NOTABLE LI-ION ALTERNATIVES

An at-a-glance look at up and coming zero-emission technologies

HYDROGEN FUEL CELLS

DEVELOPMENT STAGE
For sale today in CA as test market; still being refined for broader distribution

ENVIRONMENTAL IMPACT
Excellent provided mass scale production can be solved

INFRASTRUCTURE NEEDS
High – requires new fuel distribution and delivery mechanisms

RECHARGING SPEED
High – five minutes adds 400-mile (650 km) range

PASSENGER SAFETY
Safe or safer than ICE. Unlike gasoline, hydrogen quickly dissipates if tank is punctured

COST
Low if hydrogen can be obtained from sea water

PROGNOSIS 5-10 years before widespread adoption. Limited to urban and high traffic corridors

SOLAR PANELS

DEVELOPMENT STAGE
First mass-produced solar-powered vehicle rolling off assembly line this year: the Aptera

ENVIRONMENTAL IMPACT
3-25 times less impact than when generating same amount of energy from fossil fuels. Still requires a battery

INFRASTRUCTURE NEEDS
Low, although will soon require more recycling plants and/or better overall recycling for panels

RECHARGING SPEED
Requires ideal weather conditions but battery or supercapacitor can even out periods of varying sunlight

PASSENGER SAFETY
Too early to tell. Vehicles with low drag and low weight may not be as crashworthy

COST
Coming down, starting with $25,900 for the Aptera

PROGNOSIS Great potential especially if Musk turns his interest in solar panels from buildings to solar-powered cars

GRAPHENE SUPERCAPACITORS

DEVELOPMENT STAGE
Some commercial applications exist but not yet capable to primarily power a vehicle

ENVIRONMENTAL IMPACT
Poor given current manufacturing techniques, however, material is a carbon-sink with excellent environmental potential

INFRASTRUCTURE NEEDS
High – requires completely new charging infrastructure

RECHARGING SPEED
Very high – able to fully charge within seconds

PASSENGER SAFETY
Excellent – material is non-toxic and non-reactive

COST
Low – carbon is cheap and readily available, but manufacturing techniques need to catch up

PROGNOSIS Limited to a battery companion technology for foreseeable future since supercapacitors have difficulty maintaining charge

MICROBIAL BATTERIES

DEVELOPMENT STAGE
Very early. Proof of concept has been completed but not in commercial use

ENVIRONMENTAL IMPACT
Excellent – bacteria are organic, create acetate (which is biodegradable), and are self-renewing

INFRASTRUCTURE NEEDS
Low, assuming batteries are paired with solar panels – their most likely use case

RECHARGING SPEED
Slow – batteries currently require 16 hours to charge for 8 hours of use

PASSENGER SAFETY
Organic components are much safer than Li-ion batteries

COST
Low since the primary component – bacteria – are self-replicating

PROGNOSIS 10 years plus. Although work continues, hurdles in efficiency and cycles need to be overcome

COBALT-FREE LITHIUM BATTERIES

DEVELOPMENT STAGE
Cathodes using other metals are in various stages of R&D. Expect to see some in production by 2023

ENVIRONMENTAL IMPACT
Replacement chemistries don't have all the concerns of cobalt, but many don't eliminate mining problems either

INFRASTRUCTURE NEEDS
Pricing equivalent to that of current EV infrastructure

RECHARGING SPEED
With careful formulation, charging rate can be same as existing cobalt-based Li-ion batteries

PASSENGER SAFETY
Issues with thermal regulation and fires need to be solved as cobalt does better job of shedding heat

COST
Much better than standard Li-ion – for example manganese is 18 times cheaper than cobalt

PROGNOSIS Has promise given Musk's ambitions plans to ditch cobalt and given several other OEMs are pursuing cobalt-free battery designs

SOLID-STATE BATTERIES

DEVELOPMENT STAGE
In production for small devices like RFID tags, pacemakers, and smart watches; R&D stage for cars

ENVIRONMENTAL IMPACT
Many electrolyte materials are under investigation. Chemistry of "winner" will determine final impact

INFRASTRUCTURE NEEDS
With longer ranges possible, fewer mid-trip EV charging stations are required

RECHARGING SPEED
Potential to charge much faster than Li-ion

PASSENGER SAFETY
Excellent – non-toxic solvents have low flammability, are non-volatile, and have thermal stability

COST
Expensive now but expected to be lower. Only materials less expensive than Li-ion will survive market pressures

PROGNOSIS Initial commercialization expected by 2024 but not likely widespread until 2030

Visit the Third Law ZEV blog for more detailed information on each of these technologies.

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