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Motor Vehicle Roundtable Federal Fleet Electrification



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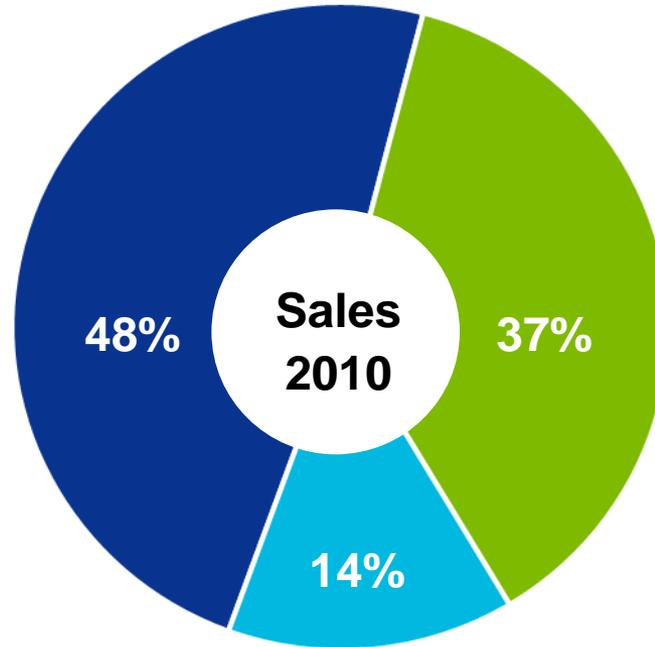
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Johnson Controls, Inc.: A global \$35 billion diversified multi-industrial company

Automotive Experience

Interior systems for cars, light trucks and vans.



Building Efficiency

Controls systems, services and integrated facility management for non-residential buildings.



Power Solutions

Global leader in lead-acid starter batteries, advanced batteries for Start-Stop vehicles, and lithium-ion hybrid battery systems that make vehicles more energy efficient.



Technology – Accelerating pace and global

Mega Trends - Mature Markets



*Place
a call*

**Call, surf, play,
organize**



*Read a
newspaper*

**Information
anywhere, anytime**



*Develop
film*

**Electronic storage
and accessibility**



Insights

- **Technological breakthroughs have created new industries and companies—and obsoleted others**
- **Consumers expect high value—improved capabilities at same or lower prices**
- **Emerging market development is further accelerating the pace of change—leapfrogging technologies where current norms and infrastructure do not exist**
- **Energy storage markets are entering a period of unprecedented change**

Lithium-Ion battery technology

Li-Ion Battery Technology Advantages for HEVs



Much of today's technology is Nickel Metal Hydride (NMH)



Lithium-Ion is the target of every OEM as the obvious next-step battery solutions

WHY?

30% Smaller

50% Lighter

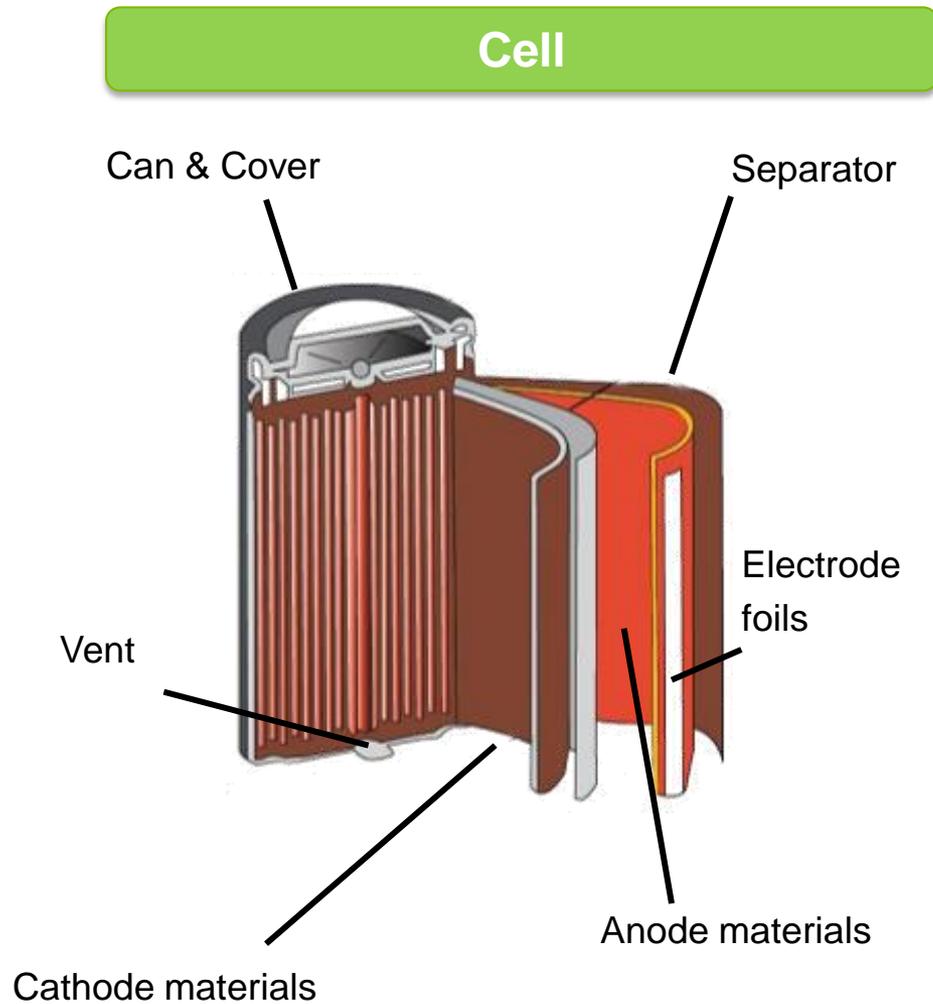
More Powerful

Faster Recharge

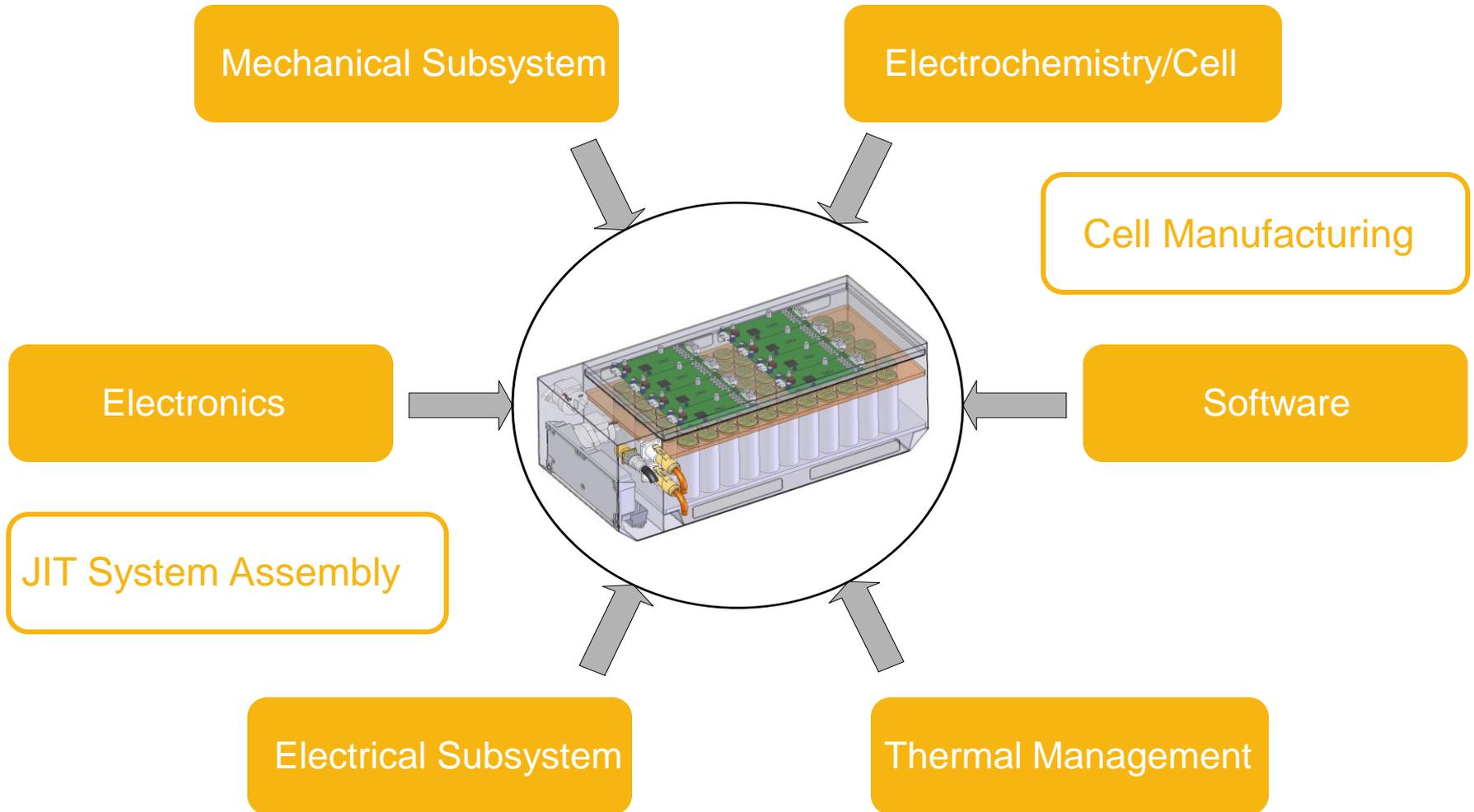
Enhanced Cycle Life

More Energy

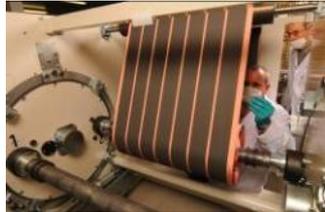
The battery cell



Advanced technology batteries—a complex system



Johnson Controls Li-Ion Cell Manufacturing and Battery System Assembly Plant—Holland, MI



Holland, Michigan

Johnson Controls' first Li-Ion manufacturing site in the US



Transit Connect EV



Azure Dynamics HEV



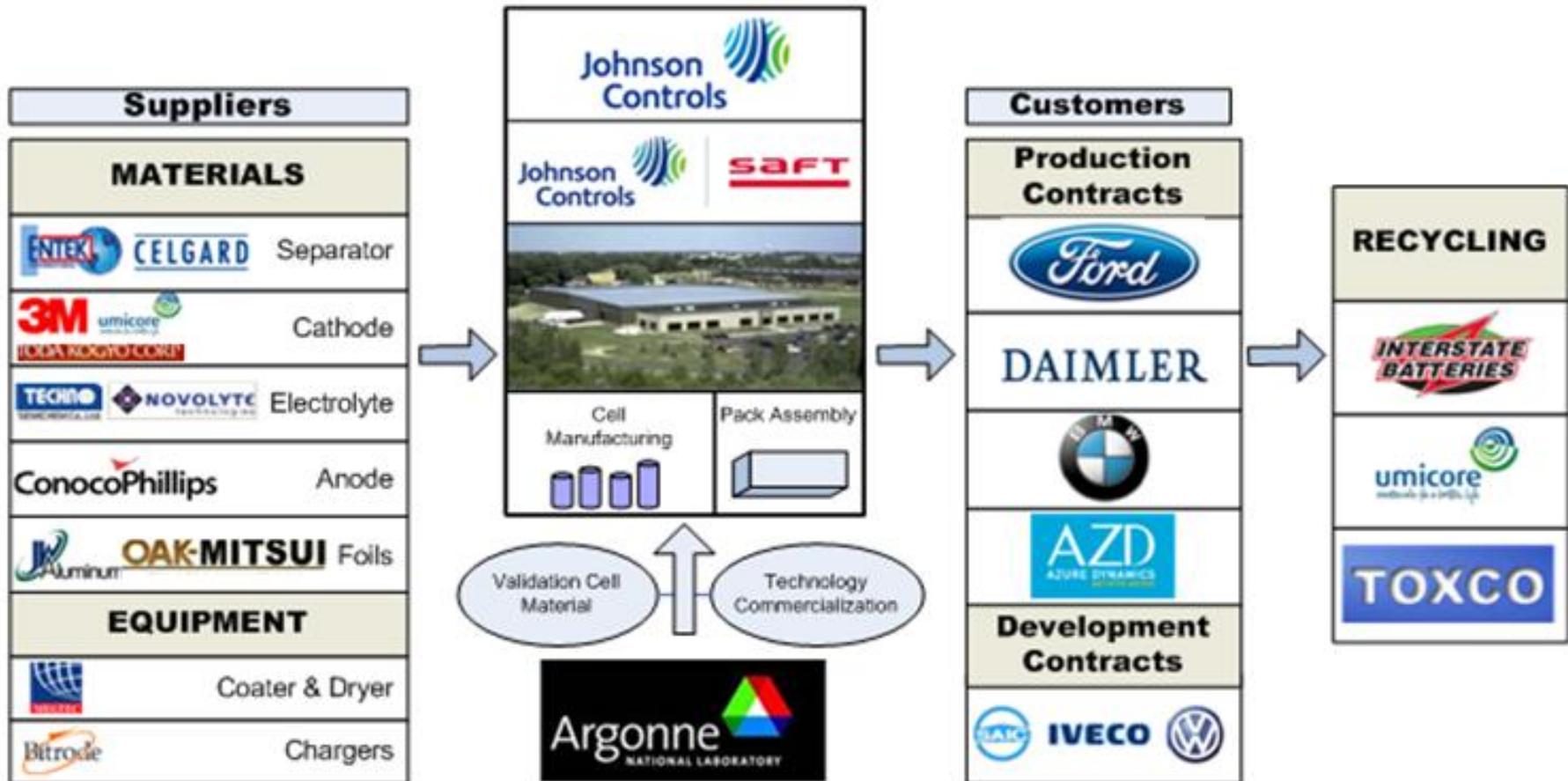
Mercedes S-Class HEV



BMW 7 Series HEV



Standing up a domestic Li-Ion industry



Integrated systems across the powertrain electrification portfolio

Internal
Combustion
Engine (ICE)



Start-Stop with
Advanced
Lead-Acid
Batteries



Hybrid Electric Vehicle
(HEV) with
Advanced Li-Ion
Battery Technology



Plug-In & Electric
Vehicle (PHEV) & EV
with Advanced Li-Ion
Batteries



Pb-acid

Li-Ion

Beyond Li-Ion



VARTA
BY JOHNSON CONTROLS



Start/Stop

Accessory Loads

Cranking

OPTIMA
BATTERIES
THE ULTIMATE POWER SOURCE™



100% Electric Range

Substantial Electric Range

Minimal Electric Range

Boost/Regen Braking



New Battery Technologies



Increasing Energy Throughput

A practical EV available now for fleets
80 mile range, 75 mph top speed

transit connect electric

Driving a world of difference in a light-duty electric vehicle.



The 2010 Ford Transit Connect—North American Truck of the Year.

Azure Dynamics Corporation (AZD) and Ford Motor Company have joined in a collaborative effort to deliver the Transit Connect Electric for North America and Europe.



Hybrid Alternatives

Ford F-450



Improve fuel economy by up to **40%** and reduce your **maintenance costs** by up to **30%**

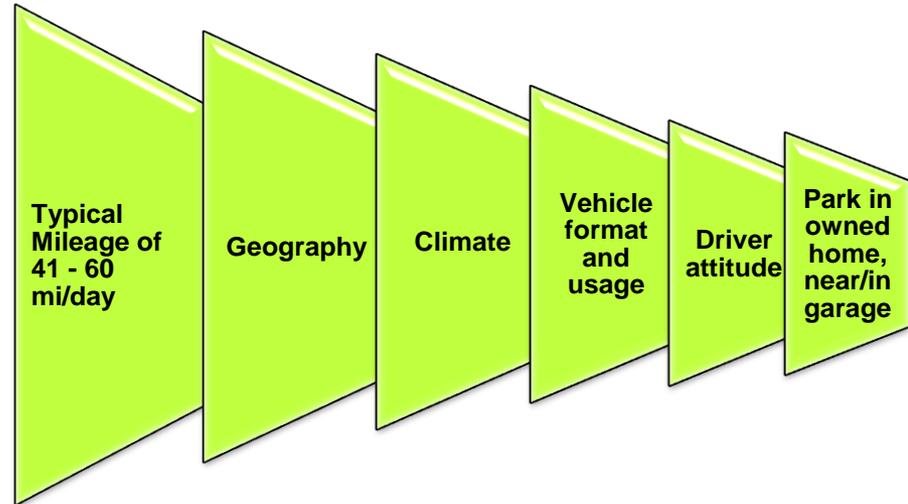


Case study

Introduction of EVs into Johnson Controls' fleet

Determine the “sweet spot” for Electric Vehicles in the fleet

Multiple filters to apply before EVs can be placed in to the fleet



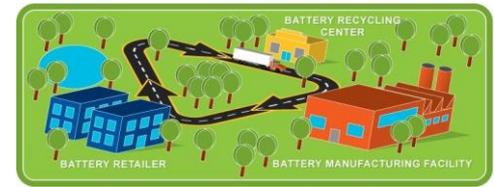
3 Step Process

- 1) Vehicle and Payload Analysis** – Review existing inventory of vehicles in terms of payload and performance requirements. Evaluate the available EVs in the market meeting the size and payload needed.
- 2) Drive Pattern Analysis** – Analyze specific daily driving profiles. Select drivers with predictable routes (those servicing the same customer on repeated basis).
- 3) Driver Survey** – determine attitudes and behavior towards EVs. Maximize the probability of success for initial deployment of EVs and manage typical challenges.

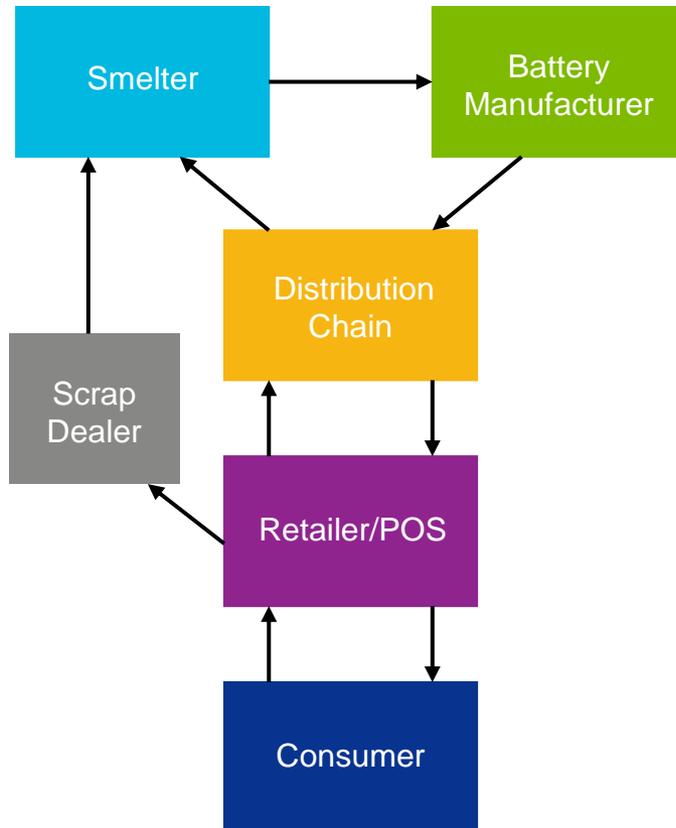
Lithium supply is abundant and growing

- Although a critical component, the weight percentage of lithium in a Li-Ion battery is small, about 2%
- Current global reserves of lithium are sufficient to power 10 billion, 40 mile all-electric range PHEVs
- Current annual demand for lithium for other applications is modest; 20,000 metric tons or 0.075 % of known reserves
 - Pharmaceuticals
 - Ceramics
 - Aluminum alloys
 - Lubricants
 - Consumer cells
- Recycling and recovery technology will help to ensure supply efficiency and pricing stability

Model for advanced battery recycling



Battery Core Return Process



Optimize Supply Chain Network

Core Battery Management

- Balance return rate flow with available recycling
- “Own the materials” through the recycling process

Closed Loop Distribution

- Ensure battery returns for recycling, incentives to customers/retailer (core deposit)
- Investigate re-use of secondary materials in product

Key Factors for success

- Leverage existing JCI infrastructure for battery returns
- Establish proper level of regional recycling capacity
- Ensure growth in recycling capability is in line with market growth

OE customer strategies—Vehicle development

Start-Stop

Internal Combustion Engine



ICE w/ Start-Stop



Hybrid Electric Vehicle



Plug in Hybrid Electric Electric Vehicle



Improve fuel efficiency and emissions with minimum change to vehicle systems

- Allows engine to be shut off instead of idling while the vehicle is stopped
- Responding to CO₂ reduction targets set by EU
- All OE's launching platforms in Europe with transition to Asia and US markets

Battery required to start engine more frequently

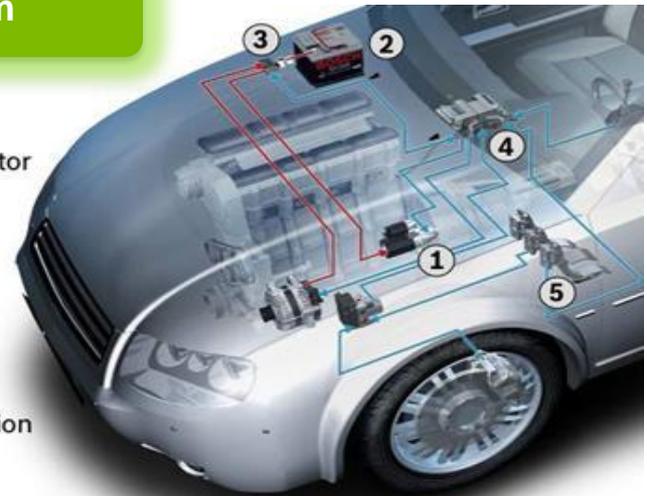
What is a Start-Stop?

Main components

Start-Stop requires some additional and modified components and increased communication between existing components and control modules

Start/Stop System

- ① Start/Stop Starter Motor
- ② Improved Battery
- ③ Electronic Battery Sensor
- ④ Engine Control Unit incl. Start/Stop Function
- ⑤ Pedals and Sensors



Leveraging successful partnerships to drive focused innovation and successful commercialization

Federal Laboratories



Academia



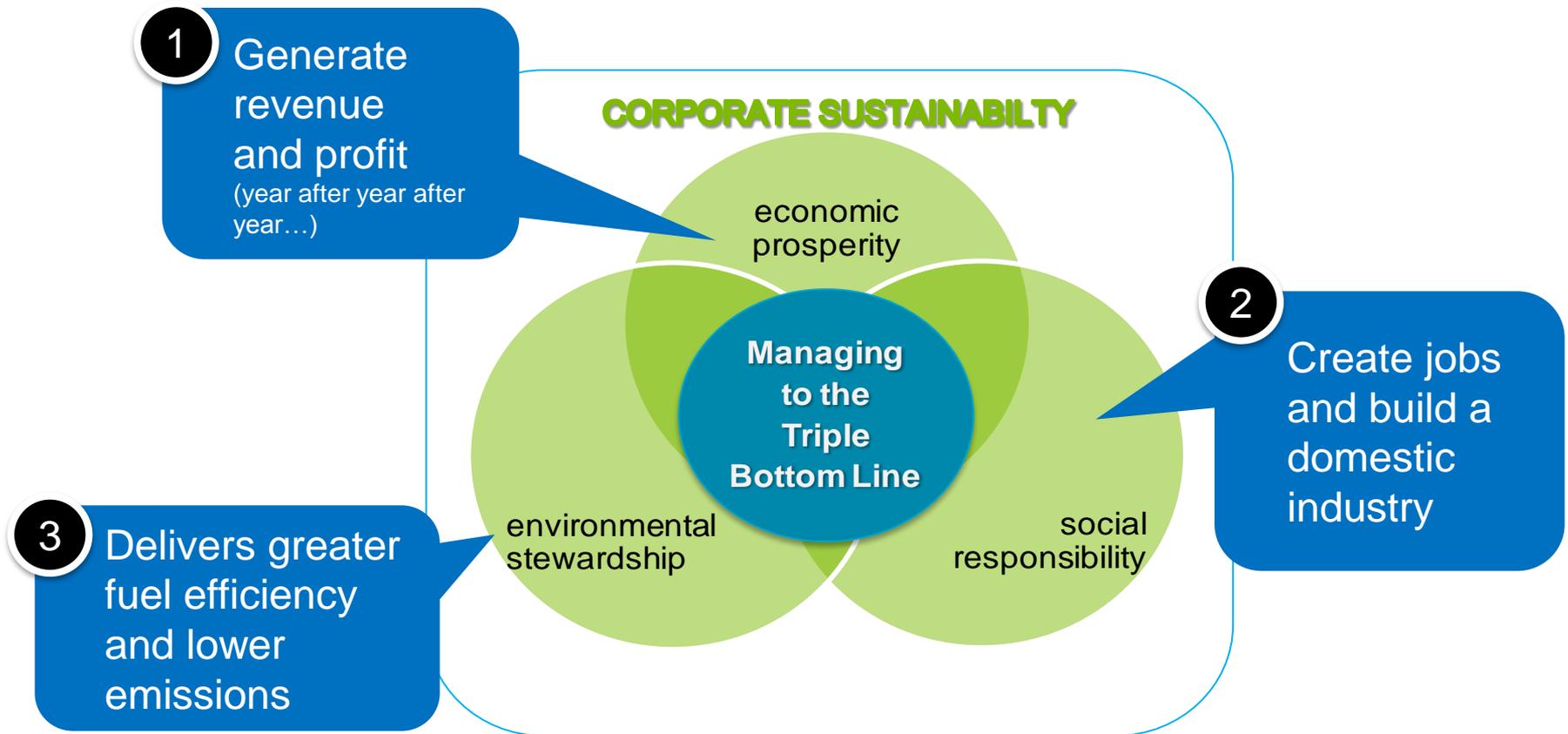
Technology Companies



Consortia



Bottom line: Mass adoption comes with a sustainable business case



**We need to get No. 1 right.
Without an economic foundation, No. 2 and No. 3 can't follow**