

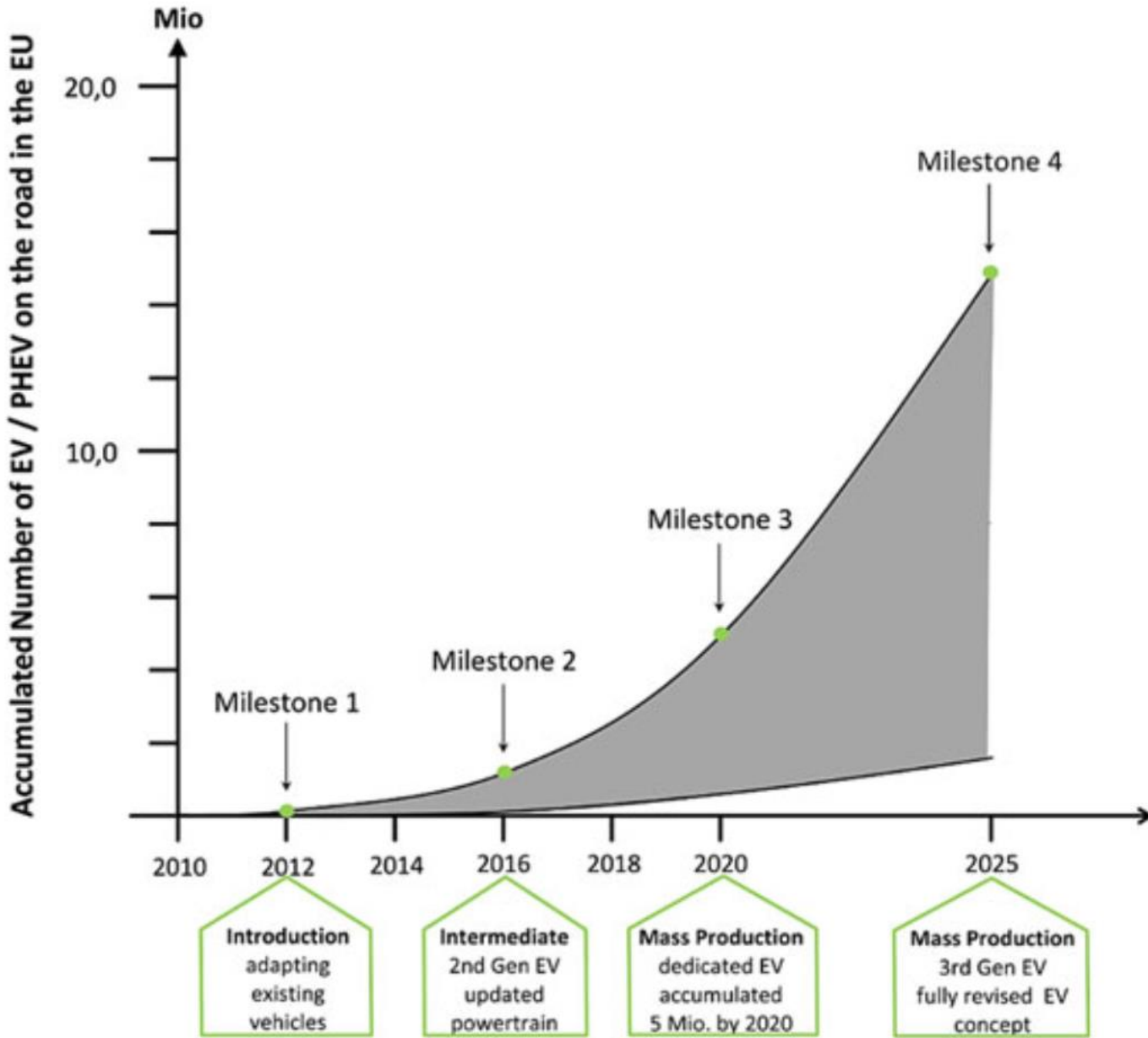
Elektrikli Araç Teknolojileri



Dr. Öğr. Üyesi Fatih SERTTAŞ

Avrupa Yol Ulaşımı Elektrifikasyonu Yol Haritası

- Avrupa Birliği'nin "Karayolu Taşımacılığının Avrupa Yol Haritası Elektrifikasyonu"na göre, altı teknoloji alanında temel ilerleme sağlanırsa, özel BEV'lerin ve PHEV'lerin seri üretimi 2020 yılına kadar mümkün olacaktır:
- enerji depolama sistemleri,
- aktarma organları teknolojileri,
- araç entegrasyonu,
- emniyet,
- yol entegrasyonu ve
- şebeke entegrasyonu



☞ Kilometre Taşları – Avrupa Karayolu Araçları Elektrifikasyonu

Bugünün Ortalama Deęerleri

- ☞ Menzil : 90 km (minimum) – 800 km (maksimum), çoęunluk 300 km
- ☞ Őarj süresi: yarım saat ile 20 saat arasında deęiŐiyor, genellikle 4-8 saat
- ☞ Batarya kapasitesi ortalama: 22 kWh
- ☞ Ortalama fiyat 30.000 € (En uygunu Renault Twizy 7150 €, ölkemizde 191.900 TL, 08.10.2021)



NISSA:
NISSAN LEAF



Type: Compact car	Drive: Front-wheel	Top speed: 145 km/h (90 mph)
Production: Series	Motor: Synchronous AC	Battery: Li-ion
Length: 4.445 m (175 in)	Distance between wheels: 2.7 m (106.23 in)	Torque: 280 Nm
Width: 1.770 m (72.2 in)	Base curb weight: 1,525 kg (3,362.1 lb)	Charging (time): 110 V/220 V— 0.5 h/8 h
Height: 1.409 m (69.69 in)	Motor weight: 130 kg (280 lb)	Battery weight: 300 kg (660 lb)
	Battery capacity: 24 kWh	Electric range: 121 km (75 mi)

TESLA:
MODEL S



Type: Full-size Luxury

Drive: Rear-wheel

Top speed: 201 km/h
(125 mph)

Production: Series

Motor: Three phase, four pole AC induction motor with copper rotor

Battery: Li-ion

Length: **4.976 m (196.1 in)**

Distance between wheels: 2.96 m
(116.54 in)

Torque: 600 Nm

Width: **1.963 m (77.2 in)**

Base curb weight: 2,108 kg (4,643 lb)

Charging (time):
110 V/220 V—0.5 h/4 h

Height: **1.435 m (59.7 in)**

Motor weight: 130 kg (280 lb)

Battery weight: 1200 kg
(2646 lb)

Battery capacity: 85 kWh

Electric range: 120 km
(75 mi)

**RENAULT:
RENAULT TWIZY URBAN
45 Z.E.**



Type: Microcar	Drive: Rear-wheel	Top speed: 50 km/h (31 mph)
Production: Series	Motor: Synchronous AC	Battery: Li-ion
Length: 2.337 m (92,2 in)	Distance between wheels: 1.7 m (66.5 in)	Torque: 57 Nm
Width: 1.191 m (47.3 in)	Base curb weight: 350 kg (772 lb)	Charging (time): 220 V—3.5 h
Height: 1.461 m (57.5 in)	Motor weight: 130 kg (280 lb)	Battery weight: 100 kg (220.5 lb)
	Battery capacity: 6.1 kWh	Electric range: 80 km (50 mi)

RENAULT:
RENAULT ZOE



Type: Supermini	Drive: Front-wheel	Top speed: 140 km/h (87 mph)
Production: Series	Motor: Synchronous AC	Battery: Li-ion
Length: 4.086 m (160.87 in)	Distance between wheels: 2.59 m (101.96 in)	Torque: 222 Nm
Width: 1.788 m (70.47 in)	Base curb weight: 1,392 kg (3,068 lb)	Charging (time): 220/400 V—0.5–6/8 h
Height: 1.540 m (60.63 in)	Motor weight: n.a.	Battery weight: 290 kg (640 lb)
	Battery capacity: 22 kWh	Electric range: 200 km (15 mi)

**MITSUBISHI:
MITSUBISHI IMIEV**



Type: Subcompact car

Drive: Rear-wheel

Top speed: 130 km/h (80 mph)

Production: Series

Motor: Permanent synchronous

Battery: Li-ion

Length: **3.475 m (136.8 in)**

Distance between wheels: 2.55 m
(98.52 in)

Torque: 180 Nm

Width: **1.475 m (58.08 in)**

Base curb weight: 1,185 kg (2,612 lb)

Charging (time):
110/220 V—0.5–8 h

Height: **1.610 m (63.39 in)**

Motor weight: n.a.

Battery weight: 200 kg (440 lb)

Battery capacity: 16 kWh

Electric range: 160 km (100 mi)

BMW:
BMW MINI E



Type: Subcompact car	Drive: Front-wheel	Top speed: 153 km/h (95 mph)
Production: Demonstration	Motor: Permanent synchronous	Battery: Li-ion
Length: 3.713 m (146.06 in)	Distance between wheels: 2.47 m (97.1 in)	Torque: 240 Nm
Width: 1.684 m (66.15 in)	Base curb weight: 1,460 kg (3,218 lb)	Charging (time): 110/220 V—3.5–20 h
Height: 1.407 m (67.33 in)	Motor weight: n.a.	Battery weight: 259 kg (572 lb)
	Battery capacity: 35 kWh	Electric range: 170 km (105 mi)

**MERCEDES:
SLS AMG E-CELL**



Type: Sports car	Drive: All-wheel	Top speed: 317 km/h (197 mph)
Production: Series	Motor: 4 x synchronous	Battery: Li-ion
Length: 4.638 m (181.1 in)	Distance between wheels: 2.69 m (106.3 in)	Torque: 880 Nm
Width: 1.939 m (76.38 in)	Base curb weight: 1,620 kg (3,570 lb)	Charging (time): 110/220 V—3–20 h
Height: 1.407 m (49.65 in)	Motor weight: n.a.	Battery weight: 550 kg (1212.52 lb)
	Battery capacity: 48 kWh	Electric range: 260 km (160 mi)

Hibrit

GA

TOYOTA:
PRIUS HYBRID III



Type: Mid-size car

Drive: Front-wheel

Top speed: 180 km/h (112 mph)

Production: Series

Motor: Permanent motor

Battery: Li-ion

Length: **4.480 m**
(**176.378 in**)

Distance between wheels: 2.7 m
(106.3 in)

Torque: 207 Nm

Width: **1.745 m (68.71 in)**

Base curb weight: 1,490 kg
(3,284 lb)

Charging (time): 110/220 V—1.5–3.5 h

Height: **1.490 m (58.66 in)**

Motor weight: n.a.

Battery weight: 53 kg (118 lb)

Engine: **1.8 L 4 cylinders**
Otto Motor

Battery capacity: 4.4 kWh

Electric range: 23 km (14.3 mi)

PHEV



BMW: BMW i8



Type: Sports car

Drive: Front-wheel

Top speed: 250 km/h (155 mph)

Production: Series

Motor: Hybrid synchronous e-motor

Battery: Li-ion

Length: **4.869 m (195.27 in)**

Distance between wheels:
2.8 m (110.24 in)

Torque: 320 Nm

Width: **1.942 m (76.46 in)**

Base curb weight: 1,490 kg
(3,284 lb)

Charging (time): 110/220 V—1.5–3.5 h

Height: **1.293 m (50.91 in)**

Motor weight: n.a.

Battery weight: 98 kg (216 lb)

Engine: **1.5 L turbo-charged Inline-gasoline**

Battery capacity: 7.2 kWh

Electric range: 40 km (25 mi.)

FCEV



TOYOTA MIRAI



Type: Compact car

Drive: n.a.

Top speed: 175 km/h (108 mph)

Production: Series

Motor: Synchronous motor

Battery: Nickel metal hydride

Length: **4.890 m (192.5 in)**

Distance between wheels: 2.780 m (109.5 in)

Torque: 335 Nm

Width: **1.815 m (70.8 in)**

Base curb weight: 1,850 kg (4,078 lb)

Pressure: 700 bar

Height: **1.655 m (71.26 in)**

Motor weight: n.a.

Range: 310 km (500 mi.)

Tank volume: **n.a.**

Battery capacity: 1.6 kWh

Consumption: n.a.

Kullanıcı için:

Specification	ICE (VW GOLF 1.4TSI)	HEV (Toyota Prius III)	BEV (Nissan Leaf)	FCEV (Honda Clarity)
Power supply	ICE	ICE, e-motor	Battery and e-motor	PEM fuel cells and e-motor
Fuel	Petrol, diesel & alternative fuel	Petrol/diesel as main fuel	'Electricity'	Hydrogen
Top speed (km/h) (mph)	200 124	180 112	150 94	160 100
Acceleration (s)	9,5	10,4	7	10
Range (km) (mi.)	890 552	1150 716	117-175 73-109	390 240
Running fuel price (per mile)	0.2 EUR (0.22 USD)	0.12 EUR (0.14 USD)	from 0.01 EUR (0.02 USD)	from 0.06 EUR (0.07 USD)
Fuel economy (mpg or mpg equivalent)	45.6	72.4	99	84
Tailpipe CO ₂ emission (g/km)	144	89	0	0

Characteristic Reference vehicle	Conventional VW Golf VI	Hybrid Toyota Prius III	Hydrogen Honda FCX Clarity	Battery Nissan Leaf
Fuel weight (kg) (lb)	40.8 89.9	33.3 73.4	4.1 9	171 377 ^a
Storage capacity (kWh)	500	409	137	24
Specific energy (Wh primary/kg fuel)	12,264	12,264	33,320	140 ^a
Storage system weight (kg)	48 105.8	40 88.2	93 205.1	300 ^b 661.4
Specific energy (Wh primary/kg of storage)	10,408	10,261	1,469	80
Net power (kW)	90	100	100	80
Power plant and auxiliary weight (kg) (lb)	233 513.7	253 557.8	222 489.4	100 220.4
Specific energy (Wh primary/kg total equipment)	1,782	1,389	315	60
Average conversion efficiency	21 %	35 %	60 %	92 %
Effective storage capacity (kWh useable)	105.0	143.1	82.0	22.1
Specific energy (Wh useable/kg total equipment)	374	489	260	55

Region	VAT	Tax Scheme		Subsidy
		One-time	Annual	One-time
Norway	25% BEVs exempted	<ul style="list-style-type: none"> Registration tax based on vehicle weight, engine power, nitrogen oxide emissions, and CO₂ emissions. BEVs are exempted. 	<ul style="list-style-type: none"> Circulation tax about 350 EUR 	
Netherlands	21%	<ul style="list-style-type: none"> Registration tax based on the CO₂ emission level of the vehicle. BEVs and most PHEVs are exempted. 	<ul style="list-style-type: none"> Circulation tax based on the vehicle weight, fuel type, and CO₂ emission. BEVs and most PHEVs are exempted. [Company car] Income tax for cars emitting more than 50 g/km CO₂ of 25% of the vehicle's catalogue value in 2013. BEVs and some PHEVs are exempted. 	
US (including California)	7.3%* (8.4%)	<ul style="list-style-type: none"> Registration fee around 33 EUR Gas-guzzler tax for very fuel-inefficient vehicles 		<ul style="list-style-type: none"> Up to about 5,500 EUR based on battery capacity (federal); About 1,800 EUR for BEVs and 1,100 EUR for PHEVs (Calif.).
France	19.6%	<ul style="list-style-type: none"> Registration tax based on engine power. EVs are exempted. 	<ul style="list-style-type: none"> [Company car] Income tax based on CO₂ emission. BEVs and some PHEVs are exempted 	<ul style="list-style-type: none"> Up to 7,000 EUR for EVs
Japan	5%	<ul style="list-style-type: none"> Acquisition tax based on engine displacement and vehicle price. EVs are exempted. 	<ul style="list-style-type: none"> Tonnage tax based on vehicle weight. EVs are exempted; Automobile tax based on engine displacement. EVs are exempted 50% 	<ul style="list-style-type: none"> Up to about 6,500 EUR based on price difference for EVs.
Sweden	25%		<ul style="list-style-type: none"> Road tax based on CO₂ emission. EVs are exempted. [Company car] Income tax partially based on vehicle price. EVs are exempted 40%. 	<ul style="list-style-type: none"> Up to about 4,600 EUR based on price difference for EVs.

Region	VAT	Tax Scheme		Subsidy
		One-time	Annual	One-time
Denmark	25%	<ul style="list-style-type: none"> Registration fee mostly based on vehicle price. EVs weighing less than 2000 kg are exempted. 	<ul style="list-style-type: none"> Annual circulation tax based on fuel consumption. BEVs weighing < 2000 kg are exempted. [Company car] Income tax based on price. 	
Austria	20%	<ul style="list-style-type: none"> Registration tax based on fuel consumption. EVs have deductions. 	<ul style="list-style-type: none"> Circulation tax based on engine power. EVs are exempted. [Company car] Income tax based on price. 	
Germany	19%		<ul style="list-style-type: none"> Circulation tax based on engine displacement and CO₂ emission. EVs are exempted for 10 years. [Company car] Income tax based on price. EVs have deductions. 	
United Kingdom	20%	<ul style="list-style-type: none"> First year excise duty based on the CO₂ emission and vehicle price. BEVs and some PHEVs are exempted. 	<ul style="list-style-type: none"> Excise duty from second year of purchase based on the CO₂ emission and vehicle price. BEVs and some PHEVs are exempted. [Company car] Income tax based on CO₂ emission and price. BEVs are exempted. 	<ul style="list-style-type: none"> Up to 5,900 EUR for BEVs and some PHEVs
China	17%	<ul style="list-style-type: none"> Acquisition tax (10%) Excise tax based on zvehicle engine displacement and price. 	<ul style="list-style-type: none"> Vehicle and vessels fee based on engine displacement and price. EVs are exempted. 	<ul style="list-style-type: none"> Up to 7,200 EUR for EVs

Türkiye'de durum



☞ Otomotiv Distribütörleri Derneği verilerine göre, 2019'da 222 adet elektrikli otomobil satışı gerçekleşmişti. Türkiye otomobil pazarında 2020'de 844 elektrikli araç satıldı. 2020'de elektrikli otomobil satışları yüzde 280,2 artış gösterdi.

Türkiye'de durum



Elektrikli ve hibrit otomobillerin payı da yüzde 3,2'den yüzde 3,8'e yükseldi.

Türkiye'de durum



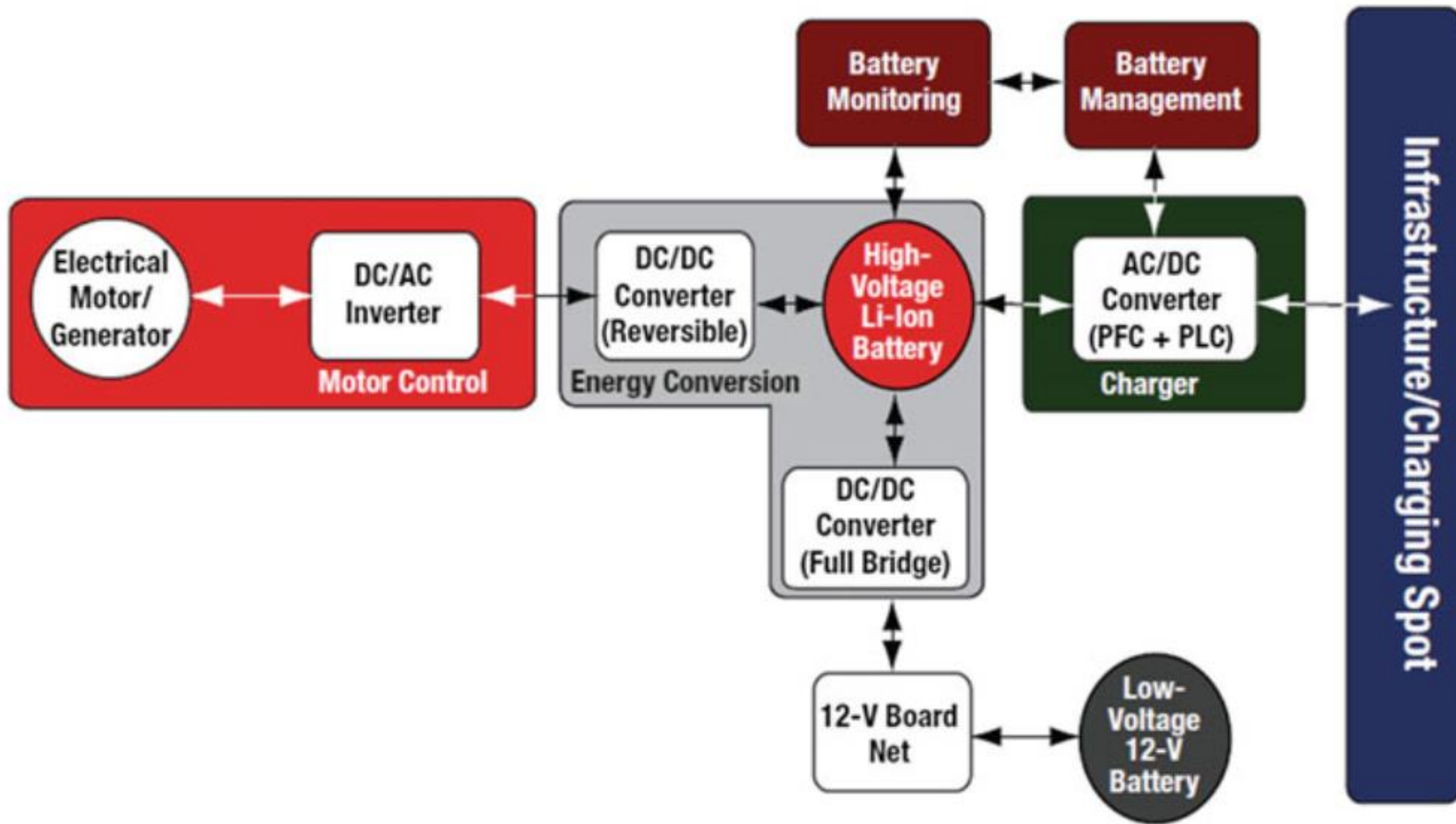
- Resmi Gazete'de yayımlanan Cumhurbaşkanlığı kararıyla 4760 sayılı Özel Tüketim Vergisi kanununa ekli II sayılı listede yer alan elektrikli araç tiplerinde farklı oranlarda ÖTV artışı yapıldı.
- Buna göre özel tüketim vergisi (ÖTV) oranı motor gücü 85 kW'yi geçmeyen **elektrikli** araçlarda yüzde 3'ten yüzde 10'a, motor gücü 85 kW'yi geçen fakat 120 kW'yi geçmeyen **elektrikli** araçlarla yüzde 7'den yüzde 25'e, motor gücü 120 kW'yi geçen **elektrikli** araçlarda yüzde 15'ten yüzde 60'a yükseltildi.

Batarya Teknolojileri



Batarya Performans Metrikleri

- ❧ Spesifik Enerji
- ❧ Enerji Yoğunluğu
- ❧ Özgül Güç (Spesifik Enerji)
- ❧ Güç Yoğunluğu
- ❧ Ömür
- ❧ Döngü Süresi
- ❧ Nihai Fiyat
- ❧ İşletim Çevresi
- ❧ Kapasite
- ❧ Yeniden şarj süresi
- ❧ 1 saatlik sürekli deşarj
- ❧ Güç ve kapasite bozunumu (eskimesi)



Spesifik Enerji (Wh/kg)



☞ Birim ağırlık başına Batarya paketinin toplam enerji yoğunluğunun bir ölçüsü. Araç menzilin bir göstergesini sağlar. Toplam enerji, geleneksel, içten yanmalı motorla çalışan bir otomobildeki benzin deposunun boyutuna benzer. Bu metrik, EV Bataryaları için önemlidir, çünkü eklenen kütle hareket etmek için daha fazla enerji gerektirir.

Enerji yoğunluđu

(Wh/L)

- ✧ Birim hacim başına Batarya paketinde depolanan toplam enerjinin bir ölçüsü. Bu metrik, boyutun genellikle sınırlı olduđu taşınabilir elektroniklerde önemlidir.

Özgül Güç (W/kg)



œ Birim ağırlık başına verilebilecek toplam gücün bir ölçüsü. Enerjinin teslim edildiği zamana bölümü olan güç, kaynağın hızlandırma kabiliyetine dönüşür. EV'lerde güç, bir Batarya paketindeki enerjinin motorlara veya elektrik devrelerine ne kadar hızlı iletilebileceği ile sınırlıdır.

Güç Yoğunluğu (W/L)



- ⌘ Hızlanma sırasında olduğu gibi kısa bir süre içinde teslim edilebilen Batarya takımının birim hacmi başına toplam gücünün bir ölçüsü.

Ömür (Yıl)



- ❧ Bir EV batarya takımının tam olarak şarj edilip deşarj edilebileceđi ve belirli bir kapasite eşıđini koruyacađı beklenen süreye ilişkin bir mühendislik tahmini.
- ❧ Paketin özgül enerjisinde zamanla bir miktar bozulma meydana gelir ve kapasitesi orijinal deđerin belirli bir yüzdesinin altına düştüğünde Bataryanın deđiştirilmesi gerekir.

Hayat d6ngüsü (Cycle)



œ Bir Batarya paketinin kaç kez şarj edilip boşaltılabileceđi. Her şarj-deşarj olayı bir d6ngü oluşturur. Tipik olarak çevrim ömrü, Batarya paketinin deşarj derinliđi (DOD) ile ilgilidir. Derin deşarj ve şarj d6ngüleri d6ngü ömrünü düşürür.

Nihai Fiyat (\$/kWh)



- Dolar cinsinden bir Batarya paketinin maliyeti, Bataryanın tek bir şarjında bulunan (kWh cinsinden) toplam enerjiye bölünür.

Çalışma Ortamı



- ❧ Batarya takımının bulunduğu çevresel koşullara göre faaliyet göstermesi beklenir. Çalışma ortamı genellikle bir alt sıcaklık limiti ve bir üst sıcaklık limitinden oluşur.
- ❧ Bataryalar tipik olarak aşırı soğuk koşullarda çalışmaz ve düşük performans sergileyebilir veya yüksek sıcaklıklarda güvensiz hale gelebilir.

Kapasite



⌘ Bataryada depolanan toplam enerji, genellikle kWh olarak ifade edilir.

Şarj Süresi (Saat)



- ❧ Bataryayı önceden belirlenmiş kabul edilebilir bir düzeye yeniden şarj etmek için geçen süre.
- ❧ Yeniden şarj süresi genellikle C oranı olarak ifade edilir.
- ❧ 1C'lik bir yeniden şarj hızı, Bataryanın tam kapasitesinin 1 saatlik şarjdan sonra geri yüklenebileceği anlamına gelirken, 0,1C'lik bir yeniden şarj hızı, pil takımının tam olarak şarj edilmesinin yaklaşık 10 saat sürdüğünü gösterir.

1 saatlik sürekli deřarj



1 saatlik sabit güç deřarjında sağlanan enerji kapasitesinin yüzdesi olarak belirtilen, tepe (yokuř) tırmanma ve yüksek hızlı seyir için bir EV'nin gerektirdiđi sabit bir güç deřarjında iletilen enerji.

Güç ve kapasite düşüşü



- Performans düşüşü, pil sisteminin orijinal performans spesifikasyonunu ne ölçüde karşılayamayacağını tanımlar.

Table 3.1 NiMH HEV car sales, by model and year, 1999 through 2012

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Honda Insight	17	3,788	4,726	2,216	1,168	583	666	722	3	–	20,572	20,962	15,549	5,846
Toyota Prius ^a		5,562	15,556	20,119	24,627	53,991	107,897	106,971	181,221	158,886	139,682	140,928	136,463	223,905
Honda Civic ^b				13,707	21,771	26,013	25,864	31,253	32,575	31,297	15,119	7,336	4,703	–
Honda Accord ^c						653	16,826	5,598	3,405	198	1	–	–	–
Toyota Camry ^d								31,341	54,477	46,272	22,887	14,587	9,241	45,656
Lexus GS 450h ^c								1,784	1,645	678	469	305	282	607
Nissan Altima									8,388	8,819	9,357	6,710	3,236	103
Lexus LS 600h									937	980	258	129	84	54
Chevrolet Malibu										3,118	4,162	405	–	–
Saturn Aura										310	527	55	–	–
Fusion & Milan											17,022	22,232	11,286	14,100
Lexus HS 250h											6,699	10,663	2,864	649
Honda CR-z												5,249	11,330	4,192
Lincoln MKZ												1,192	5,739	6,067
Mercedes ML450												766	1	20
Mazda Tribute												655	484	90
Lexus CT 200h													14,381	17,671
Porsche Panamera S													52	570
Ford C-Max														10,935
Lexus ES														7,041
Toyota Avalon														747
Total	17	9,350	20,282	36,042	47,566	81,240	151,253	177,669	282,651	250,558	236,755	232,174	215,695	338,253

Sources: Sales data were compiled from J.D. Power, EDTA, Hybrid Dashboard, and Green Car Congress. See: www.hybridcars.com. See specifically, for 2011 and 2012, www.hybridcars.com/december-2012-dashboard.

☞ Nikel-metal hidrit pil

Table 3.3 Li-ion HEV sales, by model and year, 2010 through 2012

	2010	2011	2012	Total
Mercedes S400	955	309	121	1,385
BMW ActiveHybrid	350	381	1,041	1,772
Hyundai Sonata		19,673	20,754	40,427
Buick Lacrosse		1,801	12,010	13,811
Kia Optima		403	10,084	10,487
Infiniti M		378	691	1,069
Buick Regal		123	2,564	2,687
Malibu		24	16,664	16,688
Honda Civic			7,156	7,156
Acura ILX			972	972
Audi Q5			270	270
Volkswagen Jetta			162	162
Year total	1,305	23,092	72,489	96,886

Sources: Sales data were compiled from J.D. Power, EDTA, Hybrid Dashboard, and Green Car Congress. See: www.hybridcars.com. See specifically for 2011 and 2012: www.hybridcars.com/december-2012-dashboard.

∞ Lityum İyon pil

Table 3.4 PHV/EV (Li-ion) sales, by model and year, 2011 through 2012

	2011	2012	Total
GM Volt ^a	7,671	23,461	31,132
Nissan Leaf	9,674	9,819	19,466
Smart ED	388	139	527
Mitsubishi i	80	588	668
Ford Focus	8	685	693
Toyota Prius PHV ^a		12,750	12,750
Tesla Model S		2,400	2,400
Ford C-Max Energi PHV ^a		2,374	2,374
BMW Active E		671	671
Toyota RAV4 EV		192	192
Honda Fit EV		93	93
Year total	17,821	53,172	70,993

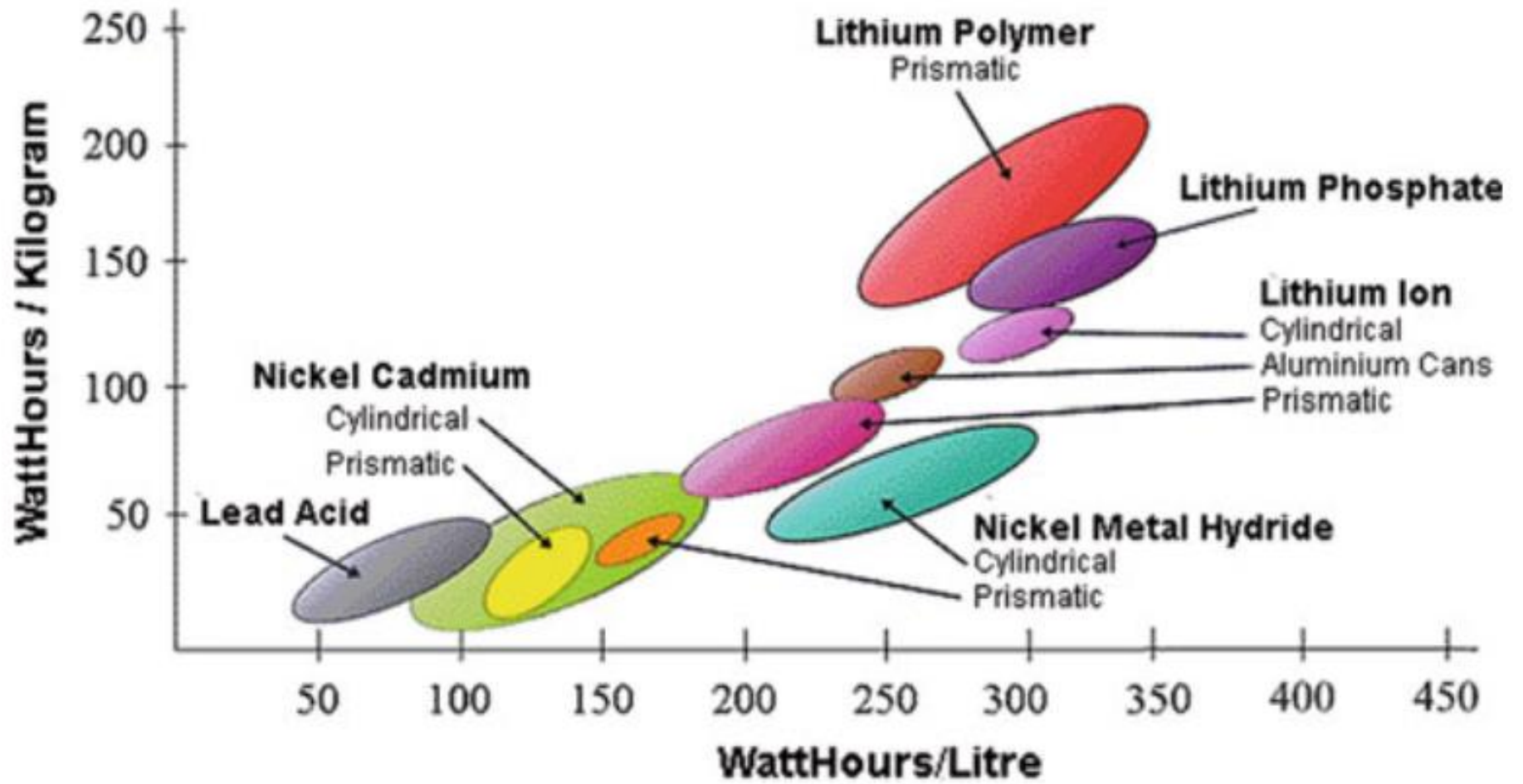
Sources: Sales data were compiled from J.D. Power, EDTA, Hybrid Dashboard, and Green Car Congress. See: www.hybridcars.com/december-2012-dashboard.

Note

^a Plug-in hybrids.

Performans Karakteristiği	Kurşun Asit	Nikel Kadmiyum (NiCd)	Nikel Metal Hidrit (NiMH)	Lityum-iyon (Li-ion)
Electrolyte	Water based	Water based	Water based	Organic
Nominal cell voltage (V)	2.0	1.2	1.2	3.6
Energy density (Wh/kg) ^a	35	40–60	60	120
Power density (W/kg) ^b	180	150	250–1,000	1,800
Cycle life ^c	4,500	2,000	2,000	3,500
Cost (\$/kWh) ^{d,e}	\$269	\$280	\$500–\$1,000	Consumer electronics: \$300–\$800 Vehicles: \$1,000–\$2,000 ^e
Battery characteristics	High reliability, low cost	Memory effect	Currently, best value and most popular for hybrid electric vehicles (HEVs)	Small size, light weight

Source: Lowe, Tokuoka, Trigg, and Gereffi (2010, p. 13).



Tesla Model S - 2021



- ❧ Sıvı soğutmalı Lityum İyon
- ❧ 450 Vdc
- ❧ -30 ila +60 derece arasında çalışabilme olanağı
- ❧ Kapasite: yaklaşık 100 kWh

Model S



 **2.3s**
From 0-60 mph

28 cu ft
Best in Class Storage

402mi
Range
(EPA est.)

[ORDER NOW](#)

Porsche Taycan - 2021

Batarya

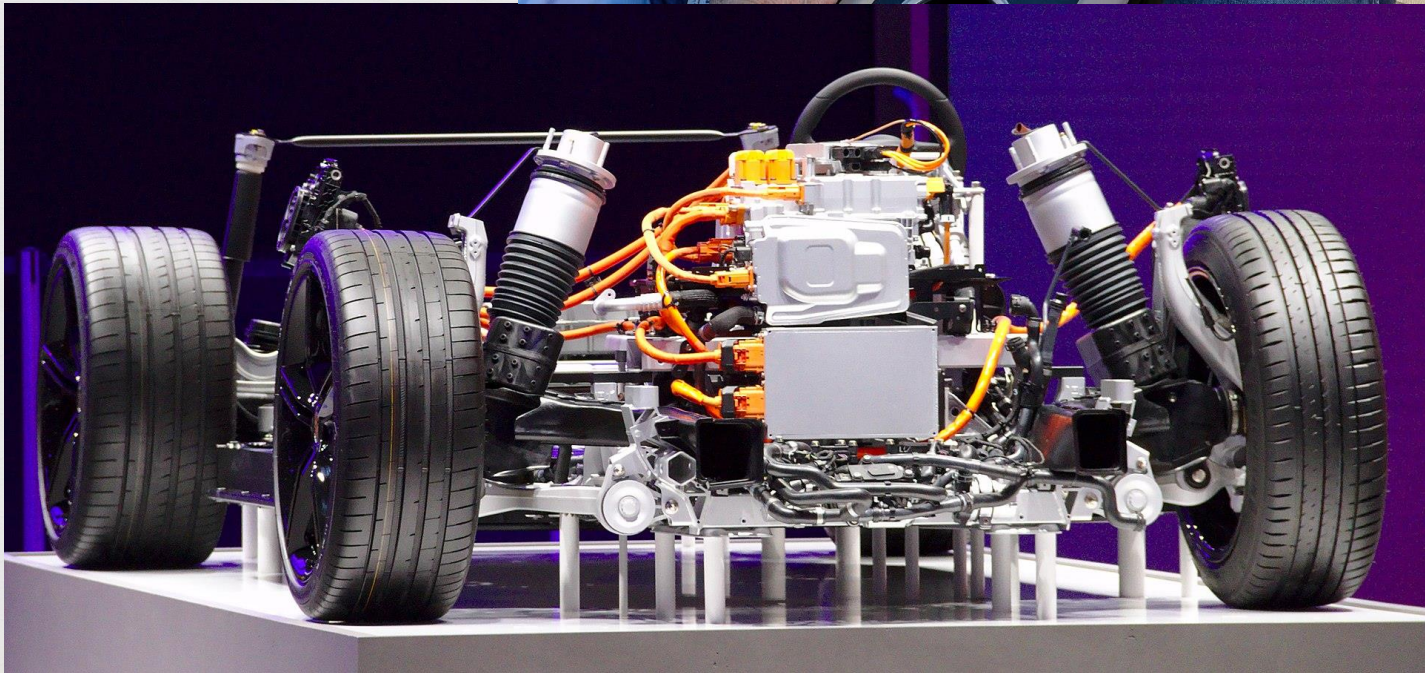
79.2 kWh (71.0 kWh usable) liquid-cooled lithium-ion or 93.4 kWh (83.7 kWh usable) liquid-cooled lithium-ion

Menzil

206.9 to 287.7 mi (333 to 463 km) (WLTP combined), 201 mi (323.5 km) (EPA)

Plug-in (Fişe takılı) Şarj

270 kW (800 volt) DC 11 kW (230/240 volt 3 phase) 9.6 kW (230/240 volt single phase) AC



Batarya türü

<i>Characteristic</i>	<i>Li-ion</i>	<i>NiMH</i>
Electrochemical cycle	Lithium	Hydrogen
Electrolytes supported by	Organic solvents	Water
Cell voltage	Typically higher voltage per cell (nominally 3.5 volts or higher), allowing Li-ion batteries to store higher amounts of energy than is possible with lower cell voltages; higher cell voltage is enabled by using organic electrolytes that have higher voltage stability	Typically lower voltage per cell
Weight of materials	Intrinsically lighter weight materials (e.g., the density of carbon, a typical Li-ion battery electrode, is 2.3 grams per cubic centimeter, roughly a quarter the density of nickel)	Typically heavier materials (e.g., the density of nickel is nearly four times that of carbon), leading to lower energy storage capacity per unit weight (i.e., gravimetric energy density) compared with Li-ion
Safety	Organic solvents are flammable in combination with higher operational volts raise greater safety concerns compared with NiMH	Water-supported electrolytes are more stable than organic electrolytes

Batarya Yönetim Sistemleri

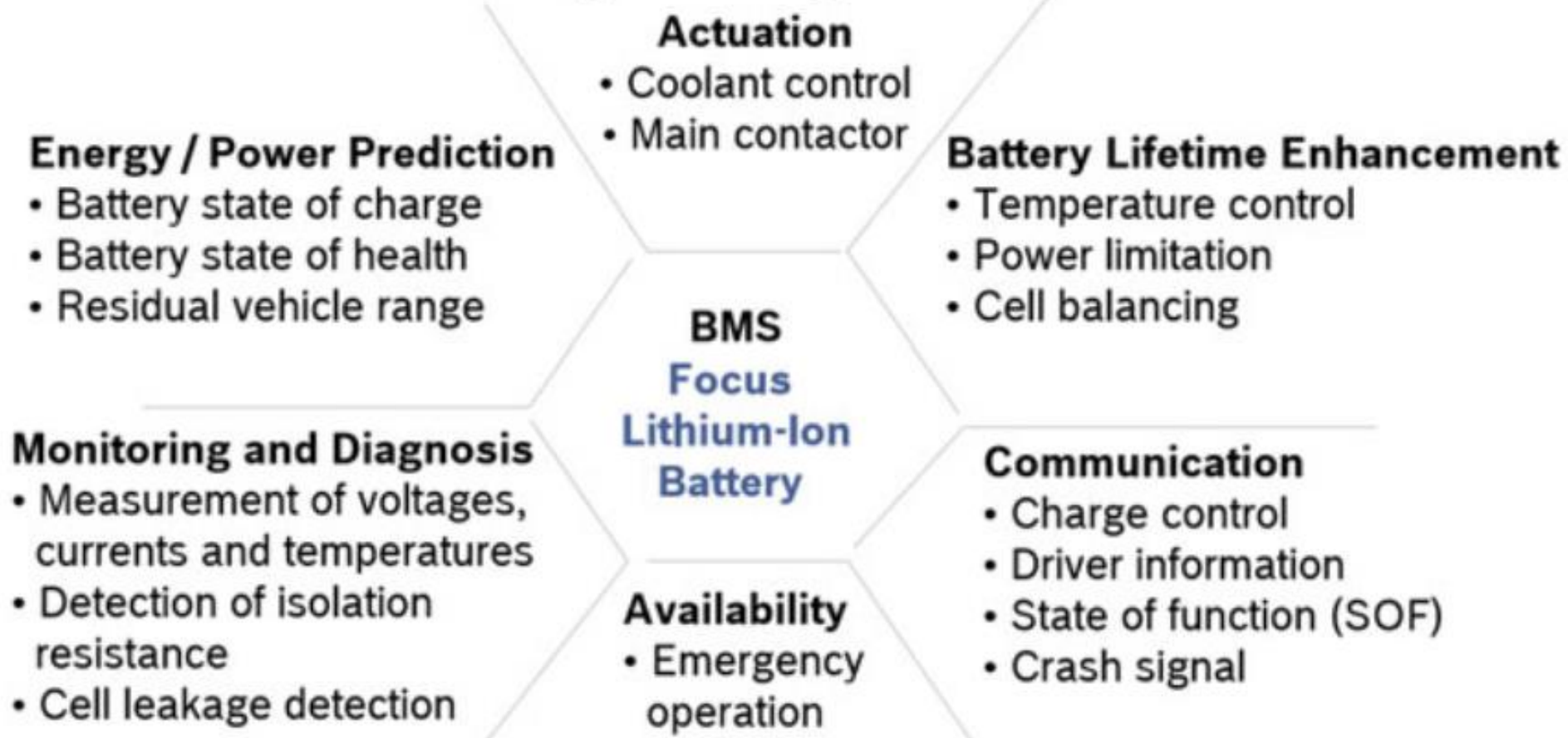
∞ BMS (Battery management systems)

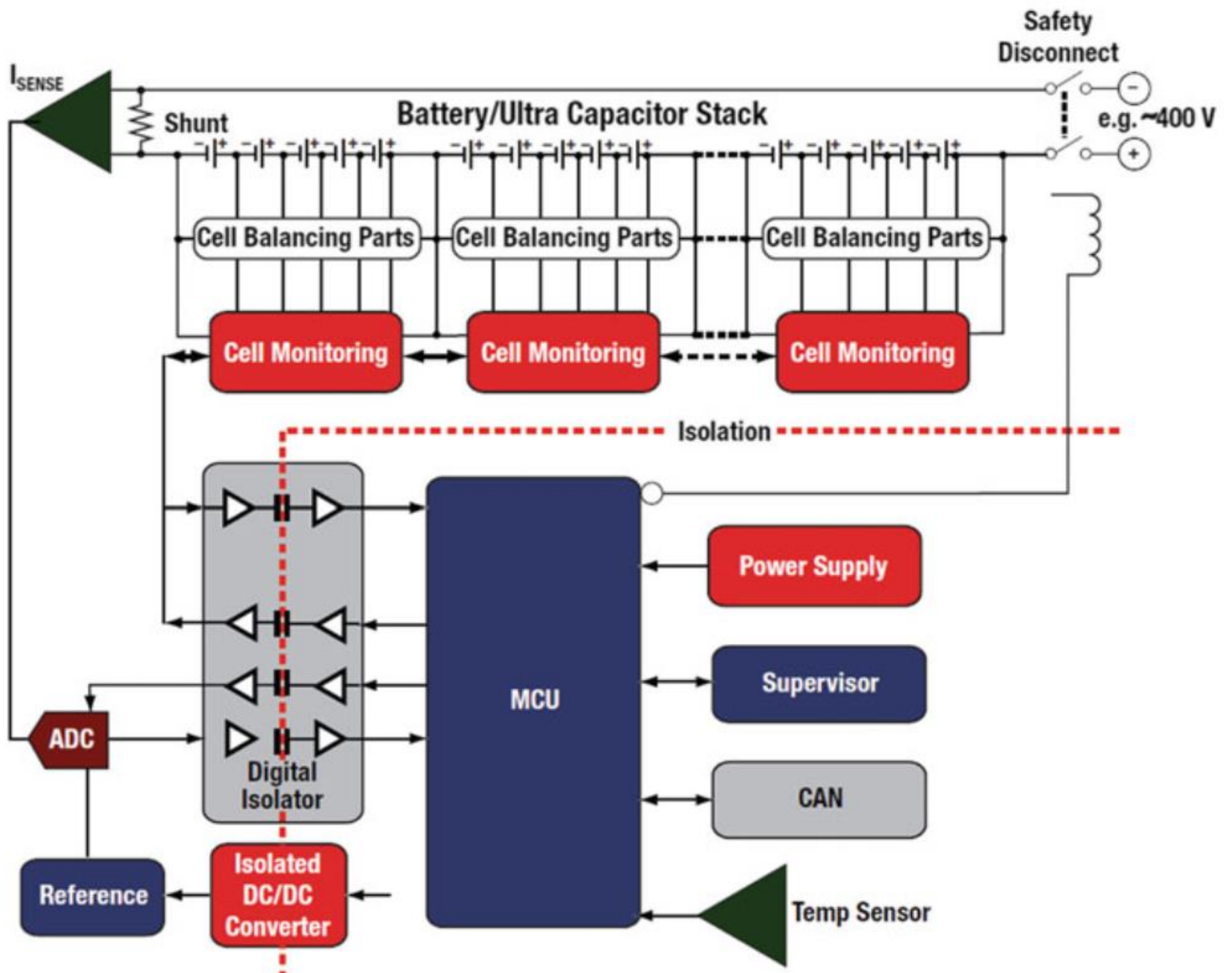
Conv. ICE**HEV****PHEV****EV REX****EV**

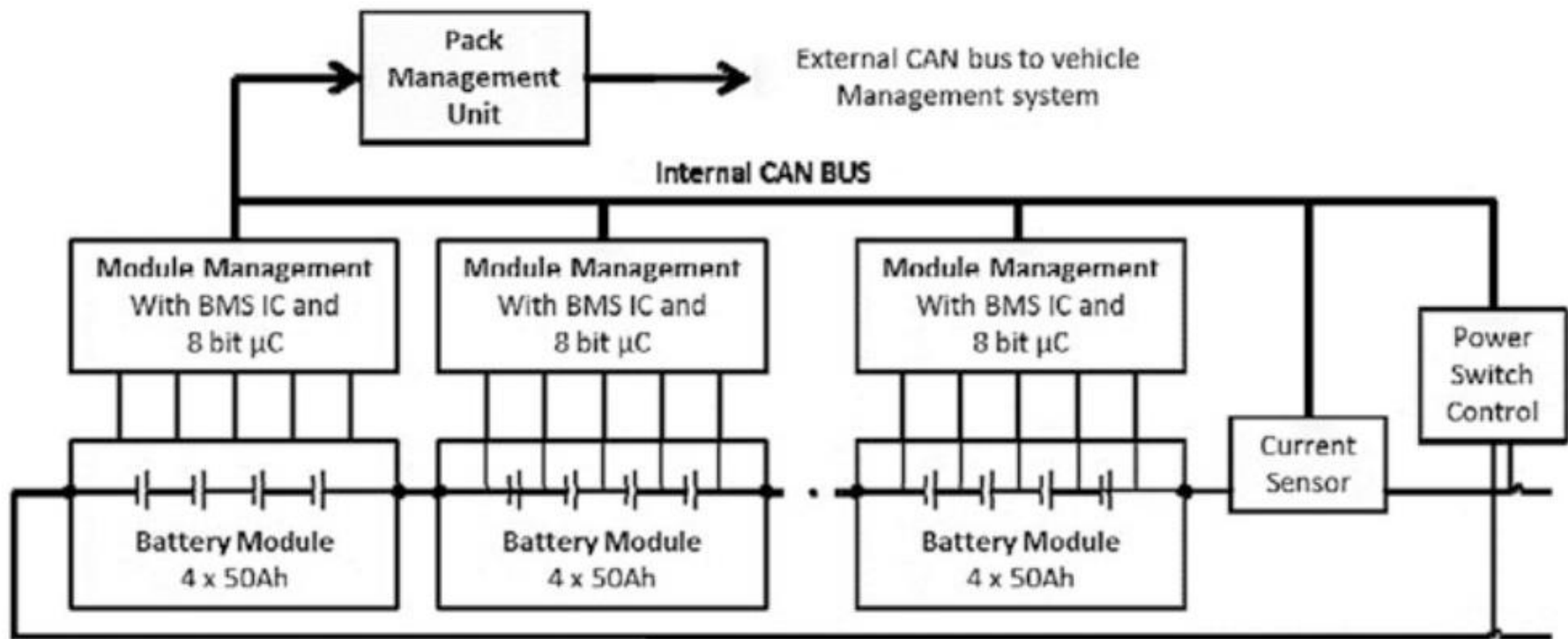
Add. components		Inverter <20 kW	Inverter >20 kW	Inverter 60 kW	Inverter >60 kW
			Charger	Charger	Charger
	Battery 12 V	Battery HV 1.3 kWh	Battery HV 12 kWh	Battery HV 15 kWh	Battery HV > 20 kWh
Powertrain incl. EM					

High Voltage (>60V) Battery Systems require advanced BMS

BMS Tasks for High Voltage Batteries







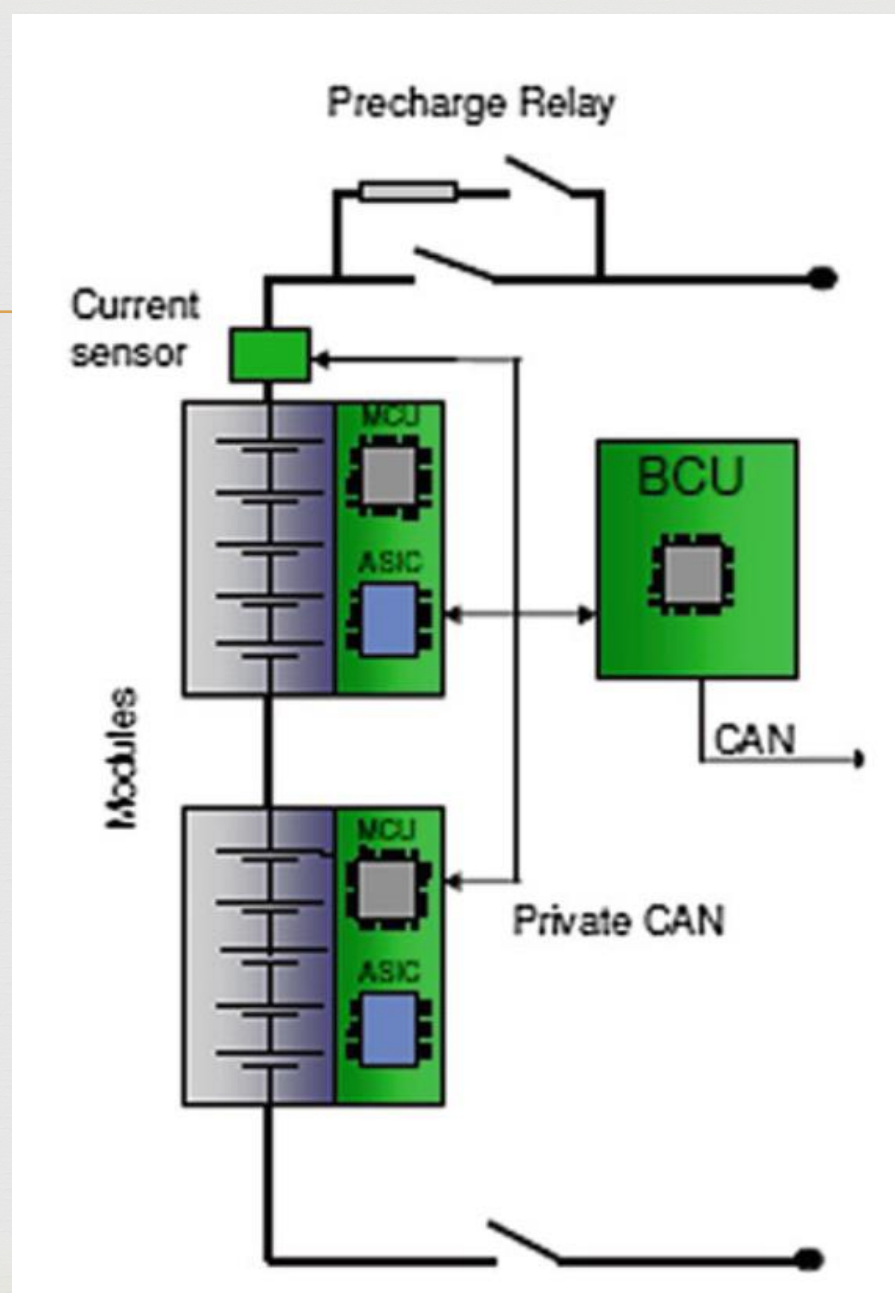


Fig. 12 Combining current and voltage based SOC-algorithm for higher accuracy [14]

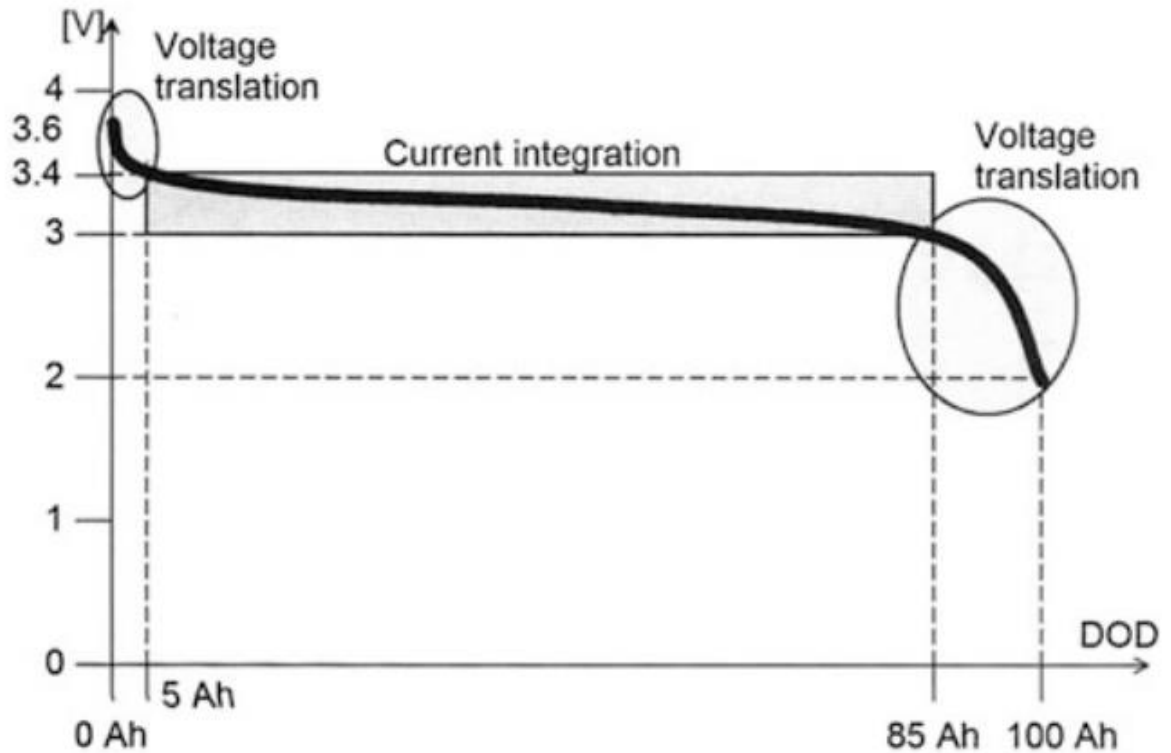
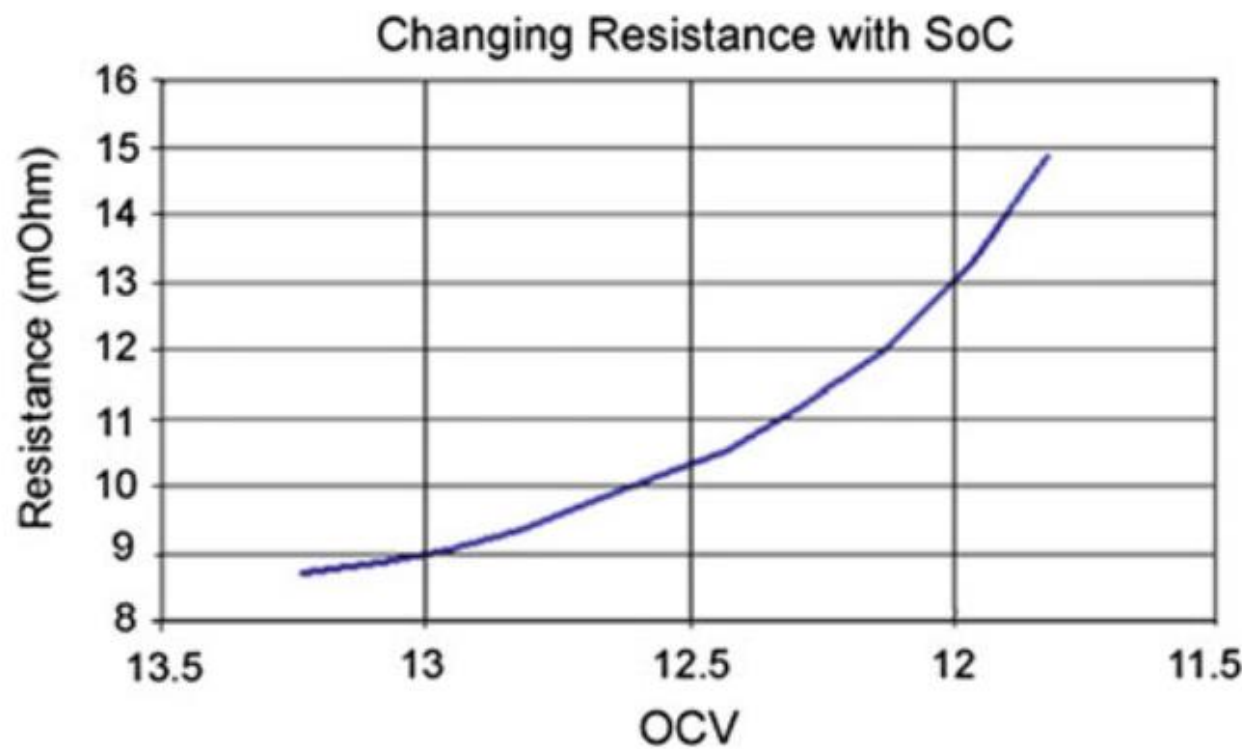


Fig. 13 Internal resistance of a lead acid battery versus OCV—Open Circuit Voltage [15]



Vehicle Energy Management Functions

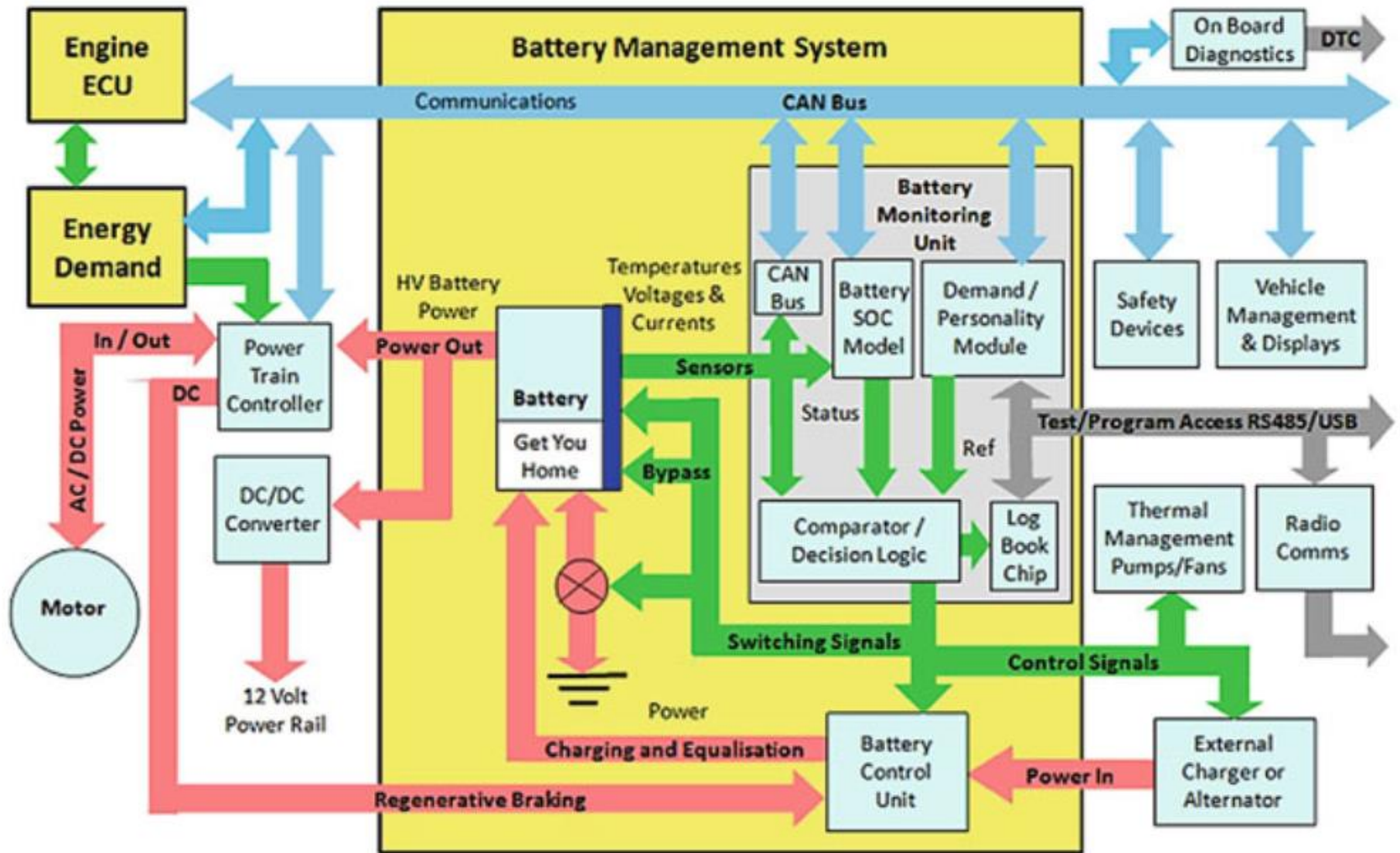


Fig. 16 Implementation of BMS [18]

