1915.

In the early years of the automobile, drivers used iron hand cranks to start the internal combustion process that powered the engines on their cars. In addition to requiring great hand and arm strength, this system was not without certain risks: If the driver forgot to turn his ignition off before turning the crank, the car could backfire or roll forward, as at the time most vehicles had no brakes.

How Did Gasoline Car Win?

- **The invention of the electric starter:** Charles Kettering in 1912 eliminated the need for the hand crank.
- **Better and longer roads – longer distance driving:** By the 1920s, America had a better system of roads that now connected cities, bringing with it the need for longer-range vehicles.
- **Better gasoline availability:** The discovery of Texas crude oil reduced the price of gasoline so that it was affordable to the average consumer.
- **Mass production of Model-T:** The initiation of mass production of internal combustion engine vehicles by **Henry Ford** made these vehicles widely available and affordable in the **$500 to $1,000** price range.
- **Higher price of electric cars:** The price of the less efficiently produced electric vehicles continued to rise. In 1912, an electric roadster sold for **$1,750**, while a gasoline car sold for **$650**.

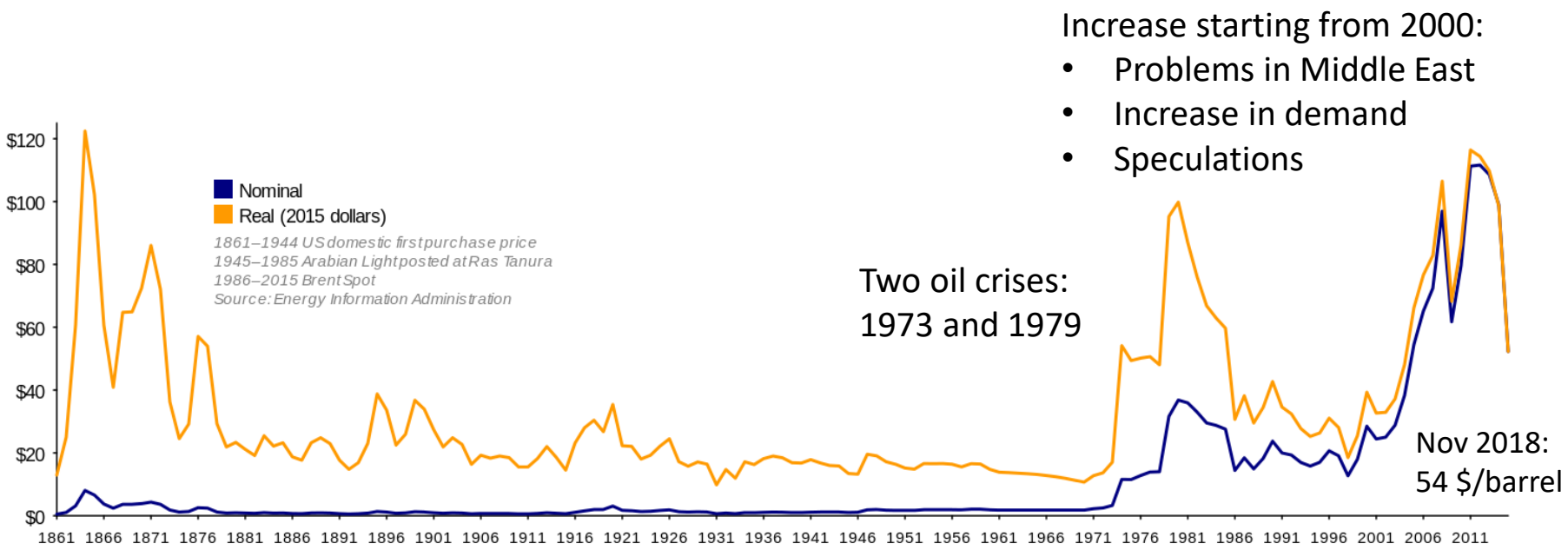
Source: https://avt.inl.gov/sites/default/files/pdf/fsev/history.pdf



And there is a long “Electric Vehicle” brake between 1910s and 1970s.

History Continues after a Long Break

- 1966: Congress introduces the earliest bills recommending use of electric vehicles as a means to reducing **air pollution**.
- 1970s: Concerns about the soaring price of oil – peaking with the **Arab Oil Embargo of 1973-** and growing **environmental movement** results in renewed interests in electric cars from both consumers and producers.



Source: https://en.wikipedia.org/wiki/2000s_energy_crisis

Modern Hybrid Electric Vehicle with Semiconductor Switches in 1970's

Dr. Victor Wouk's **parallel hybrid** version of Buick Skylark sedan:

- Mazda rotary engine
- Manual transmission
- 15 hp separately excited **DC machine**
- **12 V automotive batteries** for energy storage
- V_{max}= 80 mph (**129 km/h**)
- Acceleration from 0 – 60 mpg in 16 sec

Importance:

- More than **twice the fuel economy** of the previously converted vehicles
- Emission rates were only about **9%** of those of a gasoline powered car

1952: Power diode
1957: Thyristor
1960s: Bipolar transistor
1970s: MOSFETs
1980s: IGBTs
1990s: IGBTs widely available

http://www.pbs.org/now/shows/223/electric-car-timeline.html

Governmental Supports

Congress passes the Electric and Hybrid Vehicle Research, Development and Demonstration Act in 1976

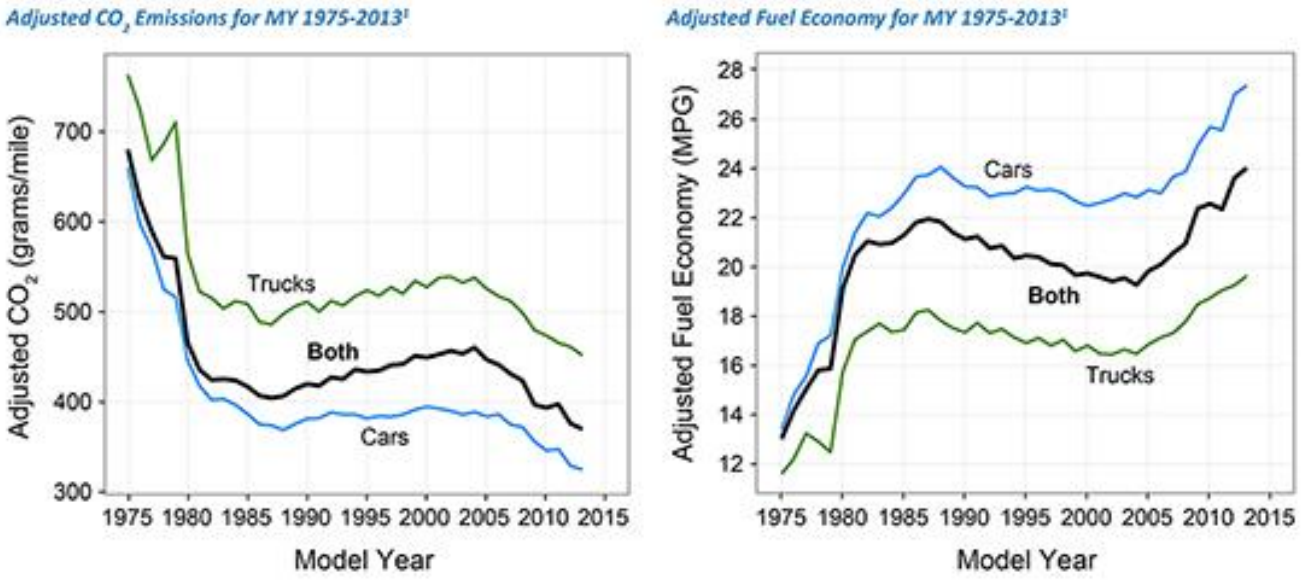
California's Zero Emission Vehicle (ZEV) Program (Mandate) was started in 1990
Aim: Initially required production of zero emission cars (2% of the state's vehicles to have no emissions by 1998 and 10% by 2003) and after 2008 supported vehicles with low emissions

- GM EV1, Toyota EV RAV4, Honda EV Plus, Ford Electric Ranger, Nissan Altra

Partnership for a New Generation of Vehicles between 1993-2001
Aim: Increase the efficiency of vehicles over 80 mpg

- Federal agencies
- National laboratories
- Universities
- United States Council for Automotive Research (USCAR)

Influence of Regulations on Fuel Economy



[1] *Adjusted CO_2 and fuel economy values reflect real world estimates and are not comparable to automaker standards compliance levels. Adjusted CO_2 values are, on average, about 25% higher than the unadjusted laboratory CO_2 values that form the starting point for GHG standards compliance, and adjusted fuel economy values are about 20% lower, on average, than unadjusted fuel economy values.*

Source: The Washington Post

Influence of Regulations on Fuel Economy

MY 2011–2013 Manufacturer Adjusted Fuel Economy and Adjusted CO_2 Emissions[1]

	MY 2011 Final		MY 2012 Final				MY 2013 Preliminary	
Manufacturer[2]	Fuel Economy (MPG)	CO_2 Emissions (g/mi)	Fuel Economy (MPG)	Change from MY 2011 (MPG)	CO_2 Emissions (g/mi)	Change from MY 2011 (g/mi)	Fuel Economy (MPG)	CO_2 Emissions (g/mi)
Mazda	25.0	356	27.1	+2.1	328	-28	27.5	324
Honda	24.1	369	26.6	+2.5	334	-35	27.0	329
Toyota	24.1	369	25.6	+1.5	347	-22	25.2	352
VW	26.0	349	25.8	-0.2	351	+2	26.2	346
Subaru	23.9	372	25.2	+1.3	352	-20	26.2	339
Nissan	23.3	381	24.1	+0.8	369	-12	25.3	351
BMW	22.7	393	23.7	+1.0	377	-16	24.4	364
Ford	21.1	422	22.8	+1.7	390	-32	22.6	394
GM	20.7	429	21.7	+1.0	410	-19	22.0	404
Daimler	19.1	469	21.1	+2.0	426	-43	22.2	402
Chrysler-Fiat	19.4	458	20.1	+0.7	442	-16	21.6	411
All	**22.4**	**398**	**23.6**	**+1.2**	**376**	**-22**	**24.0**	**370**

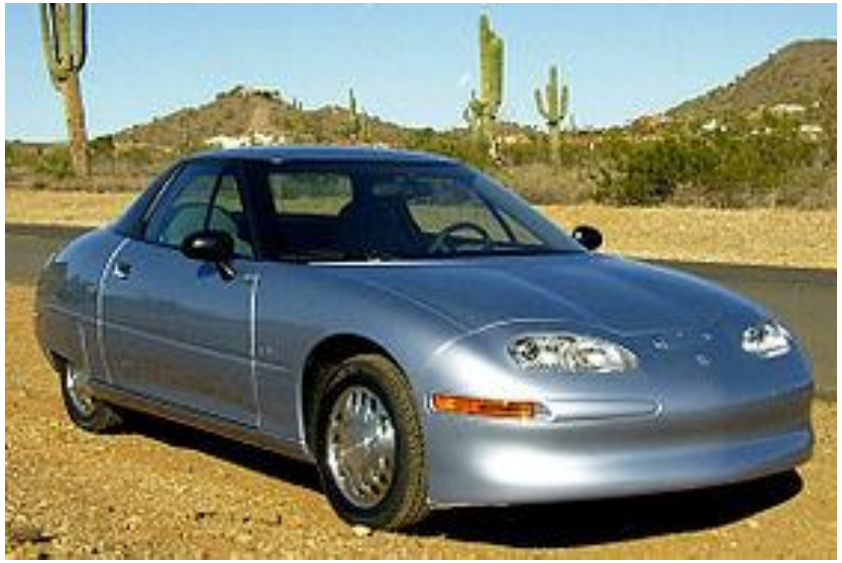
[1] Adjusted CO_2 and fuel economy values reflect real world estimates and are not comparable to automaker standards compliance levels. Adjusted CO_2 values are, on average, about 25% higher than the unadjusted laboratory CO_2 values that form the starting point for GHG standards compliance, and adjusted fuel economy values are about 20% lower, on average, than unadjusted fuel economy values.

[2] Two manufacturers, Hyundai and Kia, are not included in rows in the table above due to a continuing investigation. On November 2, 2012, EPA announced that Hyundai and Kia would lower their fuel economy estimates for many vehicle models as the result of an EPA investigation of test data. Based on these corrected data, Hyundai's values are 27.2 mpg and 327 g/mi CO_2 for MY 2011, 28.3 mpg and 314 g/mi CO_2 for MY 2012, and 28.3 mpg and 315 g/mi CO_2 for MY 2013 (preliminary). Kia's values are 25.8 mpg and 345 g/mi CO_2 for MY 2011, 26.5 mpg and 336 g/mi CO_2 for MY 2012, and 27.3 mpg and 326 g/mi CO_2 for MY 2013 (preliminary). These corrected data for Hyundai and Kia are included in industry-wide or "All," values.

Source: The Washington Post

Electric Vehicles in 1990's

GM EV1



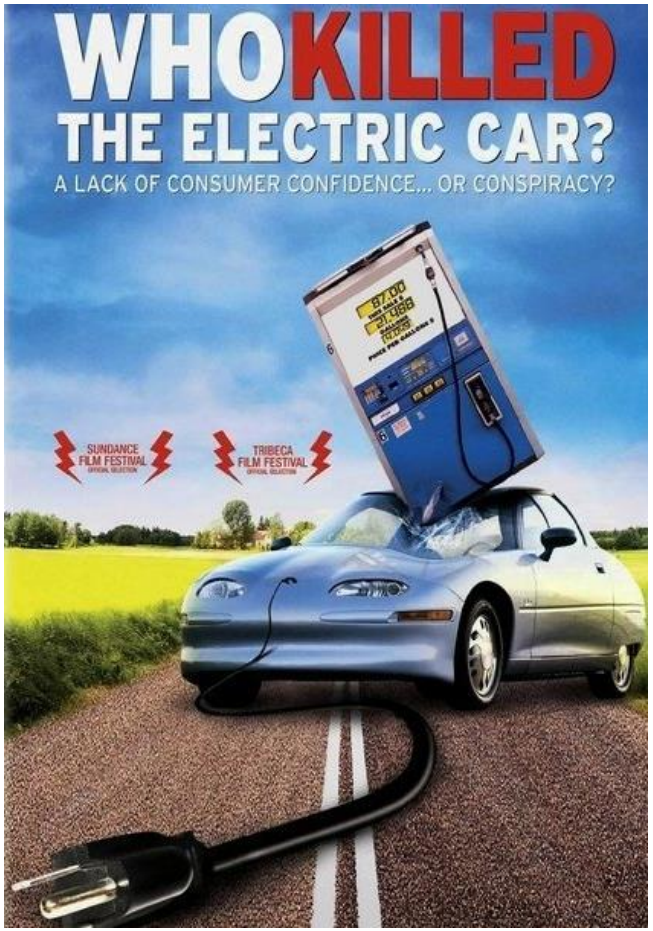
1952: Power diode
1957: Thyristor
1960s: Bipolar transistor
1970s: MOSFETs
1980s: IGBTs
1990s: IGBTs widely available

Battery chemistry changes!

Manufacturer: General Motors
Production: 1996–1999 (1,117 units)
Layout:
Transverse front-motor, front-wheel drive
Powertrain:
Electric motor three-phase alternating current
Induction motor with **IGBT** power inverter
102 kW at 7000 rpm
149 Nm at 0–7000 rpm
Transmission:
Single-speed reduction integrated
with motor and differential
Plug-in charging:
6.6 kW Magnet Charge inductive converter
Curb weight:
1,400 kg with Lead-acid batteries
1,319 kg with NiMH batteries

Movie Suggestion I

Who killed the electric car? 7.7/10
PG | 1h 32min | **Drama** | 4 August 2006 (USA)



https://www.imdb.com/title/tt0489037/

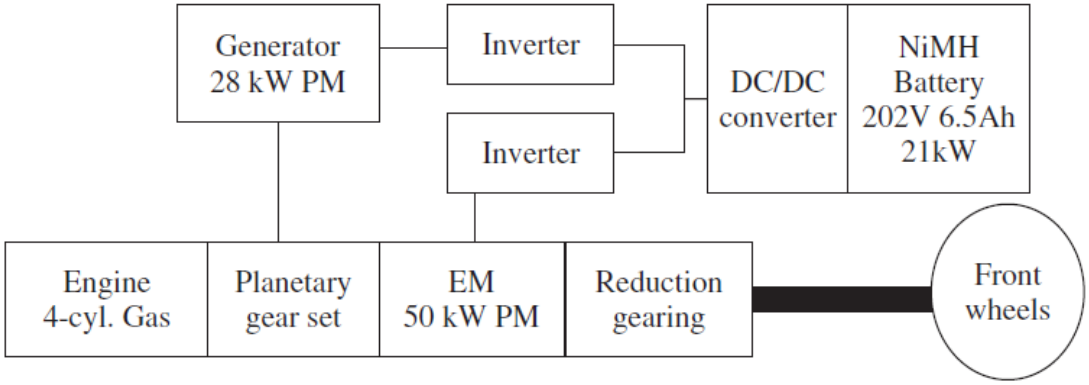
Electric Vehicles in 1990's

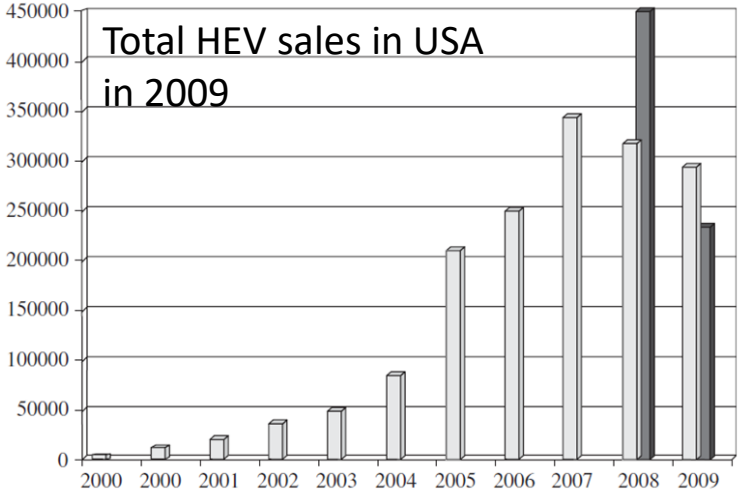
Toyota RAV4 EV

Manufacturer: Toyota
Production: 1997–2003
Layout:
Front-engine, front-wheel drive
Powertrain:
Electric motor: 50 kW (67 hp), 190 Nm
Transmission:
Fixed ratio
Battery:
27.4 kWh nickel-metal hydride battery
Range: 95 mi (153 km)
Curb weight: 1,560 kg

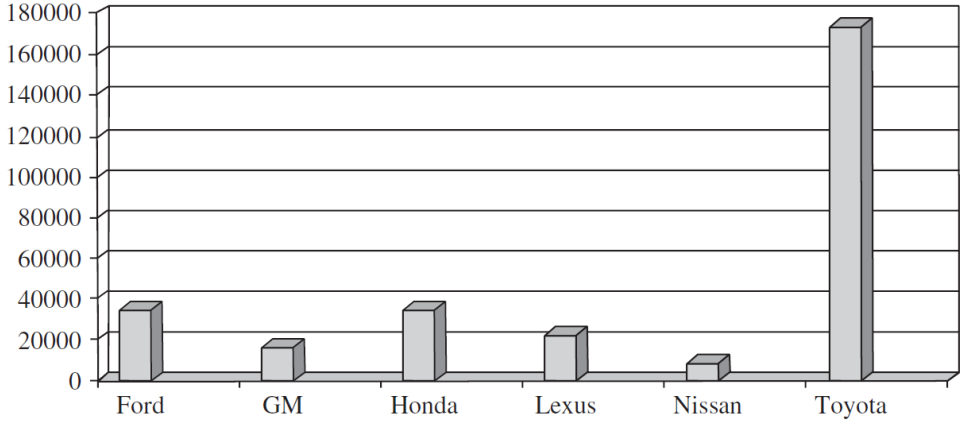
Hybrid Electric Vehicles (HEV) in late 1990's

Toyota Prius – 1997-present





HEV sales by Model in USA in 2009



Governmental Supports in USA

The FreedomCAR and Vehicle Technologies (FCVT) by Bush Admistration in 2003
Aim: Support Fuel-Cell and Hybrid Electric Vehicles

2011, President Obama's Plan to Make the U.S. the First Country to Put 1 Million Advanced Technology Vehicles on the Road

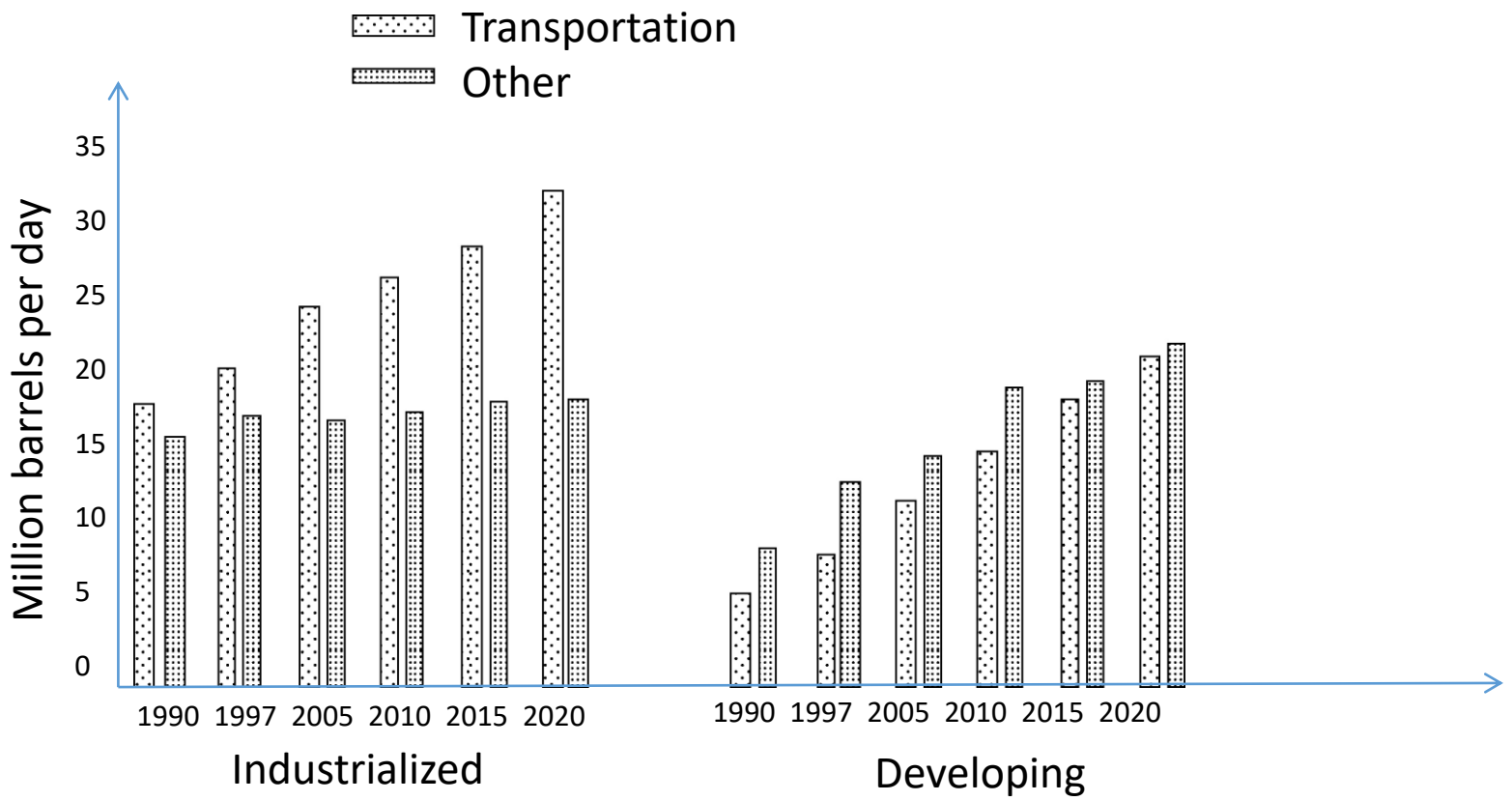
"With more research and incentives,
we can break our dependence on oil with biofuels,
and become **the first country to have a million electric vehicles on the road by 2015**"

President Barack Obama, 2011 State of the Union
"One Million Electric Vehicles by 2015: February 2011 Status Report

2018
Electric vehicles are gaining momentum, despite Trump
Policymakers and analysts are digging into the details of how to get more EVs on the road.
https://www.vox.com/energy-and-environment/2018/6/26/17500074/electric-vehicles-evs-zevs-fuel-trump

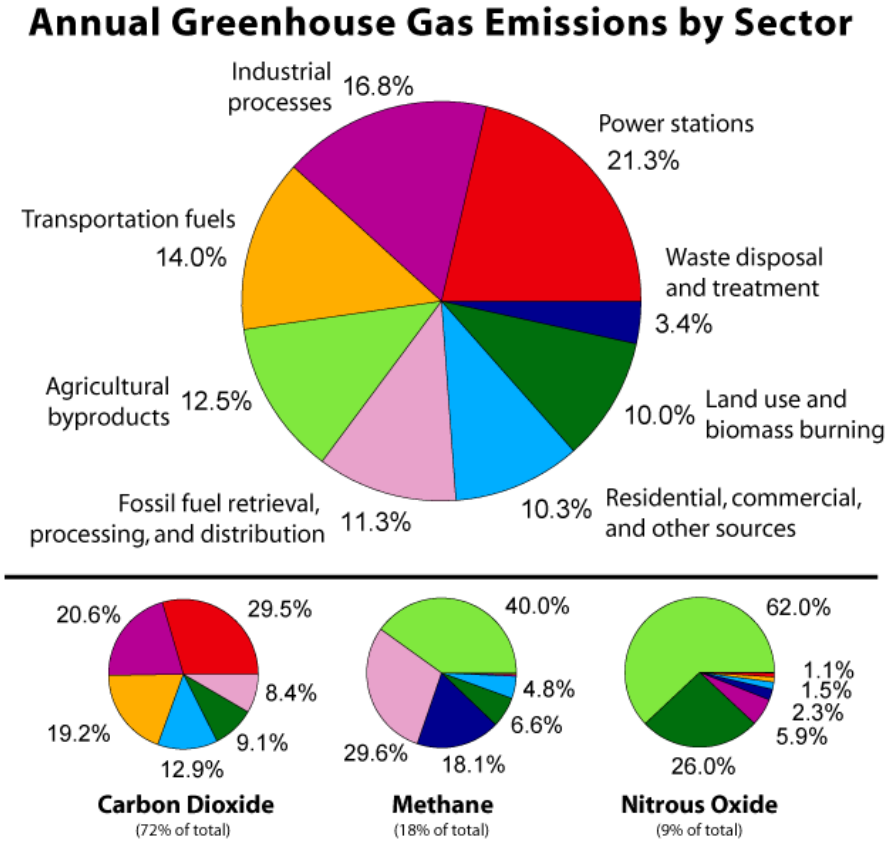
Why Vehicles with Electrified Powertrains?

1. Decrease the dependence on oil resources and unstable prices



Why Vehicles with Electrified Powertrains?

1. Decrease the dependence on oil resources and unstable prices
2. Increase efficiency of transportation to decrease emissions and pollutants
   - Decrease in emission of greenhouse gasses



Quote from Albert Einstein: Nothing will benefit human health and increase chances for survival of life on Earth as much as the evolution to a vegetarian diet.

Why Vehicles with Electrified Powertrains?

1. Decrease the dependence on oil resources and unstable prices
2. Increase efficiency of transportation to decrease emissions and pollutants
   - Decrease in emission of greenhouse gasses

Table 1.1 Partial list of HEVs available in the United States

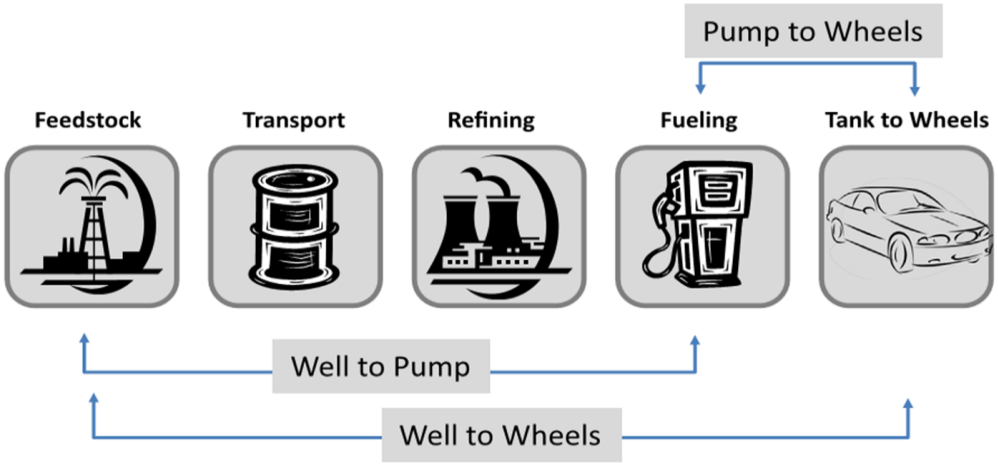
Manufacturer	Model	HEV price (US $)	Base model price (US $)	Price increase (%)	HEV MPG City	HEV MPG Hwy	Base MPG City	Base MPG Hwy	Increase in MPG (%) City	Increase in MPG (%) Hwy
Toyota	Prius[a]	22 800	15 450	47.6	51	48	26	35	96	37
	Camry	26 400	19 595	34.7	33	34	22	33	50	3
	Highlander	34 900	25 855	35.0	27	25	20	27	35	12
Ford/Mercury	Fusion	27 950	19 695	41.9	41	36	22	34	86	6
	Escape	29 860	21 020	42.1	34	31	22	28	55	11
	Mariner	30 105	23 560	27.8	34	31	21	28	62	11
	Milan	31 915	21 860	46.0	41	26	23	34	78	−24
Honda	Insight[b]	19 800	15 655	26.5	40	43	26	34	54	26
	Civic	23 800	15 655	52.0	40	45	26	34	54	32
Nissan	Altima	26 780	19 900	34.6	35	33	23	32	52	3
Lexus	RX 450h	42 685	37 625	13.4	32	28	18	25	78	12
	GS 450h	57 450	54 070	6.3	22	25	17	24	29	4
	LS 600h	108 800	74 450	46.1	20	22	16	23	25	−4

US mpg	L/100 km
26	9.05
27	8.71
28	8.40
29	8.11
30	7.84
31	7.59
32	7.35
33	7.13
34	6.92
35	6.72
36	6.53
37	6.36
38	6.19
39	6.03
40	5.88
41	5.74
42	5.60
43	5.47
44	5.35
45	5.23
46	5.11
47	5.00

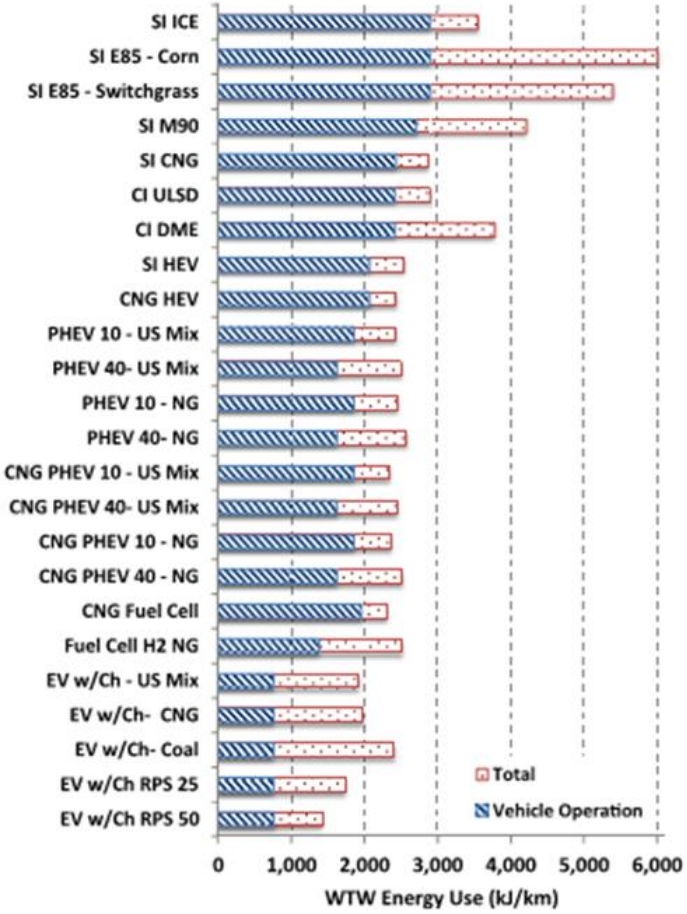
https://www.calculateme.com/gas-mileage/us-mpg-to-liters-per-100-km

Why Vehicles with Electrified Powertrains?

1. Decrease the dependence on oil resources and unstable prices
2. Increase efficiency of transportation to decrease emissions and pollutants
   - Decrease in emission of greenhouse gasses

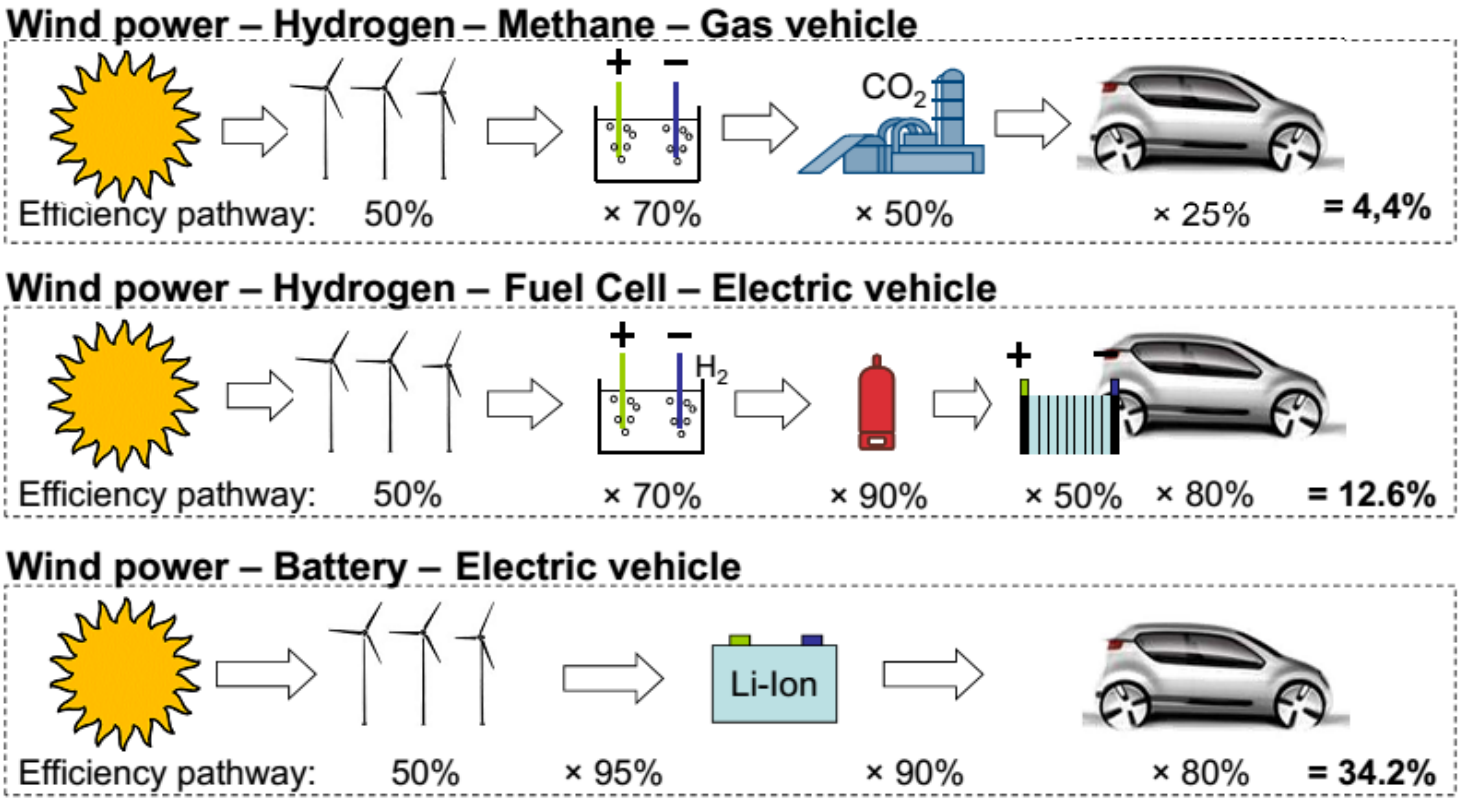


Definition of Well-to-Wheels (WTW) fuel pathway



Why Vehicles with Electrified Powertrains?

1. Decrease the dependence on oil resources and unstable prices
2. Increase efficiency of transportation to decrease emissions and pollutants
   - Decrease in emission of greenhouse gasses



Why Vehicles with Electrified Powertrains?

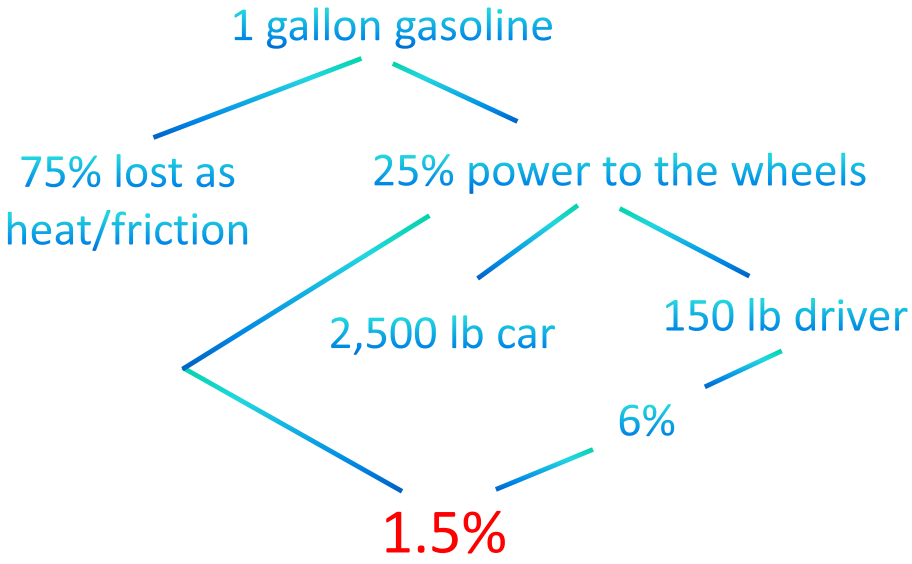
1. Decrease the dependence on oil resources and unstable prices
2. Increase efficiency of transportation to decrease emissions and pollutants
   - Decrease in emission of greenhouse gasses
   - Decrease in local pollutions

Beijing air on a 2005-day after rain (left) and a smoggy day (right)

Why Vehicles with Electrified Powertrains?

1. Decrease the dependence on oil resources and unstable prices
2. Increase efficiency of transportation to decrease emissions and pollutants
   - Decrease in emission of greenhouse gasses
   - Decrease in local pollutions

Question:
How much of the energy in a gallon of gasoline is used to move the driver of a car?



Current ***system*** is very inefficient!

Why Vehicles with Electrified Powertrains?

1. Decrease the dependence on oil resources and unstable prices
2. Increase efficiency of transportation to decrease emissions and pollutants
   - Decrease in emission of greenhouse gasses
   - Decrease in local pollutions
3. Enable new technologies and start a new era of transportation

Question: Difference between?

Why Vehicles with Electrified Powertrains?

1. Decrease the dependence on oil resources and unstable prices
2. Increase efficiency of transportation to decrease emissions and pollutants
   - Decrease in emission of greenhouse gasses
   - Decrease in local pollutions
3. Enable new technologies and start a new era of transportation

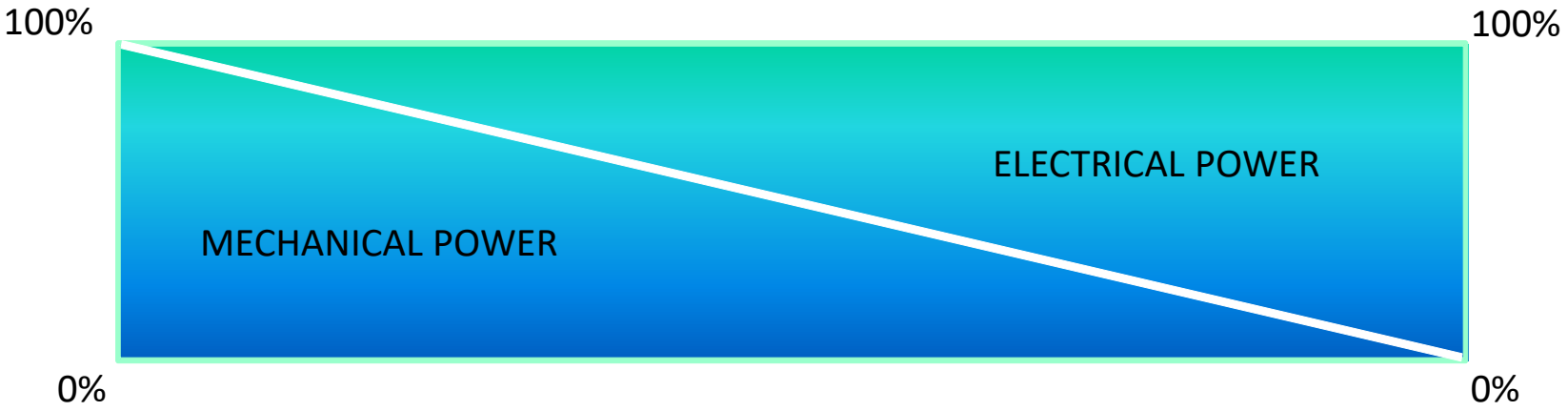
Content

Part I: Course Information

Part II: Brief History of Electrified Powertrains

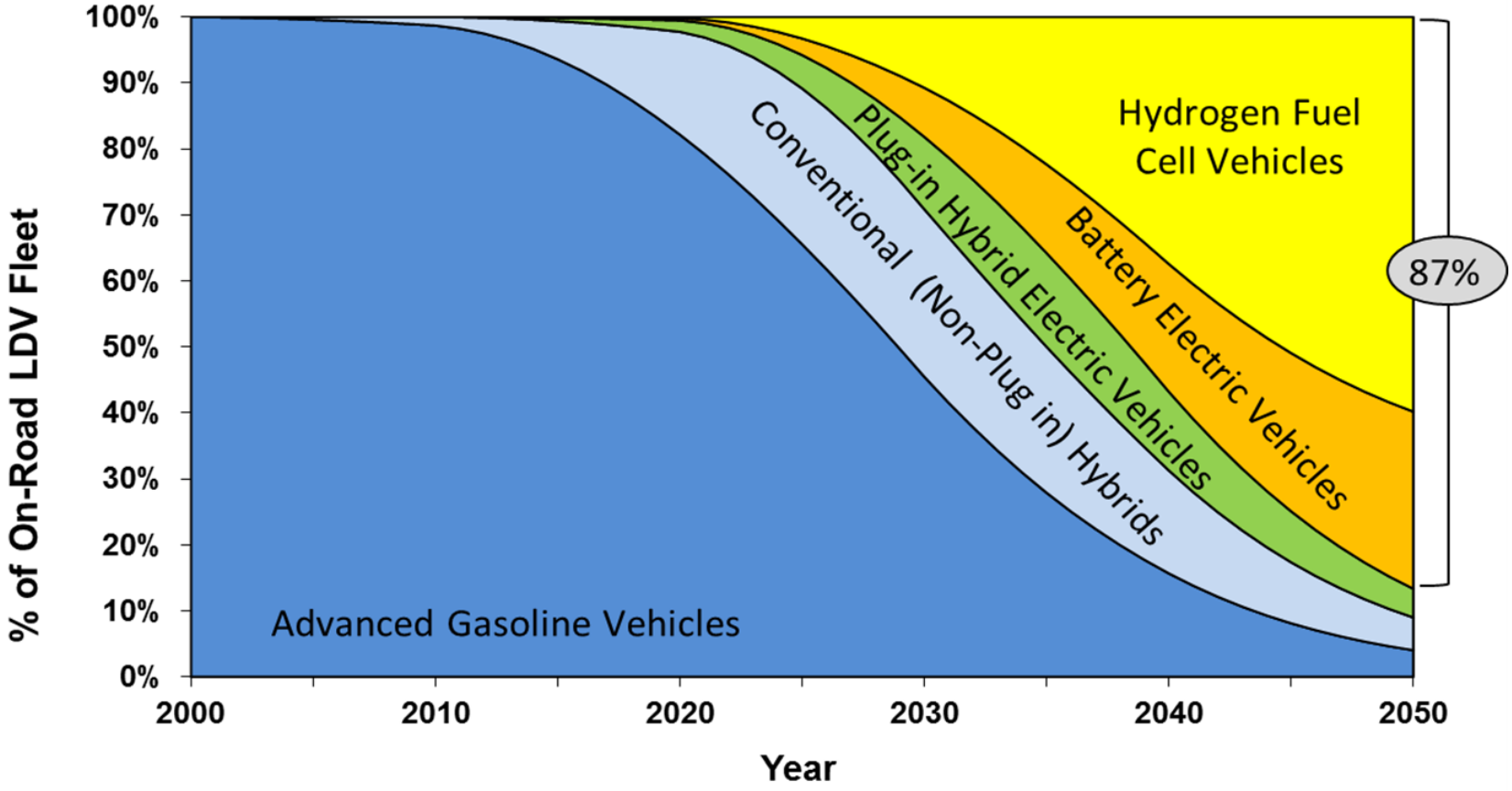
Part III: Today's Electrified Vehicles

Today's Electrified Vehicles



Internal Combustion Engine (ICE)	Hybrid (HEV)	Plug -In Hybrid (PHEV)	Extended Range Electric (EREV)	Battery Electric (BEV) Fuel Cell Electric (FCEV)
Mechanical Drive	Mechanical Drive with Electrical Assist		Electrical Drive with Mechanical Assist	Electrical Drive

Today's Electrified Vehicles – Powertrain Options



Hybrids

2.8% U.S. Market Share (2014)

- 462,000 sold
- ***16 years to attain this share***
- About 50 different models for sale
  - Driven by 2016 CAFE

Toyota Prius 45% of Hybrid Market

- Price Range of $19,000 (Prius C) to $27,000 (Prius V)
- Fuel Economy Range of 44/40 MPG (Prius V) to 53/46 MPG (Prius C)

Ford Fusion Hybrid (2013)

- 47 mpg combined (vs. 28 for non-hybrid)
- $27,000 (+$5,000 vs. non-hybrid, ***10 year payback at $3.00/gal***)
- 37,000 sold (8% share of U.S. Hybrid Market and 12% of Fusion sales)

Plug-In Electric Vehicles

0.7% U.S. Market Share (2014)

- 119,000 sales (up 23% vs. 2013)
  - More models for sale (22)
  - Nissan, Chevrolet and Ford offering significant price reductions
    - Leaf Lease $199 per month
    - Volt Lease $219 per month
    - C-Max Energi Lease $226 per month
    - Large financial loses likely
- Far short of initial expectations
  - President Obama: “1 Million Plug-Ins on U.S. Roads by 2015”
  - Carlos Ghosn: “Leaf sales will reach 500,000 per year”
  - GM: Initial Volt capacity set at 65,000 per year

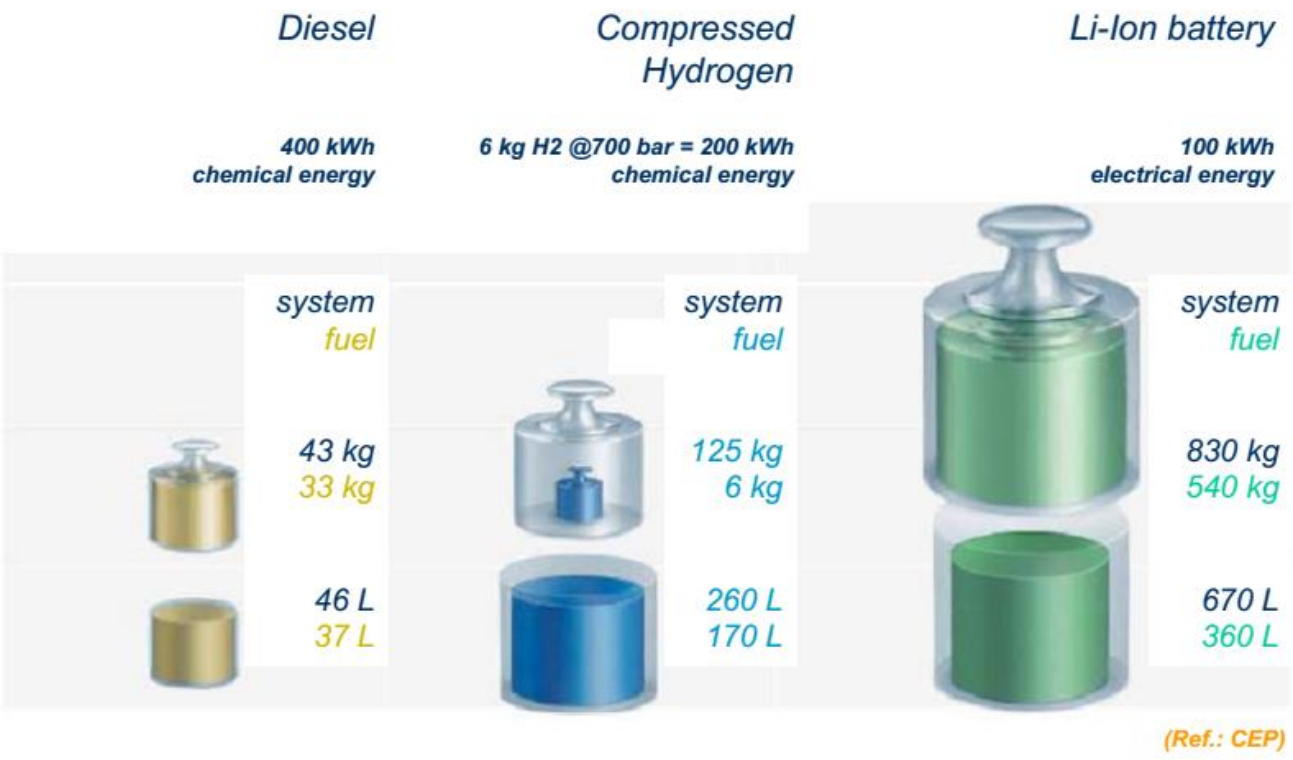
About 50% Plug-in Hybrid

- Chevrolet Volt (19,000) and Toyota Prius Plug-in (13,000)

About 50% Battery EV

- Nissan Leaf (30,000) and Tesla S-Model (17,000)

Fuel Cell Electric Vehicles (FCEVs)



Filling/Range with 1 min filling

- Diesel: 1000 km driving
- Hydrogen: 100 km driving
- Battery: 1 km driving

Fuel Cell Electric Vehicles (FCEVs)

Honda, Hyundai and Toyota announced 2015/16 commercial launches

- Hyundai Tucson FCV
- Honda Clarity/FCV Concept
- Toyota Mirai in CA
- Daimler, Ford, Renault/Nissan and GM Followers

Fuel Cell Electric Vehicles (FCEVs)

Toyota Mirai

Today's Electrified Vehicles

Chevrolet Spark EV
Combined MPGe: 119
MSRP: $26,685
Range: 82 miles

Honda Accord Plug-in
Combined MPGe: 115
MSRP: $39,780
Range: 13 miles (electric only)

Honda Fit EV
Combined MPGe: 118
MSRP: Lease only - 3 years at $259/month, $0 down
Range: 82 miles

Fiat 500e
Combined MPGe: 116
MSRP: $31,800
Range: 87 miles

Today's Electrified Vehicles

Nissan Leaf EV
Combined MPGe: 115
MSRP: $28,800
Range: 75 miles

Mitsubishi i-MiEV
Combined MPGe: 112
MSRP: $22,995
Range: 62 miles

Smart ForTwo Electric Drive
Combined MPGe: 107
MSRP: $25,000
Range: 68 miles

Ford Focus Electric
Combined MPGe: 105
MSRP: $35,200
Range: 76 miles

Today's Electrified Vehicles

Ford Fusion Energi Plug-in
Combined MPGe: 105
MSRP: $38,700
Range: 21 miles (electric only)

Tesla Model S (85 kWh battery)
Combined MPGe: 89
MSRP: $81,070
Range: 265 miles

Ford C-Max Energi Plug-in
Combined MPGe: 100
MSRP: $32,950
Range: 21 miles (electric only)

Tesla Model S (60 kWh battery)
Combined MPGe: 95
MSRP: $71,070
Range: 208 miles

Today's Electrified Vehicles

Toyota RAV4 EV
Combined MPGe: 76
MSRP: $49,800
Range: 103 miles)

Chevrolet Volt (HEV)
Combined MPGe: 98
MSRP: $34,995
Range: 38 miles (electric only)

Toyota Prius Plug-in
Combined MPGe: 95
MSRP: $29,990
Range: 11 miles (electric only)

Today's Electrified Vehicles

Today's Electrified Vehicles

Today's Electrified Vehicles

CO2 emissions 0 g/km (combined) **Fuel consumption** 0 l/100 km (combined)

Power consumption 14.6-13.1* kWh/100 km (combined)

CO2 emissions 42 g/km (combined) **Fuel consumption** 1.8 l/100 km (combined)

Power consumption 14 kWh/100 km (combined)

Today's Electrified Vehicles

Kampanya

Toyota C-HR *HYBRID'I MEVCUT*

Yaris *HYBRID'I MEVCUT*

Auris *HYBRID'I MEVCUT*

Auris Touring Sports
HYBRID'I MEVCUT

Corolla

https://www.toyota.com.tr/

Tomorrow’s Electrified Vehicle

Interesting videos:

Volkswagen Fuel Cell EV:

https://www.youtube.com/watch?v=gQZj5PiOwv8

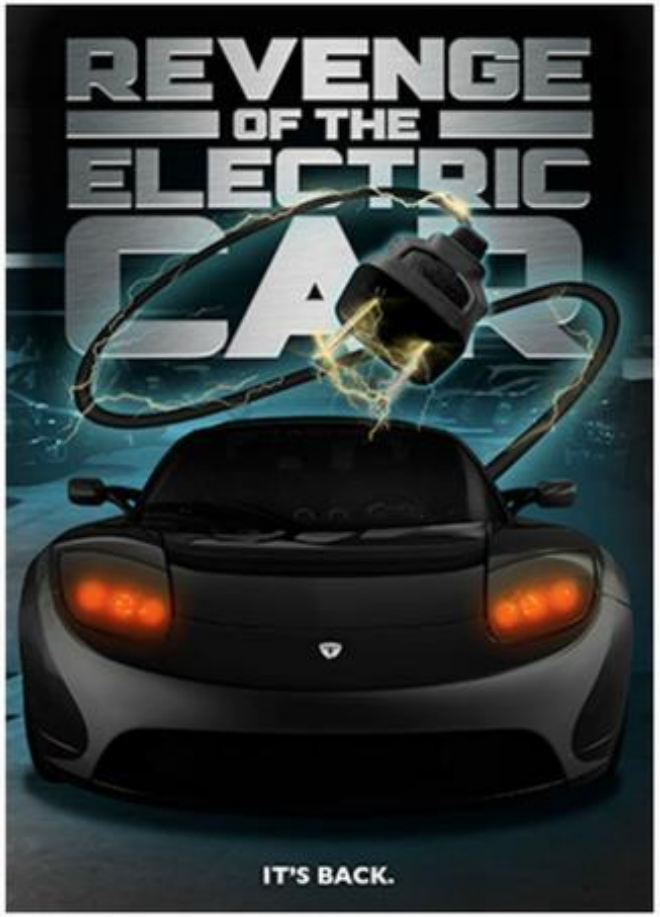
Advertisement:

https://www.youtube.com/watch?v=13bG9xnoMSQ

Movie Suggestion II

Revenge of the Electric Car 7.2/10

PG | 1h 30min | Action, Fantasy | 20 July 2012 (UK)



https://www.imdb.com/title/tt1413496/