



A Game Changer PHEV Battery

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BEV – Niche Market Only

High Battery Cost

Low Battery Performance – Limited Range

Lack of Charging Infrastructure

Slow Charging

Battery Safety

Battery Cycle and Calendar Life



Ford Focus EV



Volkswagen E-UP

- **Pure EV`s are mainly city cars**
- **Luxury pure EV`s like Tesla provide longer drive distance in a cost that few can afford**

PHEV – Ready for Mass Market

- No driving range limits
- No need for public charging infrastructure
- High portion of average driving range done in E-Mode
- 5-10k\$ powertrain cost, generate 50% extra gas efficiency (Smaller battery)



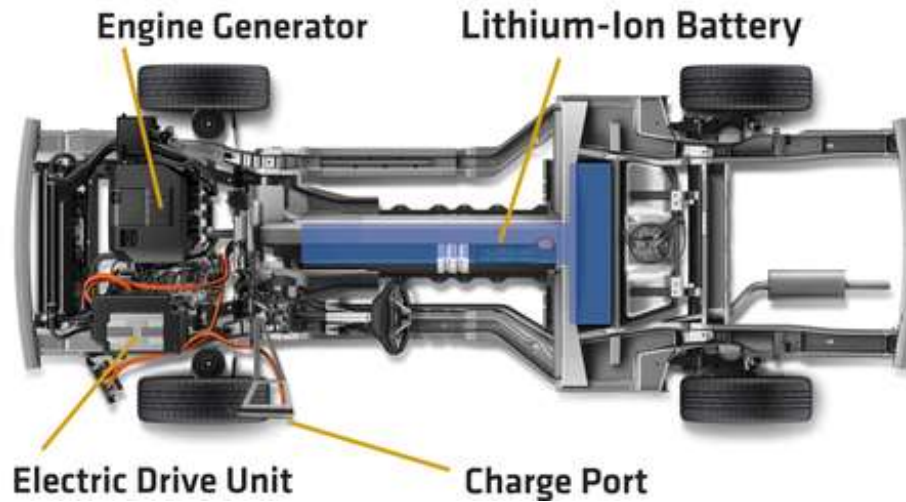
Toyota Prius PHEV



Chevrolet Volt PHEV

Why Serial PHEV?

- Only an electric engine to drive the vehicle (Low powertrain cost)
- ICE as an extended range generator (Efficiency)
- Smaller ICE – Save installation volume
- Lower vehicle assembly cost (Less components)



Chevrolet Volt Serial PHEV

Serial PHEV cost advantage is key point in the way to mass market

Typical PHEV Batteries

Mode	kWh	Wh/kg	KG	E- Driving distance km
HEV	<2	40-50 NiMh	50-60	1-3
PHEV	5-18	80-120 LPF/Li-Ion	60-200	20-60
BEV	20-70	70-140 Li-Ion	250-450	160-340

Small size battery should drive full vehicle weight at high speeds and should support high regeneration charge power



High charge/discharge (power) cells needed!



Mitsubishi Outlander PHEV's 12 kWh Lithium

HyperHybrid Vehicle



15,000 Euro for mass market with no subsidies !!!



BMW i8, 145,000 Euro in Europe



Toyota PHEV, 37,000 Euro in Europe

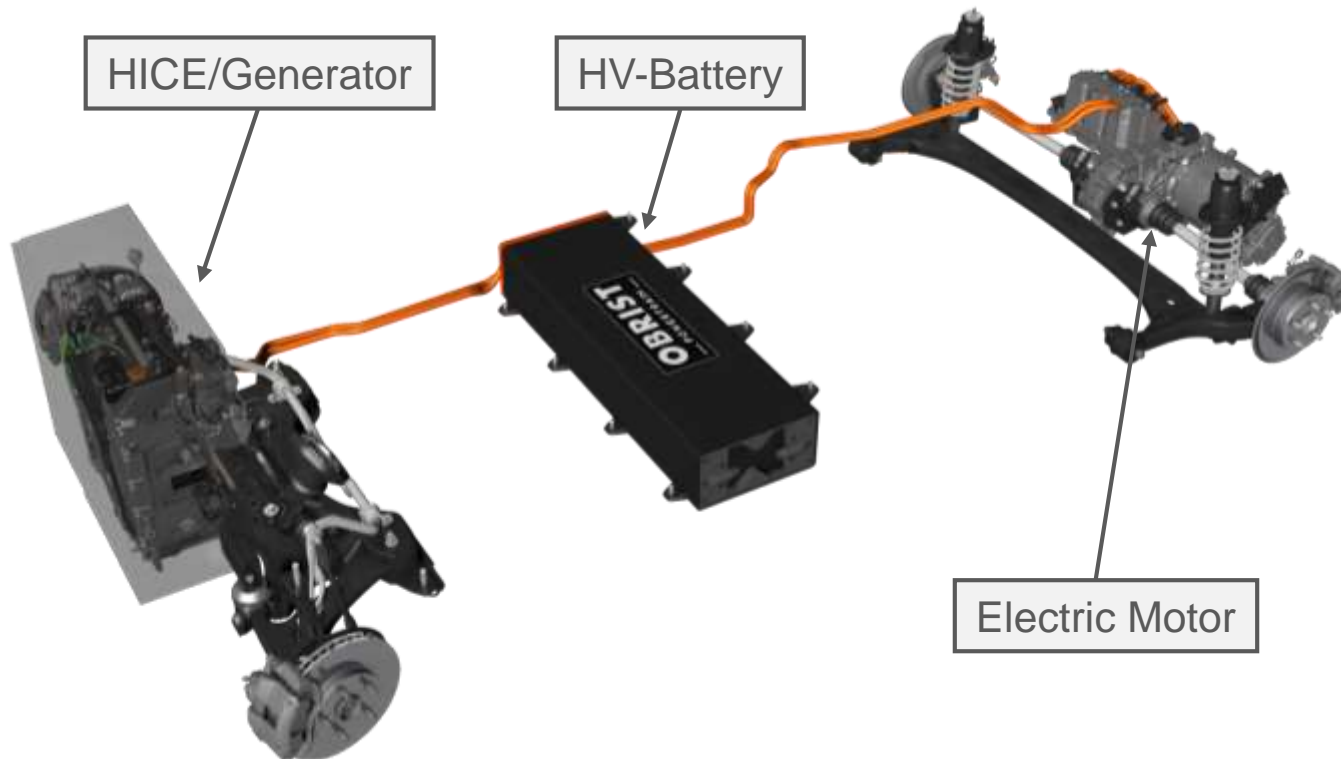
Drive Session Evaluation with Toyota PHEV



Sales price [k-Euro] w/o VAT	12.4-13.4	31.6-37.6
System performance [kW]	40 / 85 (peak)	101
Engine type	HICE 1.1L up to 40kW	I4 1.8L 73kW@5200
Battery	8.5kWh	4.4kWh
E-range	49 km	23km
Weight incl. 2 persons	1599 kg	1580 kg
Acceleration 0-60 km/h	5.1 sec	5.1 sec
NEDC [l/100km]	2.0 (ECE101)	2.1
CO2 emission	47 [g/km]	49 [g/km]
Noise	59 [dba@70km/h] w/HICE	69 [dba@70km/h]

Powertrain Development: HyperHybrid

HyperHybrid: **Series plug-in hybrid electric powertrain** for lowest costs, best fuel efficiency, +1000km range



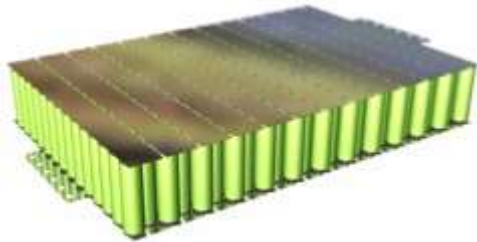
High Voltage Battery – Key Facts

- Patent protected battery system for PHEV application
- Low cost and high flexibility by the use of 18650 power cells
- High performance water/glycol cooling system
- Strong thermal insulation
- Consequent design simplification for low cost assembly
- Compact and crash safe design
- Highest mounting flexibility
- Consistent safety strategy
- Mass production ready



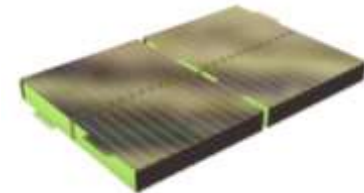
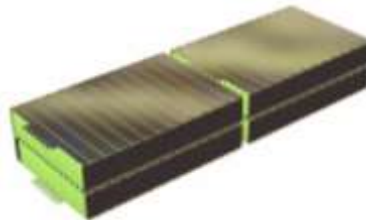
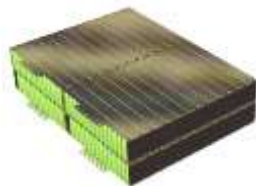
Low Cost and High Flexibility in Battery Design

Assembly of cylindrical 18650 Li-ion cells into one module



- Flexible Amp hours / amount of Li-ion cells in parallel
- Flexible voltage / amount of Li-ion cells in series
- Flexible sourcing due to standard 18650 Li-ion cell format

Flexible assembly of modules into one battery pack



Latest Obrist High Voltage Battery Design

- Nominal voltage: 345VDC (403V-240V)
- Cell configuration: 96s16p (32Ah)
- Energy: 11.1kWh w/ 2000mAh cells (high power PHEV)
17.7kWh w/ 3400mAh cells (high energy EV option)
19.9kWh w/ 3600mAh cells (high energy EV option)
- Energy density: 99Wh/kg (gravimetric); 190Wh/l (volumetric)
- Maximal discharge power: 100kW (150kW pulse)
- Maximal cont. charge power: 22kW
- Dimensions: 1011x334x182mm
- Weight: 112kg



Why 18650 High Power Cells?

- Flexible choice of supplier (2nd source) and chemistry
- High specific energy (160-200Wh/kg)
- Low cell costs (per kWh)
- Integrated safety features (SDS, Vent, CID)
- Robust cell housing (Steel)
- High surface to volume ratio (Thermal management)
- Mass market availability

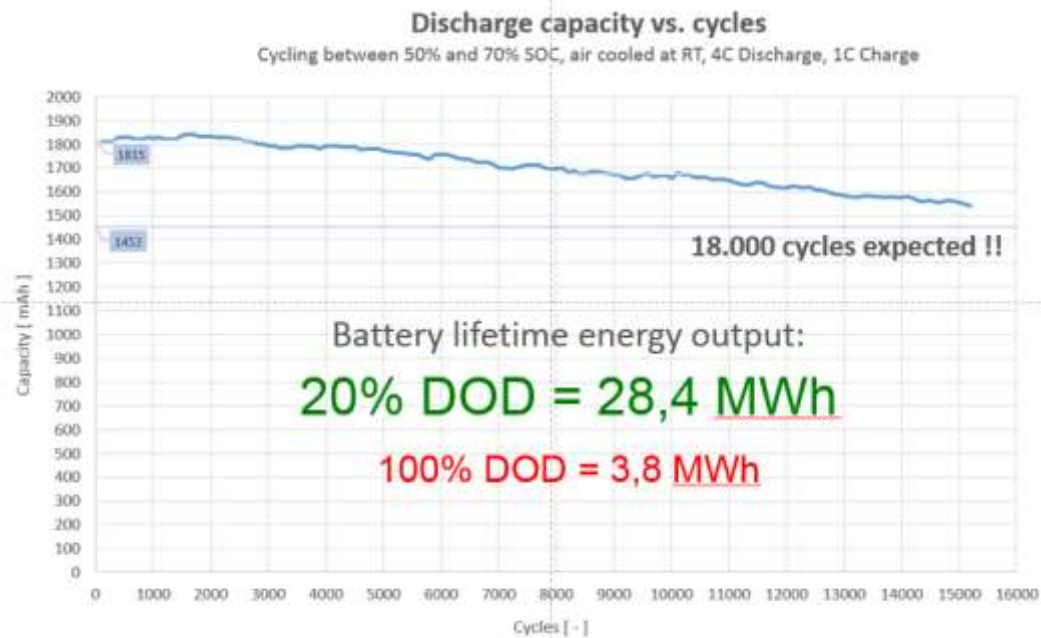
- Cycle lifetime

* covered by battery lifetime improvement strategy



Battery Lifetime Improvement Strategy

- ✓ Reduction of DOD during operation
 - 20% DOD results in 7 to 8 times higher lifetime energy output
- ✓ Limitation of maximum and minimum cell voltage
 - Significant increase of cycle and calendar lifetime



Battery Lifetime Improvement Strategy

- ✓ Low charging currents at home
 - Increased cycle lifetime
- ✓ Efficient thermal management
 - Thermal insulation of battery system
 - Efficient cell cooling
 - Homogeneous battery temperature distribution

Summary

- **Current batteries are not sufficient for mass market pure EV`s**
- **PHEV are ready - no driving range anxiety and no need for public charging infrastructure**
- **Low competitive vehicle cost is the only way to reach mass market**
- **HyperHybrid Powertrain provide compatible real solution in cost of 15,000 euro**
- **HyperHybrid powertrain is a market game changer**
- **Working now on mass production with selective Automotive OEM**

THE
GAME
CHANGER



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Information for presentation obtained by:

- 1. Public web sources.**
- 2. Shmuel De-Leon Battery/Energy Sources DataBase® (Includes 29000 cell PDF data sheets) <http://www.sdle.co.il/Default.asp?sType=0&PageId=45580>**