

luxexecutivesummit 2018

Boston • April 9-11

The Power Grid of the Future

Powering the next-generation of electric vehicles | April 10

Presenter: Chris Robinson, Analyst, Lux Research



luxexecutivesummit 2018

Boston • April 9-11

I need to buy a car...



... so should it be electric?

The quality and quantity of electric vehicles available today is drastically better than ever before



2011 Nissan Leaf

MSRP: \$32,780

Range: 84 miles

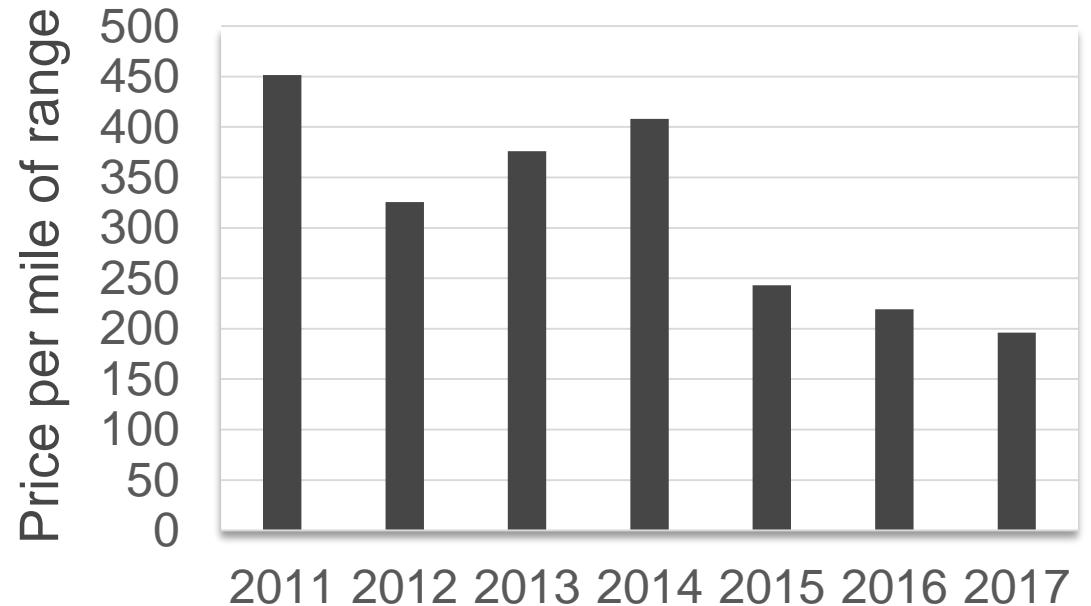


2018 Nissan Leaf

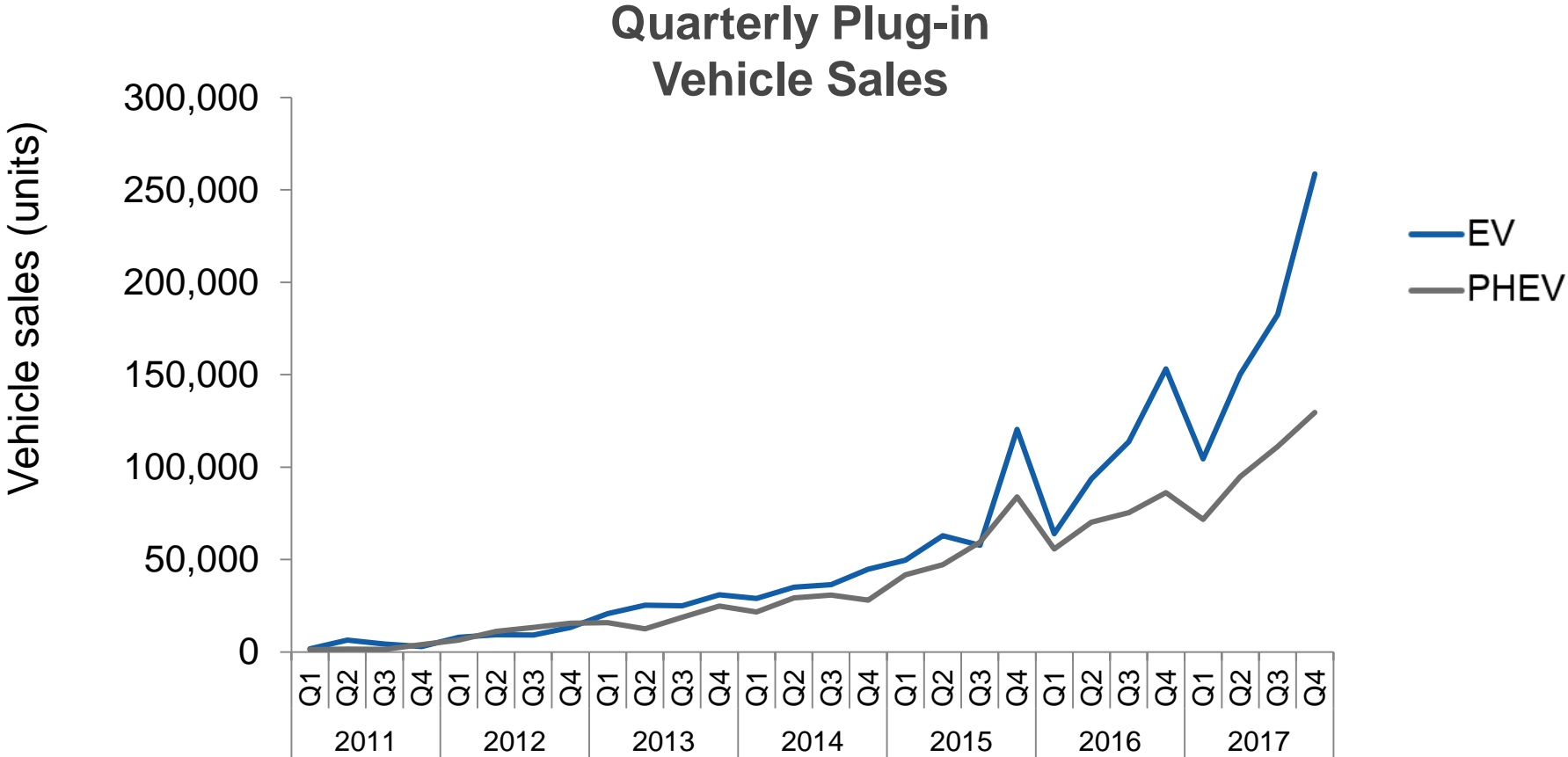
MSRP: \$29,990

Range: 151 miles

EV Range is Cheaper than Ever



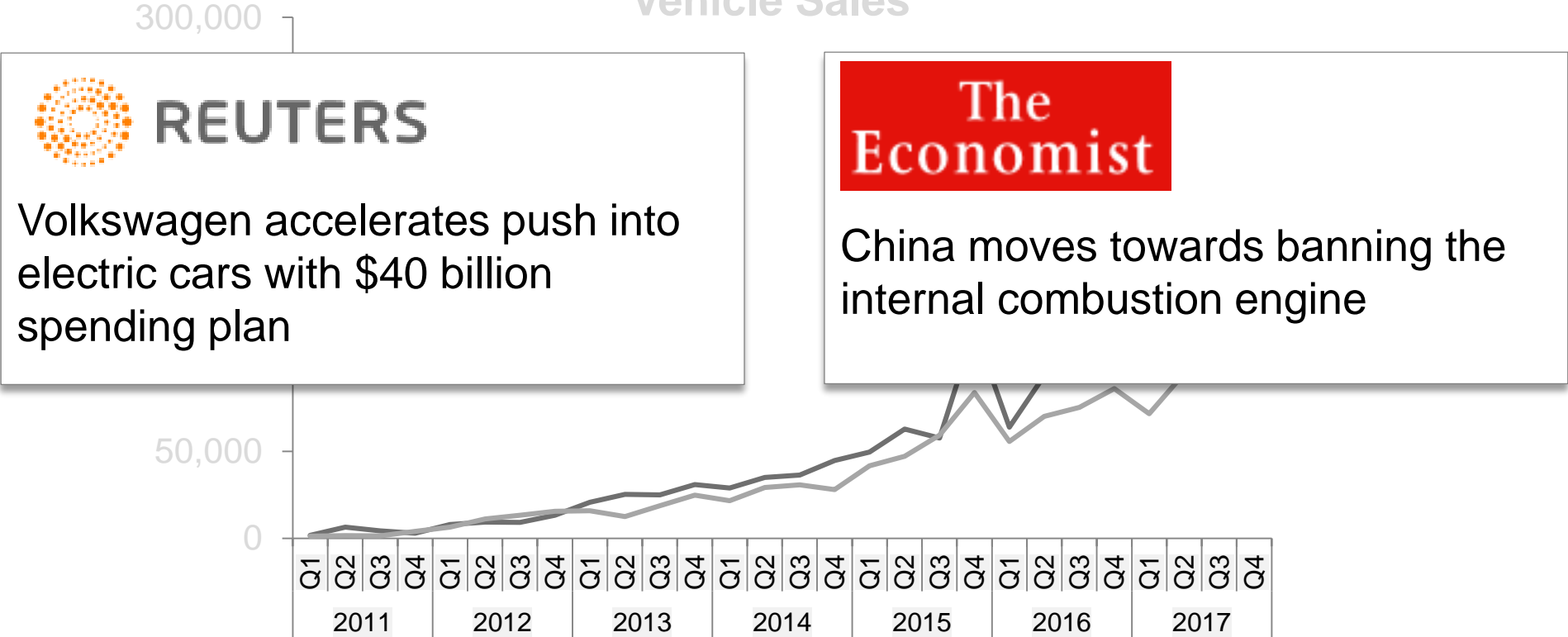
These low-cost vehicles with more range are resonating with consumers



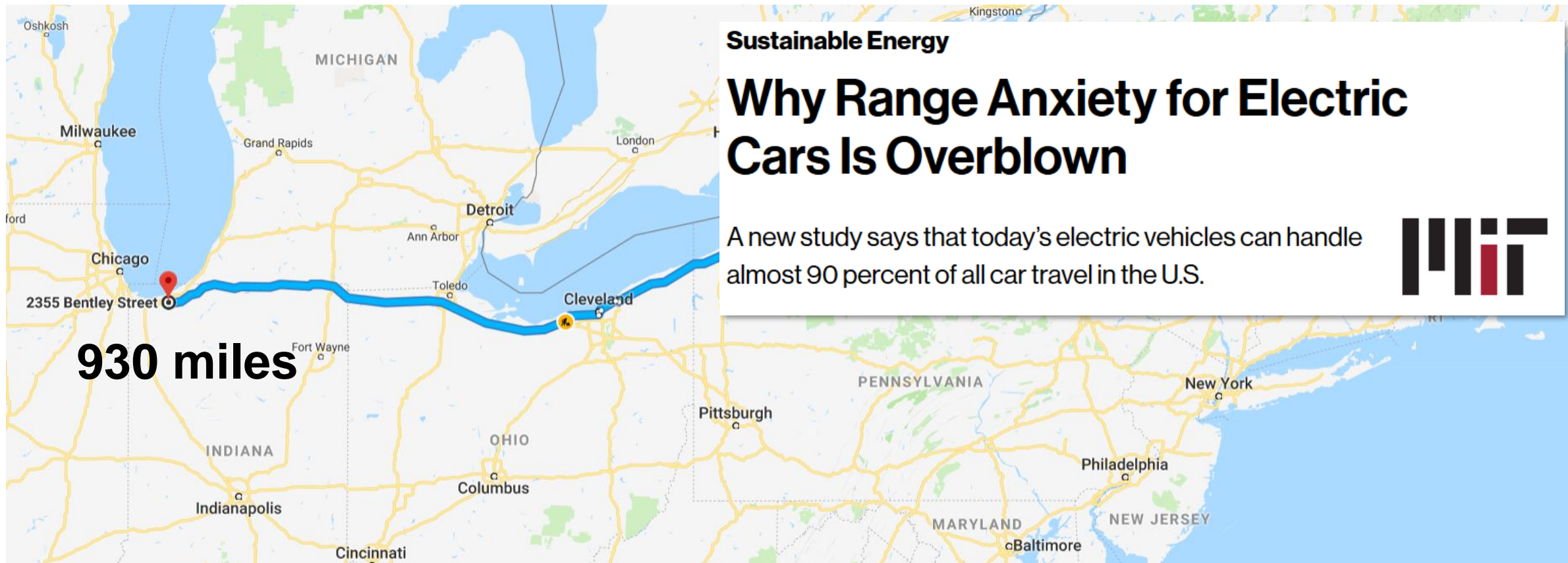
4 Source: Lux Research Automotive Battery Tracker

These low-cost vehicles with more range are resonating with consumers

Quarterly Plug-in Vehicle Sales



... but I have range anxiety



What is going to drive from a niche market to a dominant technology?



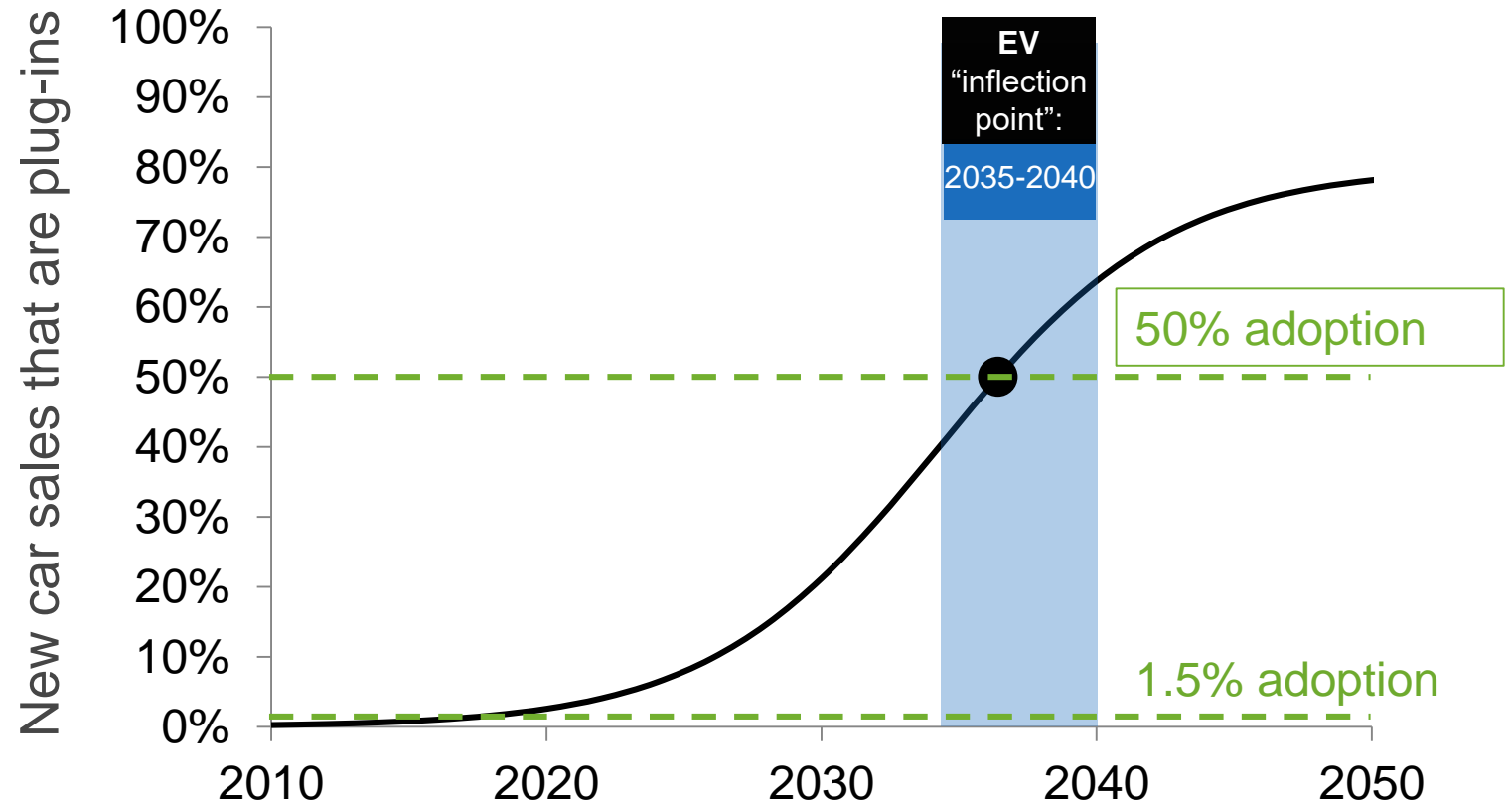
Survey: 85% cite lack of charging as limiting factor in buying EV

The New York Times

For electric car owner, 'range anxiety' gives way to 'charging time trauma'



Range anxiety powers China to invest in electric car-charging points



Agenda

The background of the slide is a blue-tinted photograph. In the foreground, there is a large array of solar panels mounted on a field. In the background, several wind turbines are visible against a hazy sky. The overall scene represents renewable energy infrastructure.

1 | How is infrastructure alleviating range anxiety today?

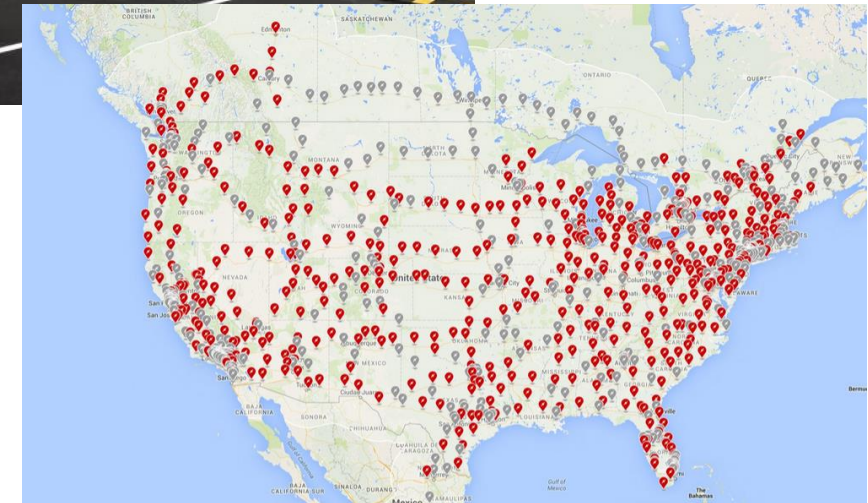
2 | A new way of thinking about range anxiety

Solutions to range anxiety aim to quickly add energy to a vehicle

Completely replacing a battery with another one filled with energy



Adding energy to the battery as quickly as possible with fast-charging



Fast-charging has emerged as the technology of choice for quickly topping up range

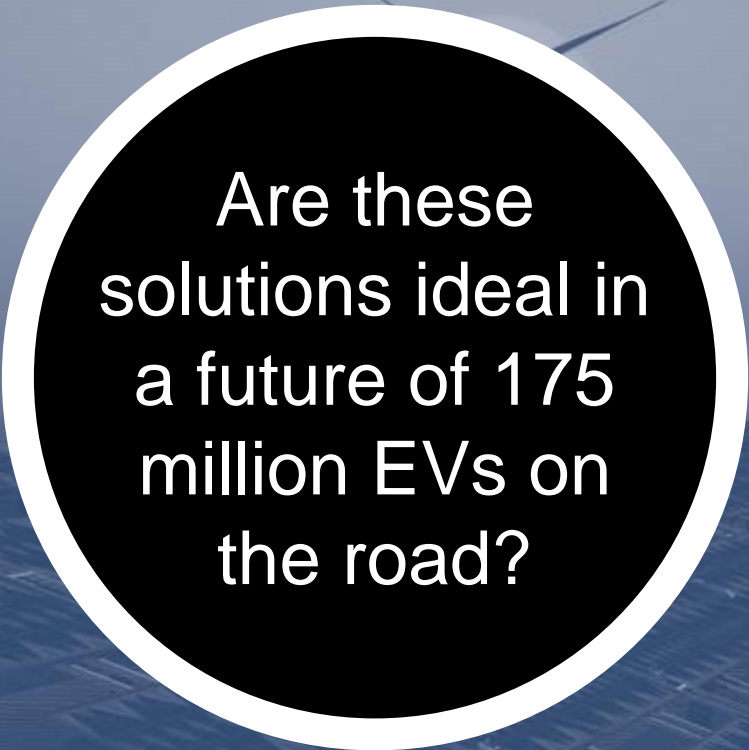
Porsche's Mission E will be the first vehicle compatible with 350 kW fast-charging



=



X 250



Are these
solutions ideal in
a future of 175
million EVs on
the road?

Cost

Is the solution
affordable to
deploy?

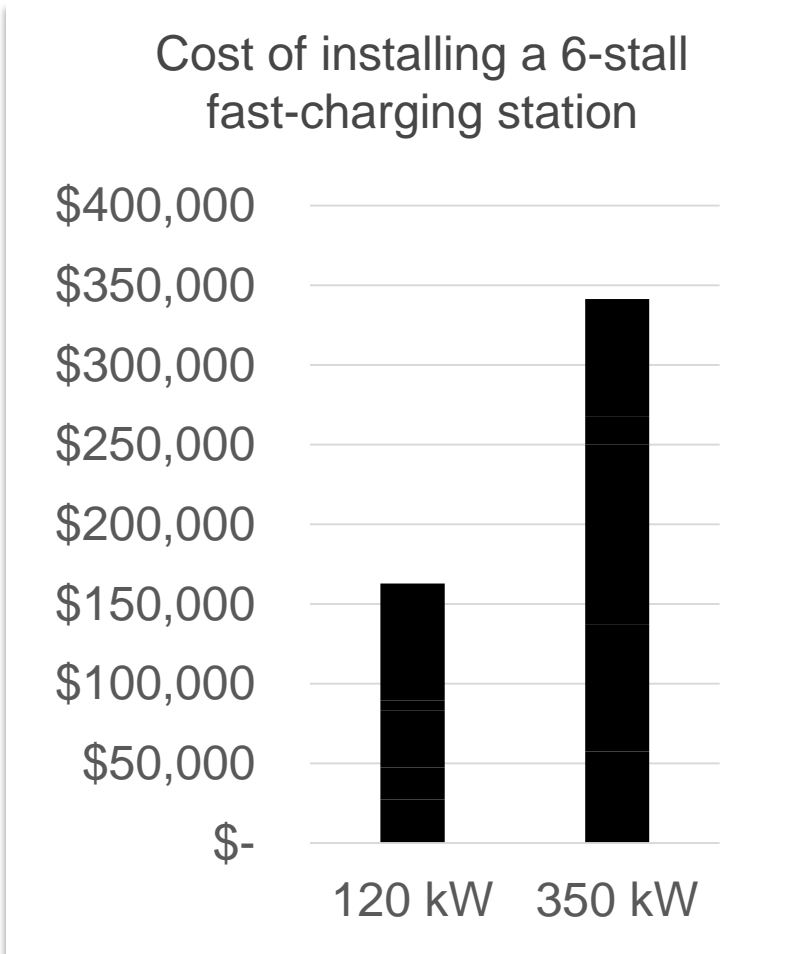
Scalability

Will the solution
face hurdles that
prevent it from
scaling?

Speed

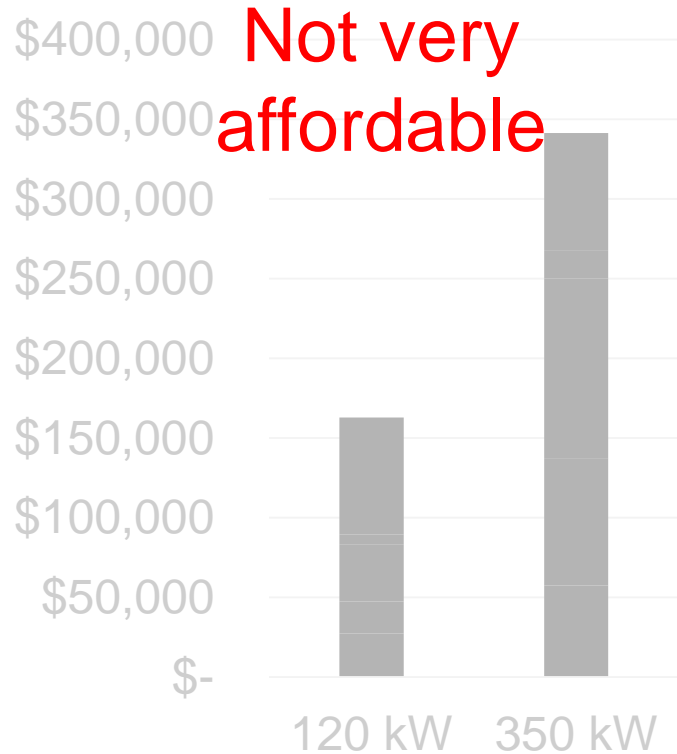
How quickly can
a solution add
range?

At the EV tipping point in 2040, fast-charging doesn't meet most needs to alleviate range anxiety

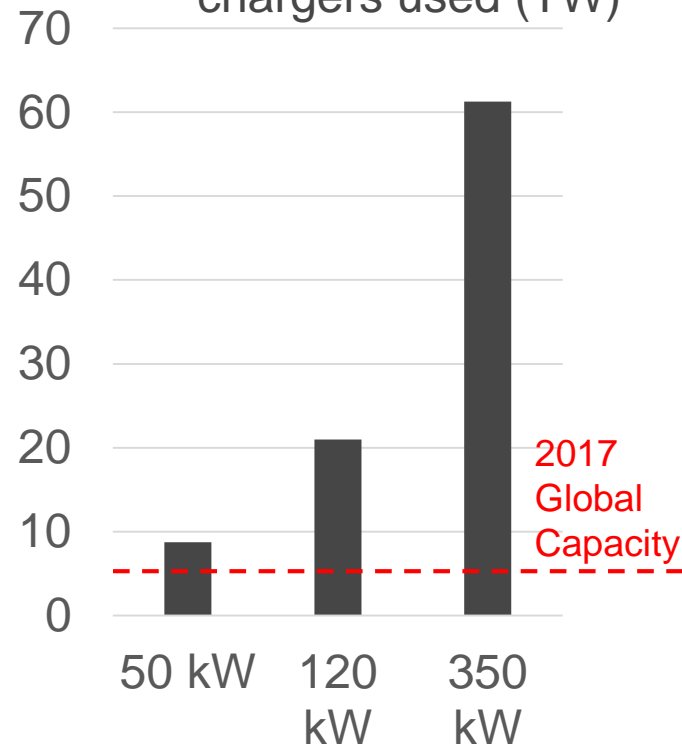


At the EV tipping point in 2040, fast-charging doesn't meet most needs to alleviate range anxiety

Cost of installing a 6-stall fast-charging station

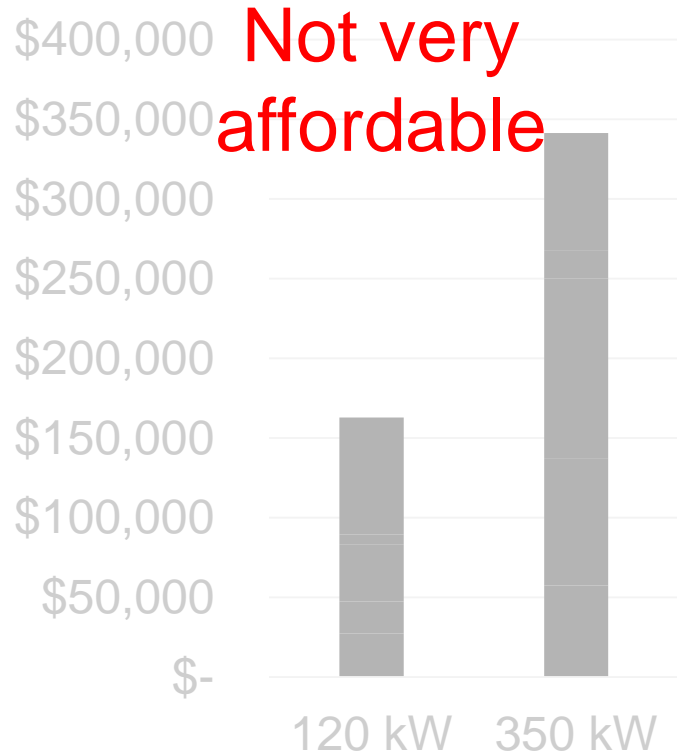


Global power demand if all chargers used (TW)

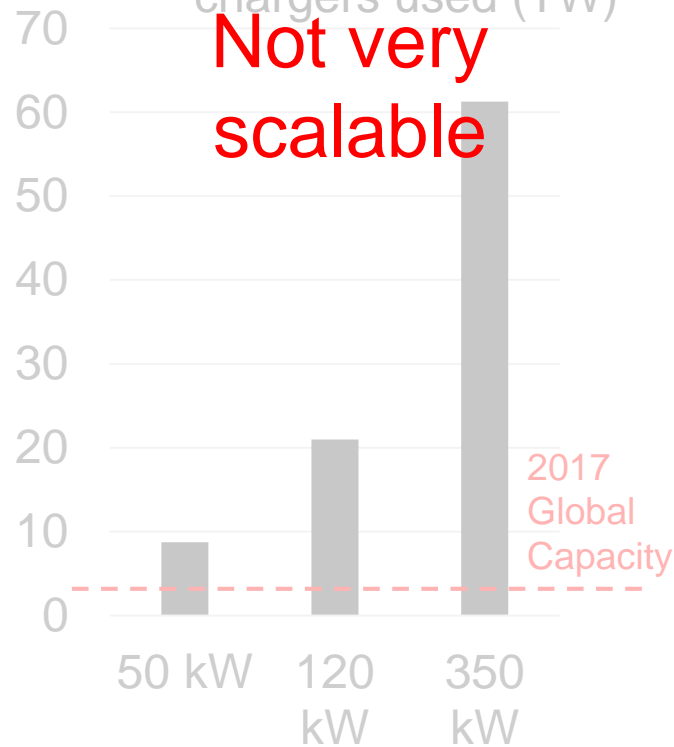


At the EV tipping point in 2040, fast-charging doesn't meet most needs to alleviate range anxiety

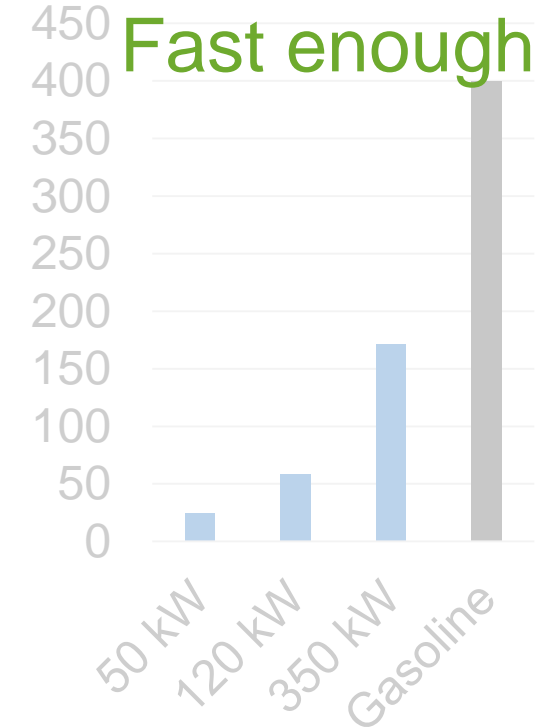
Cost of installing a 6-stall fast-charging station



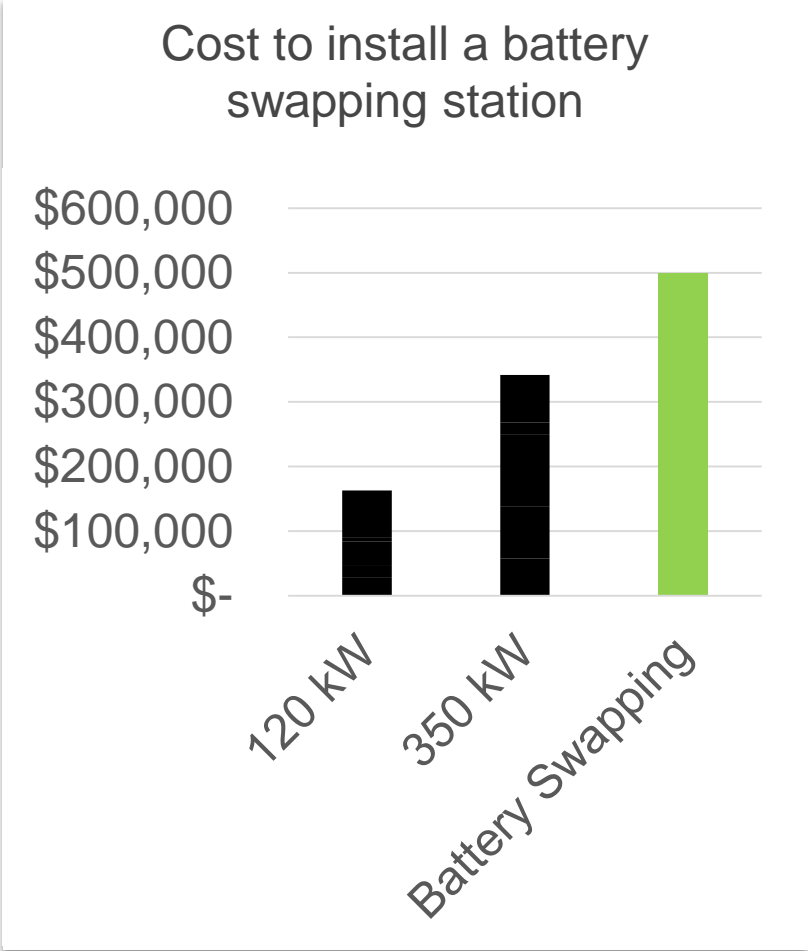
Global power demand if all chargers used (TW)



Range added in ten minutes (miles)

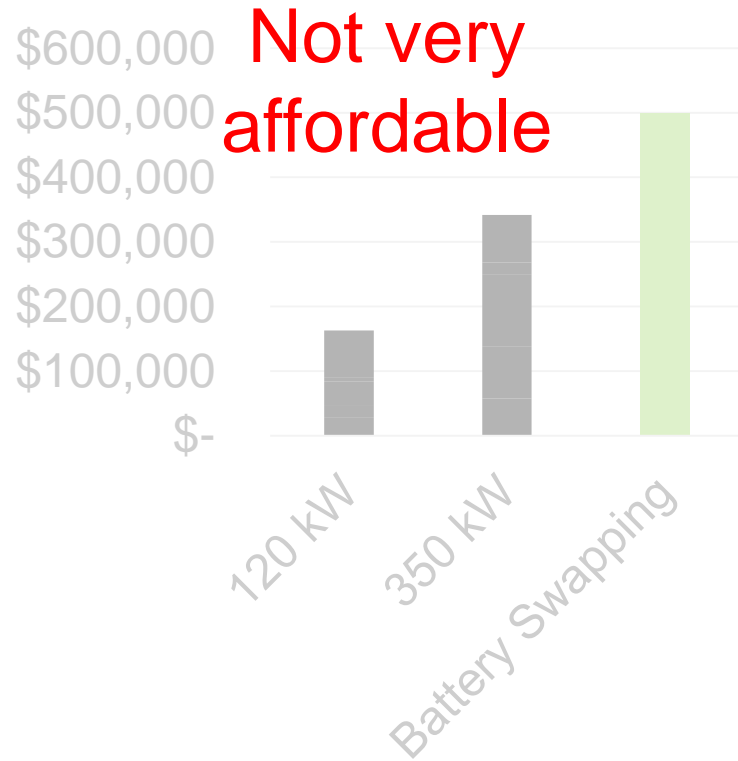


Could battery swapping be a long-term solution to long-distance EV travel?



Could battery swapping be a long-term solution to long-distance EV travel?

Cost to install a battery swapping station



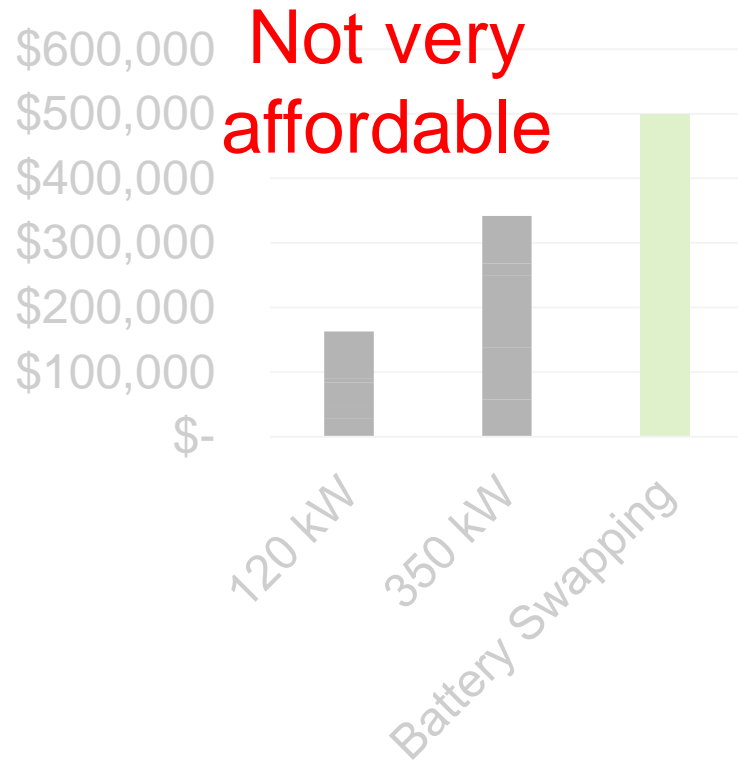
Operating costs make scaling-up a challenge

\$5,500,000

Cost of buying, charging, and replacing battery packs to support 500 swaps per day for 5 years

Could battery swapping be a long-term solution to long-distance EV travel?

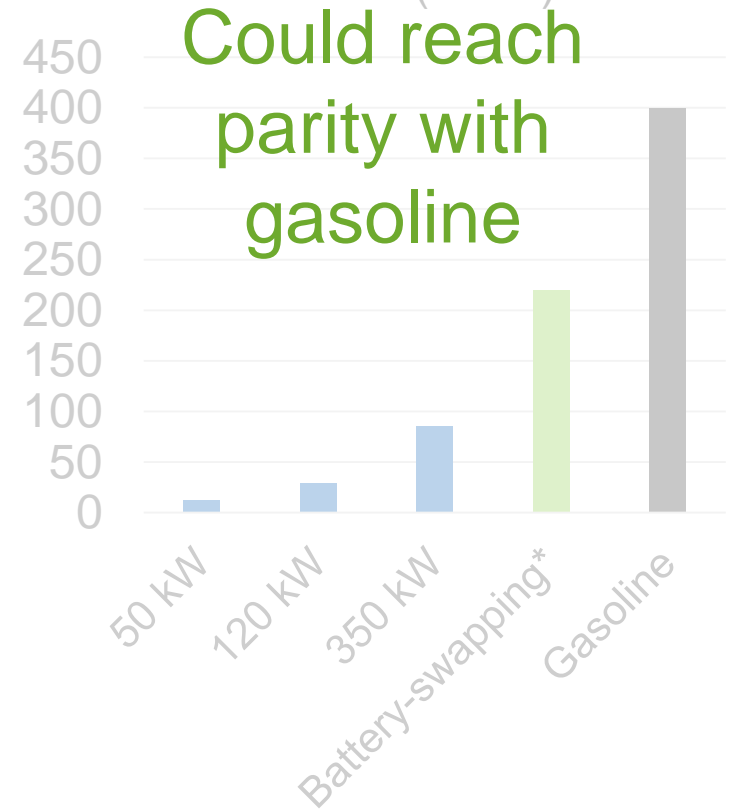
Cost to install a battery swapping station



Operating costs make scaling-up a challenge



Range added in five minutes (miles)



Current approaches focus on adding range quickly, but are not scalable or cost effective.

Agenda

The background of the slide is a blue-tinted photograph of a renewable energy facility. In the foreground, there are rows of solar panels mounted on a field. In the background, several wind turbines are visible against a hazy sky. The overall aesthetic is clean and modern, representing sustainable infrastructure.

1 | How is infrastructure alleviating range anxiety today?

2 | A new way of thinking about range anxiety

Today, Tesla's Model S 100D offers the longest highway range with just over 350 miles of range

Range Per Charge

If we can't quickly add energy during a trip, why not add more energy before leaving?

275^{MI}

351^{MI}

337^{MI}

Speed

65 MPH

Outside Temperature

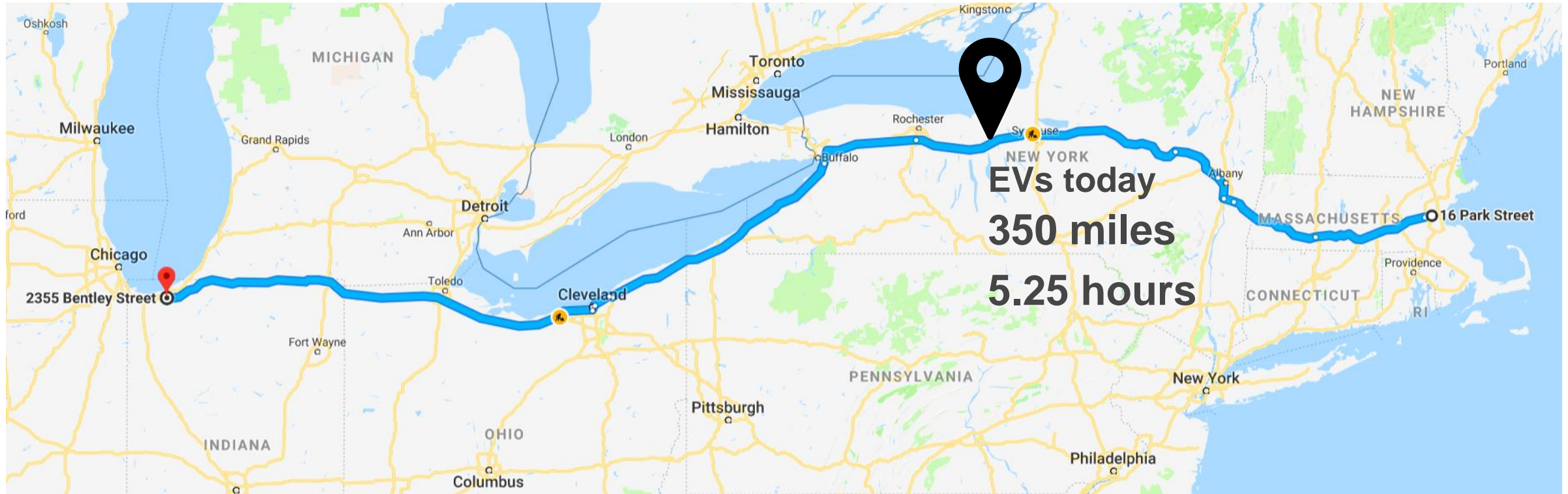
70°

Wheels

19"

21"

Today's EVs get me to Syracuse



... but how far can the EV of 2040 take me?

Building the EV of 2040 Improved Batteries



The Tesla 100D becomes the 200D with no additional weight or volume

Building the EV of 2040

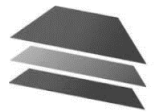
Improved Batteries



The Tesla 100D becomes the 200D with no additional weight or volume

Batteries can already exceed 400 Wh/kg

Examples:



ionic
MATERIALS

 **SolidPower**



 **amprius**

oxis ENERGY

Building the EV of 2040

Improved Batteries



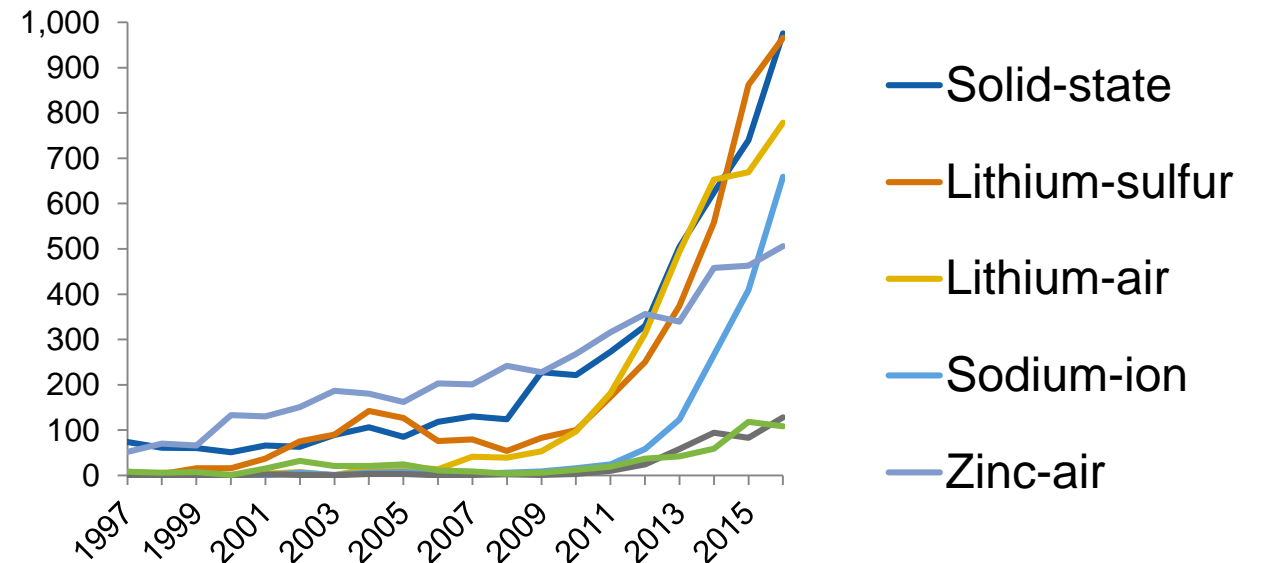
The Tesla 100D becomes the 200D with no additional weight or volume

Batteries can already exceed 400 Wh/kg

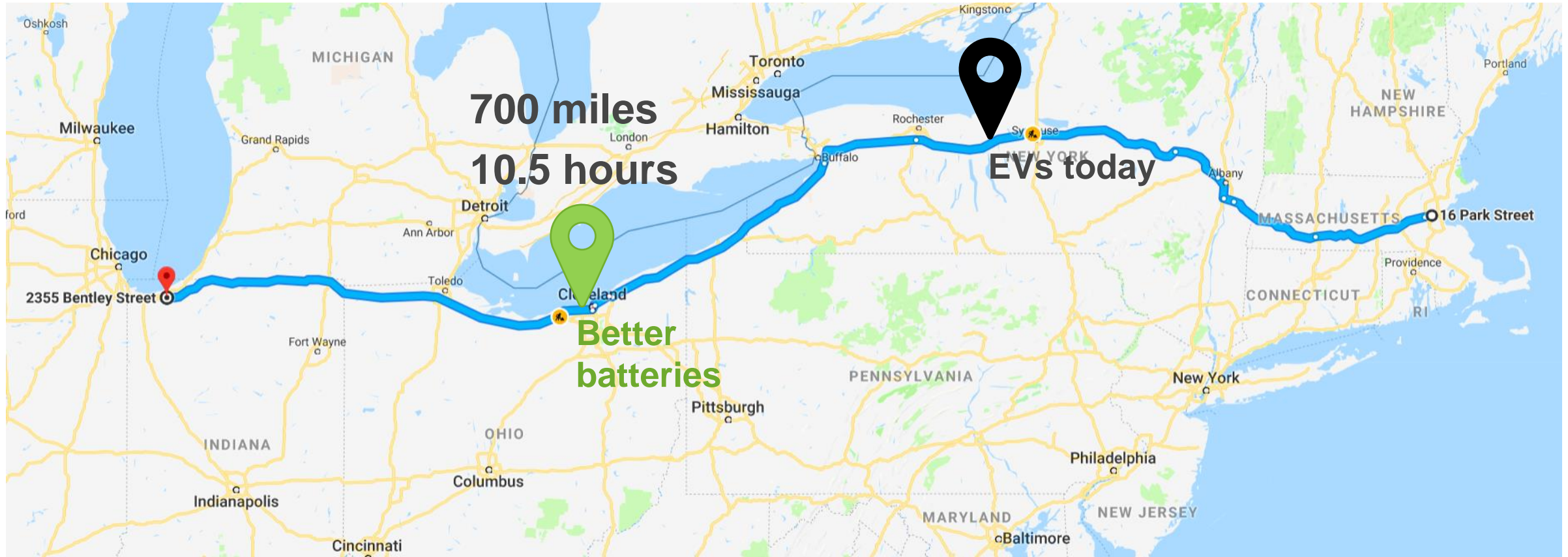
Examples:



Patent publications/year by battery type



Better batteries can get me just past Cleveland



Building the EV of 2040

Vehicle Lightweighting



Removing 600 kg of weight adds about 180 miles of range

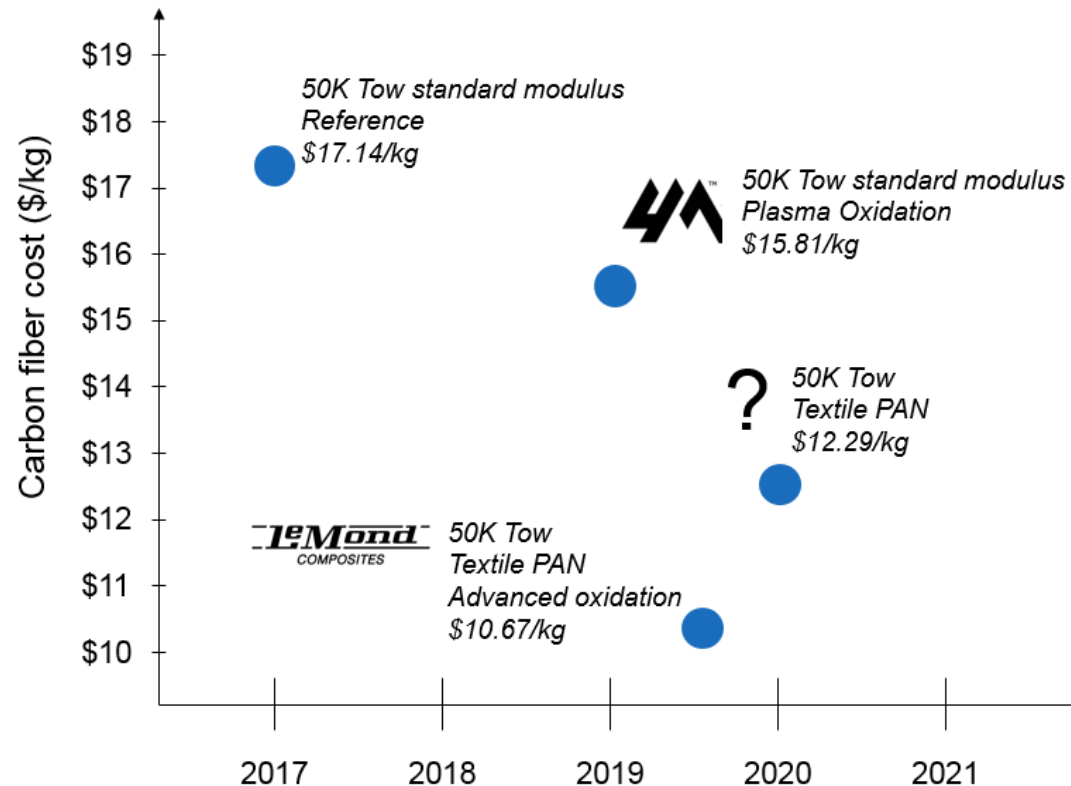
Building the EV of 2040

Vehicle Lightweighting



Removing 600 kg of weight adds about 180 miles of range

Carbon fiber prices are falling



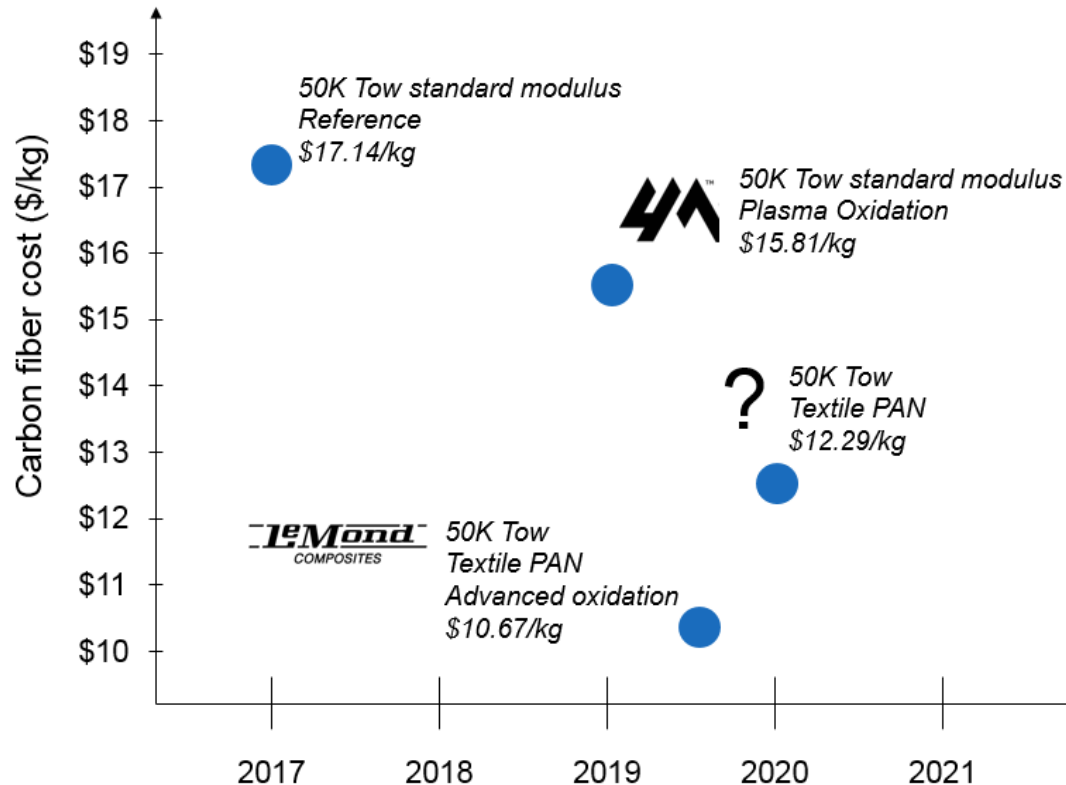
Building the EV of 2040

Vehicle Lightweighting



Removing 600 kg of weight adds about 180 miles of range

Carbon fiber prices are falling



Beyond 2040, textiles could be considered for vehicles



Lightweighting can get me into Indiana



Building the EV of 2040

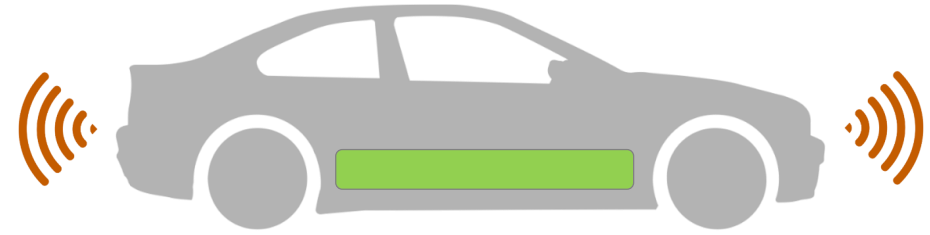
Autonomy and Efficiency



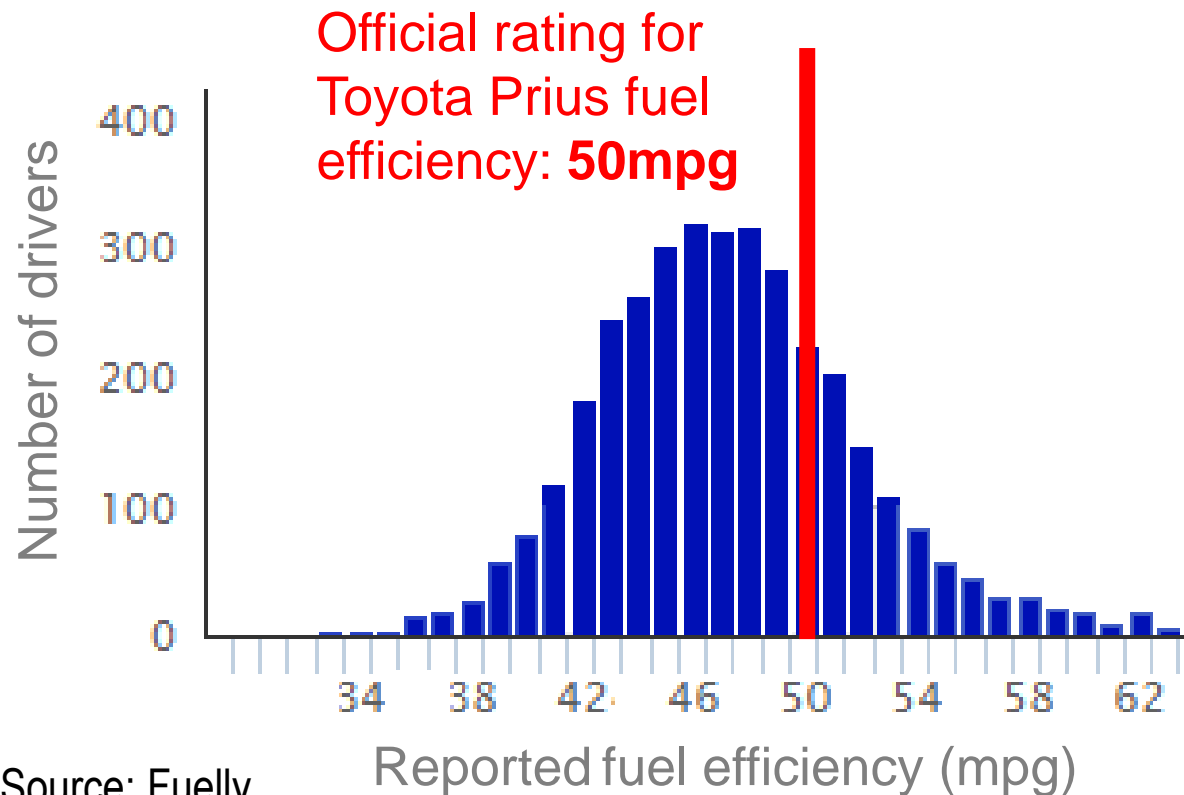
More efficient motors and aerodynamics working in tandem with autonomy increase efficiency by 15%

Building the EV of 2040

Autonomy and Efficiency



More efficient motors and aerodynamics working in tandem with autonomy increase efficiency by 15%

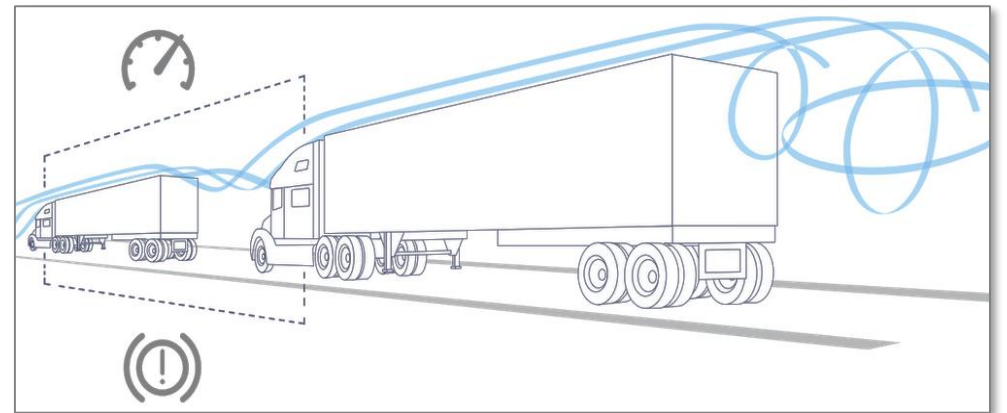
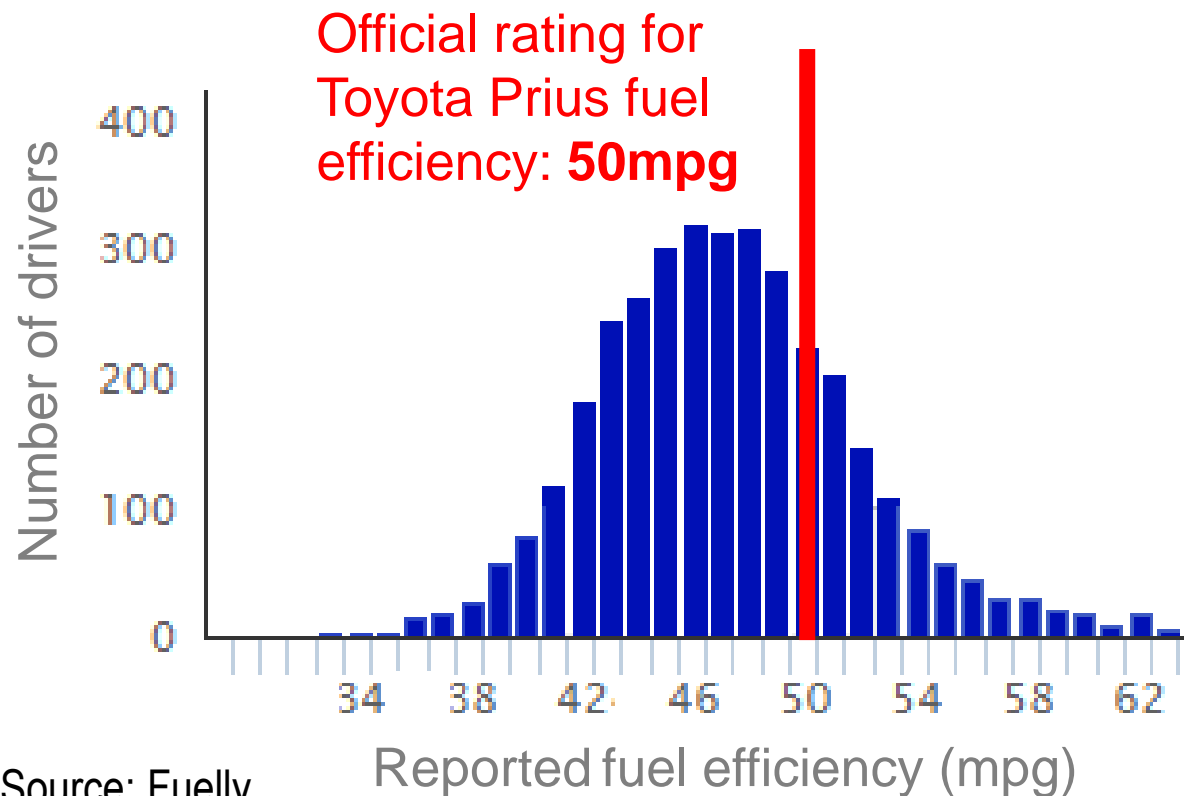


Building the EV of 2040

Autonomy and Efficiency



More efficient motors and aerodynamics working in tandem with autonomy increase efficiency by 15%



All of these technologies together can alleviate my range anxiety

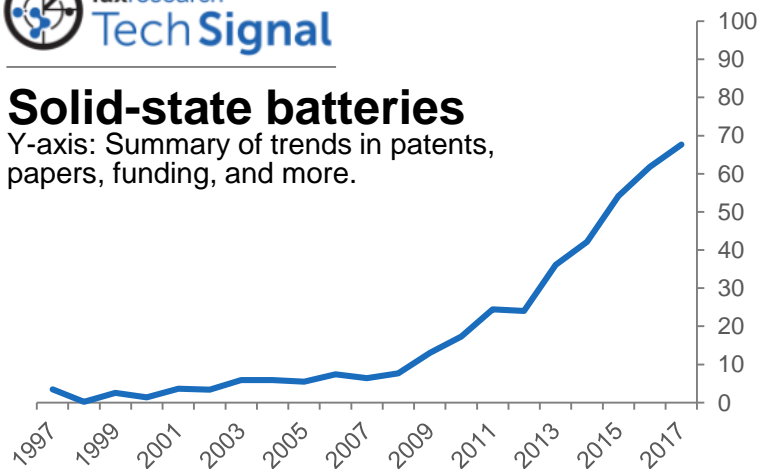


Innovation interest is high in each of these technologies



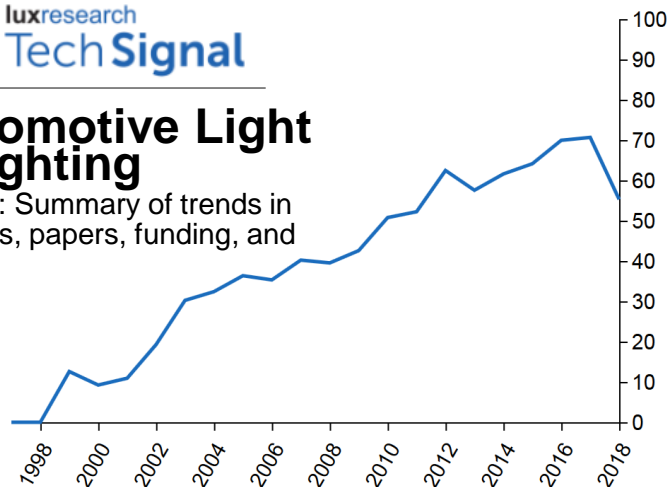
Solid-state batteries

Y-axis: Summary of trends in patents, papers, funding, and more.



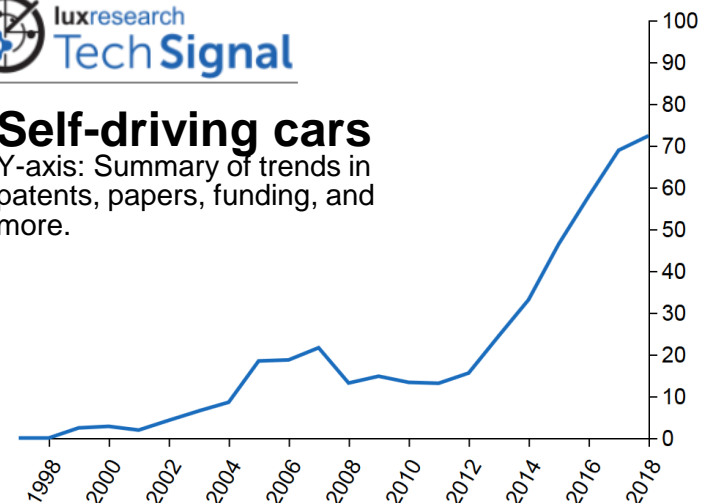
Automotive Light weighting

Y-axis: Summary of trends in patents, papers, funding, and more.



Self-driving cars

Y-axis: Summary of trends in patents, papers, funding, and more.



The 1,000 mile EV would have significant effects on vehicle charging needs

Fast-charging and battery swapping aren't long term solutions

EVs still aren't good enough, and tech innovation is still important

Self-driving cars enable new business models that threaten car ownership



2018 luxexecutivesummit

Boston • April 9-11

Thank you for joining us.





Chris Robinson

857-284-5684

christopher.robinson@luxresearchinc.com

www.luxresearchinc.com
info@luxresearchinc.com

@LuxResearch  

Lux Research, Inc. 

Lux Research 

Blog + Free Webinars
Lux Spotlight

Podcast
Lux Research, Inc. on
Soundcloud or iTunes