



**Leading The World In High-  
Performance Battery Technology  
Ready to Serve Growing Markets**



# **NiZn Battery as the alternative battery technology for PHEV**

**Presented by**

**Dr. Sadeg M. Faris and Dr. Tsepin Tsai**

**Xellerion, Inc.**



# Renaissance of NiZn Battery

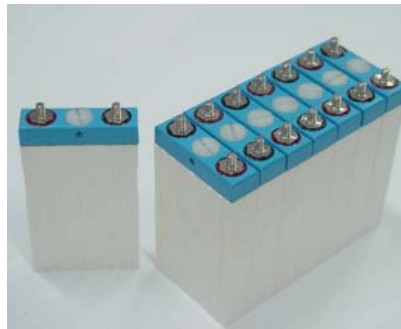
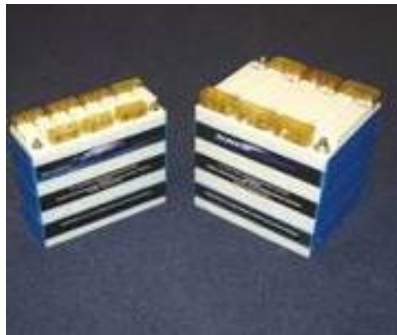
The Only Challenger To Lithium Technology in Terms of :

1. Performance
2. Cost
3. Safety
4. Recyclability
5. Availability of Reserves

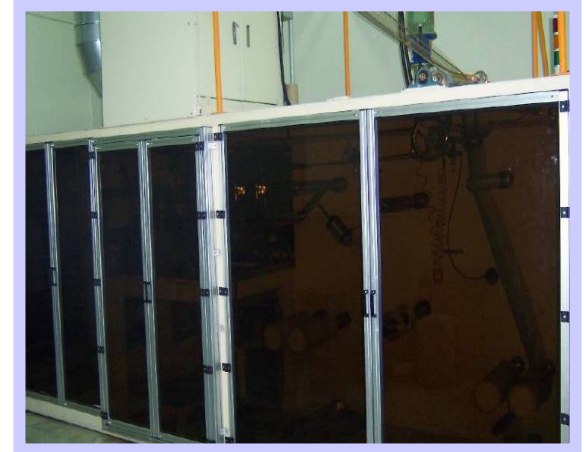
# Consumer Cost Per Mile Gap (CCPM)

**We will show that from the CCPM perspective there is a gap between Li based and Zn based systems that widens as the range increases to 300 miles**

# At Xellerion We Proudly Introduce The NiZn Battery Renaissance



# The NiZn Renaissance Ready To Ship



# Who Is Using NiZn Battery?



...a Tennessee clean transportation company



*Classic Electric*



# Why NiZn Now?

- 1899 NiCd Jungner
- 1900 NiFe Edison
- 1901 NiZn Michaelowski
- 1901 to 2000 Many attempts failed to manufacture dendrite free NiZn Battery
- 2000 eVionyx unreduced its proprietary Membrane to suppress dendrite in NiZn batteries and Zinc Air fuel cells.
- 2005 NiZn manufacturing pilot line established.
- 2005 Xellerion, a new company was established to focus on NiZn commercialization

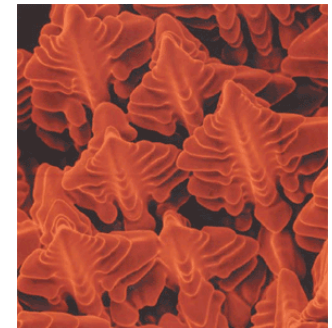
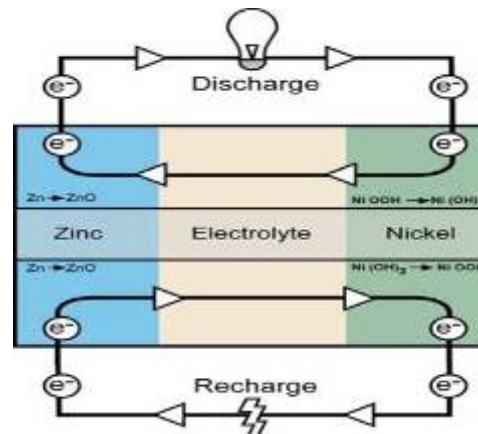
# Why NiZn Now?

## Xellerion Overcomes the Hurdles

- Developments in stabilizing the zinc electrode in alkaline electrolyte has reduced its solubility
- Membrion™, patented solid state membrane, is proven to inhibit dendrite growth during the recharge process

### Membrion Features:

- Conductivity is higher than 0.2 S/cm.
- Effective in blocking Zn dendrite to achieve high cycle life.



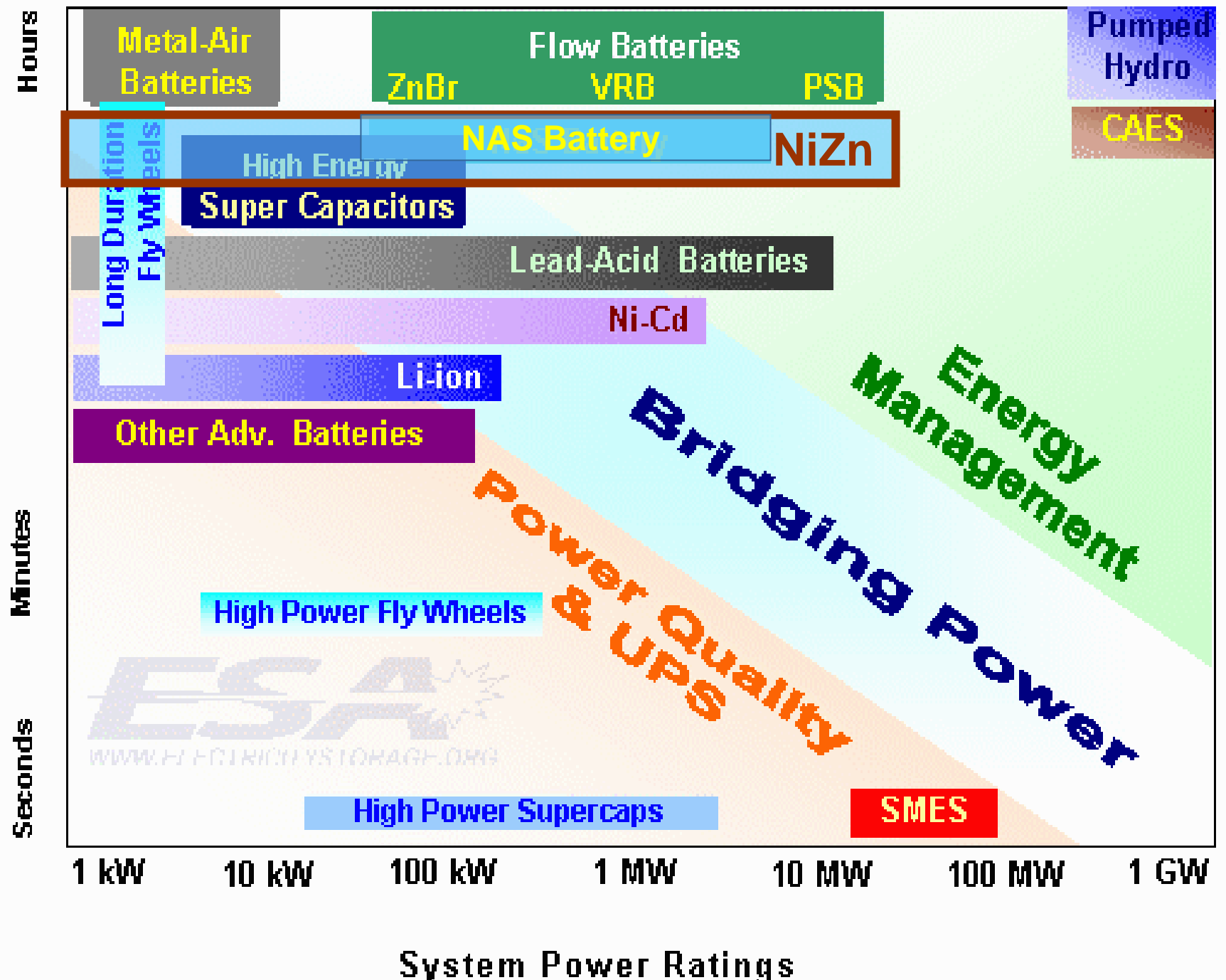
Picture of Zn Dendrite which causes short circuiting

# Why NiZn Now?

## Great Characteristics

- 60-130 Wh/Kg
- 150-250 Wh/L
- >1000 W/Kg (>10,000 W/Kg possible with Ultra Thin Electrodes)
- Long Charge Retention
- Low Cost per KWh < \$ 250 with novel recycling method.
- Much safer even without liquid or air cooling
- Zn reserve in the billions of tons (Li reserve is a serious limitation)

Discharge Time at Rated Power



System Power Ratings

# Output Energy Density (Input Energy Density x Efficiency)

N.P. Yao, et.al,  
Power Sources Conference, 29th, Atlantic City,  
NJ, June 9-12, 1980, Proceedings. (A81-49478 24-  
44) Pennington, NJ, Electrochemical Society, Inc.,  
1981, p. 247-256. Research supported by the U.S.  
Department of Energy.

Weight Energy Density - kWh / ton

↑  
Lighter

**Metal-Air  
Batteries**  
(Not rechargeable  
electrically)

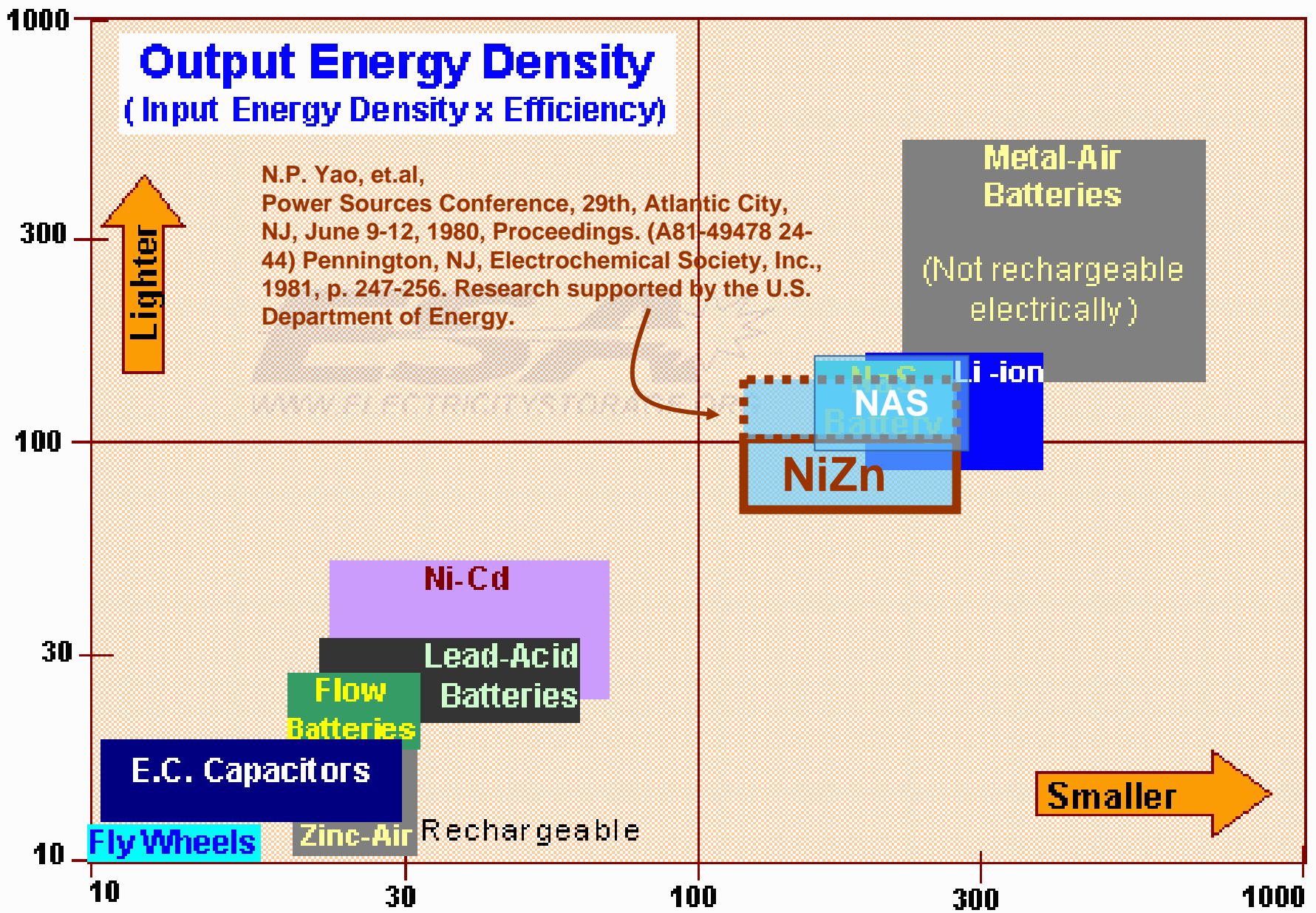
Ni-Cd  
NAS  
Li-ion  
NiZn

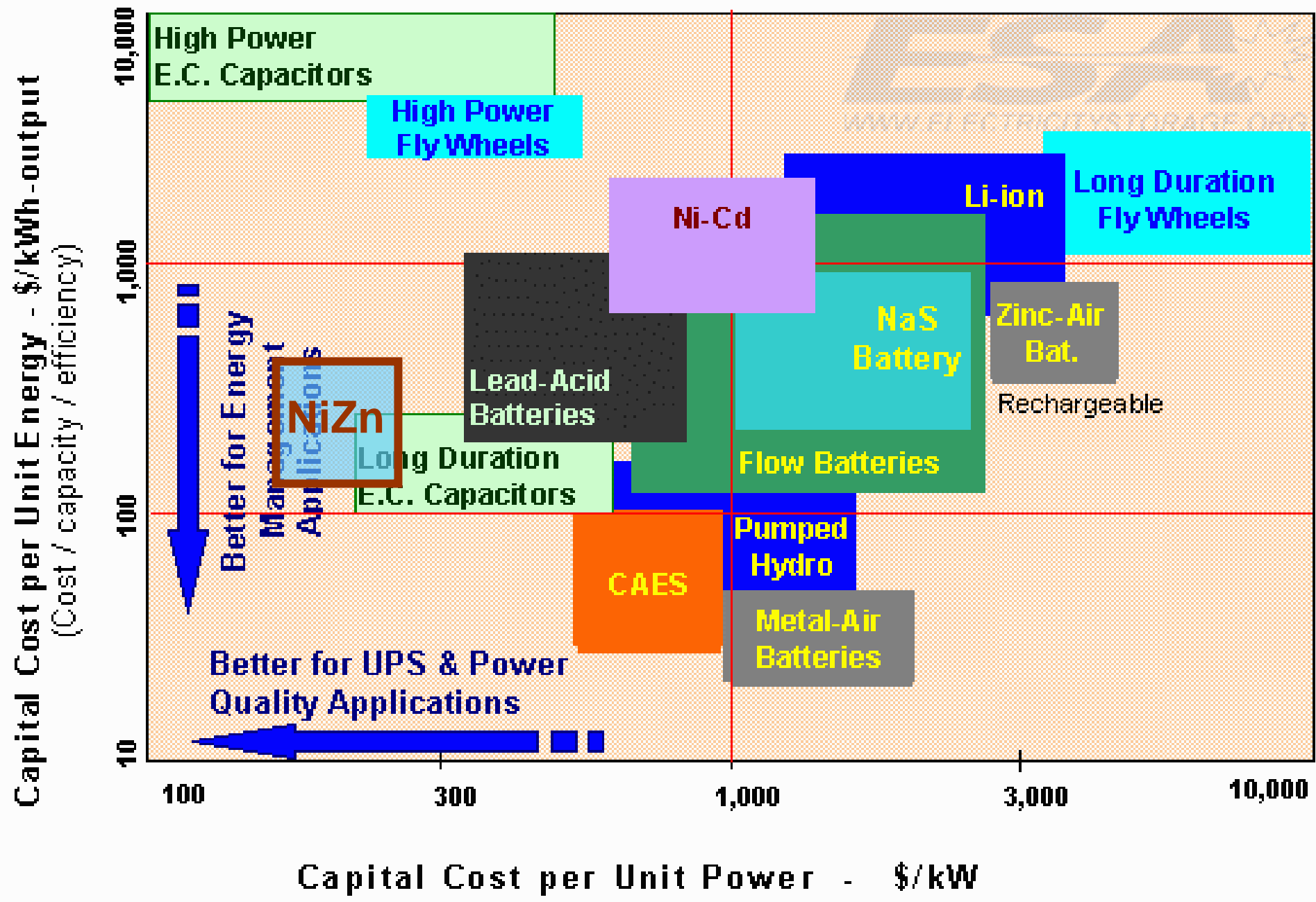
www.electrochemical.org

Ni-Cd  
Lead-Acid  
Batteries  
Flow  
Batteries  
E.C. Capacitors  
Fly Wheels  
Zinc-Air Rechargeable

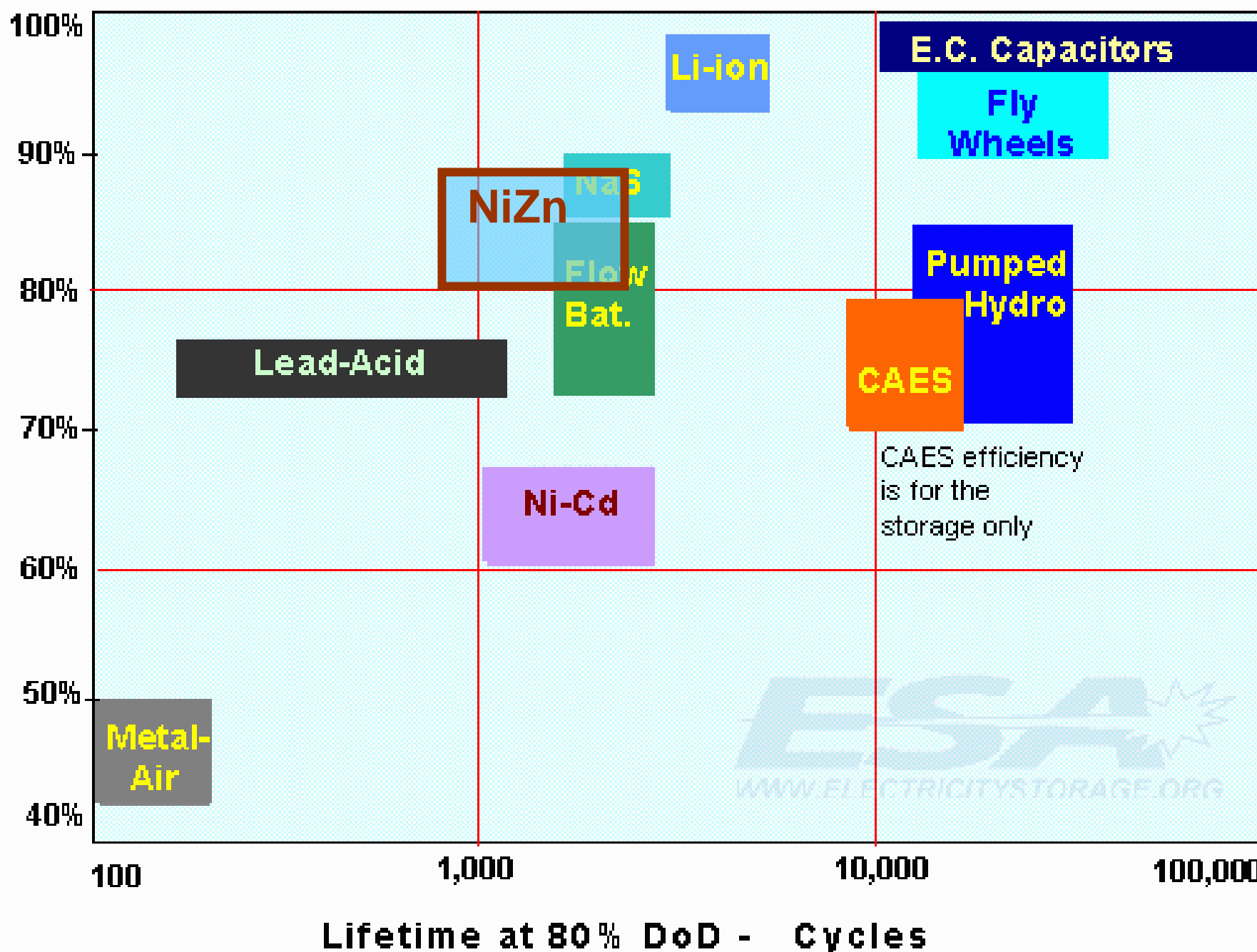
→  
Smaller

Volume Energy Density - kWh / m<sup>3</sup>





Efficiency (w/o power electronics)

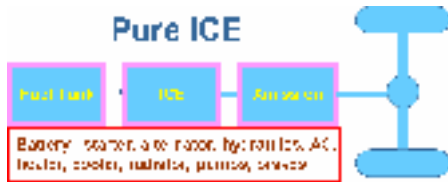


CAES efficiency is for the storage only

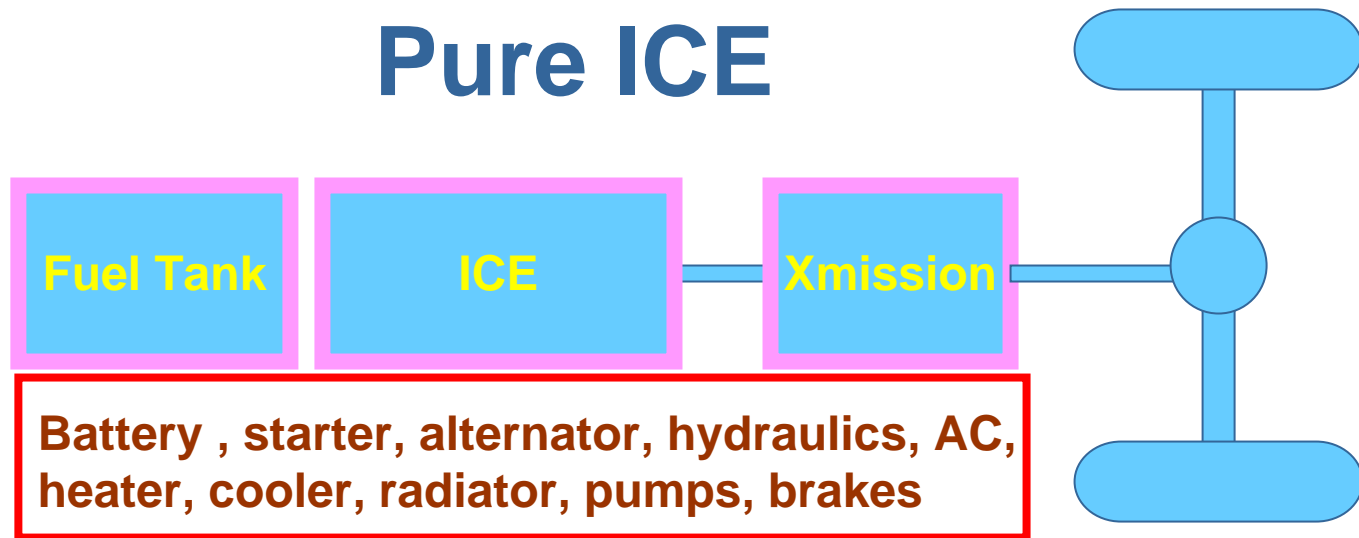


Lifetime at 80% DoD - Cycles

# Mobility Options



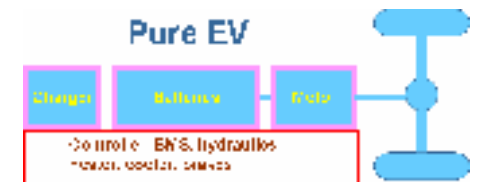
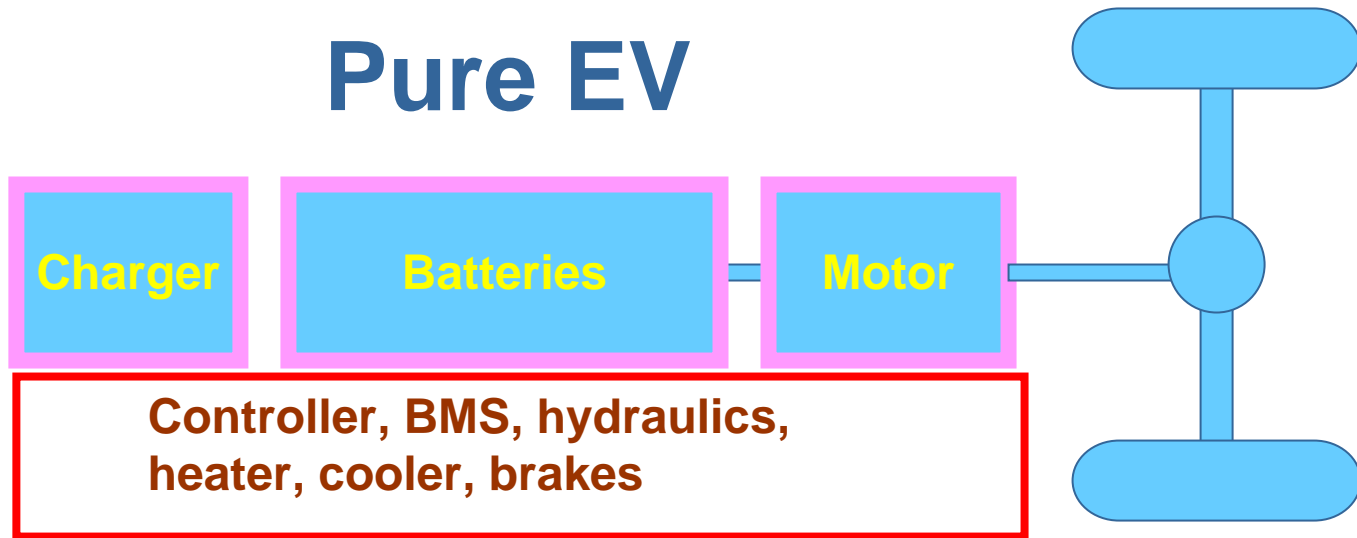
## Pure ICE



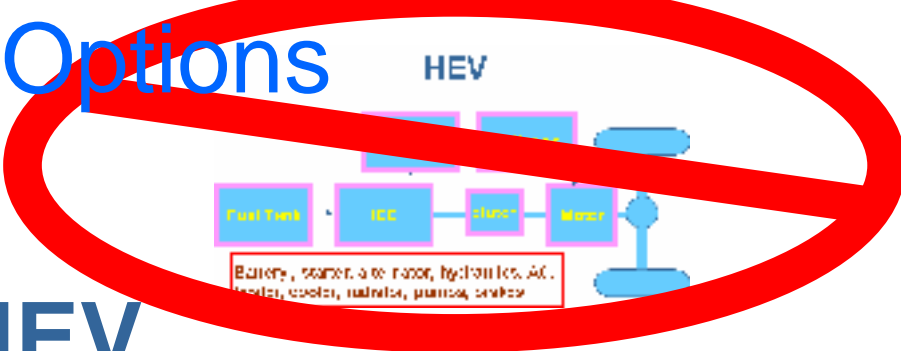
# Mobility Options



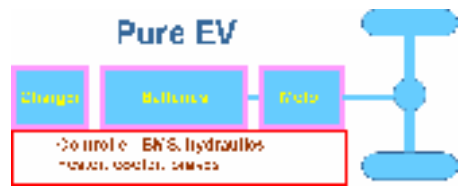
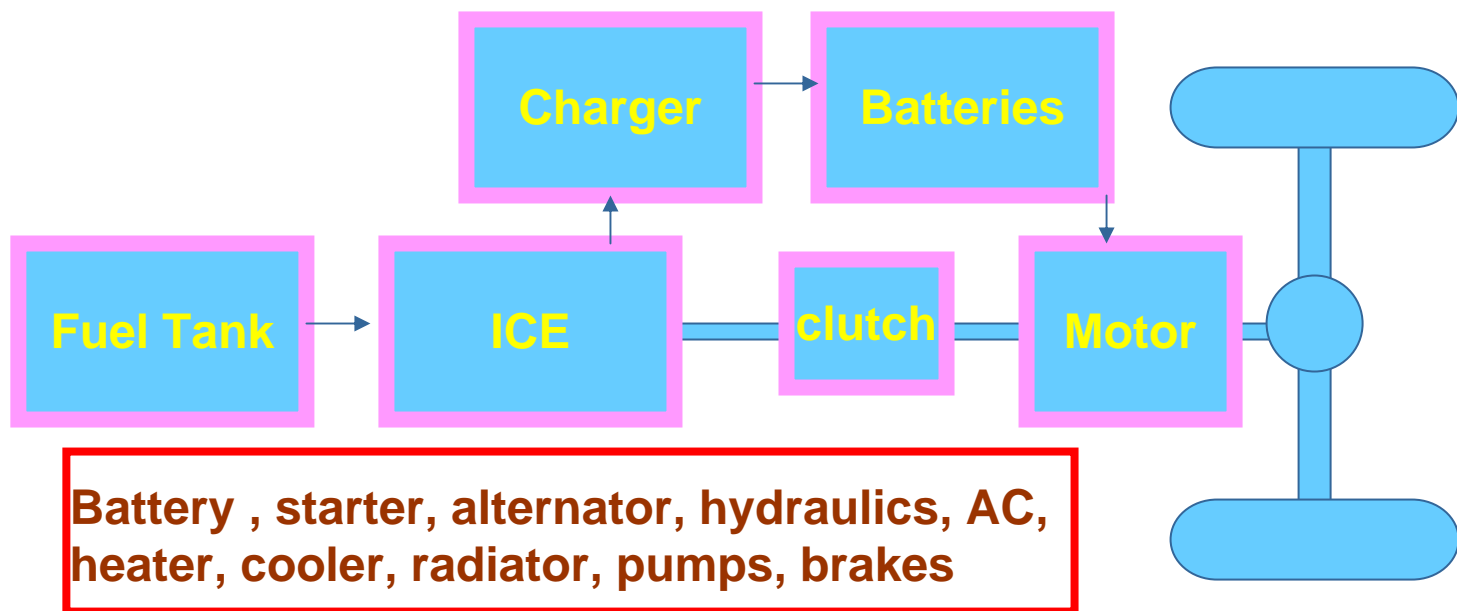
## Pure EV



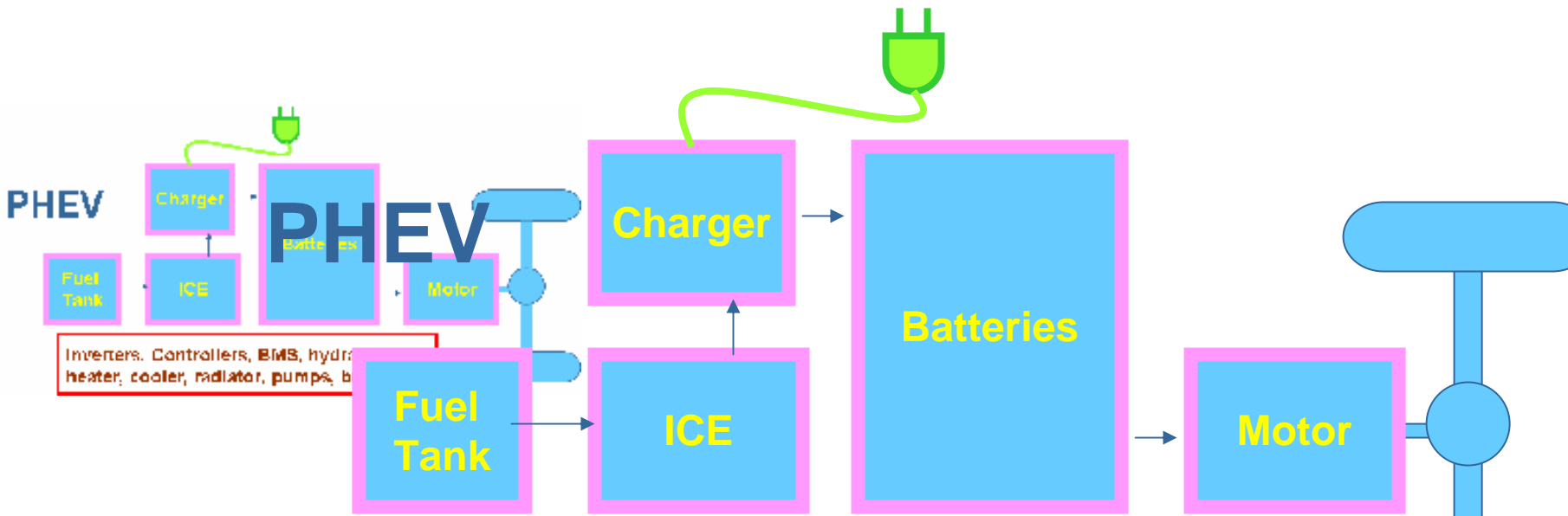
# Mobility Options



## HEV



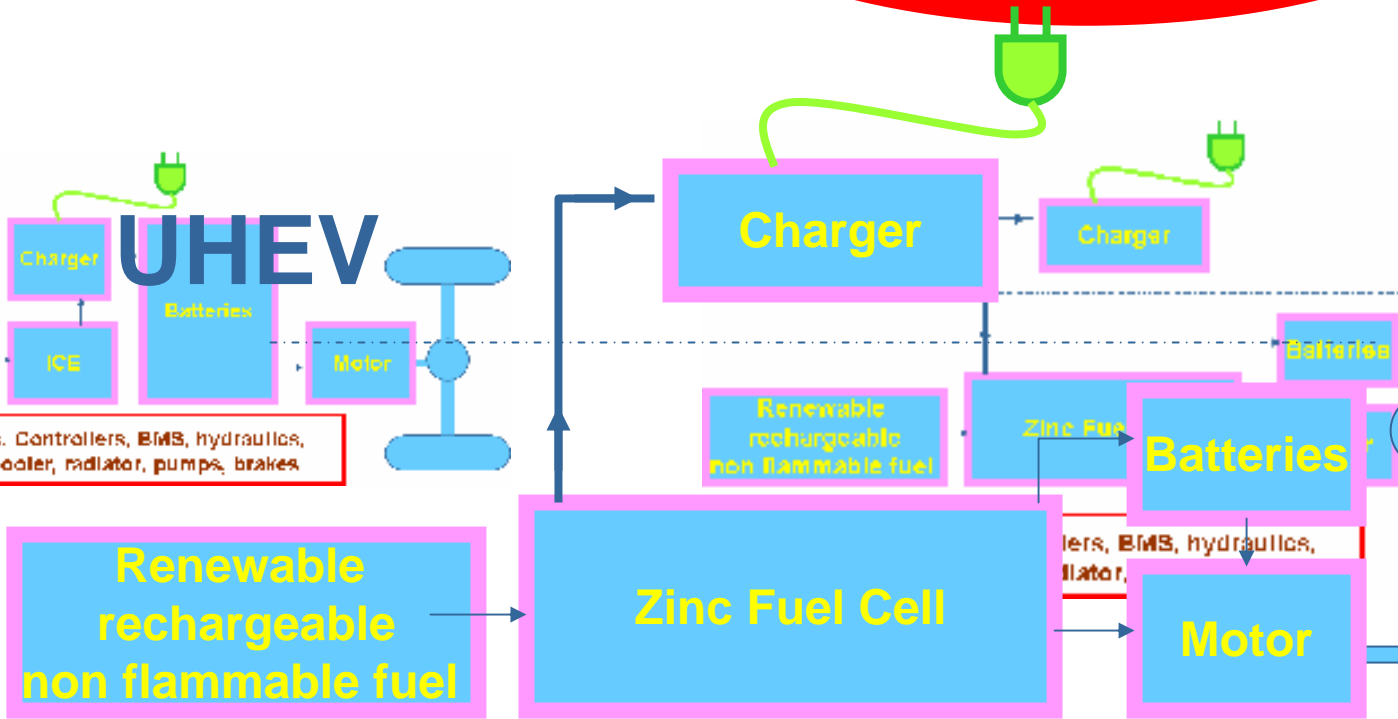
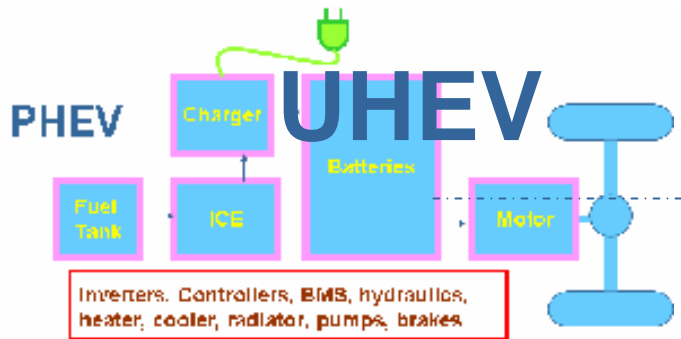
# Mobility Options



**Inverters, Controllers, BMS, hydraulics, heater, cooler, radiator, pumps, brakes**



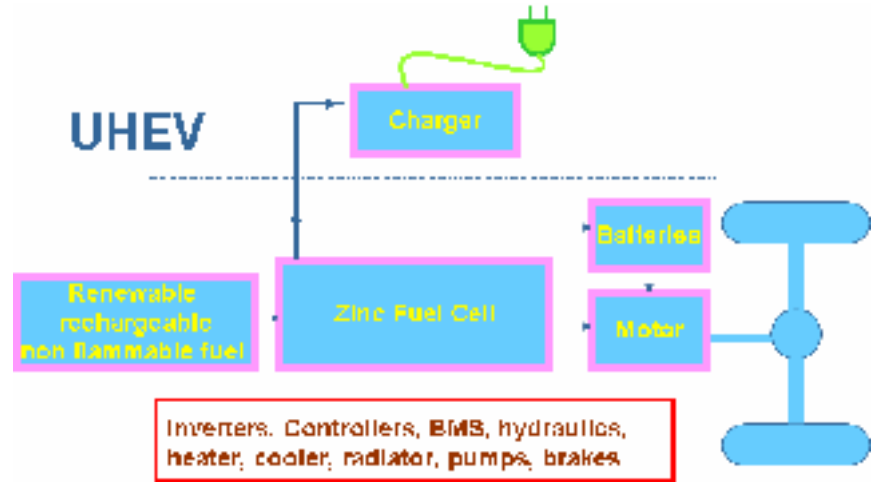
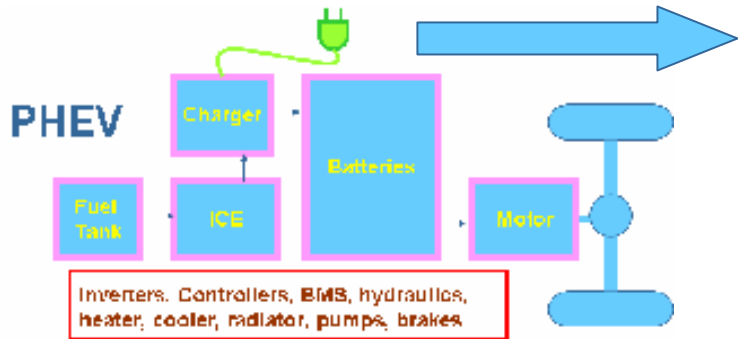
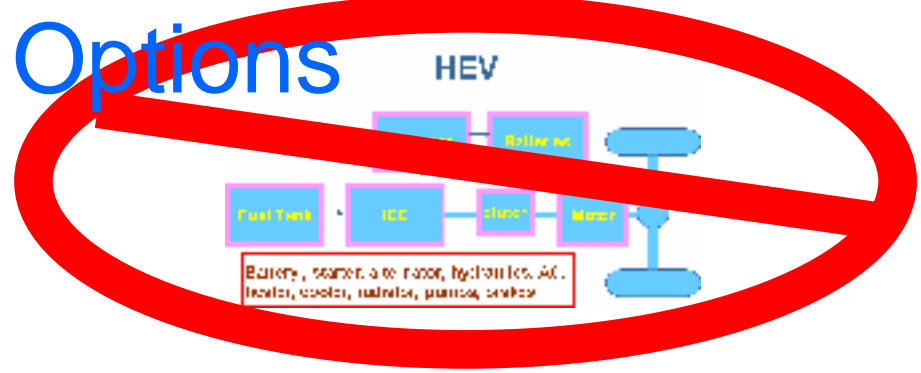
# Mobility Options



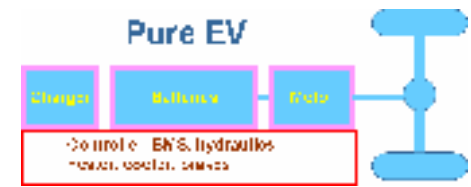
**Inverters, Controllers, BMS, hydraulics, heater, cooler, radiator, pumps, brakes**



# Mobility Options



What Consumers are  
Accustomed to

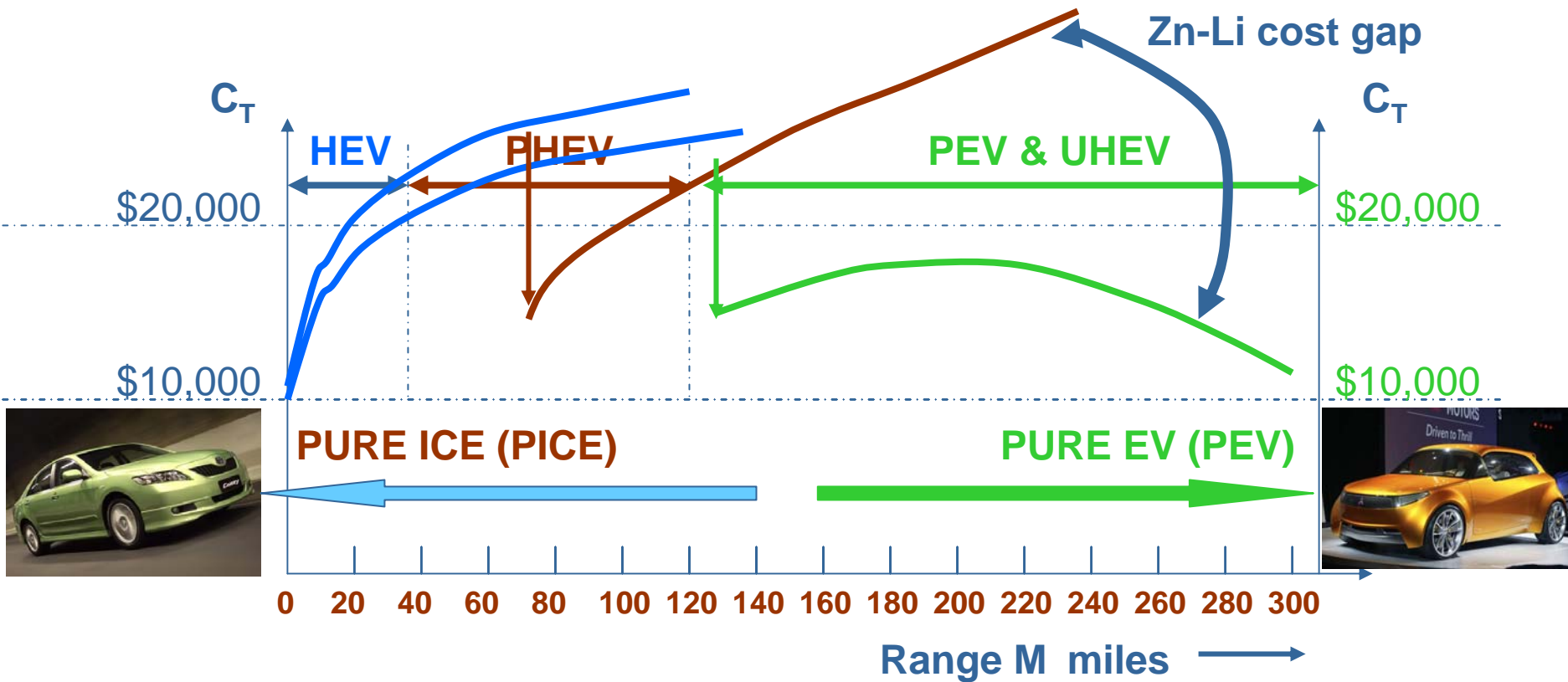


# **PHEV & Pure EV Economic Analysis Based on Consumer Cost Per Mile (CCPM) Vantage Point**

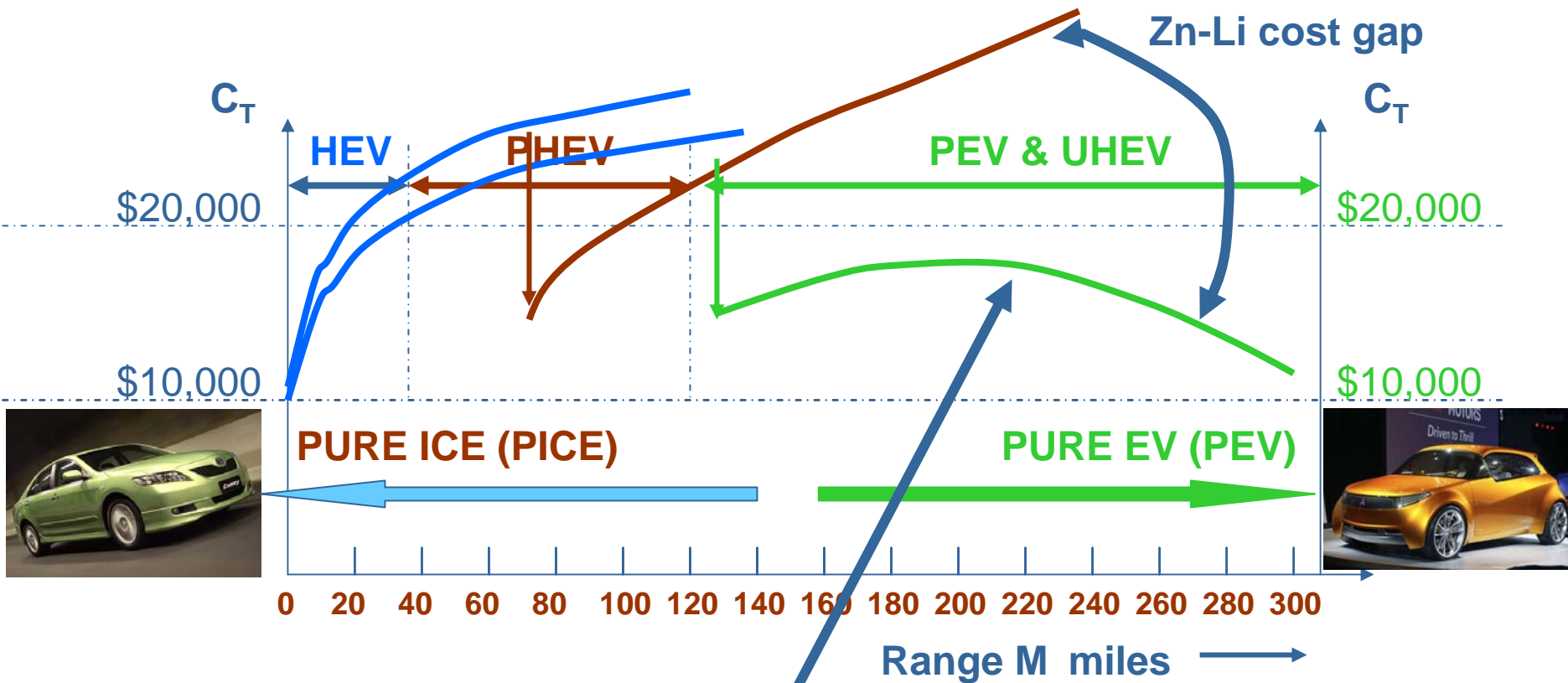
**Baseline Starting Point: What The  
Consumer Is Today Accustomed to:**

1. Fuel Cost ~ \$0.1/mile
2. Power Train Cost < \$0.1/mile
3. 300 mile range
4. 100,000 mile.
5. Refuelable in < 5 minutes

**Which Technology Can Satisfy  
these?**



$$C_T = \underbrace{\alpha C_{ice}}_{\text{Cost of ICE}} + \underbrace{\beta C_b(M)}_{\text{Cost of battery depends on range}} + \underbrace{\gamma C_{oc}}_{\text{Cost of all other components, motors etc.}}$$

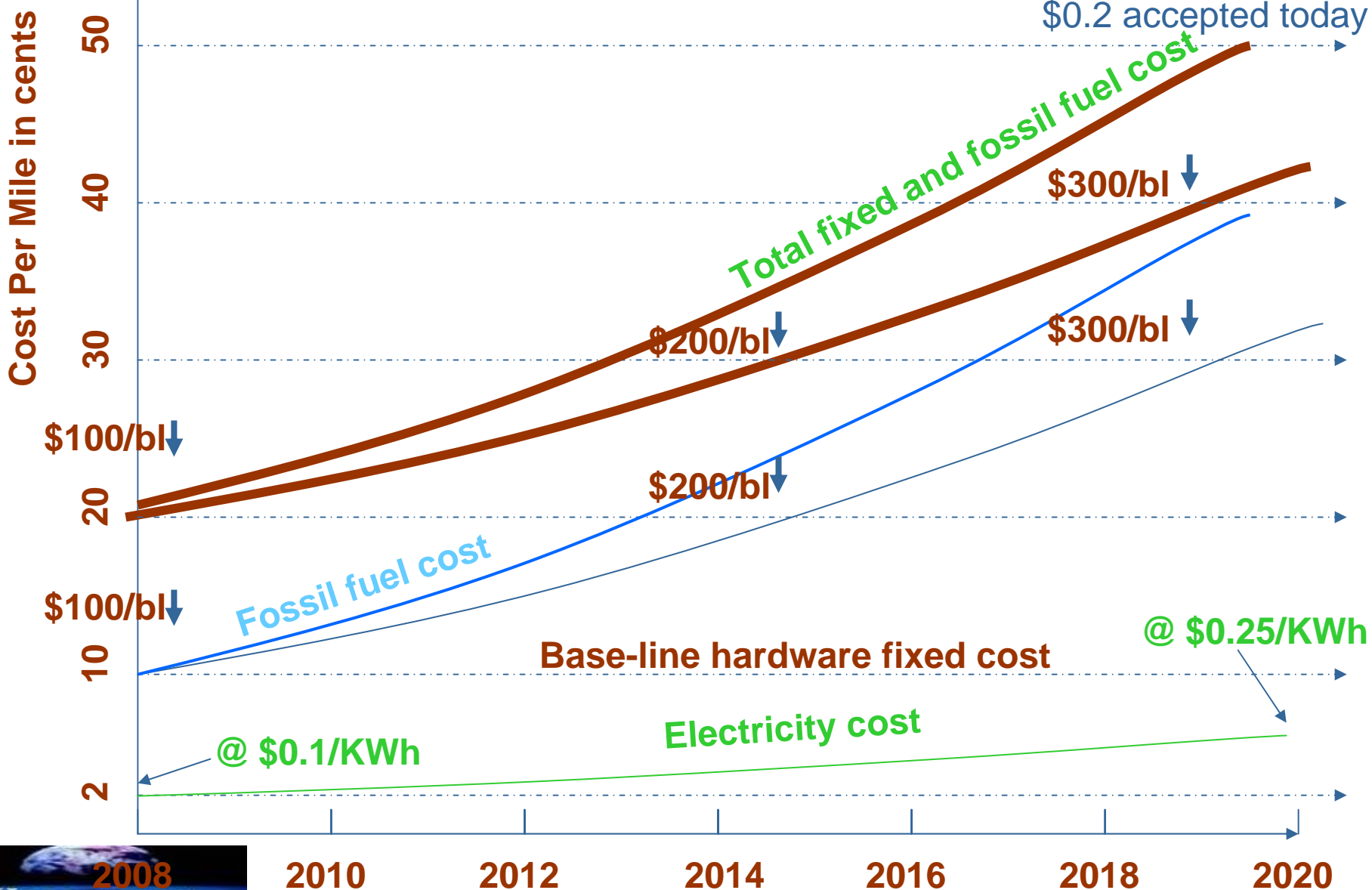


## Reasons for This Peak

1. Reduced number or cycles reduces cost
2. Reduced cost per mile reflects lower cost renewables
3. Zinc fuel with UHEV dominated by the low electricity cost
4. Less battery more fuel cell

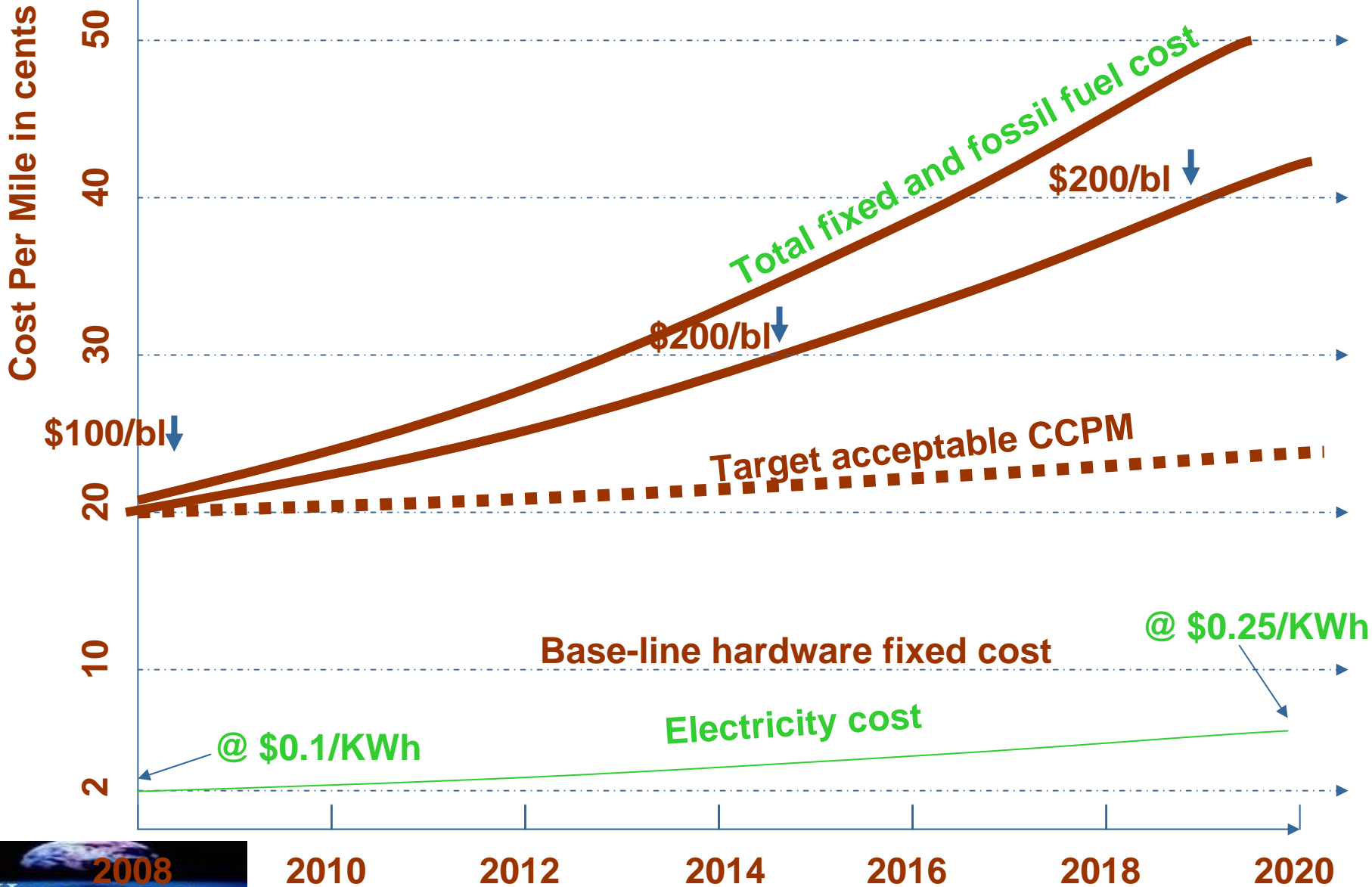
# Human Mobility Economic Analysis

## Consumer Cost Per Mile (CCPM)



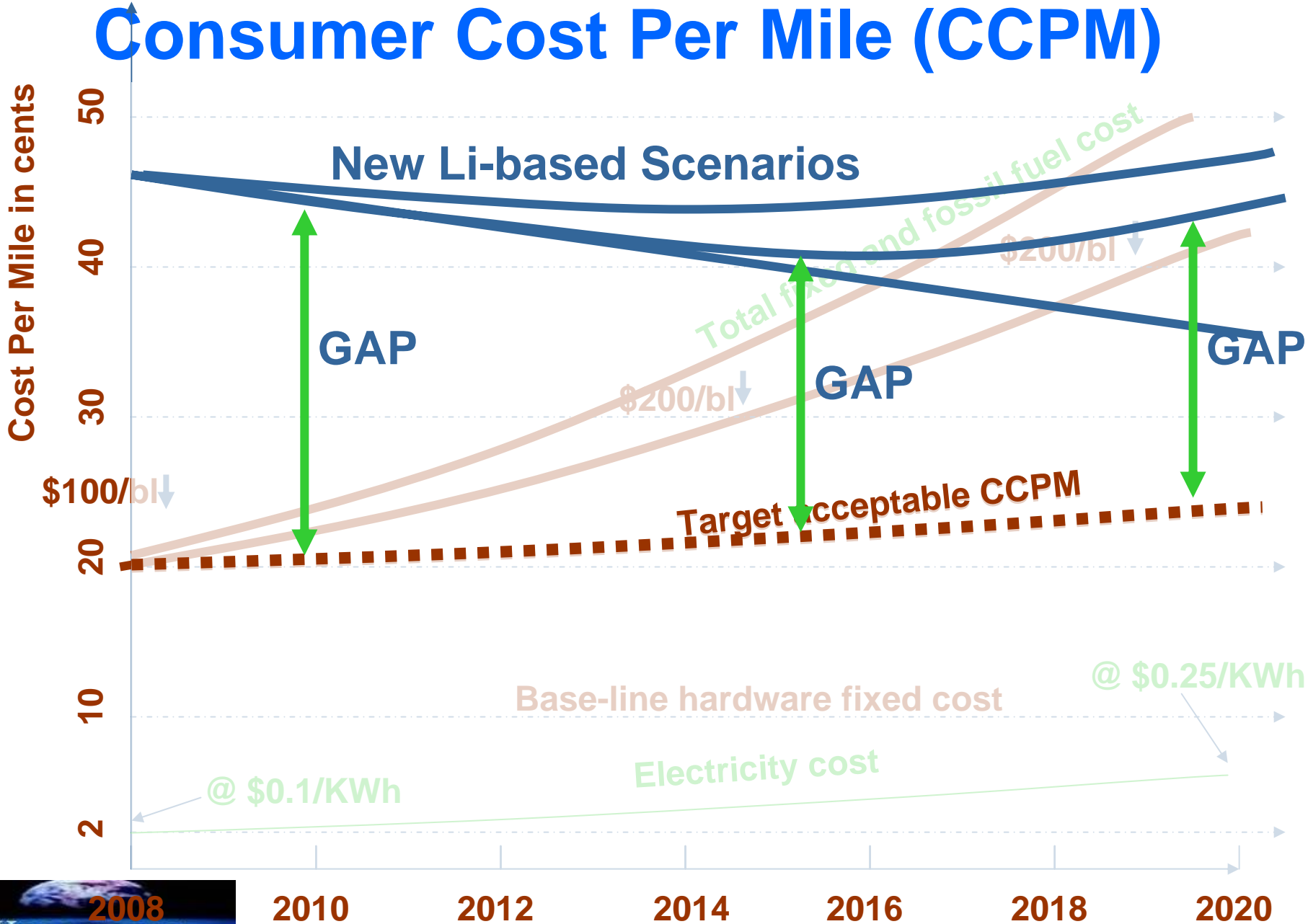
# Human Mobility Economic Analysis

## Consumer Cost Per Mile (CCPM)



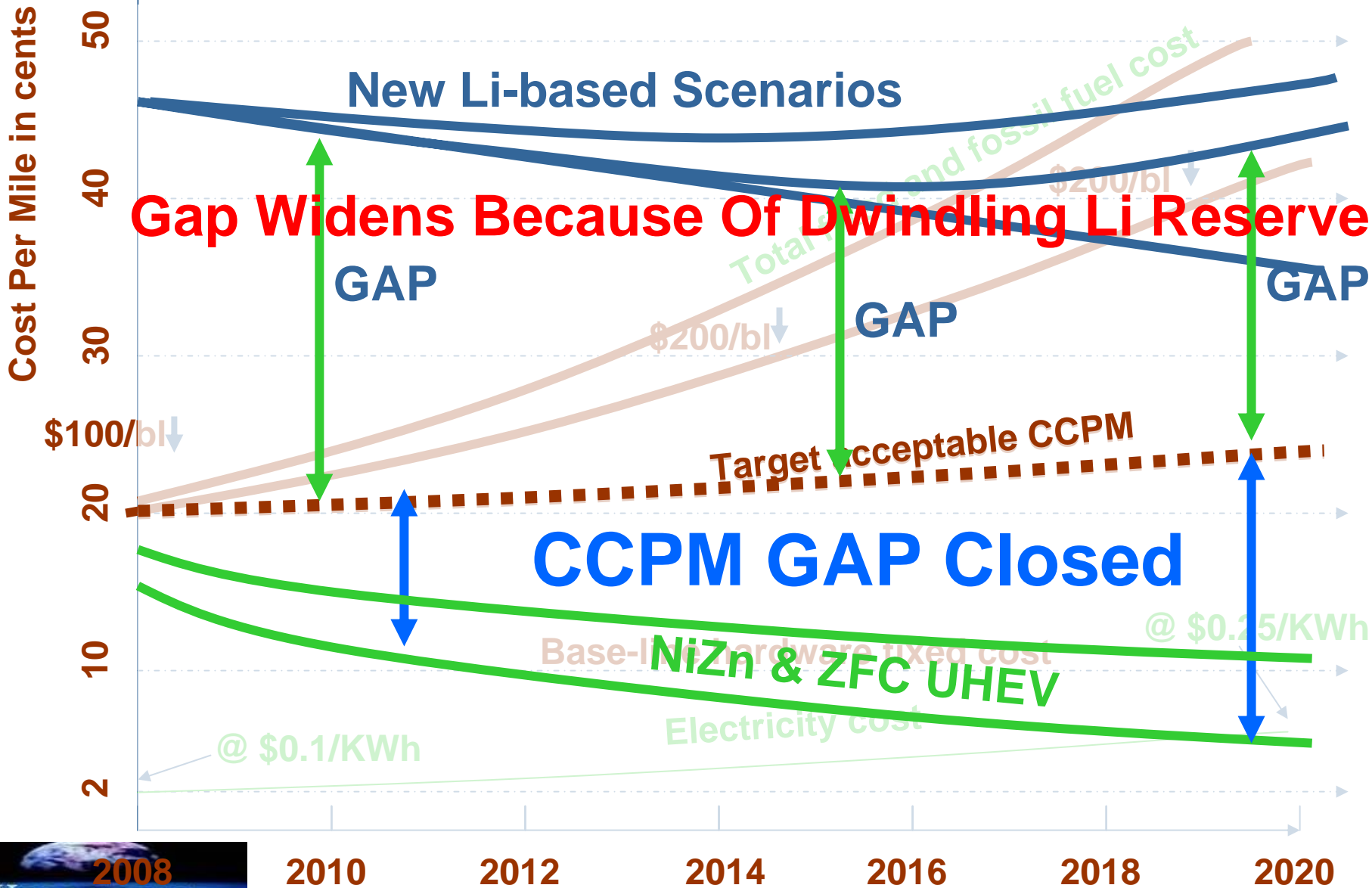
# Human Mobility Economic Analysis

## Consumer Cost Per Mile (CCPM)



# Human Mobility Economic Analysis

## Consumer Cost Per Mile (CCPM)



# What Choices Do We Have?

Lead Acid?



NiCd?



NiMH?



Old Li-Batteries?



New Li-Based Systems?

or

New Zn-Based Systems ?

1995

2000

2005

2010

H2 Economy

Biomass Economy

Lithium Economy

Zinc Economy



It is not easy to be  
green, unless



**Click**  
**Energy Transportation Engine**  
**Inventions**