The End of Traffic and the Future of Access

David Levinson
University of Sydney
Transport Lab

http://www.johomaps.com/oc/australia/nsw/sydney/atlas/g_sydney_n.html

In most industrialized countries, car travel per person has peaked and the automobile regime is showing considerable signs of instability. As cities across the globe venture to find the best ways to allow people to get around amidst technological and other changes, many forces are taking hold — all of which suggest a new transport landscape. Our roadmap describes why this landscape is taking shape and prescribes policies informed by contextual awareness, clear thinking, and flexibility.

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Future of Access

A Roadmap to the New Transport Landscape

David M. Levinson ◆ Kevin J. Krizek

Transport in Flux

Transport is changing rapidly

“Triple Convergence”

Electrification

Automation

Sharing

Implications

Electrification

Automation

Sharing

→

Demassification

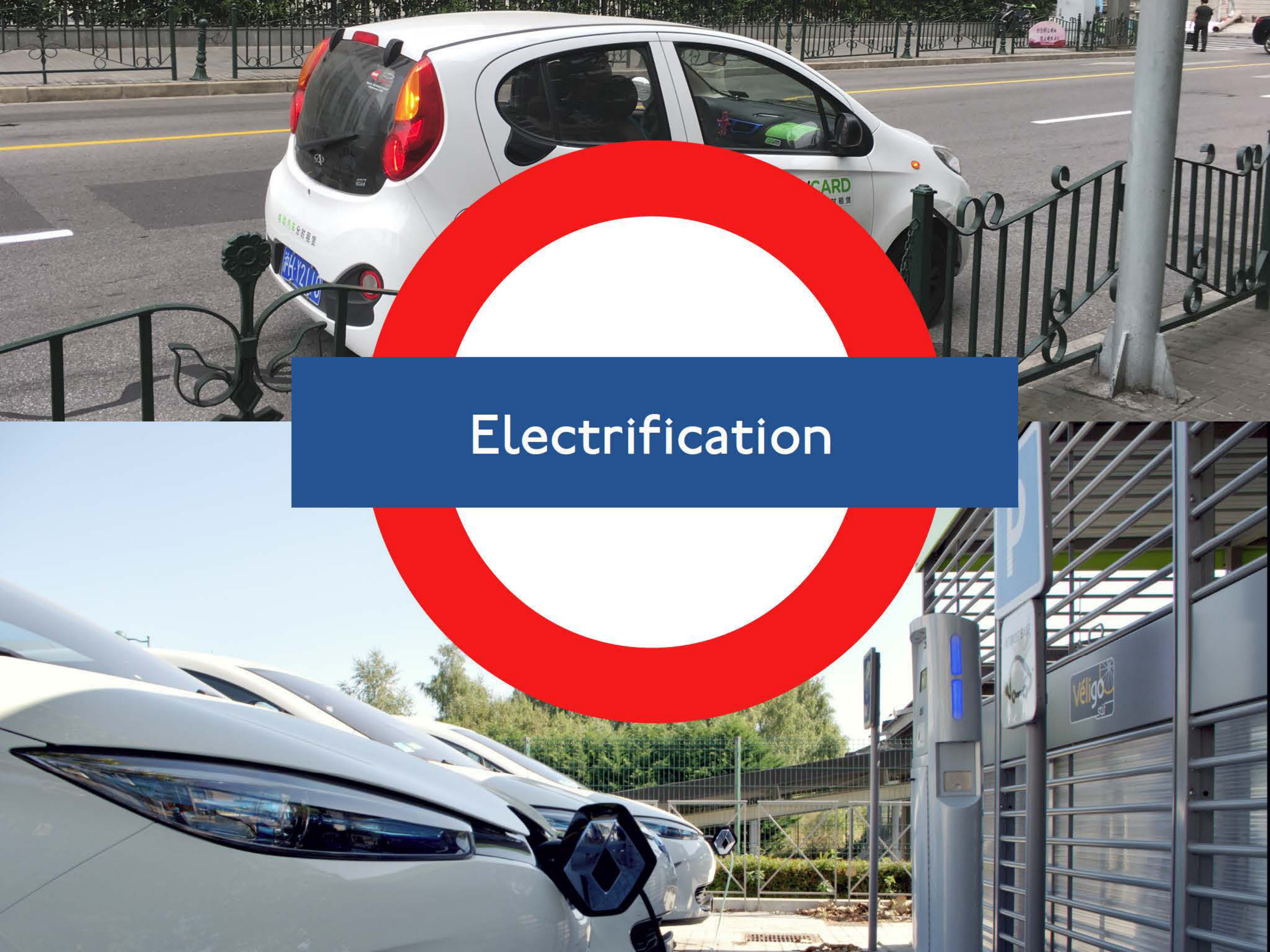
Delivery

Road Allocation

Land Use

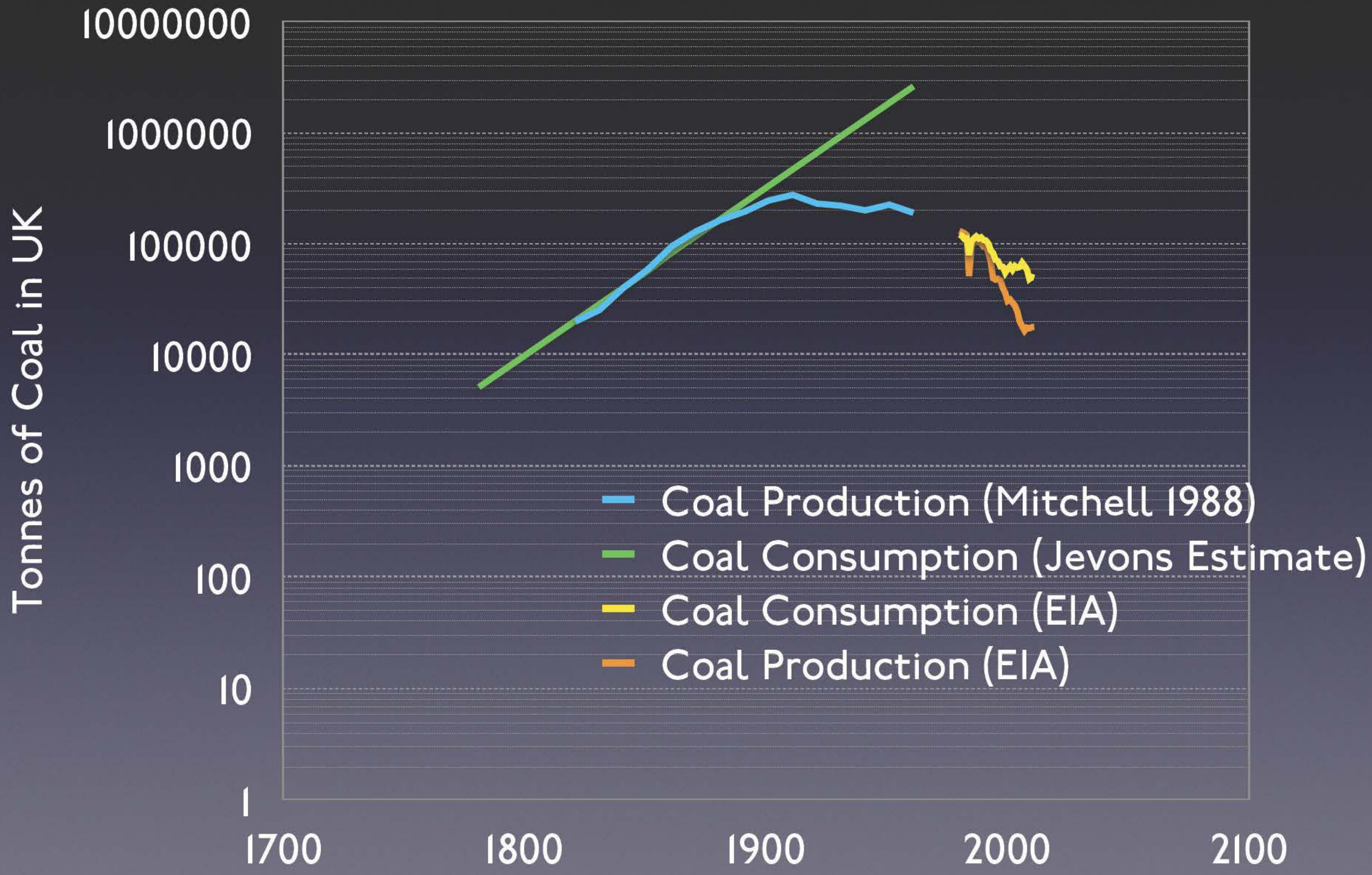
Pricing

Electrification

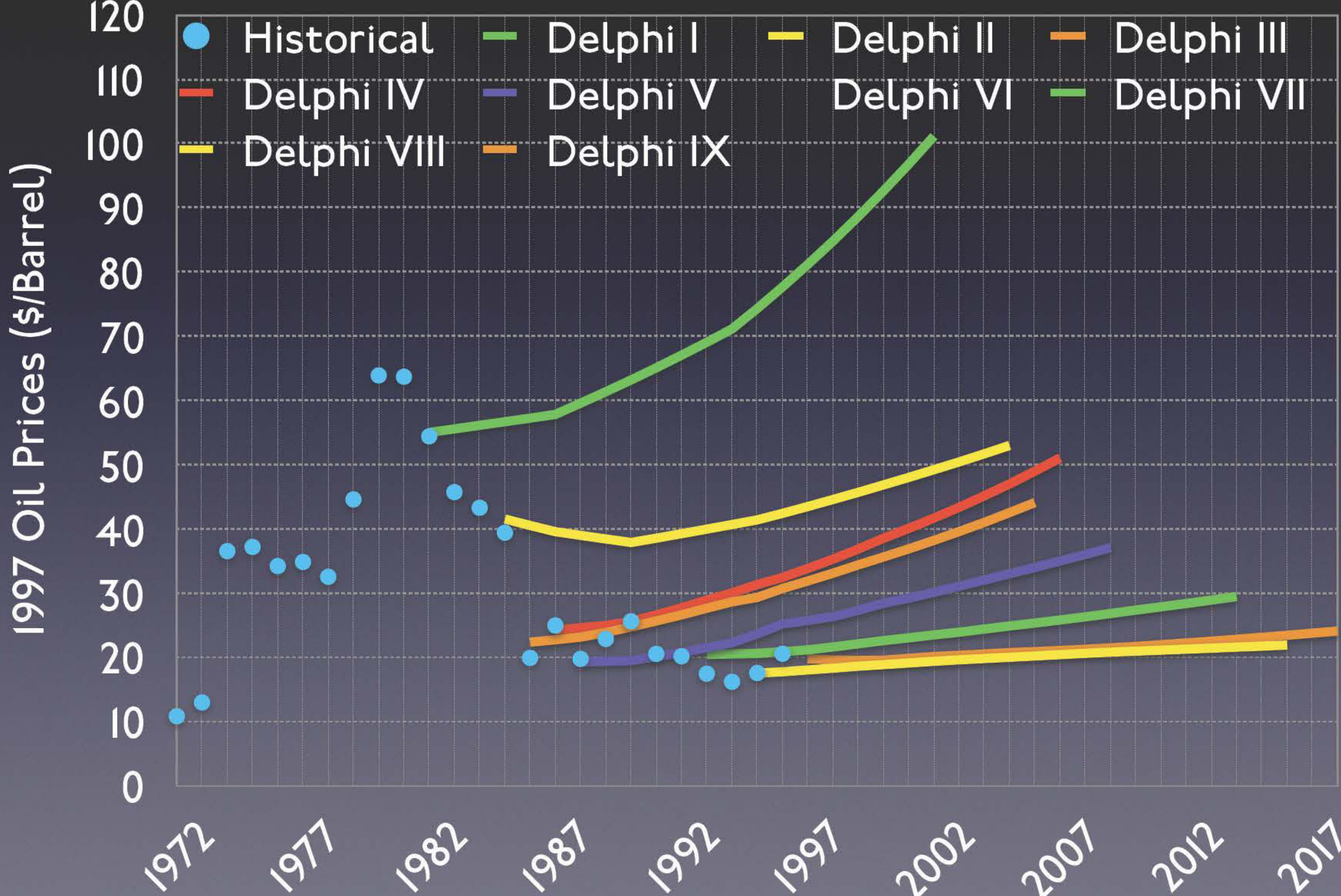


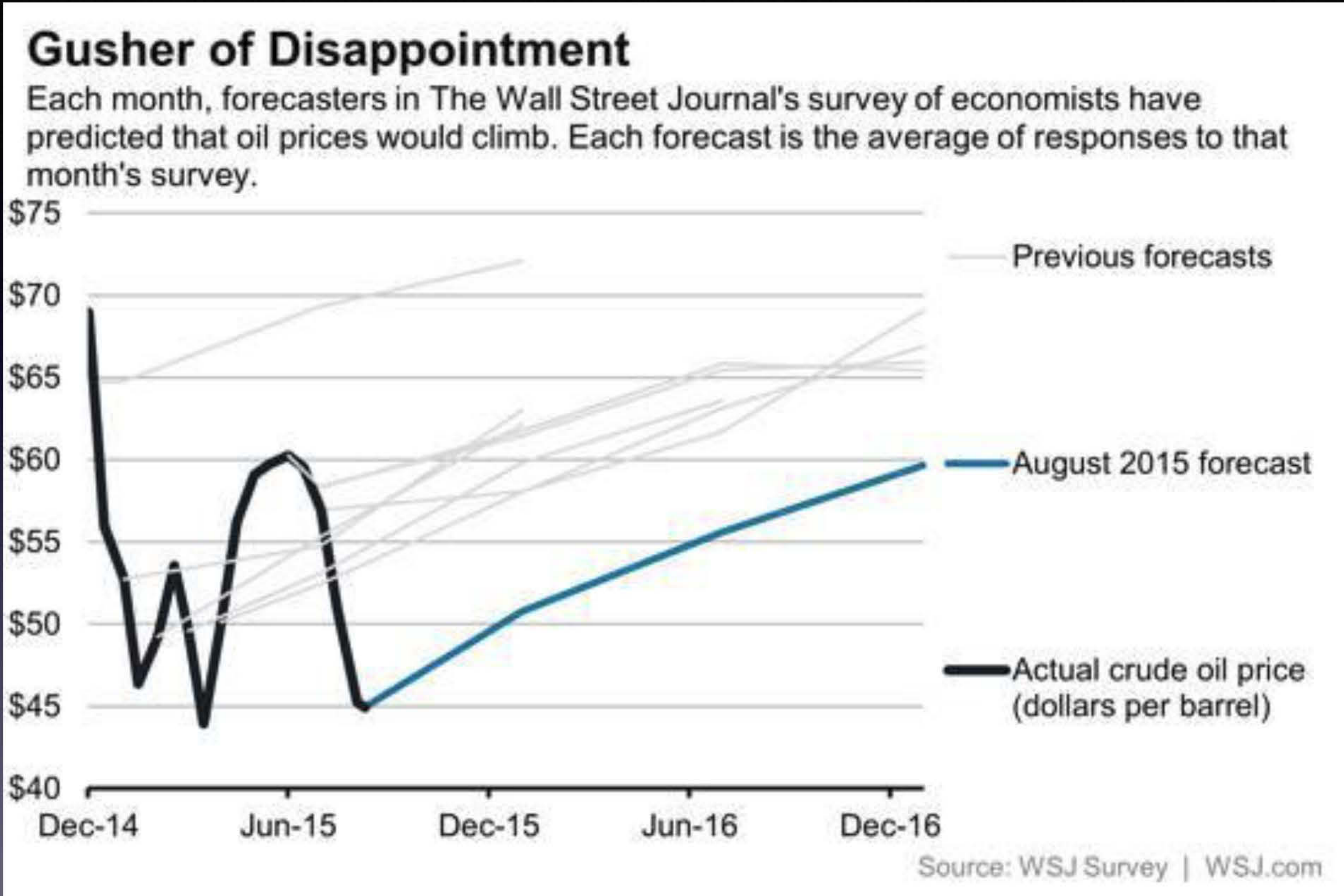
Energy Forecasts

UK (Jevons prediction vs. actual)

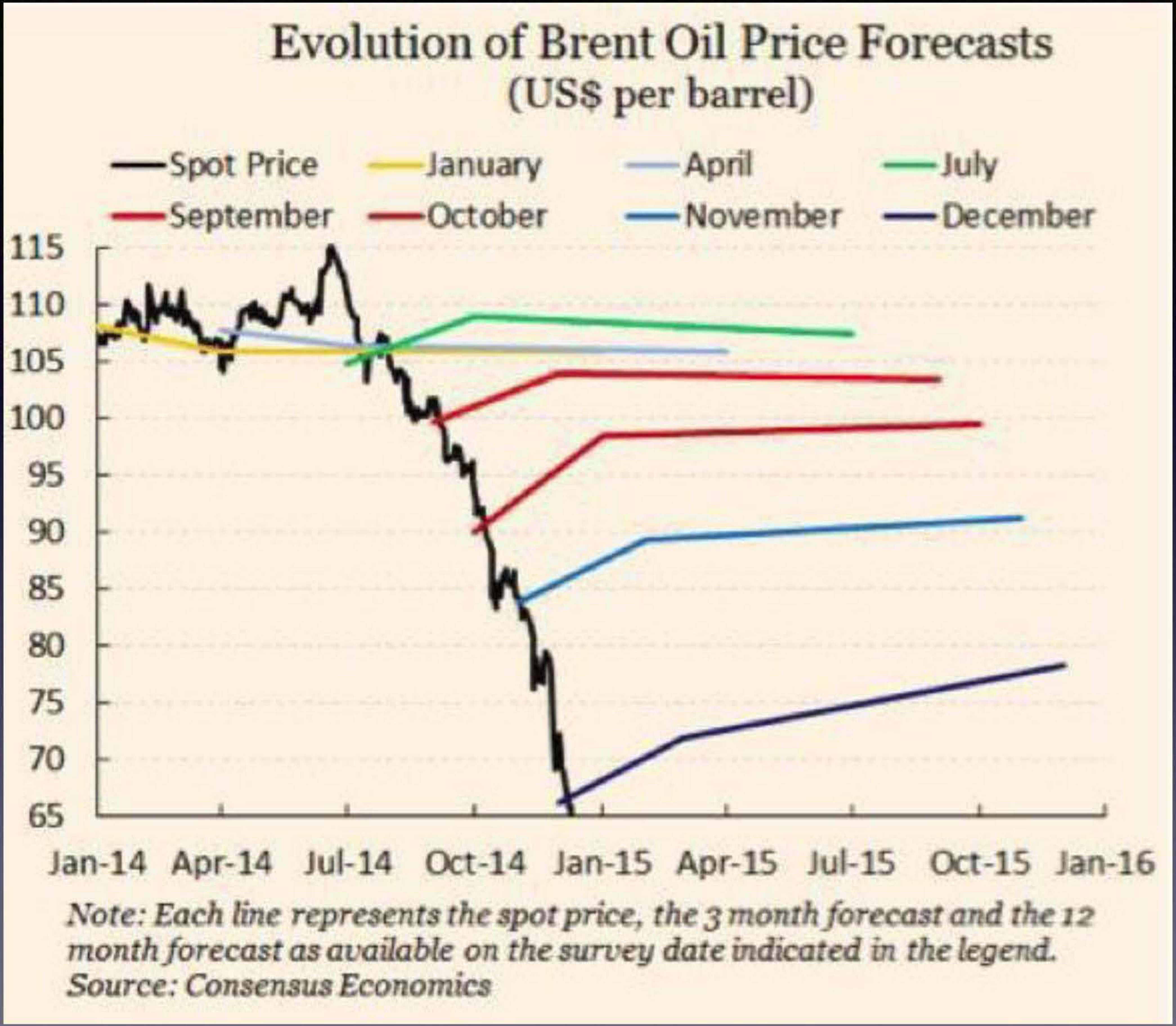


Comparison of Historical Oil Prices and Delphi Forecasts

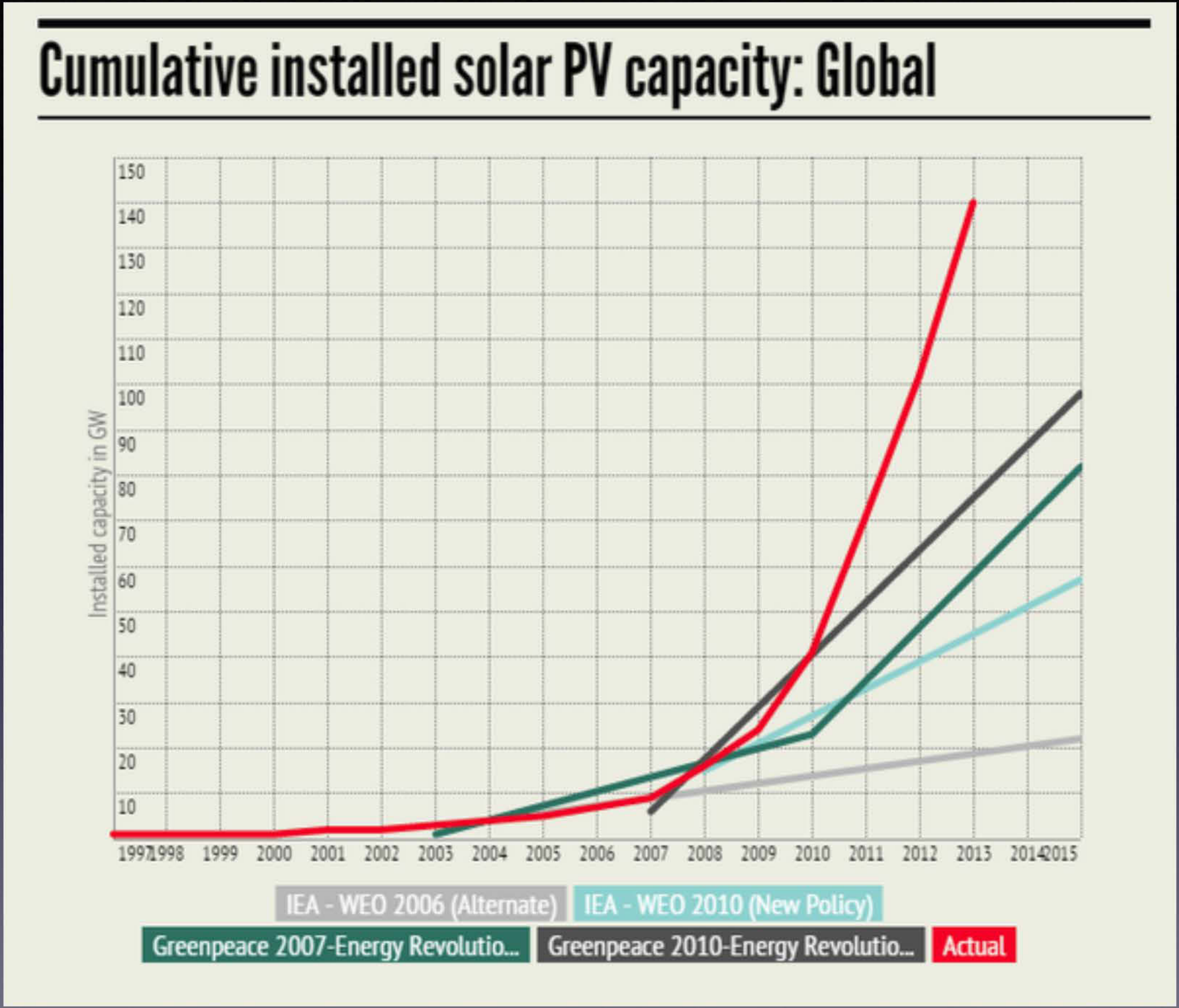




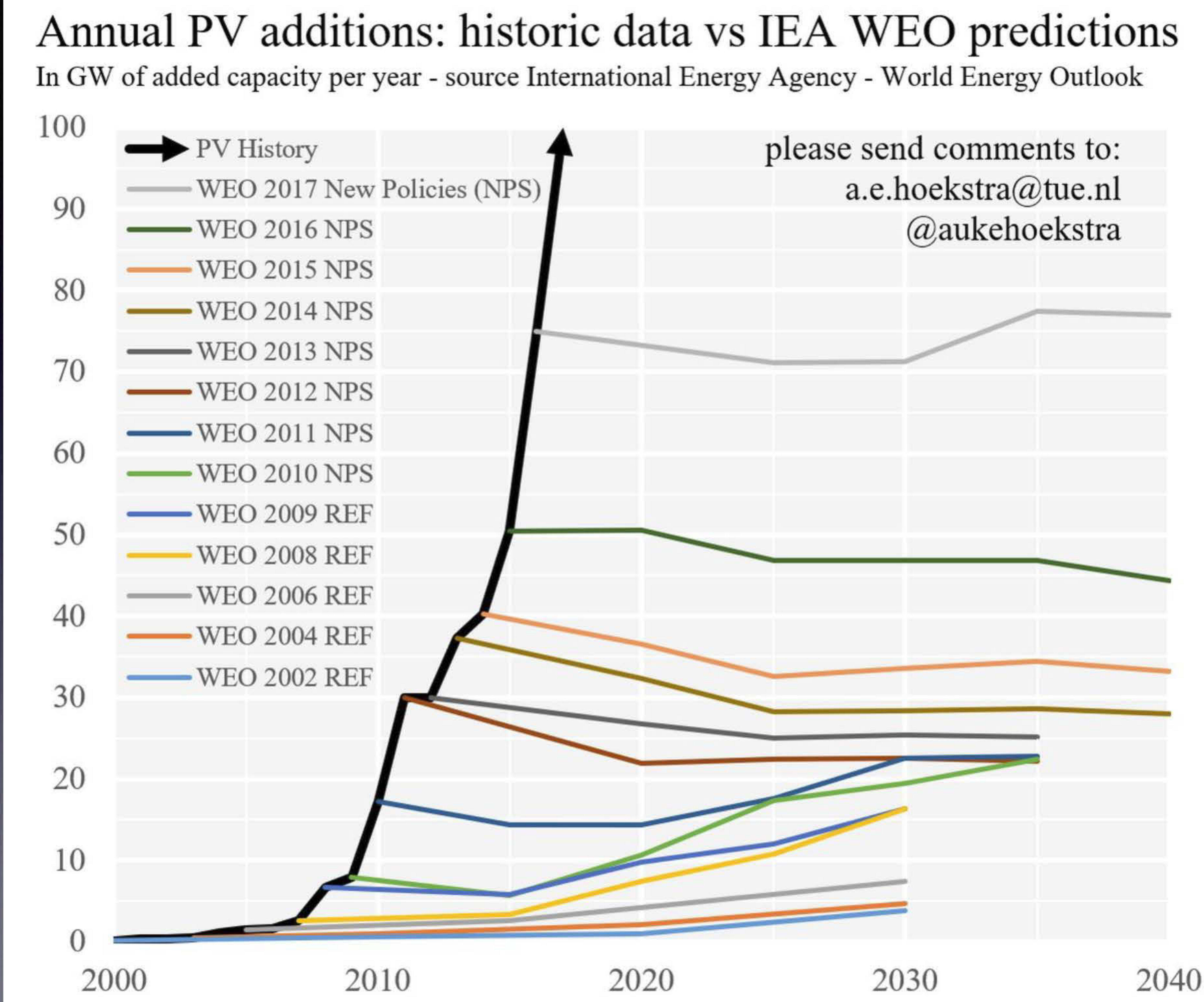
Gusher of Disappointment : Each month forecasters in the Wall Street Journal's survey of economists have predicted that oil prices would climb. Each forecast is the average of responses to that month's survey.



Evolution of Brent Oil Forecasts: Source:



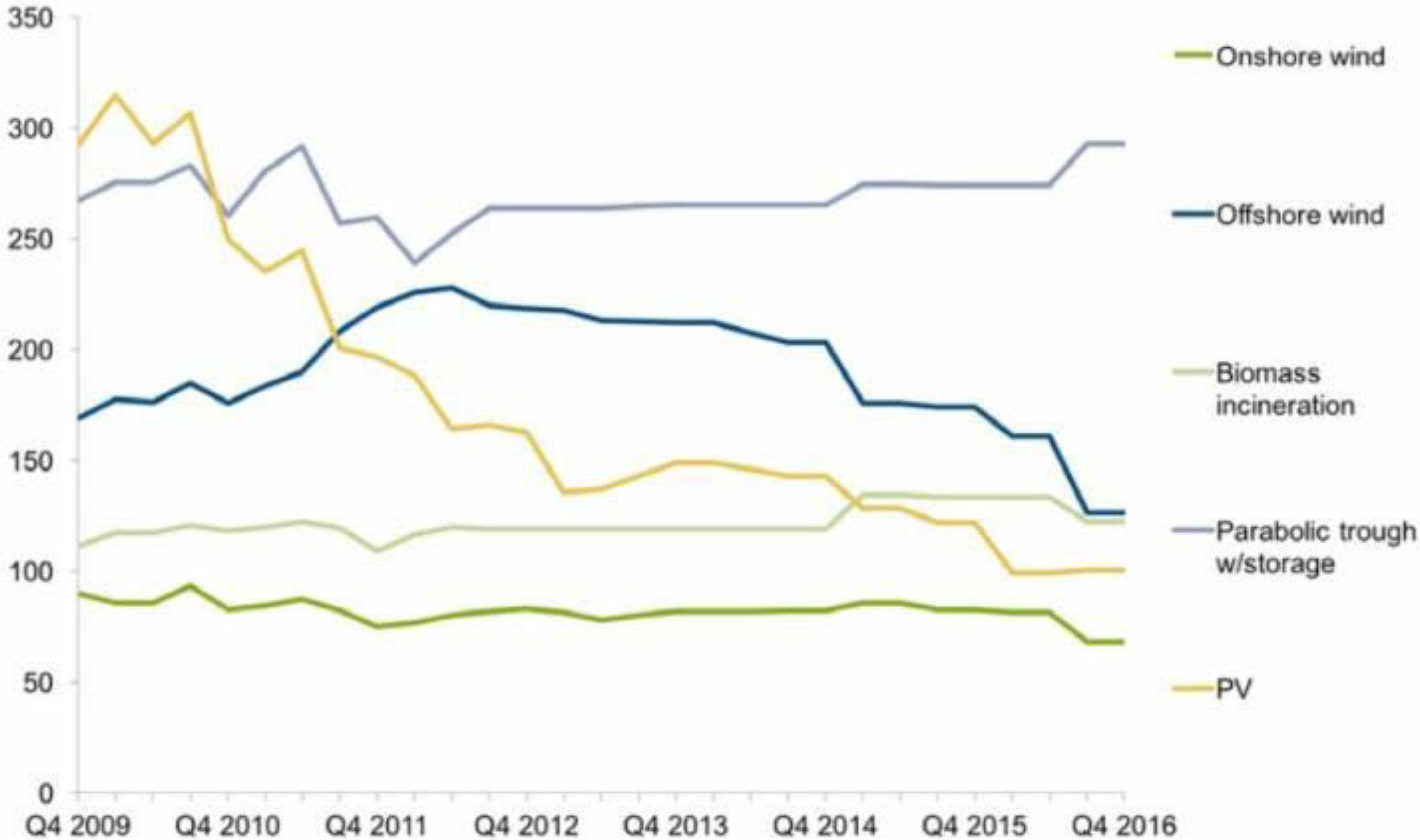
"The energy world is undergoing massive transformation. Installations of renewable energy have skyrocketed around the world, exceeding most predictions from less than a decade ago. " Source:



Annual PV additions: historic data vs IEA WEO predictions
In GW of added capacity per year - source International Energy Agency - World Energy Outlook
100
90
80
70
60
50
40
30
20
10
0
PV History
WEO 2017 New Policies (NPS)
WEO 2016 NPS
WEO 2015 NPS
WEO 2014 NPS
WEO 2013 NPS
WEO 2012 NPS
WEO 2011 NPS
WEO 2010 NPS
WEO 2009 REF
WEO 2008 REF
WEO 2006 REF
WEO 2004 REF
WEO 2002 REF
please send comments to:
a.e.hoekstra@tue.nl
@aukehoekstra
2000
2010
2020
2030
2040

Renewables

FIGURE 9. LEVELISED COST OF ELECTRICITY FROM SELECTED RENEWABLE ENERGY SOURCES, Q3 2009 TO H2 2016, $ PER MWH



Solar thermal is parabolic trough with storage, PV is crystalline silicon with no tracking

Source: Bloomberg New Energy financea

https://c1cleantechnicacom-wpengine.netdna-ssl.com/files/2017/04/UNEP-4.jpg

Summary Findings of Lazard's 2017 Levelized Cost of Energy Analysis[1]

Selected Historical Mean LCOE Values[2]

Source: Lazard estimates.

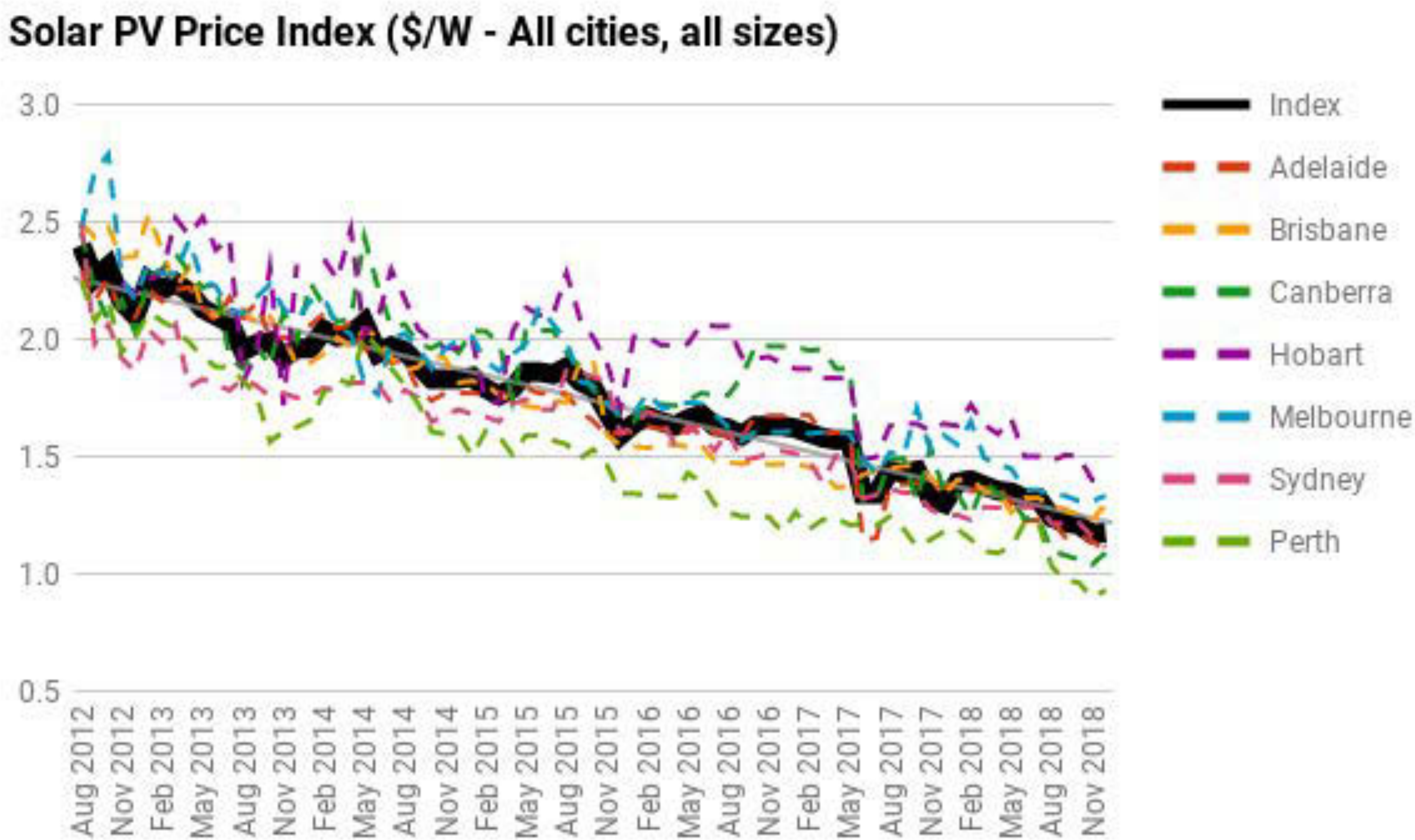
Note: Reflects average of unsubsidized high and low LCOE range for given version of LCOE study.

(1) Primarily relates to North American alternative energy landscape, but reflects broader/global cost declines.

(2) Reflects total decrease in mean LCOE since the later of Lazard's LCOE—Version 3.0 or the first year Lazard has tracked the relevant technology.

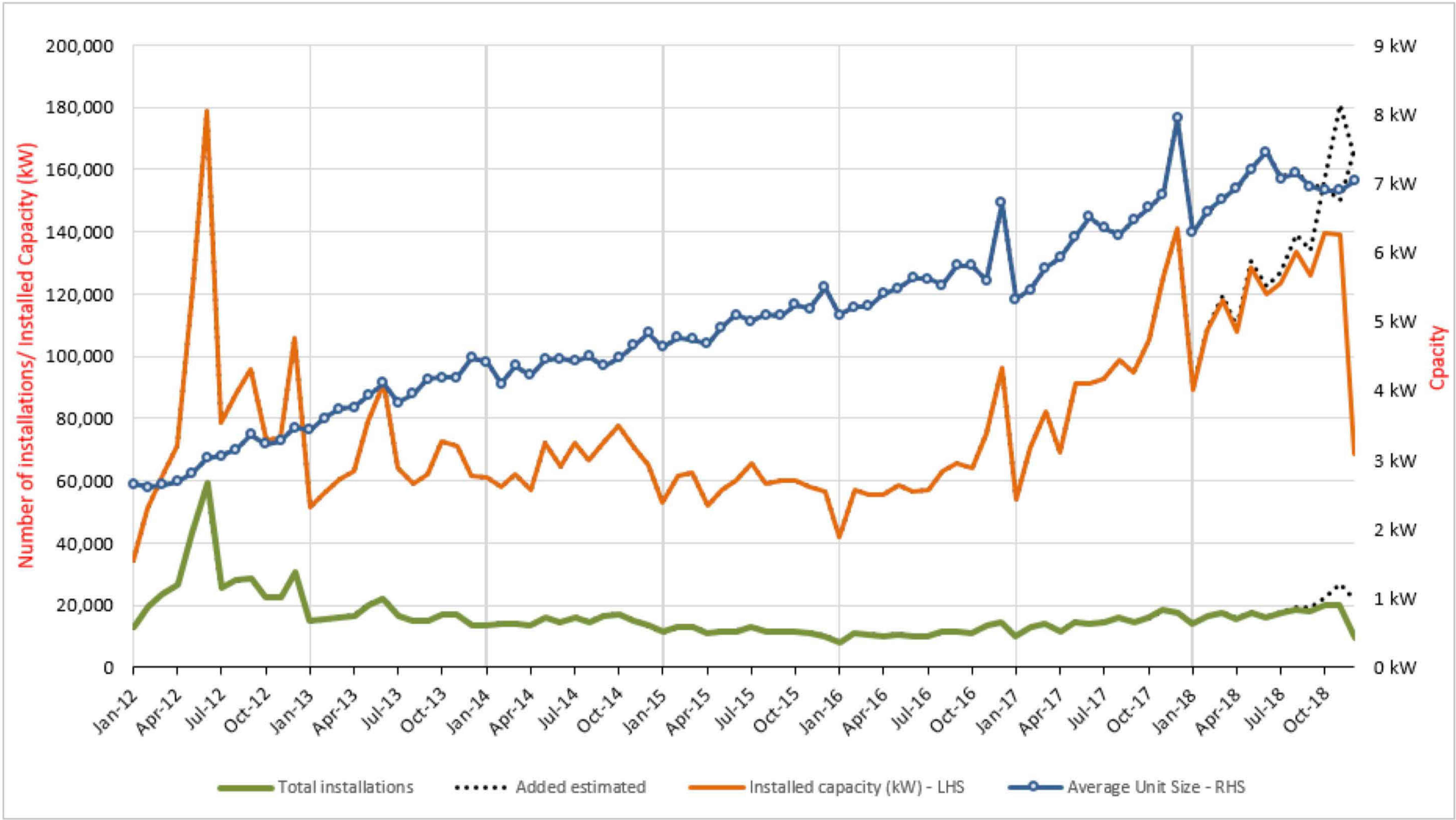
(3) Reflects mean of fixed-tilt (high end) and single-axis tracking (low end) crystalline PV installations.

https://www.lazard.com/perspective/levelized-cost-of-energy-2017/



https://www.solarchoice.net.au/blog/is-home-solar-power-still-worth-it-in-australia-in-2019/

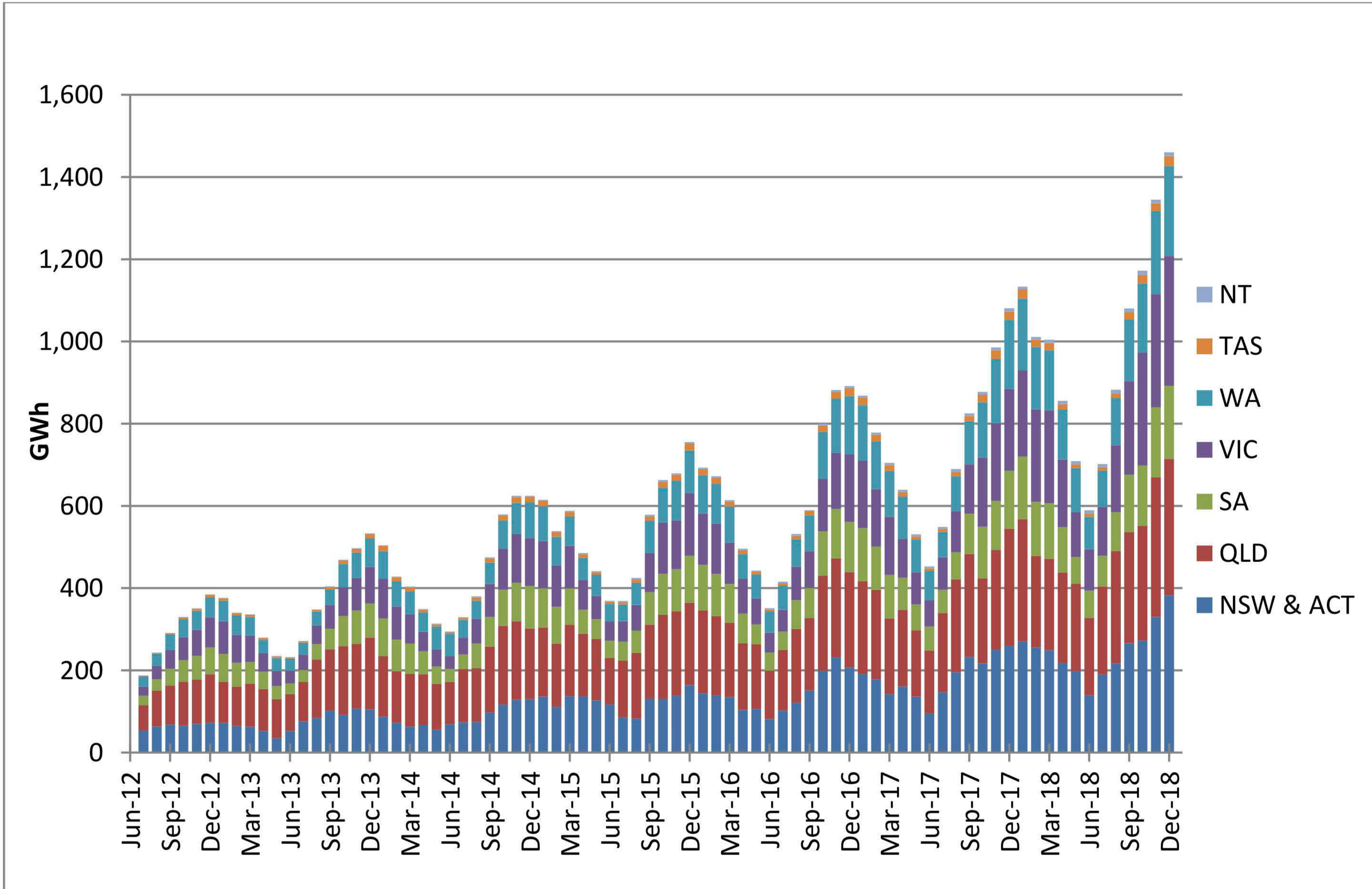
Figure 2: Monthly installations, installed solar PV capacity and average system size Jan 2012 – 2018



Source: Clean Energy Regulator (adjusted data), Australian Energy Council analysis, January 2019

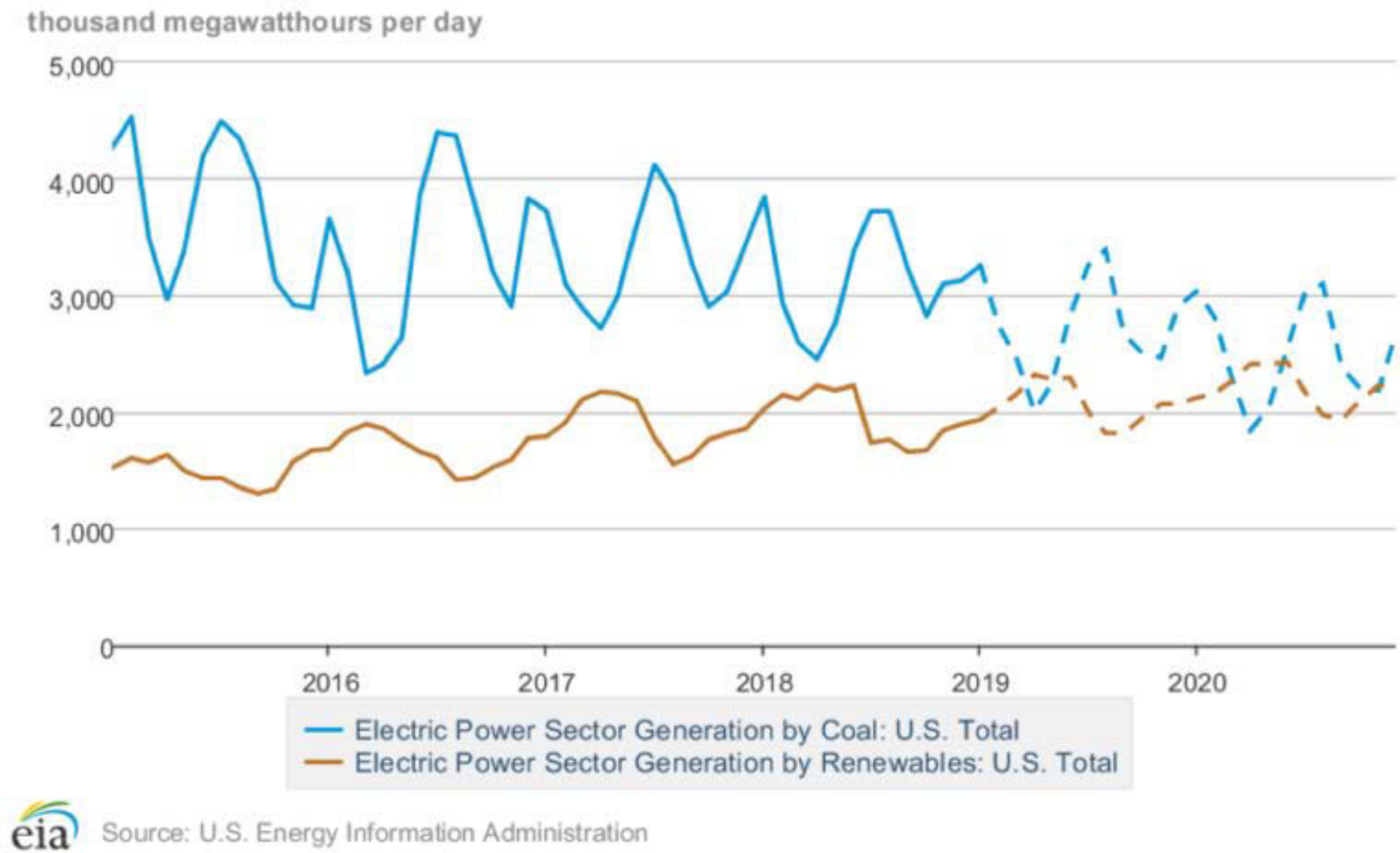
https://www.energycouncil.com.au/media/15358/australian-energy-council-solar-report_-january-2019.pdf

Figure 7: Estimated residential PV generation (GWh)



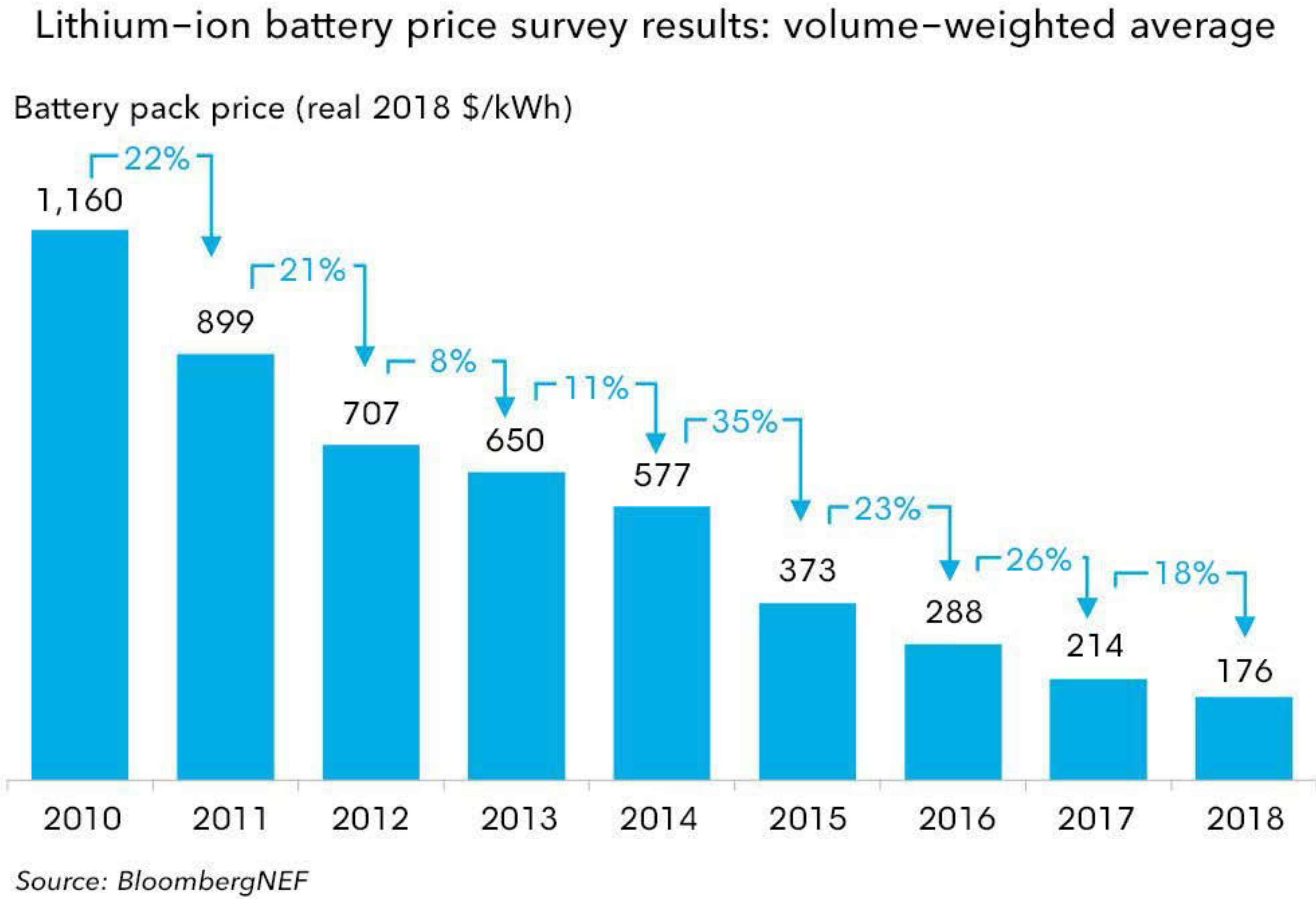
Source: Australian Energy Council analysis, January 2019

https://www.energycouncil.com.au/media/15358/australian-energy-council-solar-report_-january-2019.pdf

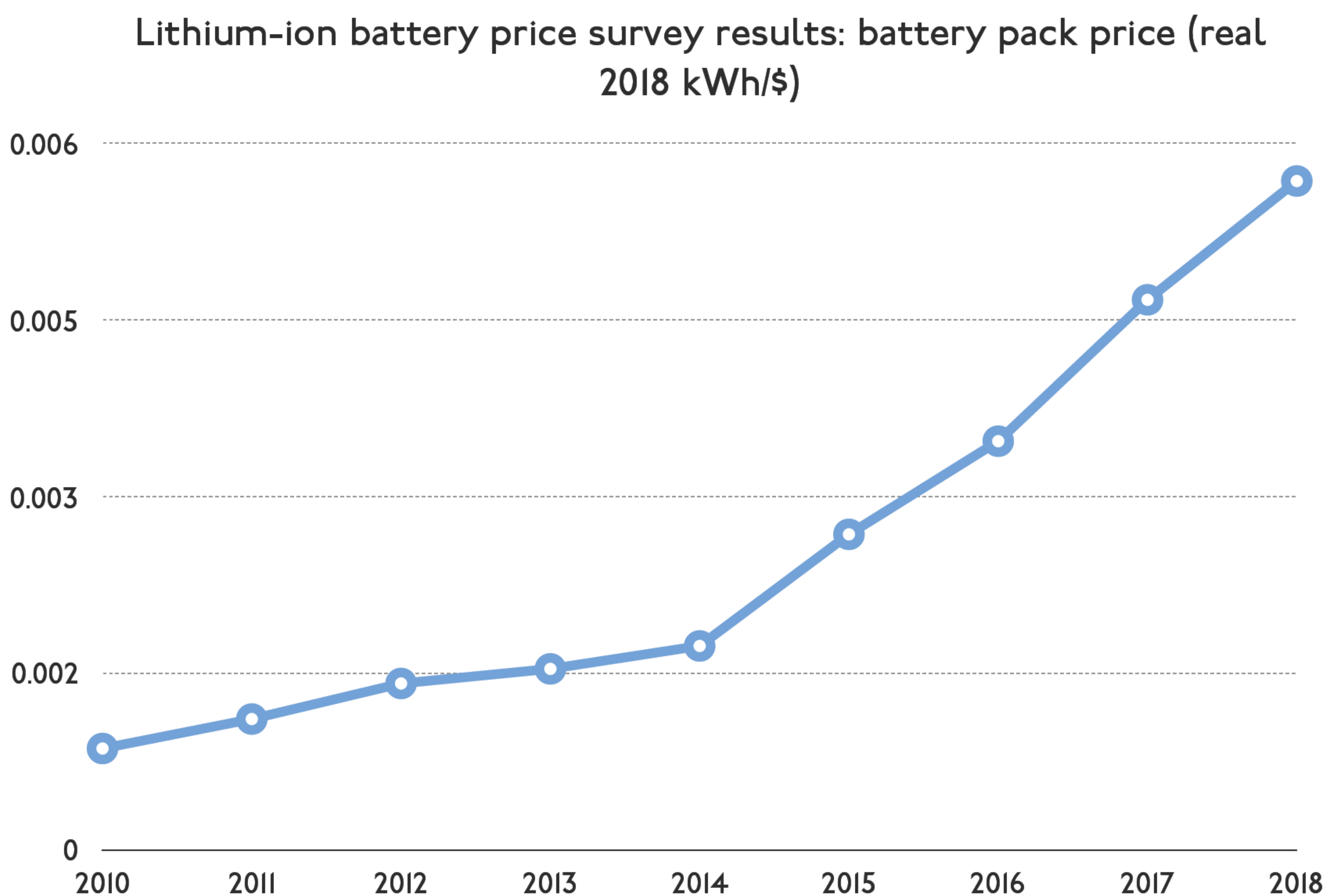


https://www.utilitydive.com/news/eia-renewables-to-top-coal-generation-for-first-time-in-aprilmay/553734/


-
Batteries
+



https://www.livewiremarkets.com/wires/part-I-ev-battery-price-falls-expect-pace-to-slow



Reciprocal of Data on Previous Slide

Constraints on further battery cost drops

1. “The raw material cost component now makes up 70% of the cost of battery cells, leaving less remaining room for cost reductions. …

2. The vast majority of the battery cost reductions have come from producing batteries in greater volumes and achieving cost efficiencies from scale. …

3. In a bid to secure their position in a rapidly growing market, battery makers have discounted on pricing to lock in contracts with automakers in recent years. …”

— Clement Tseung, Investment Analyst, PM Capital

https://www.livewiremarkets.com/wires/part-1-ev-battery-price-falls-expect-pace-to-slow

BNEF forecasts lithium-ion battery pack prices will fall to as little as $73/kWh

- Intense price competition is leading manufacturers to develop new chemistries and improved processes to reduce production costs.
- Production costs have also come down significantly. Our models calculate that producing a battery in a Korean manufacturing plant in 2017 costs $162/kWh, dropping to $74/kWh in 2030.
- The BNEF battery price survey provides an annual industry average battery price for EVs and stationary storage. The learning rate (the price decrease for every doubling of capacity) is 19%.

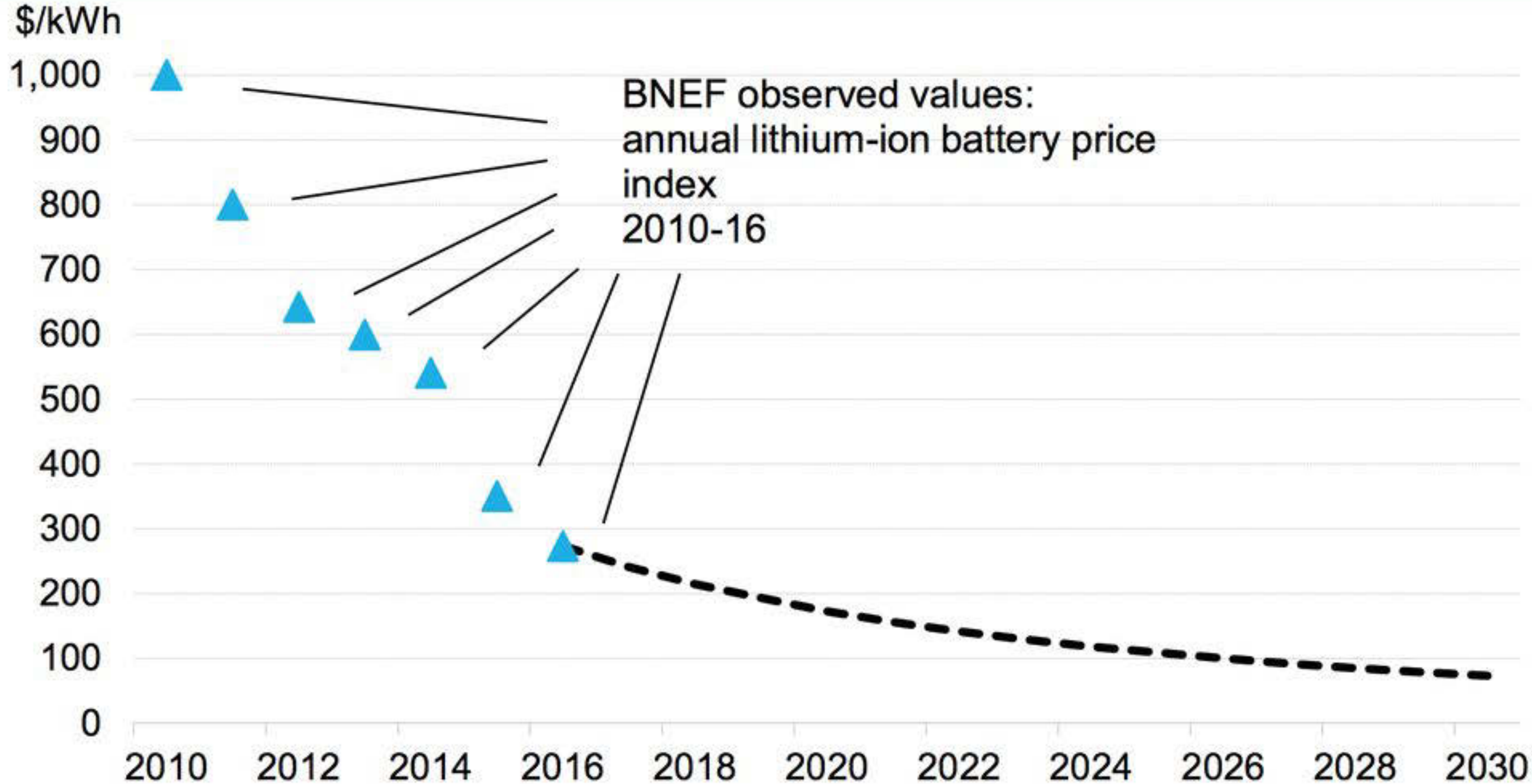
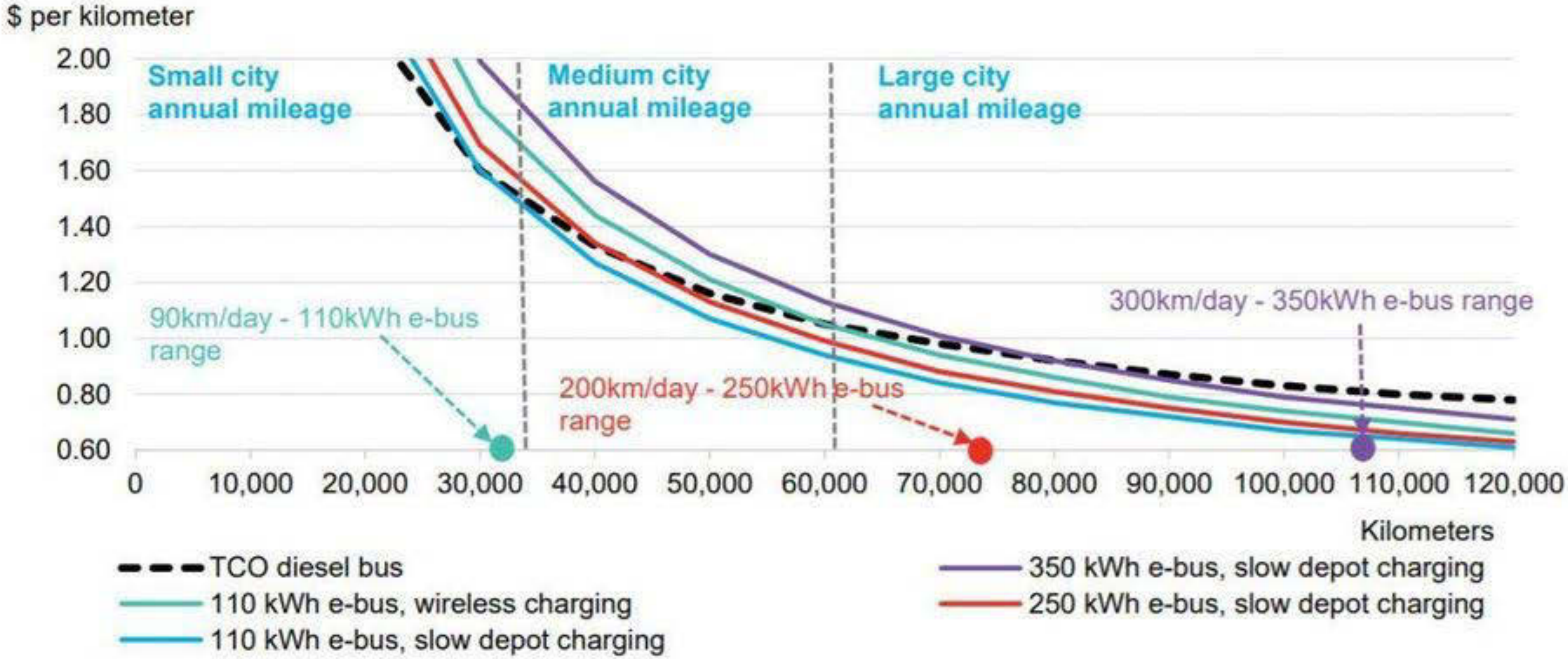


Figure 1: Total cost of bus ownership comparison with different annual distance



Source: Bloomberg New Energy Finance, AFLEET, Advanced Clean Transit Notes: Diesel price at $0.66/liter ($2.5/gallon), electricity price at $0.10/kWh, annual kilometers traveled – variable. Bus route length will not always correspond with city size.

Total cost of electric bus ownership comparison by annual distance BLOOMBERG NEW ENERGY FINANCE
https://www.forbes.com/sites/energyinnovation/2019/01/02/4-u-s-electric-vehicle-trends-to-watch-in-2019/#15d6dc4a5a3c

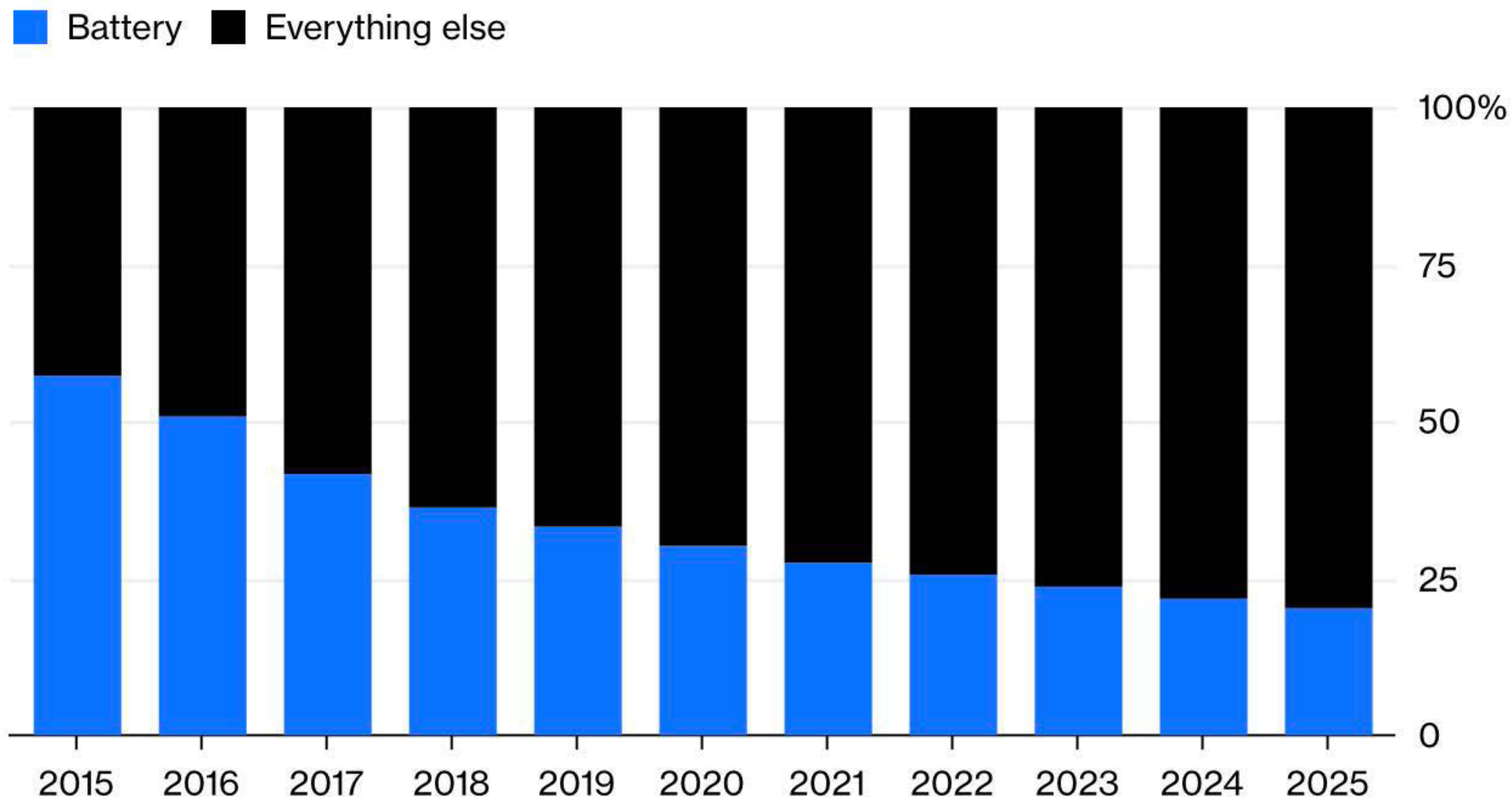
Crossover Point: ICE vs. EV

- "In 2017, a BloombergNEF analysis forecast that the crossover point was in 2026, nine years out.
- In 2018, the crossover point was in 2024 — six years (or, as I described it then, two lease cycles) out.
- The crossover point, per the latest analysis, is now 2022 for large vehicles in the European Union"

https://www.bloomberg.com/opinion/articles/2019-04-12/electric-vehicle-battery-shrinks-and-so-does-the-total-cost

The Incredible Shrinking Car Battery

EV battery cost for U.S. medium-size car as a percentage of retail price

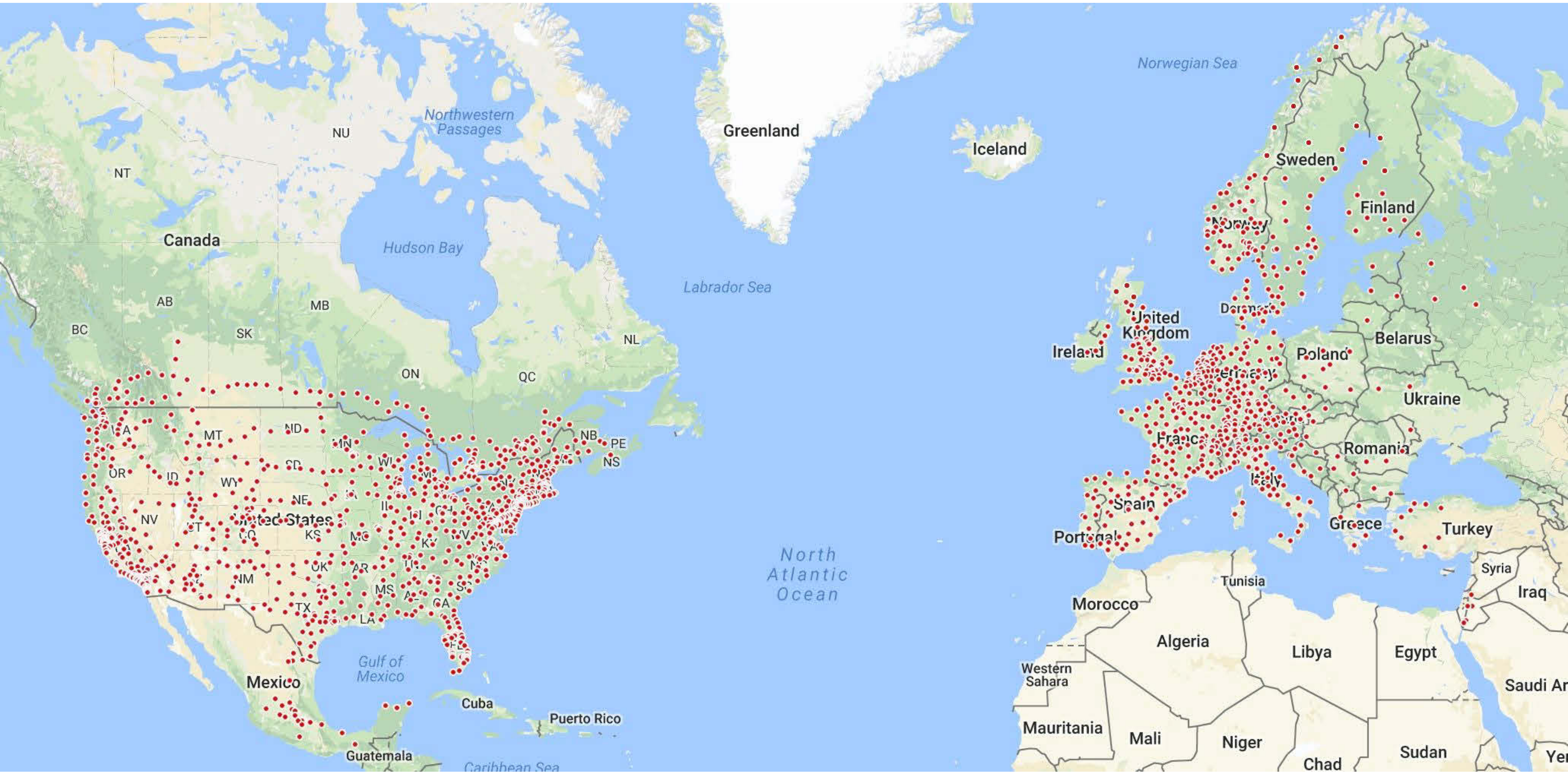


Source: BloombergNEF
Note: Includes profit margins and costs other than direct manufacturing costs.

https://www.bloomberg.com/opinion/articles/2019-04-12/electric-vehicle-battery-shrinks-and-so-does-the-total-cost

Charging

Tesla Superchargers



Superchargers Network Red . Source: Tesla

https://www.tesla.com/findus?v=2&bounds=77.90599658148808%2C133.20410037499994%2C-69.48915668108621%2C-88.98339962500006&zoom=3&filters=destination%20charger%2Csupercharger

AUSTRALIA SUPERCHARGER NETWORK

2016 ROADMAP

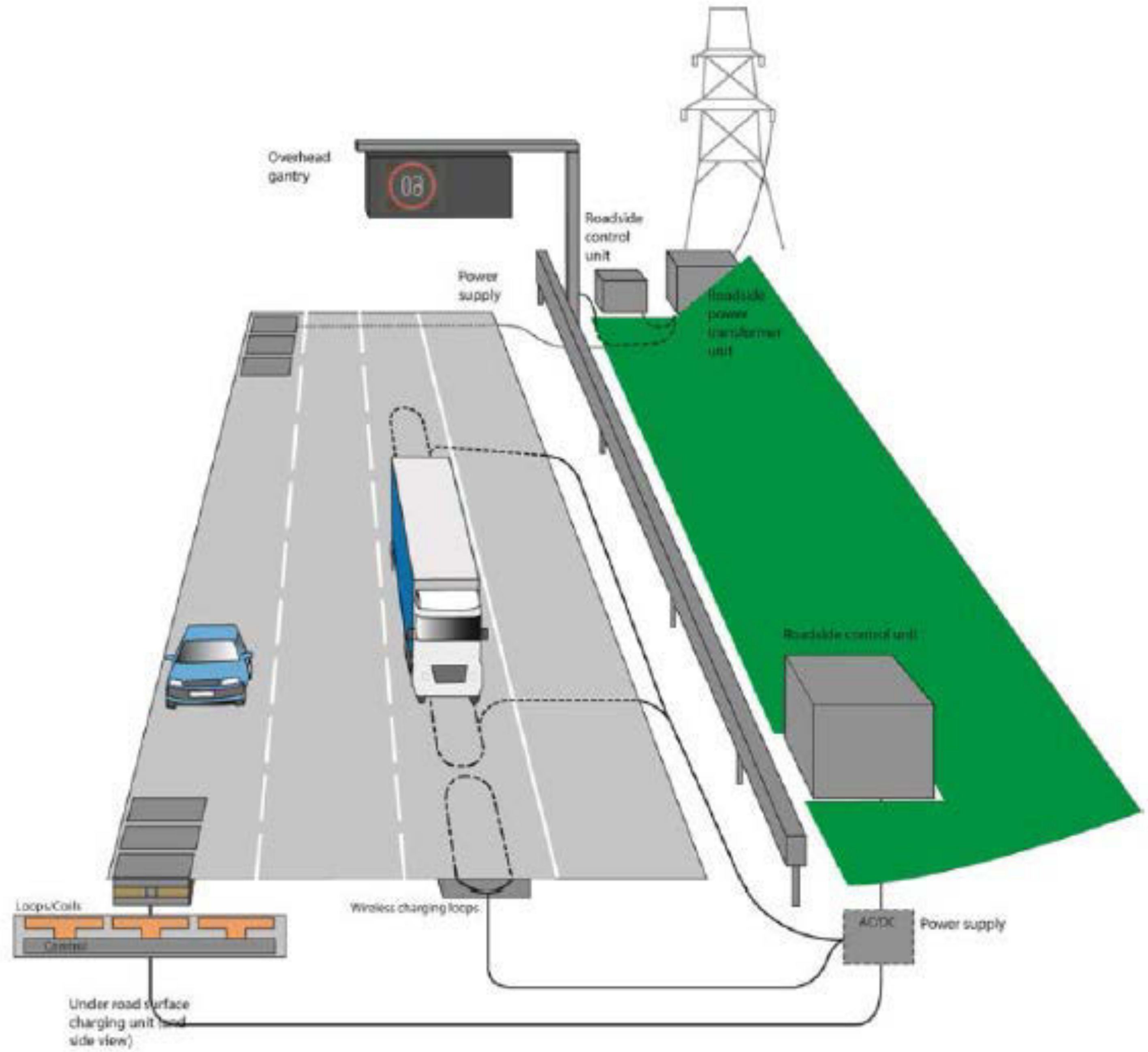
Supercharger Map – Installed (Red) and Planned to Q3 2019 (Grey). Source: Tesla

https://reneweconomy.com.au/tesla-plans-18-new-ev-supercharger-stations-australia-major-global-roll-93768/

https://reneweconomy.com.au/tesla-plans-18-new-ev-supercharger-stations-australia-major-global-roll-93768/

Full Charging Network – 500+ Destination Chargers (Dark Grey). Source: Tesla

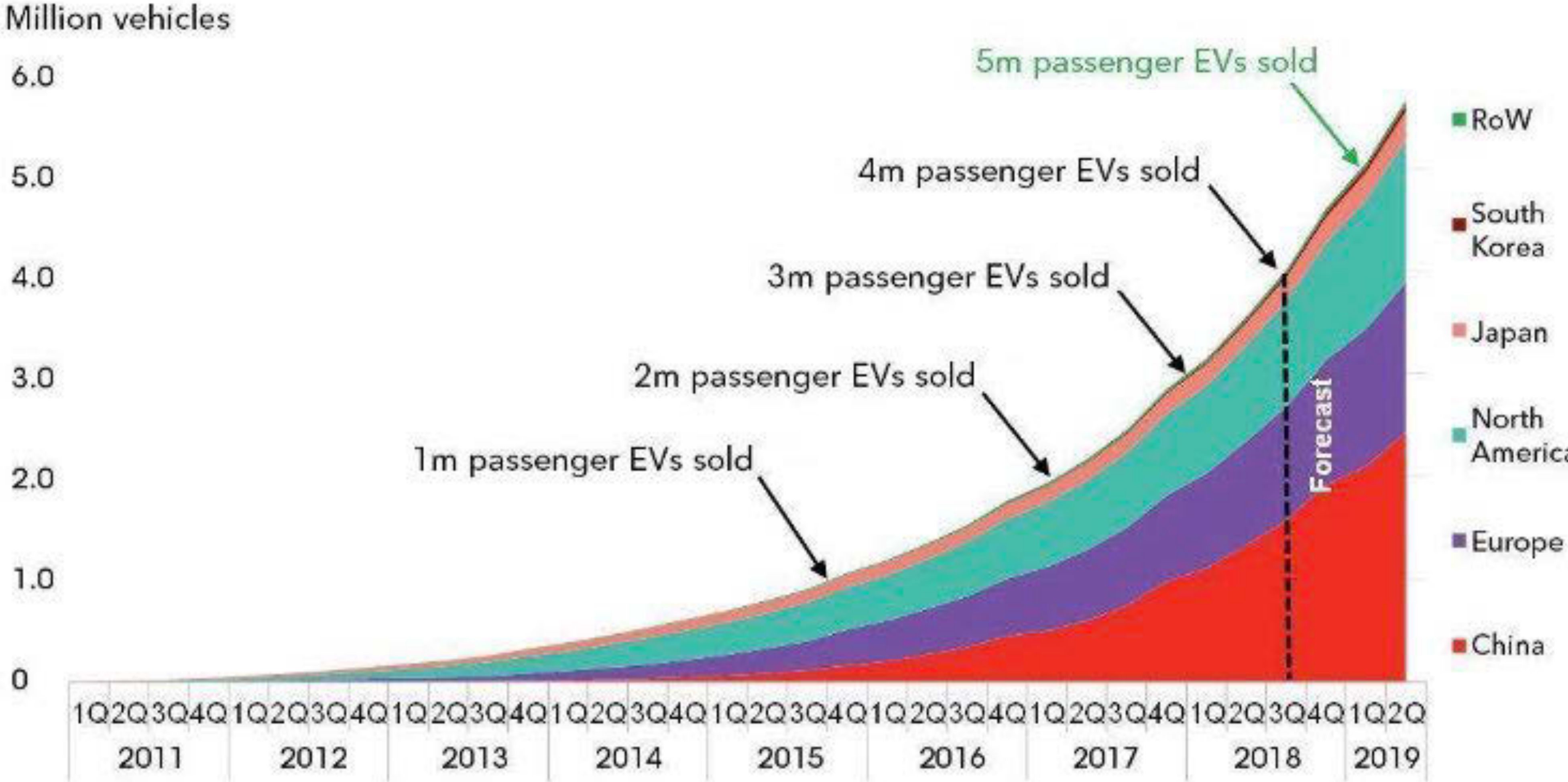
Dynamic Wireless Power Transfer



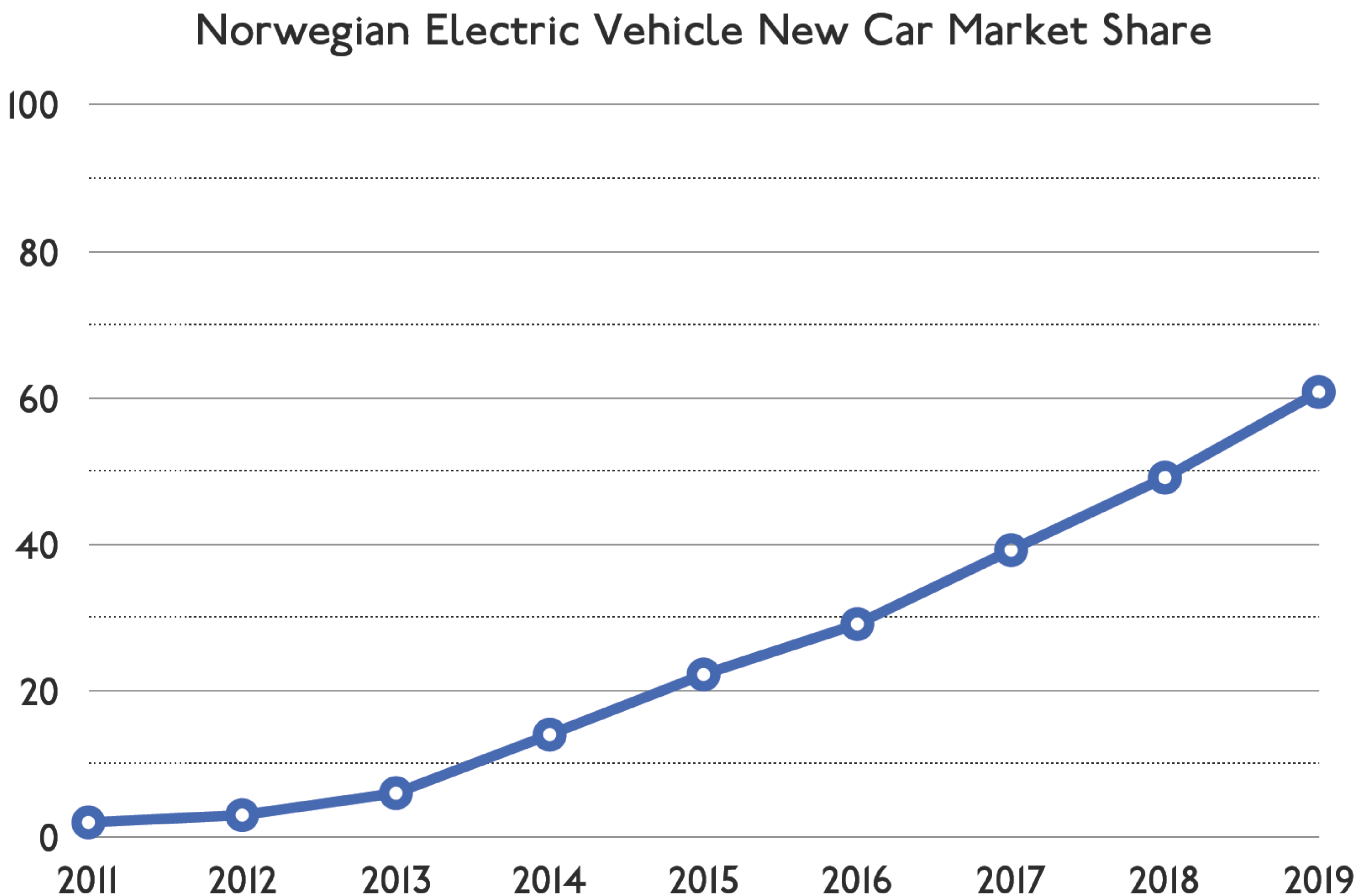
Transport Research Laboratory, 2015. Feasibility Study: Powering Electric Vehicles on England's Major Roads.

EV Sales

Figure 3: Cumulative global passenger EV sales, current and forecast



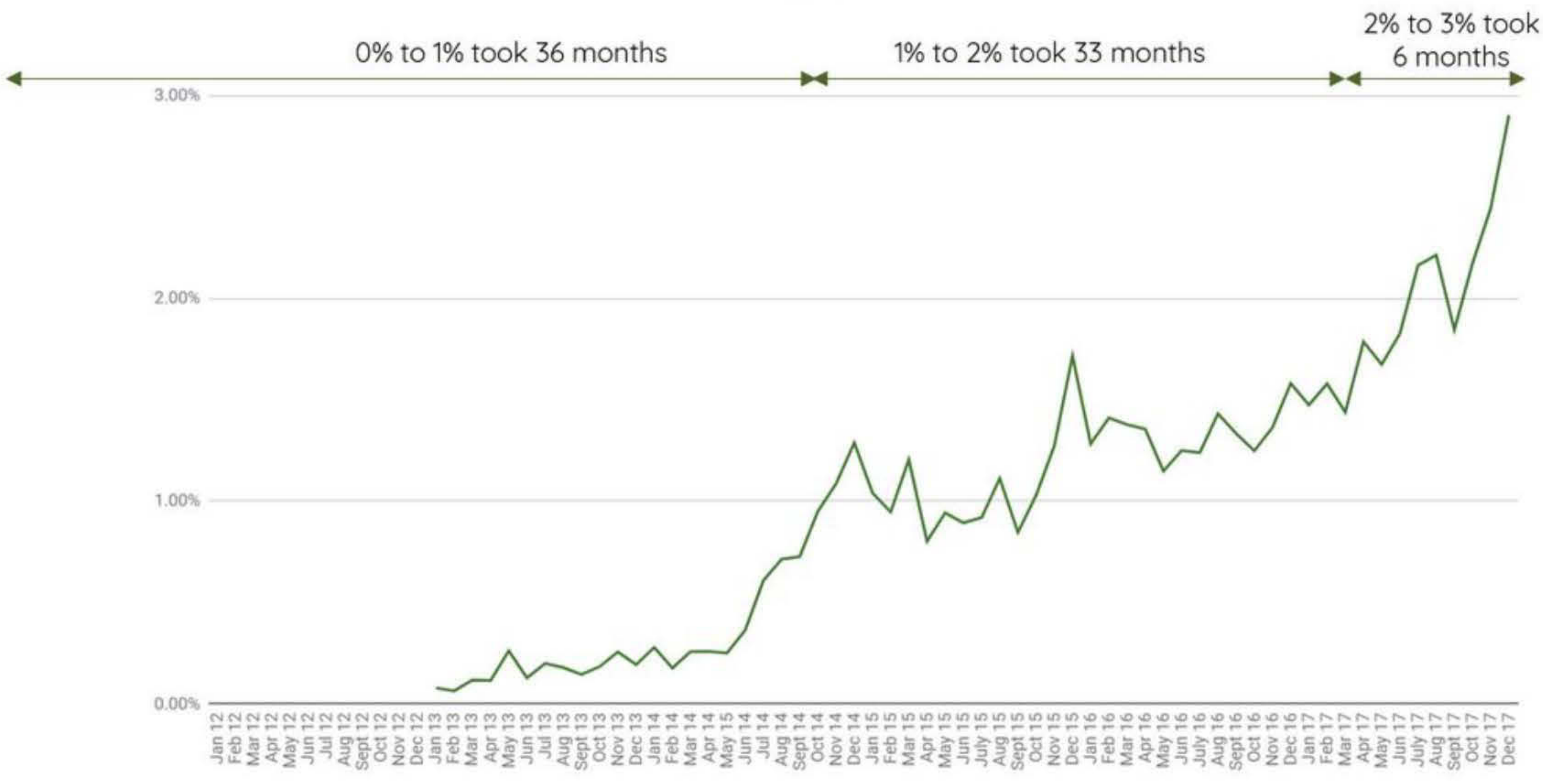
Source: Bloomberg NEF



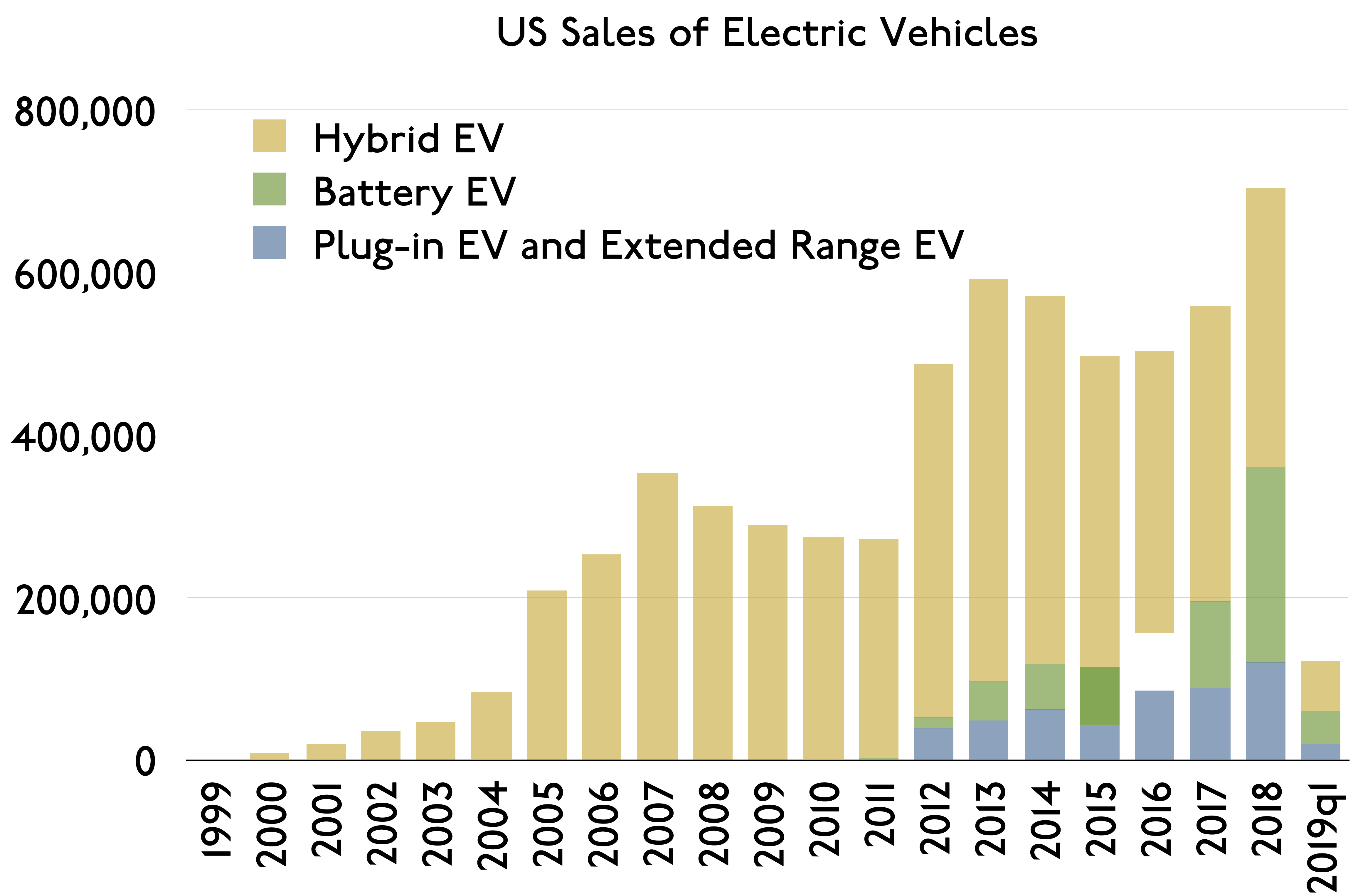
Norwegian Electric Vehicle Association,

Source: https://en.wikipedia.org/wiki/Plug-in_electric_vehicles_in_Norway
New York Times http://www.nytimes.com/2015/10/17/business/international/norway-is-global-model-for-encouraging-sales-of-electric-cars.html

UK Plug In Vehicles Sales % of New Vehicle Sales



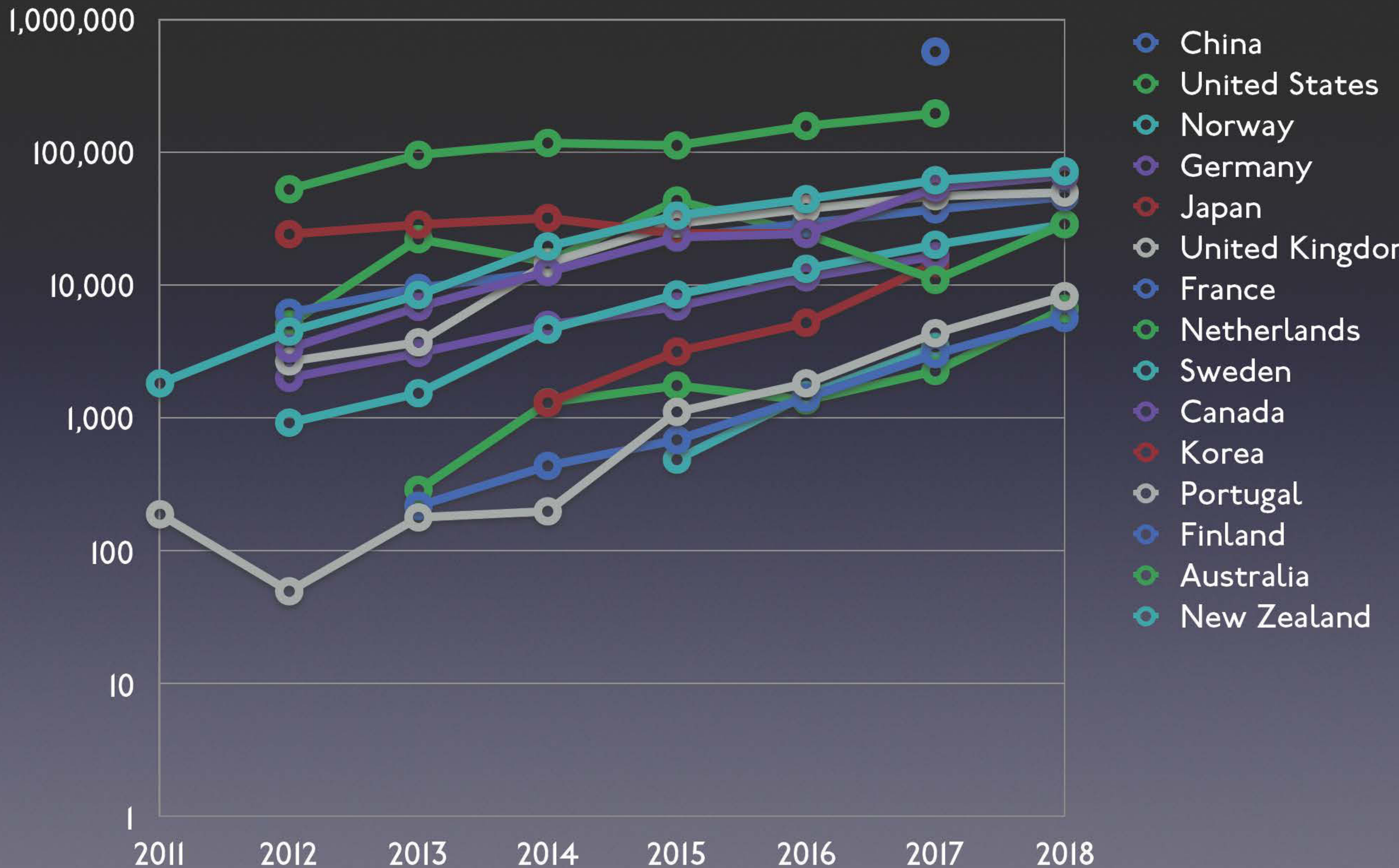
Source: https://www.smmt.co.uk/category/registrations/evs-afvs/
Assumes: 0% Jan 2011 - there were just a few G-Wizz around then ;-)



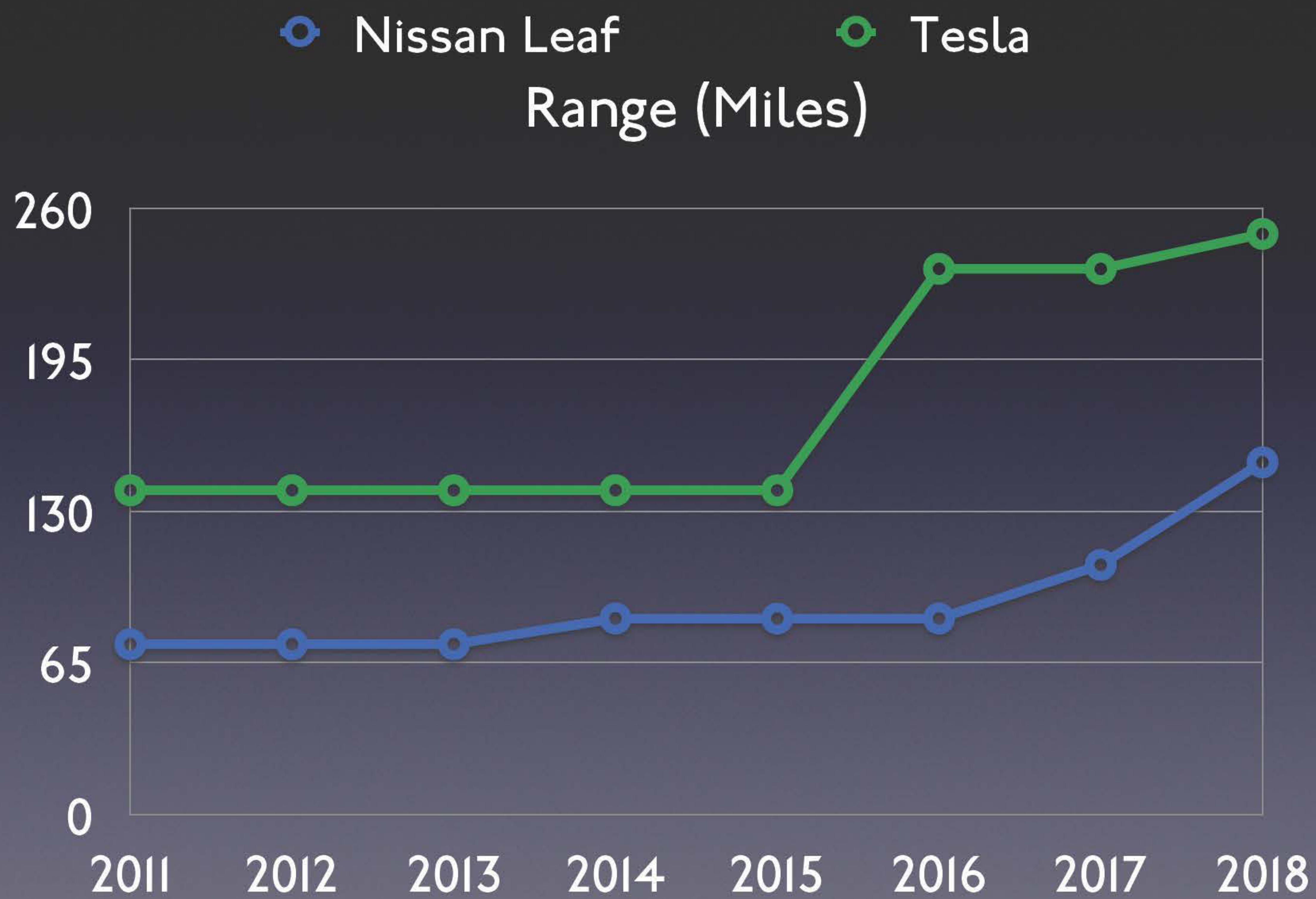
Source: Electric Drive Transportation Association

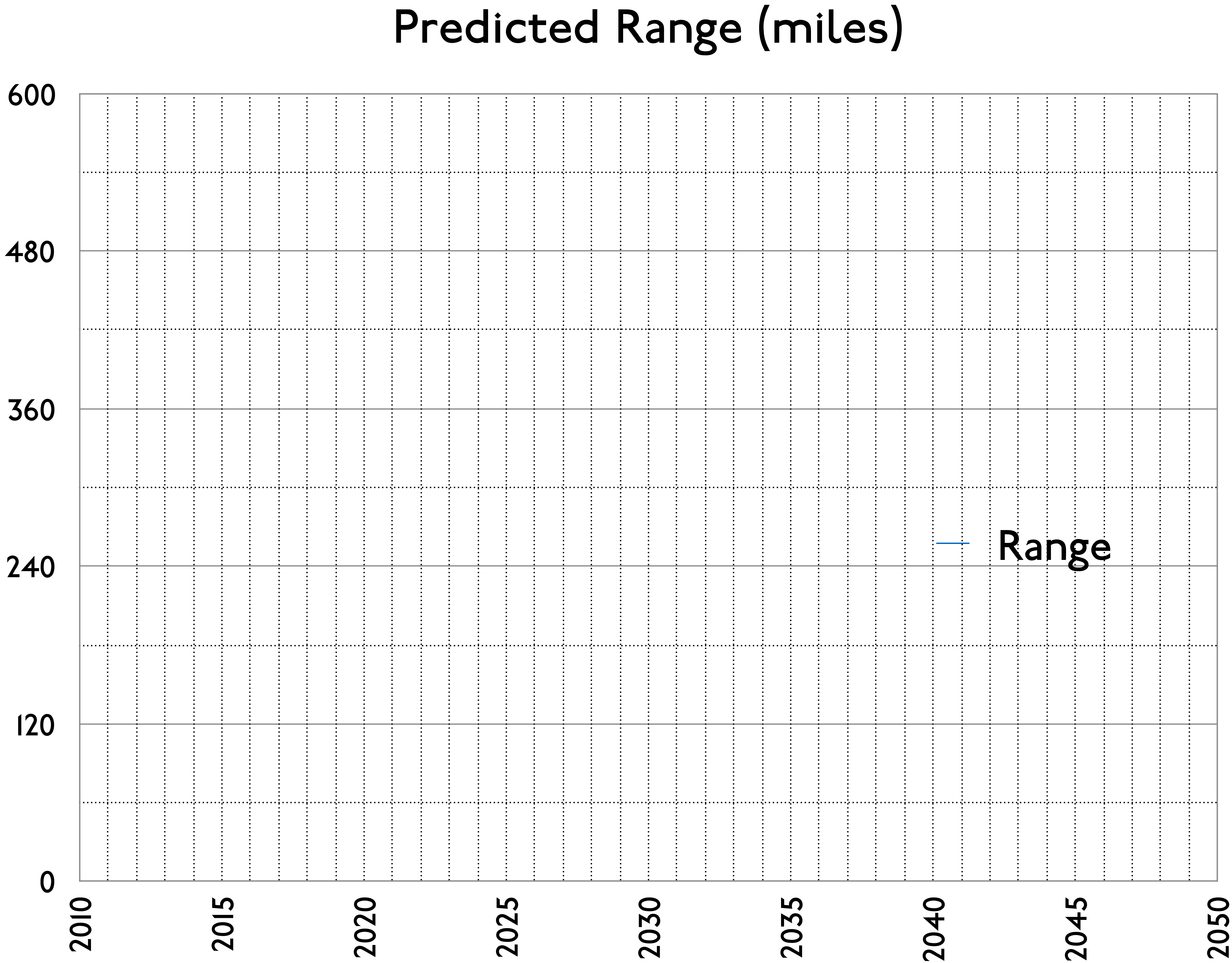
Our New EV Forecasts

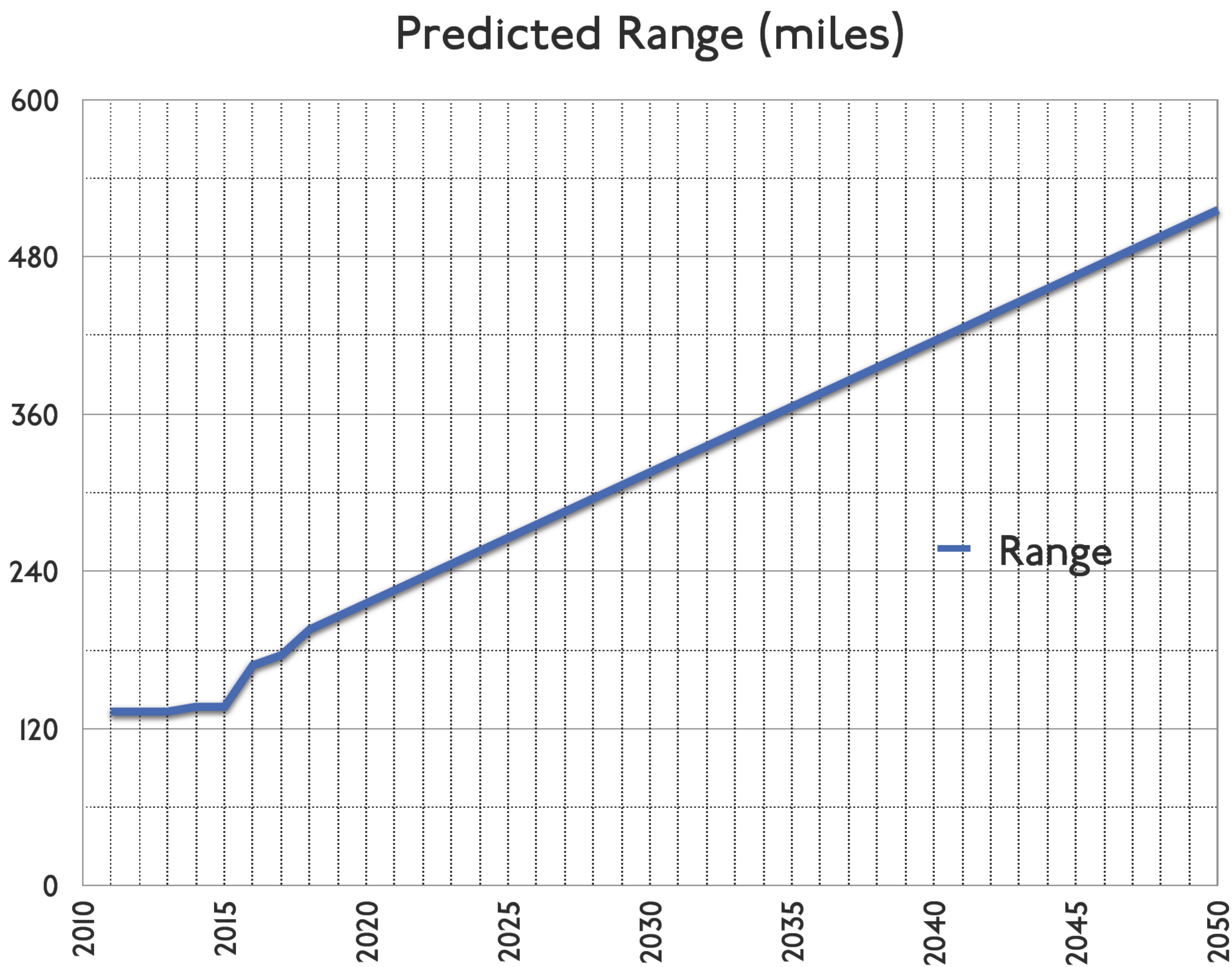
EV Sales by Country (EV+PHEV)



IEA： Global EV Outlook 2019Table A.4.


Nissan Leaf
Tesla
Range (Miles)
260
195
130
65
0
2011
2012
2013
2014
2015
2016
2017
2018


Predicted Range (miles)
600
480
360
240
120
0
2010
2015
2020
2025
2030
2035
2040
2045
2050
Range


Predicted Range (miles)
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480
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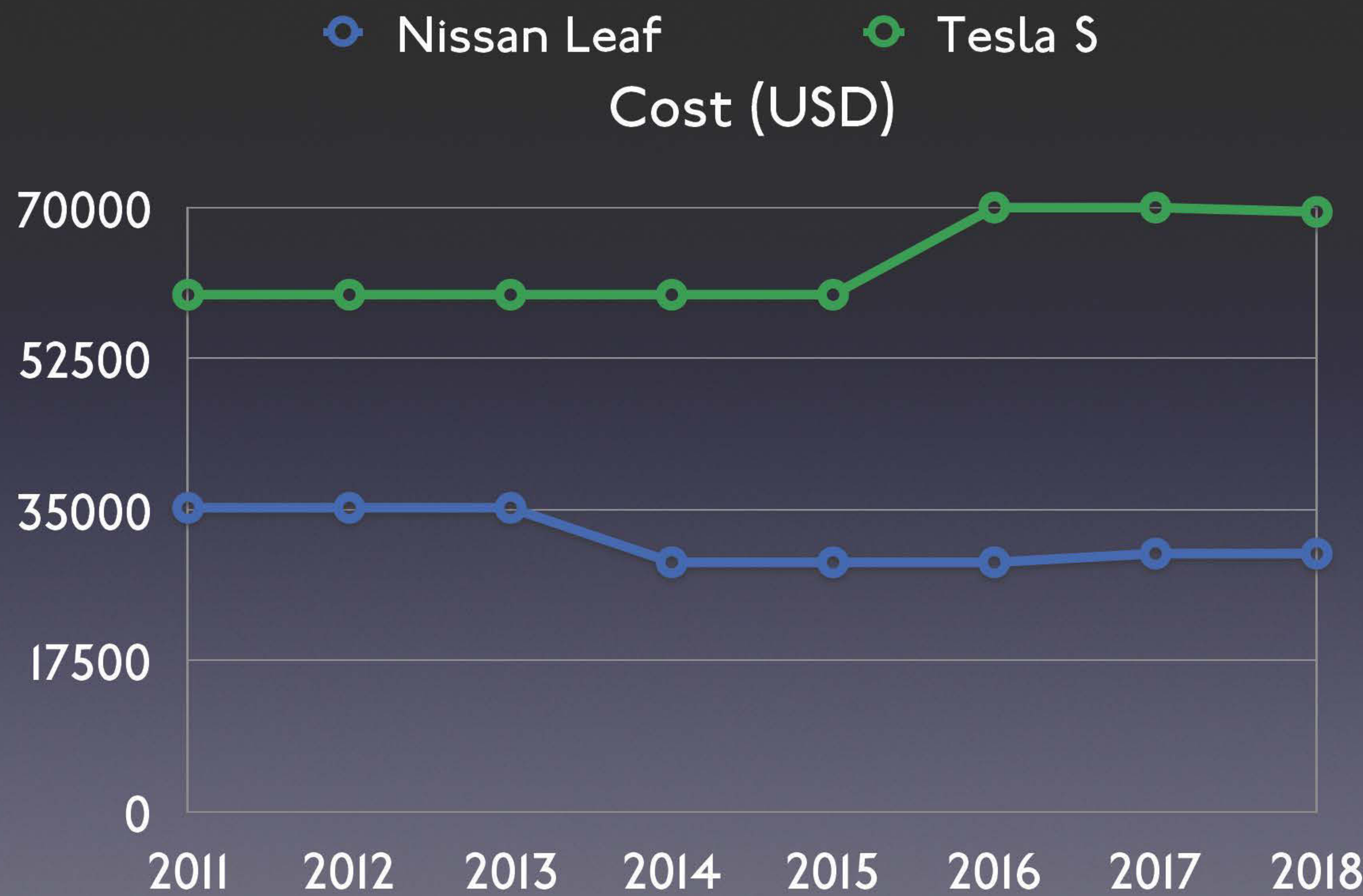
2010
2015
2020
2025
2030
2035
2040
2045
2050
Range

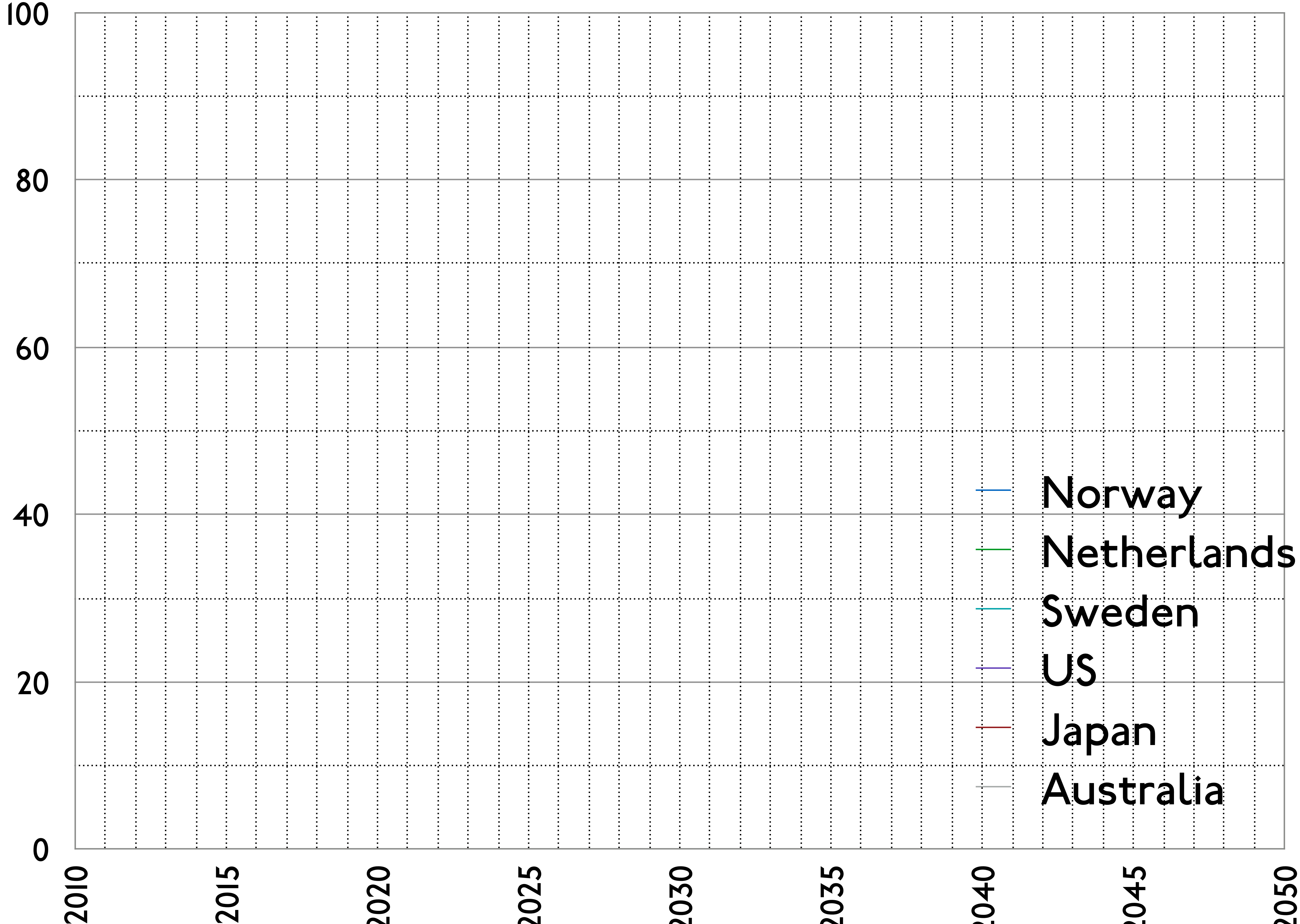

Nissan Leaf
Tesla S
Cost (USD)
70000
52500
35000
17500
0
2011
2012
2013
2014
2015
2016
2017
2018

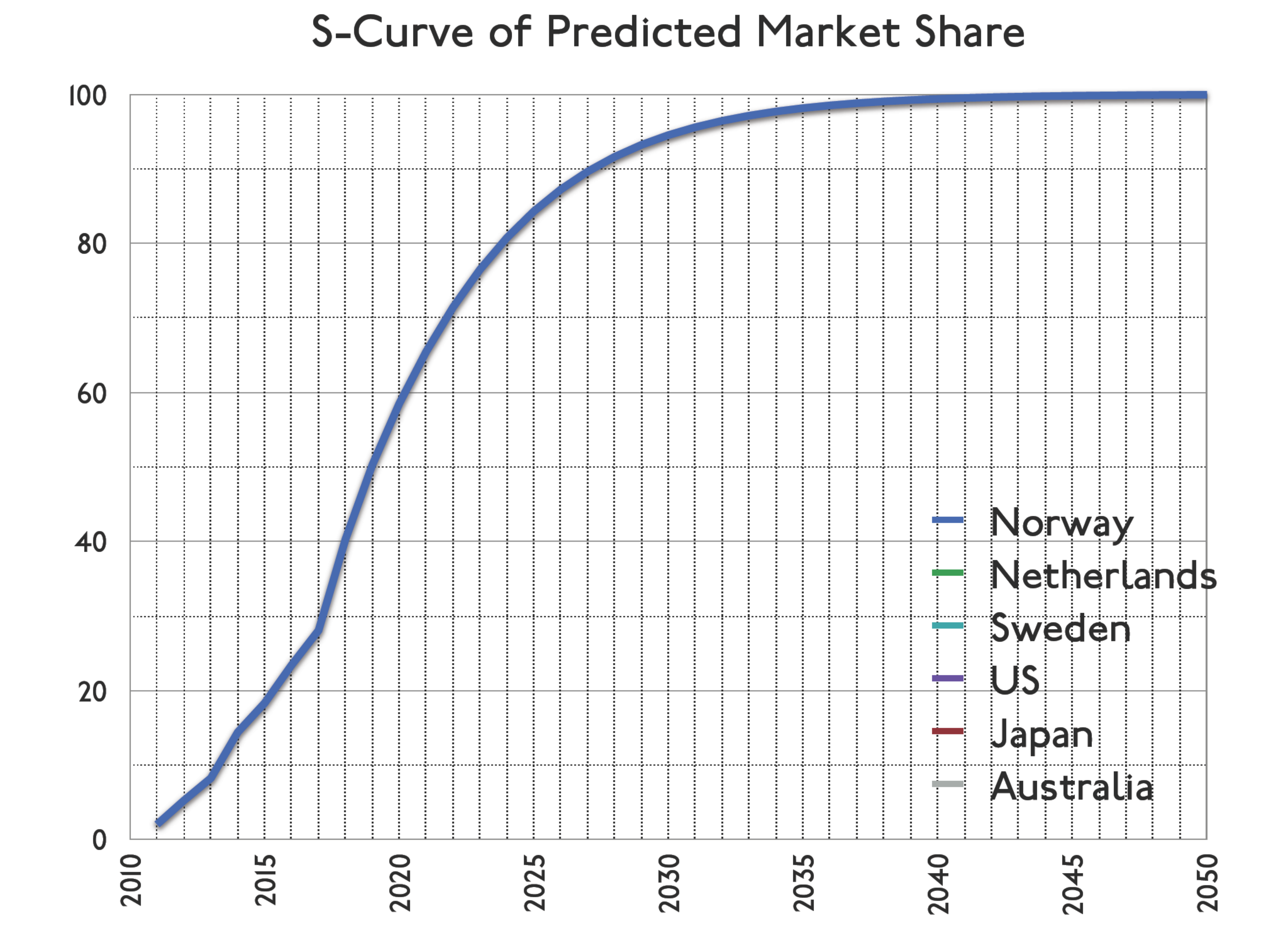
Predicted ln(Share/(1-Share))

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	1.73e+00	2.20e+00	7.89e-01	4.33e-01	
[ln(pre.share)]	5.14e-01	6.45e-02	7.97e+00	1.28e-11	***
[EV.price]	-1.50e-04	5.81e-05	-2.59e+00	1.16e-02	*
[EV.range]	2.19e-02	5.25e-03	4.17e+00	8.04e-05	***
[norway]	1.84e+00	2.71e-01	6.77e+00	2.36e-09	***
[australia]	-7.36e-01	2.46e-01	-3.00e+00	3.69e-03	**
[sweden]	7.50e-01	2.03e-01	3.70e+00	4.05e-04	***
[us]	1.95e-01	2.11e-01	9.22e-01	3.59e-01	
[france]	2.36e-01	1.96e-01	1.21e+00	2.32e-01	
[finland]	2.43e-01	2.04e-01	1.19e+00	2.39e-01	
[netherlands]	1.06e+00	2.32e-01	4.56e+00	1.92e-05	***

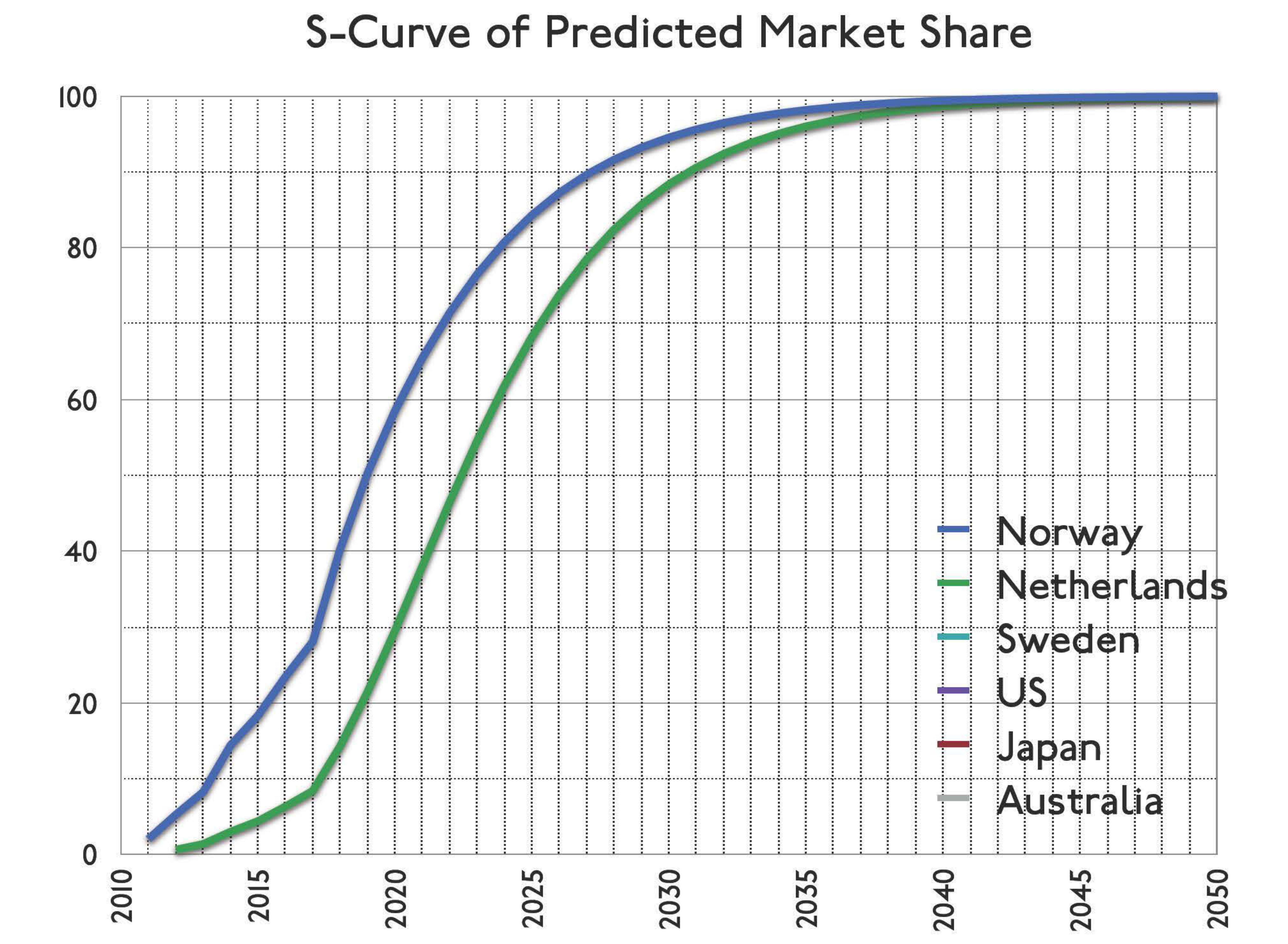
Adjusted R-squared: 0.9128

S-Curve of Predicted Market Share





S-Curve of Predicted Market Share
100
80
60
40
20
0
2010
2015
2020
2025
2030
2035
2040
2045
2050
Norway
Netherlands
Sweden
US
Japan
Australia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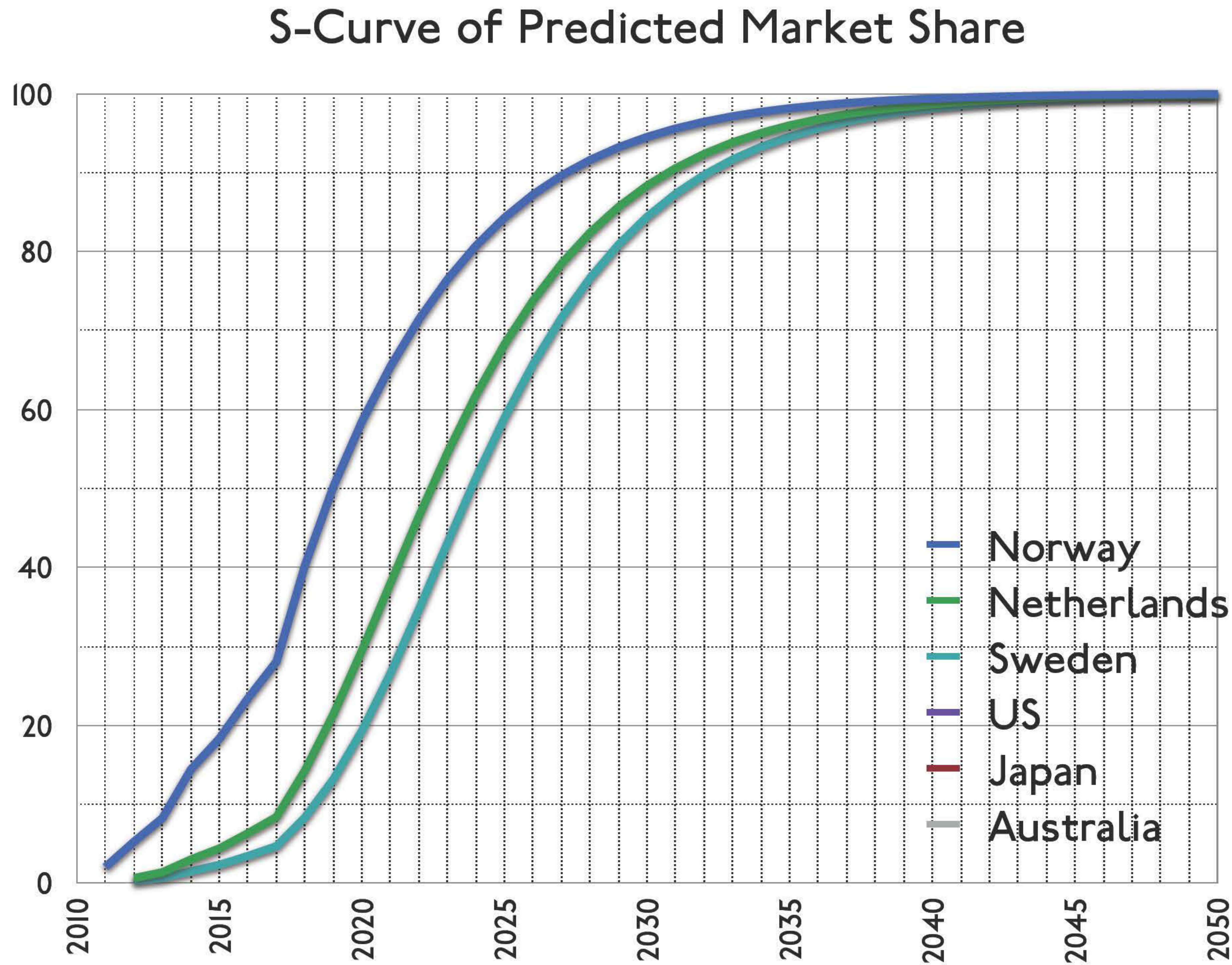
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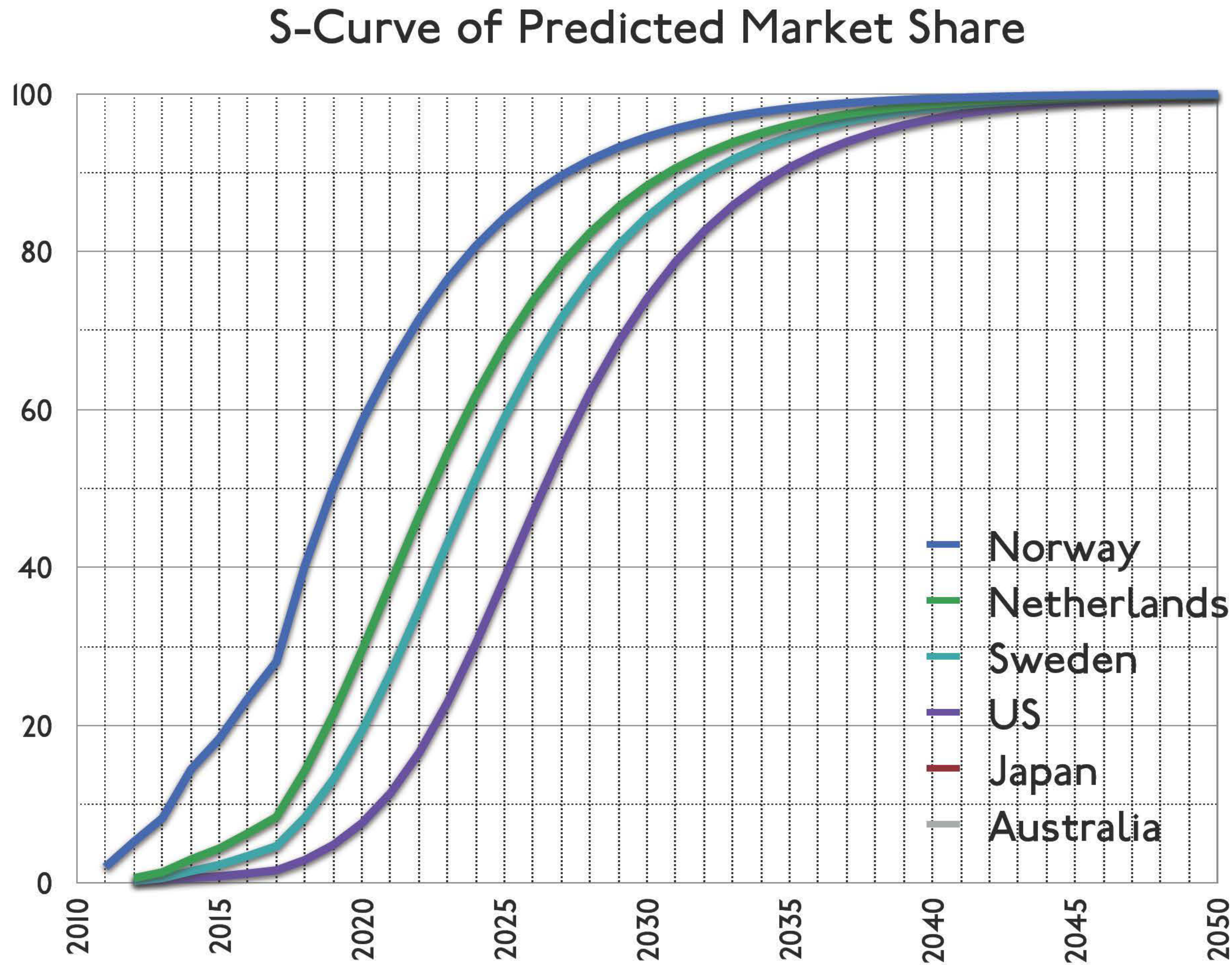
S-Curve of Predicted Market Share
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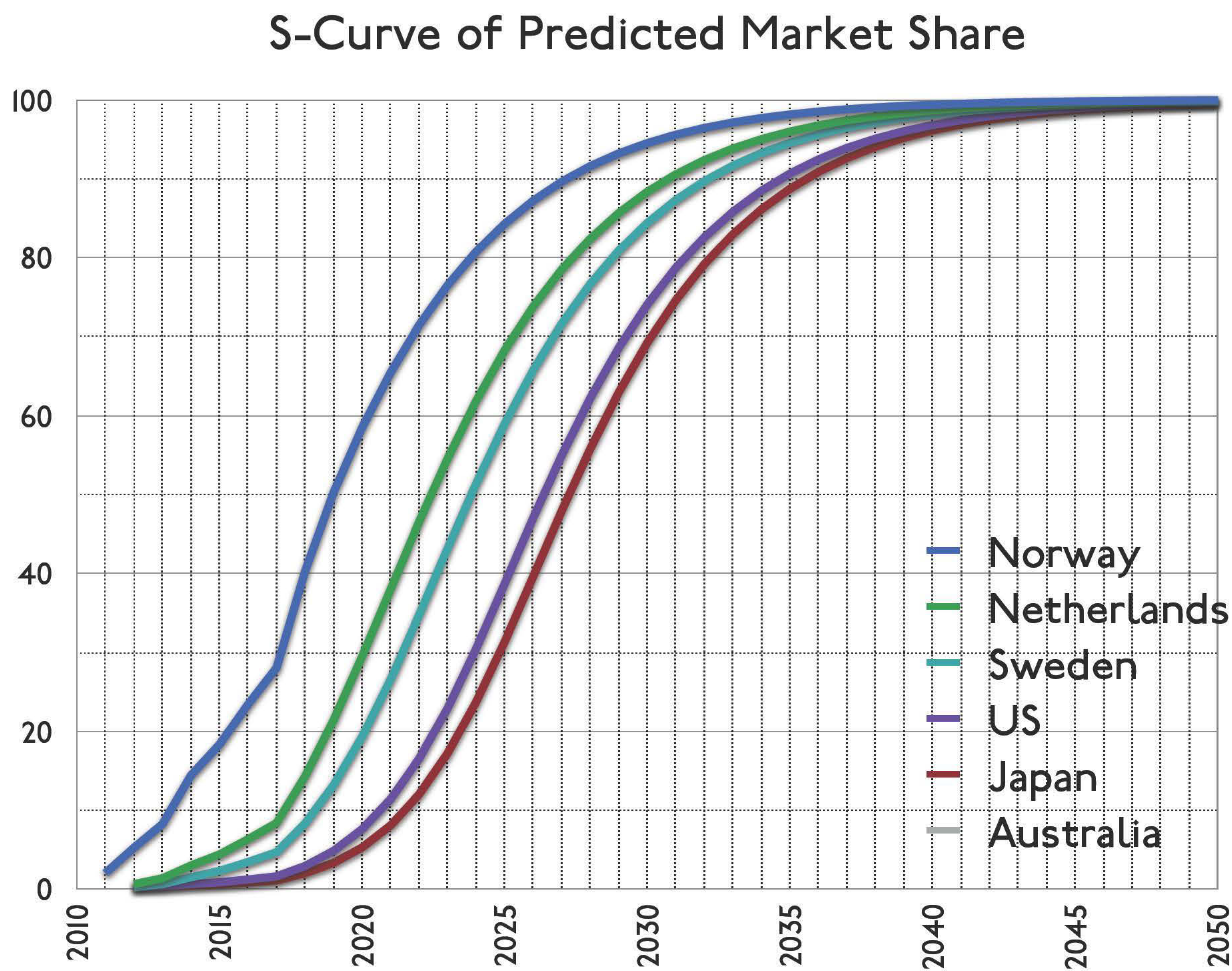
S-Curve of Predicted Market Share
100
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0
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2015
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2030
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2040
2045
2050
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Netherlands
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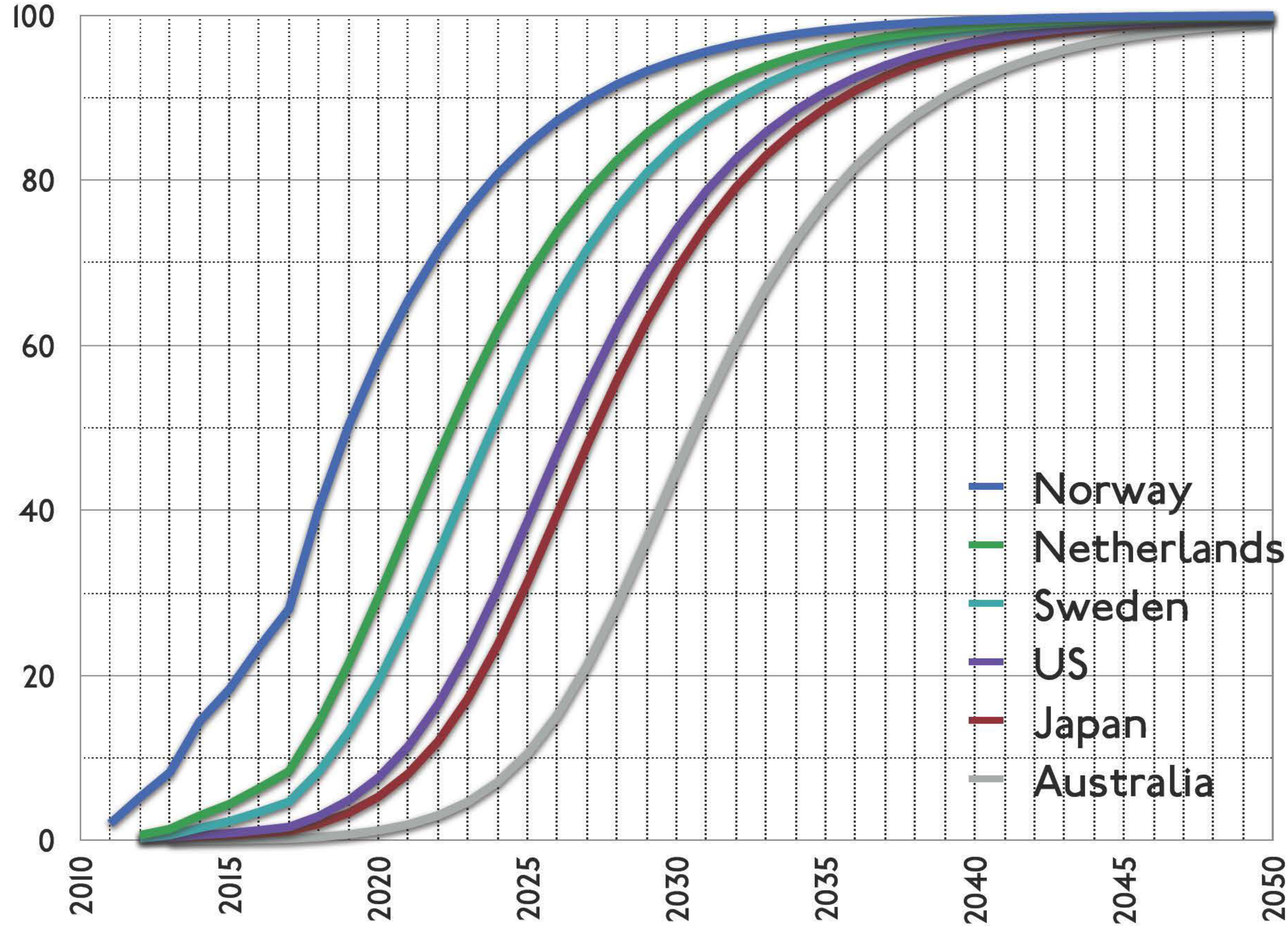
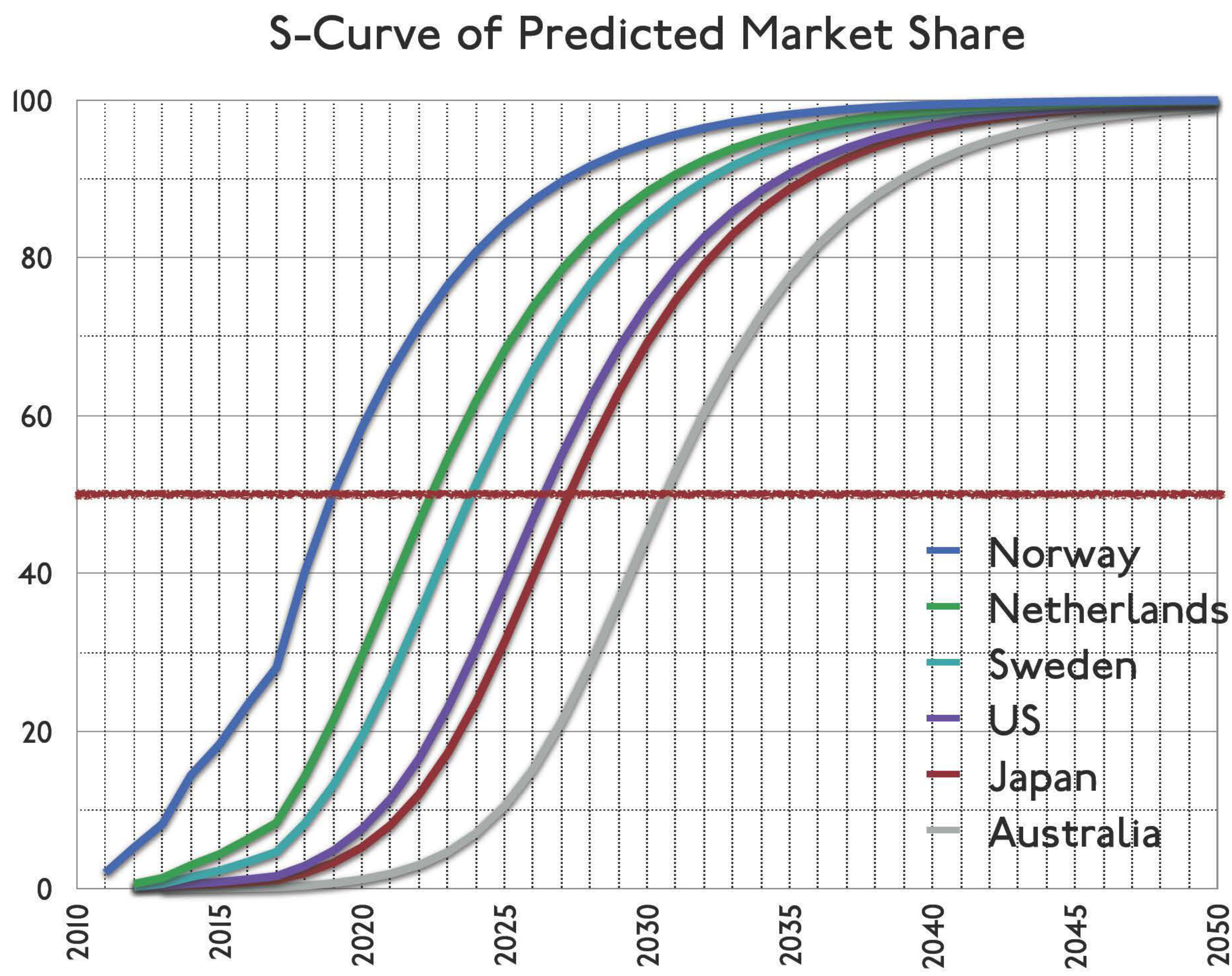
Australia

S-Curve of Predicted Market Share




S-Curve of Predicted Market Share
100
80
60
40
20
0
2010
2015
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2025
2030
2035
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2050
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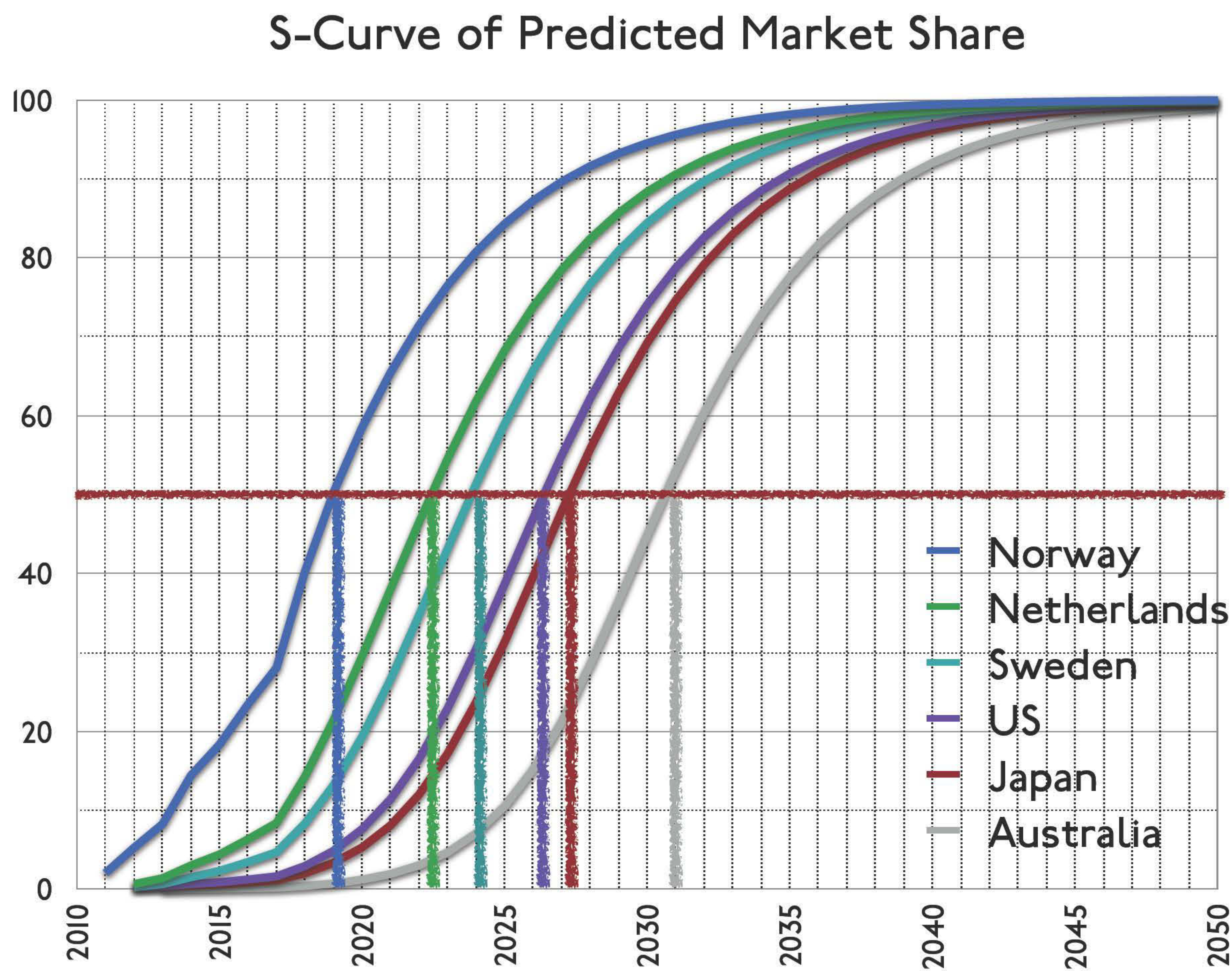
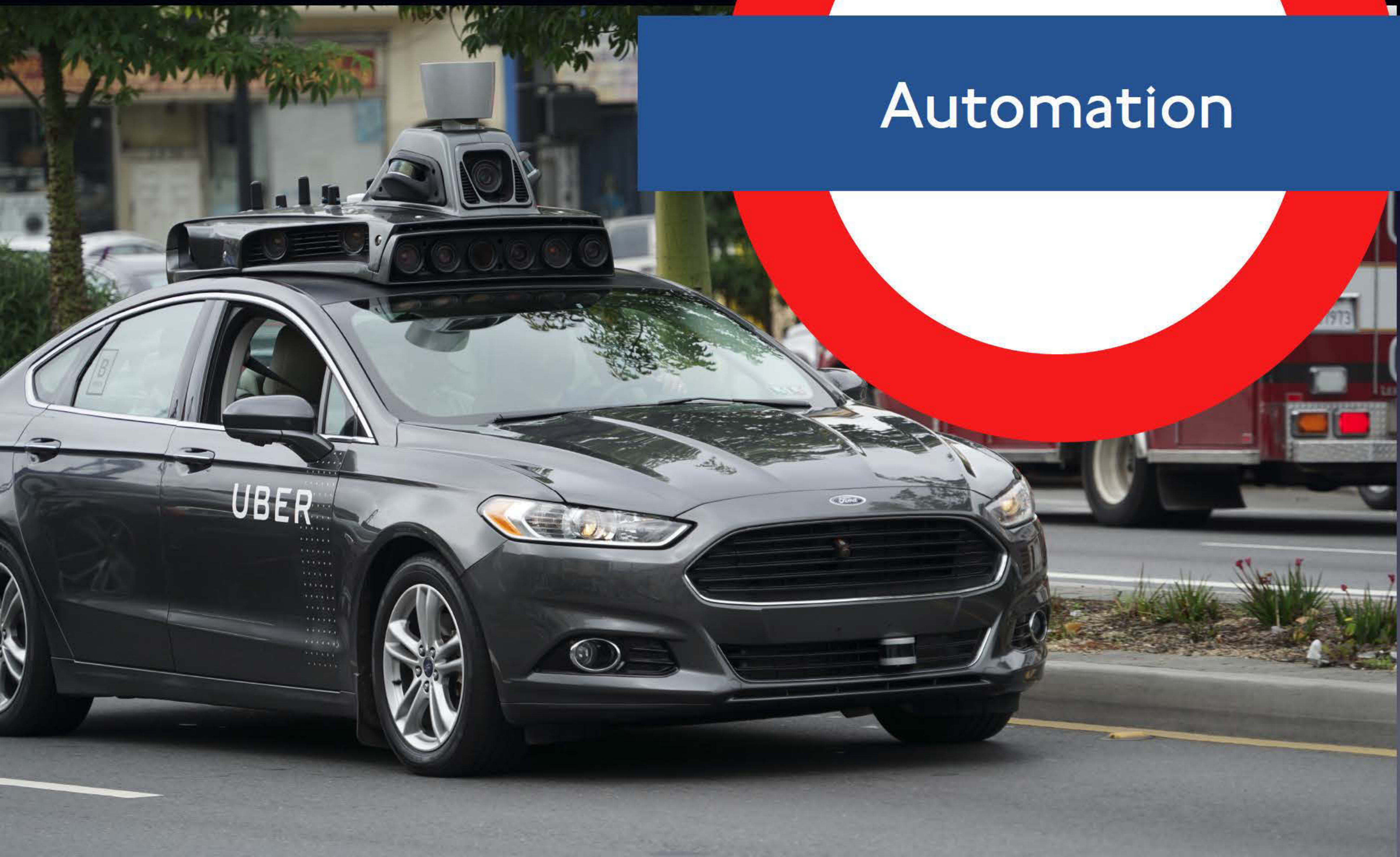

S-Curve of Predicted Market Share
100
80
60
40
20
0
2010
2015
2020
2025
2030
2035
2040
2045
2050
Norway
Netherlands
Sweden
US
Japan
Australia

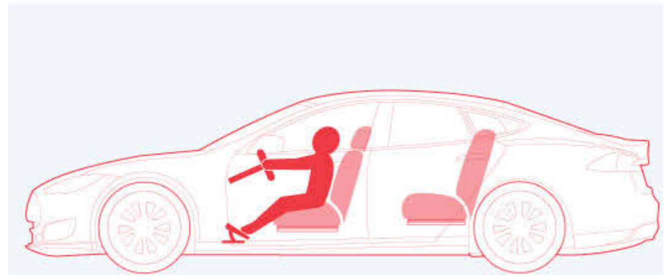
2020 Superbowl Featured 4 Electric Vehicle Ads

Automation

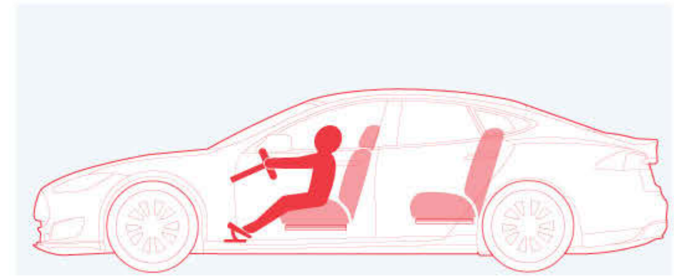


Autonomous Autos

SAE level	Name	Steering and Acceleration/ Deceleration	Monitoring of Driving Environment	Fallback Performance of Dynamic Driving Task	System Capability (Driving Modes)
	Human driver monitors the driving environment				
0	No Automation	Human driver	Human driver	Human driver	n/a
1	Driver Assistance	Human driver and system	Human driver	Human driver	Some driving modes
2	Partial Automation	System	Human driver	Human driver	Some driving modes
	Automated driving system ("system") monitors the driving environment				
3	Conditional Automation	System	System	Human driver	Some driving modes
4	High Automation	System	System	System	Some driving modes [Geofenced]
5	Full Automation	System	System	System	All driving modes



Level 0, No Automation



Level 1, Driver Assistance

Tesla
Autopilot

Danger
Zone

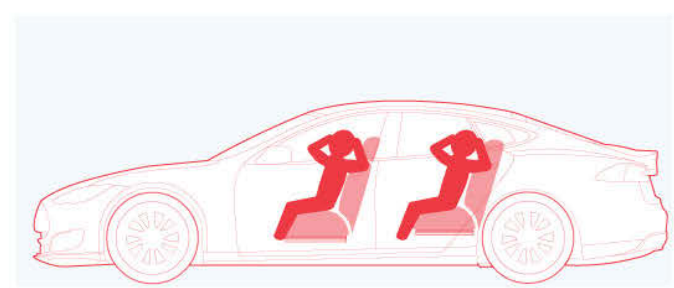
Level 2, Partial Automation
(e.g. adaptive cruise control)

Level 3, Conditional Automation

Autonomous

Waymo

Level 4, High Automation
(Self-Driving)



Level 5, Full Automation (Driverless)
(And may have no passengers)

Benefits and Consequences

Benefits and Consequences

- Safety

Benefits and Consequences

Benefits and Consequences

Benefits and Consequences

Benefits and Consequences

Benefits and Consequences

Benefits and Consequences

- Costs

Benefits and Consequences

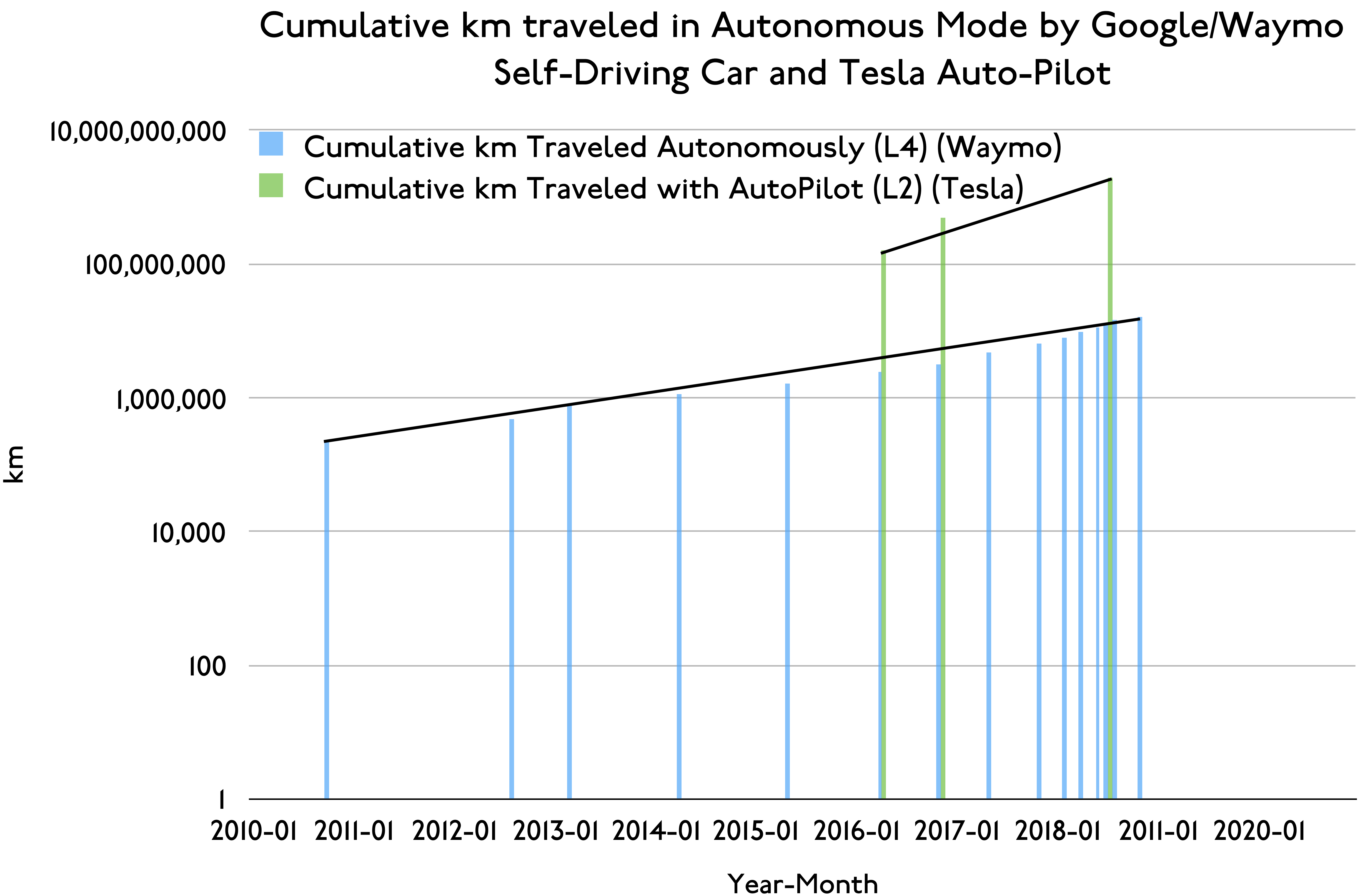
Benefits and Consequences

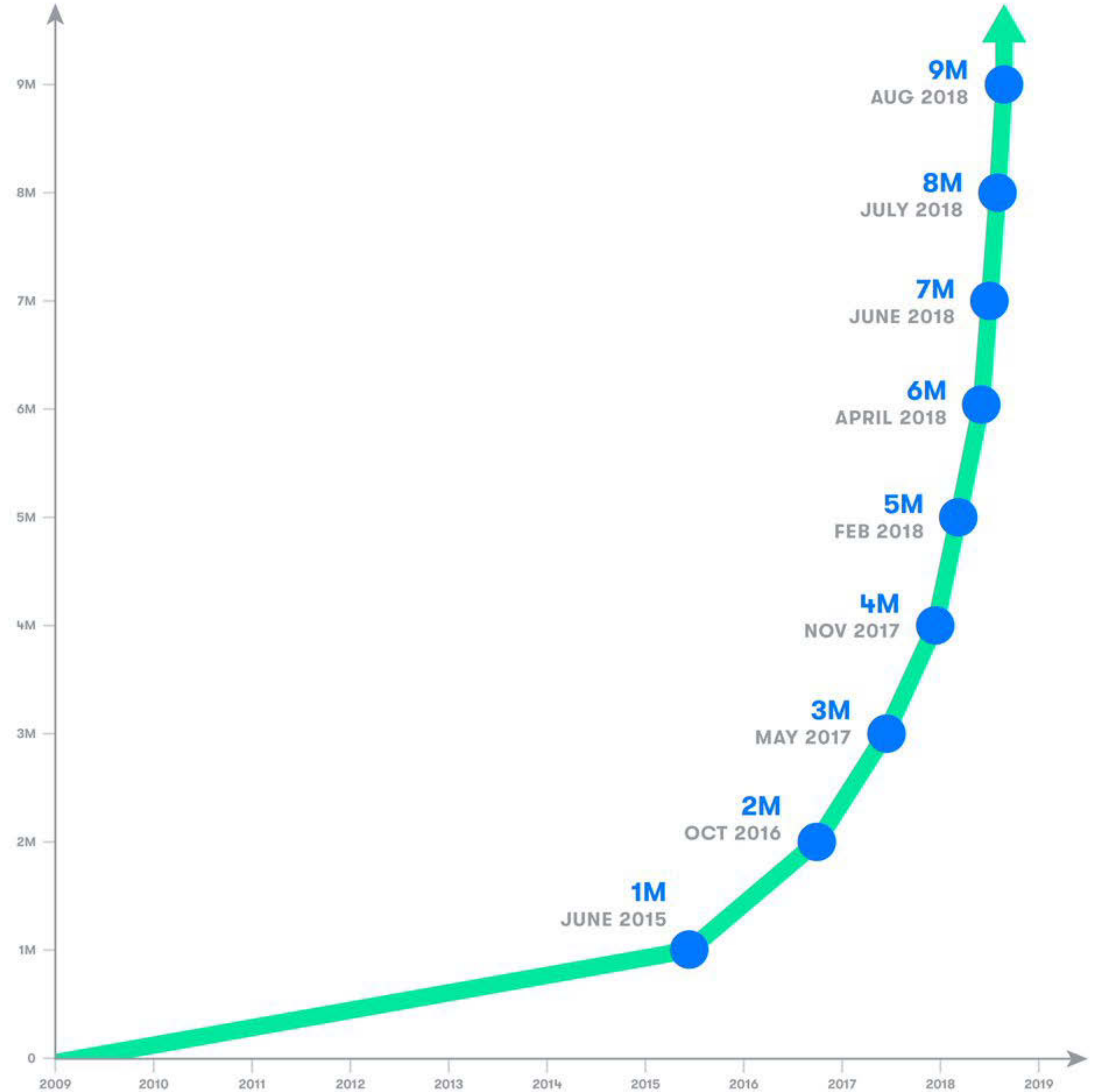
Benefits and Consequences

Benefits and Consequences

Benefits and Consequences

Benefits and Consequences

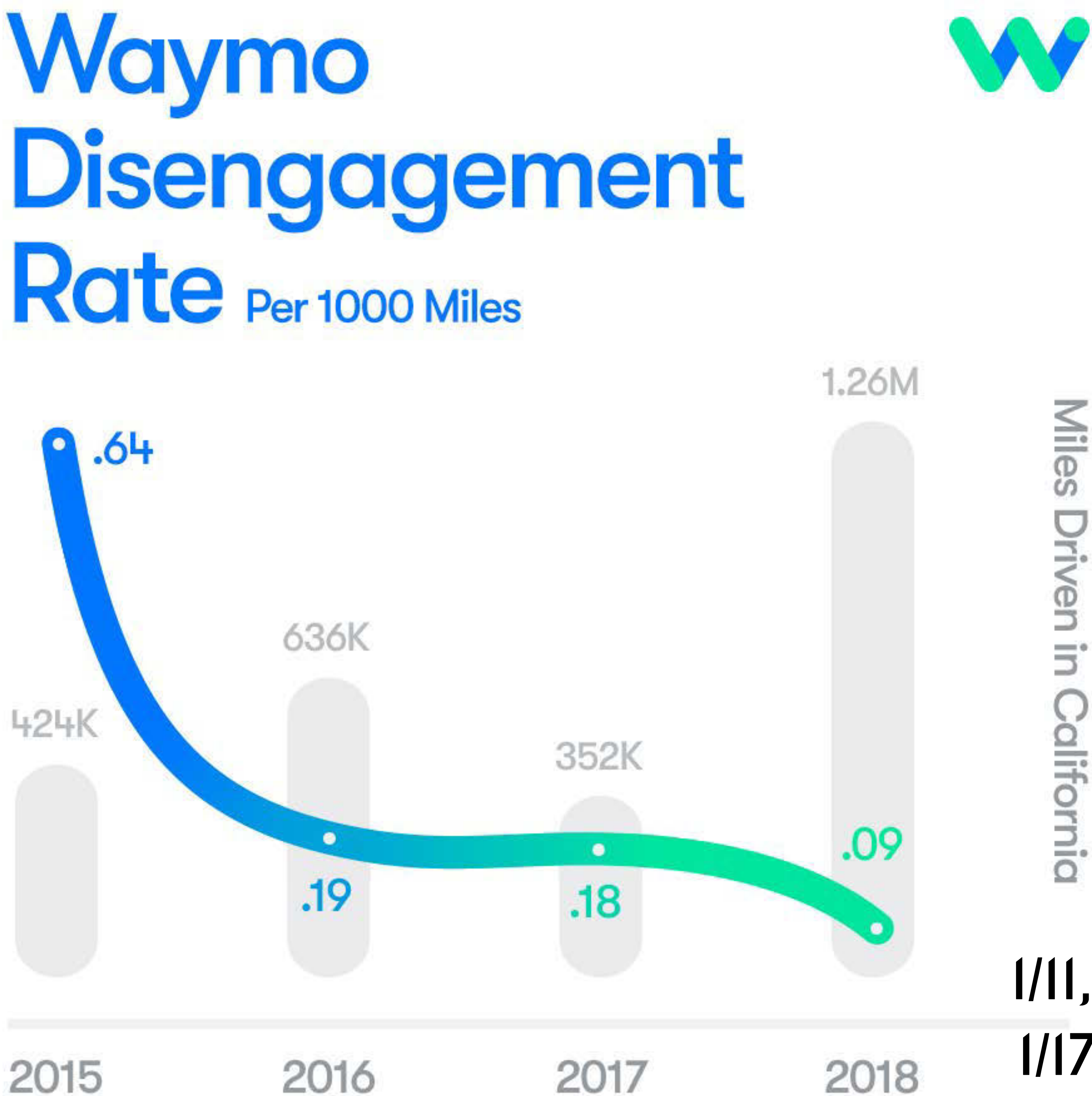

Cumulative km traveled in Autonomous Mode by Google/Waymo Self-Driving Car and Tesla Auto-Pilot
Cumulative km Traveled Autonomously (L4) (Waymo)
Cumulative km Traveled with AutoPilot (L2) (Tesla)
10,000,000,000
100,000,000
1,000,000
10,000
100
1
km
2010-01
2011-01
2012-01
2013-01
2014-01
2015-01
2016-01
2017-01
2018-01
2011-01
2020-01
Year-Month



WAYMO

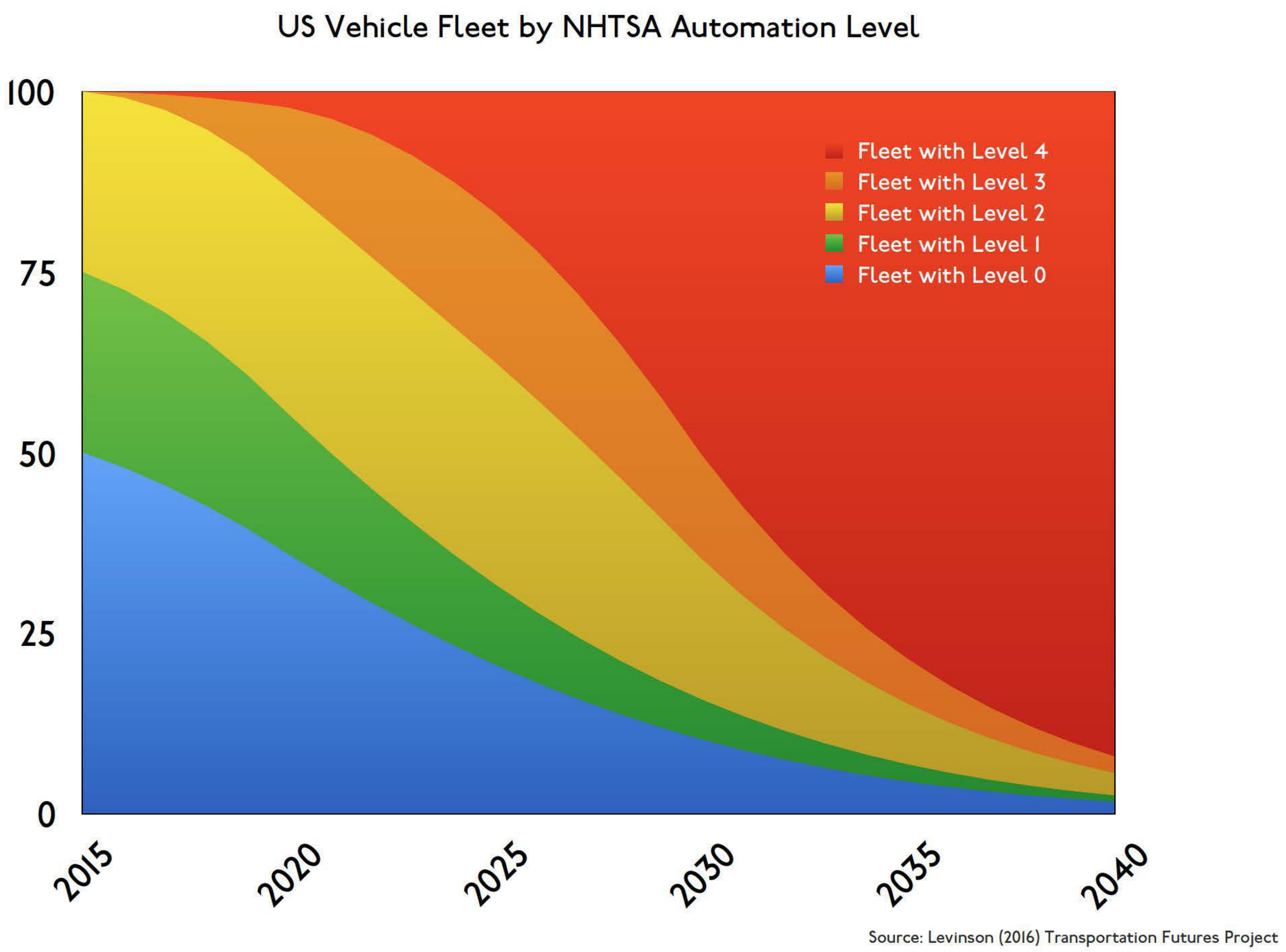
9,000,000+

MILES AND COUNTING

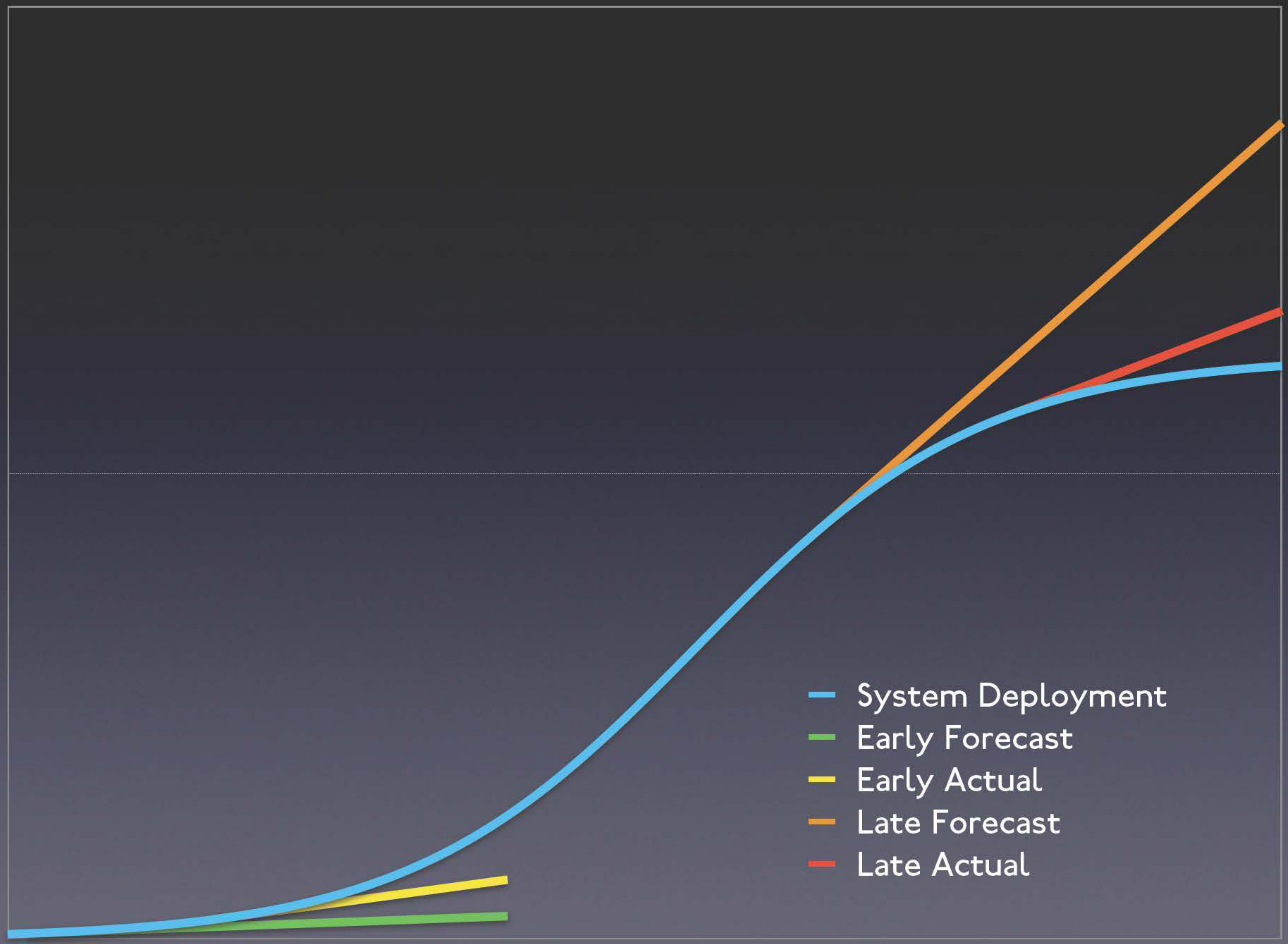


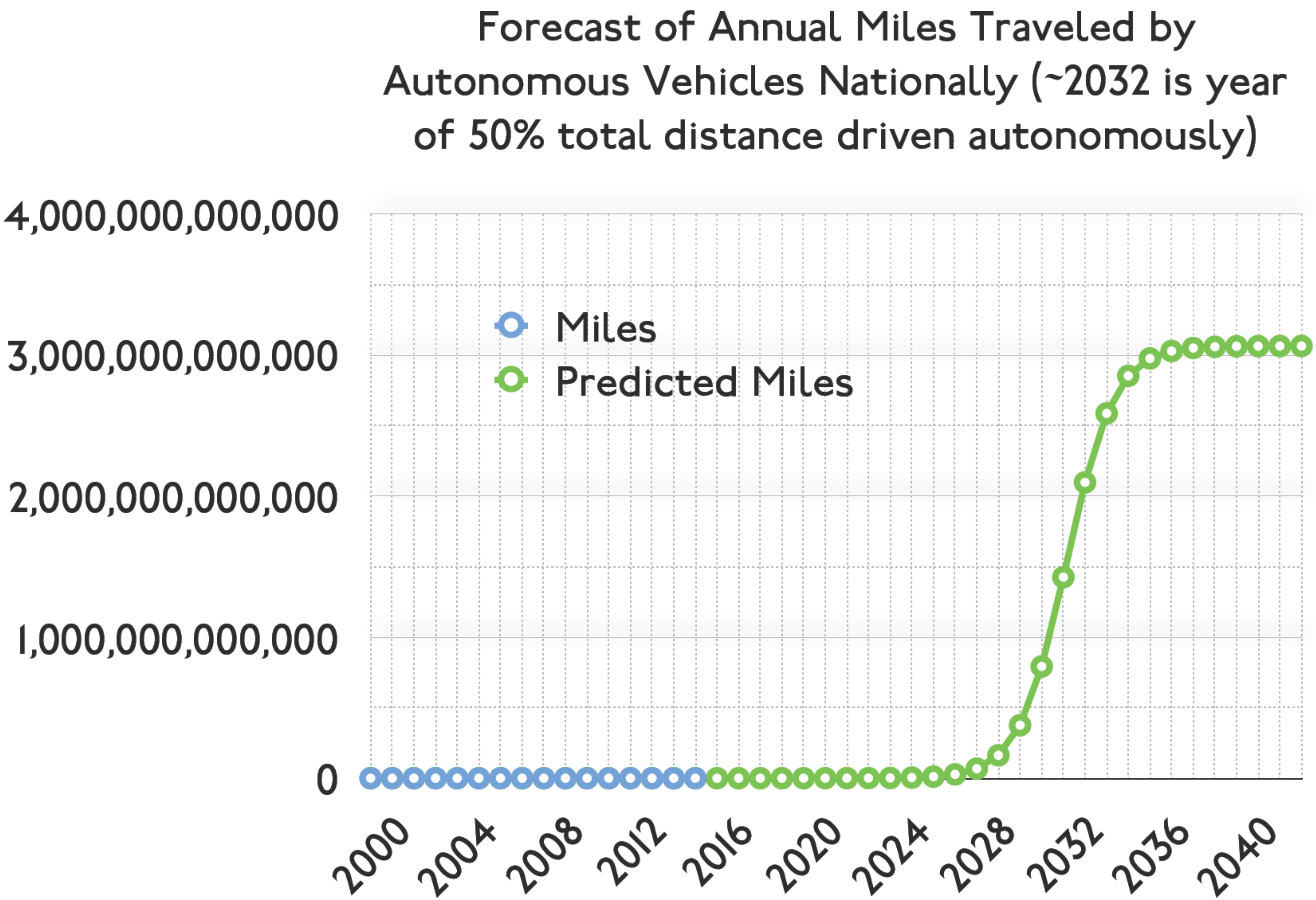
1/11,111 miles
1/17,877 km

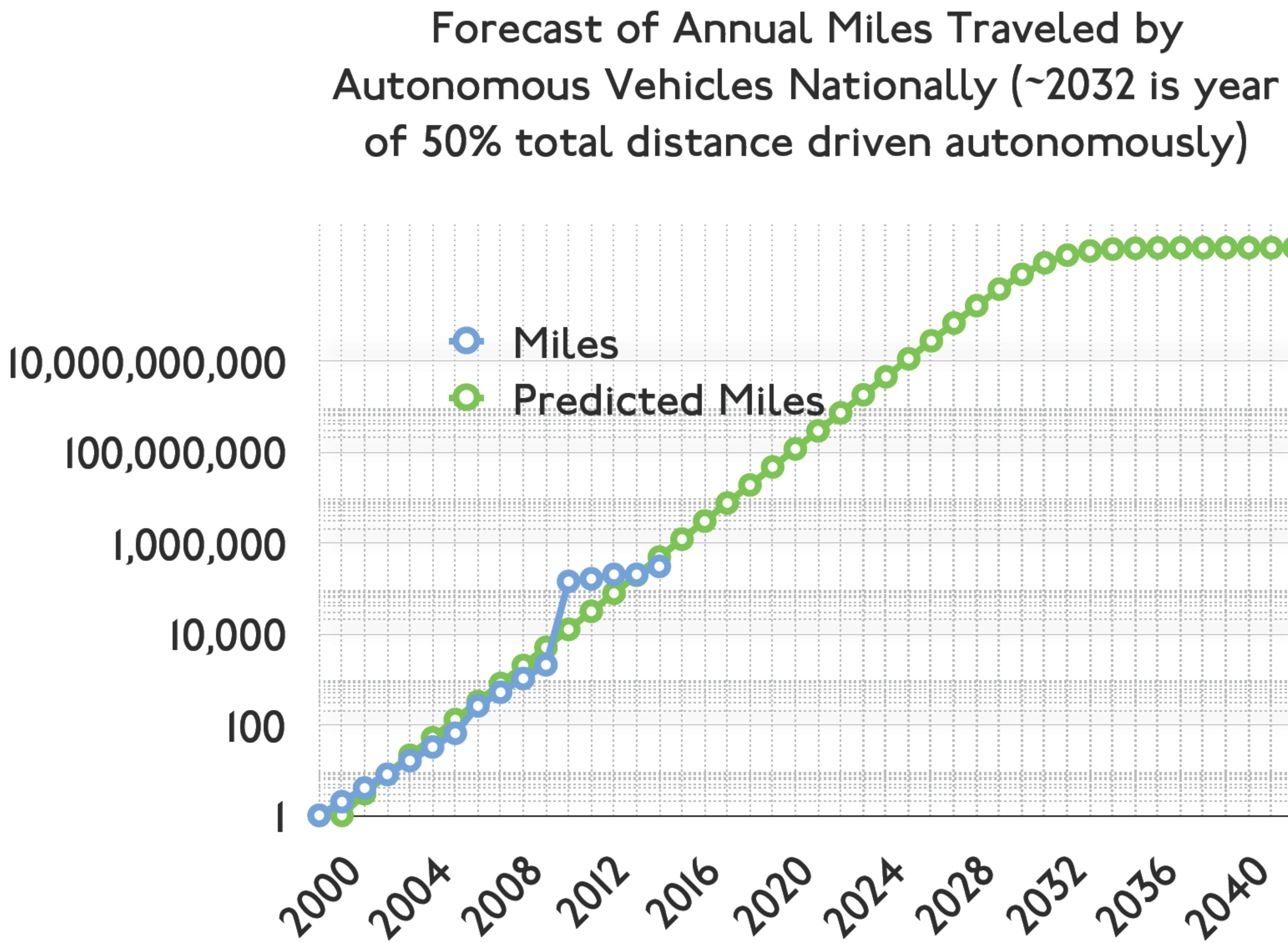
https://medium.com/waymo/an-update-on-waymo-disengagements-in-california-d671fd31c3e2

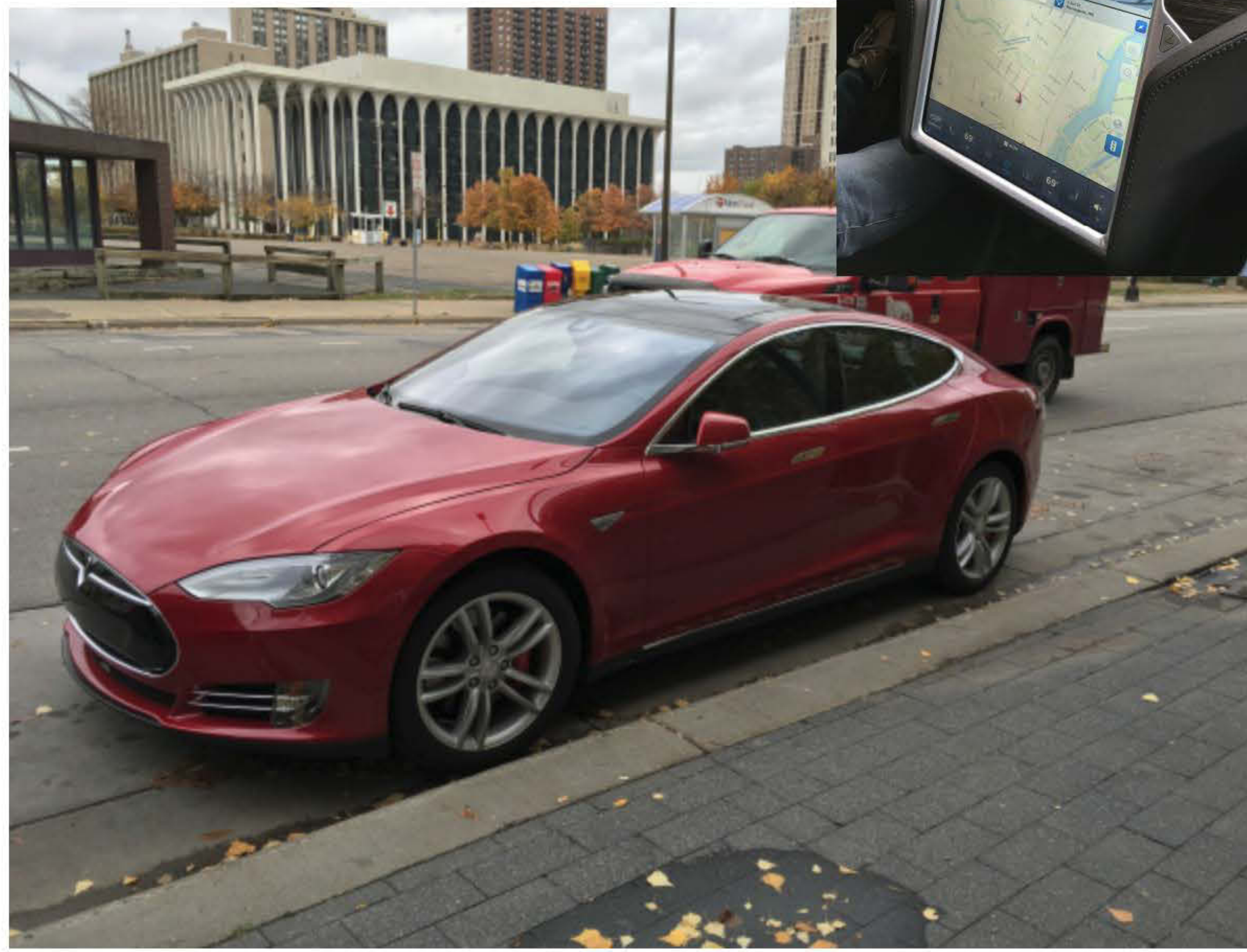


US Vehicle Fleet by NHTSA Automation Level
Fleet with Level 4
Fleet with Level 3
Fleet with Level 2
Fleet with Level 1
Fleet with Level 0
100
75
50
25
0
2015
2020
2025
2030
2035
2040
Source: Levinson (2016) Transportation Futures Project


System Deployment
Early Forecast
Early Actual
Late Forecast
Late Actual

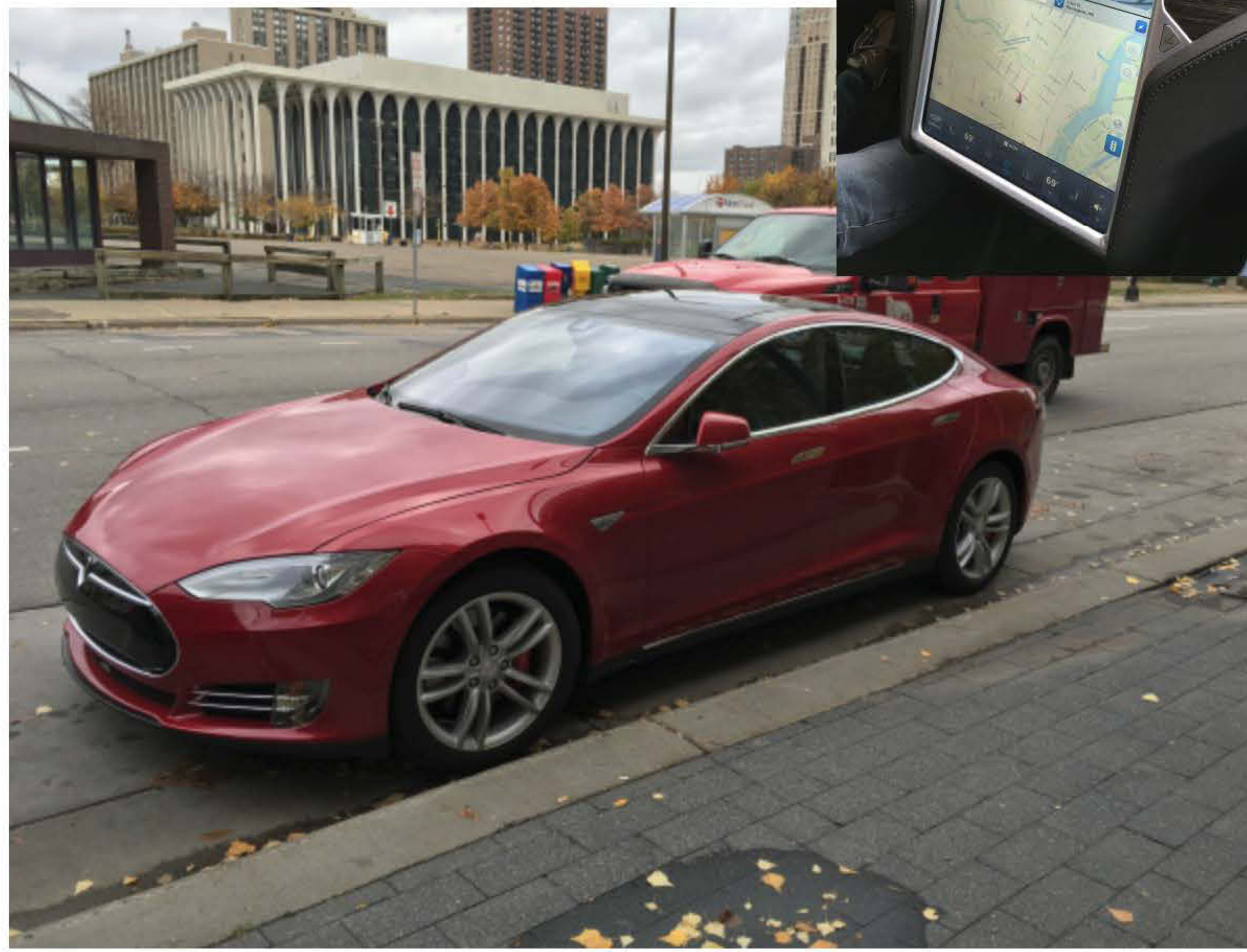

Forecast of Annual Miles Traveled by Autonomous Vehicles Nationally (~2032 is year of 50% total distance driven autonomously)
4,000,000,000,000
3,000,000,000,000
2,000,000,000,000
1,000,000,000,000
0
Miles
Predicted Miles
2000
2004
2008
2012
2016
2020
2024
2028
2032
2036
2040


Forecast of Annual Miles Traveled by Autonomous Vehicles Nationally (~2032 is year of 50% total distance driven autonomously)
Miles
Predicted Miles
10,000,000,000
100,000,000
1,000,000
10,000
100
1
2000
2004
2008
2012
2016
2020
2024
2028
2032
2036
2040



Tesla S

- Level 2, 2.5 Now (Tesla Auto-Pilot, etc.)

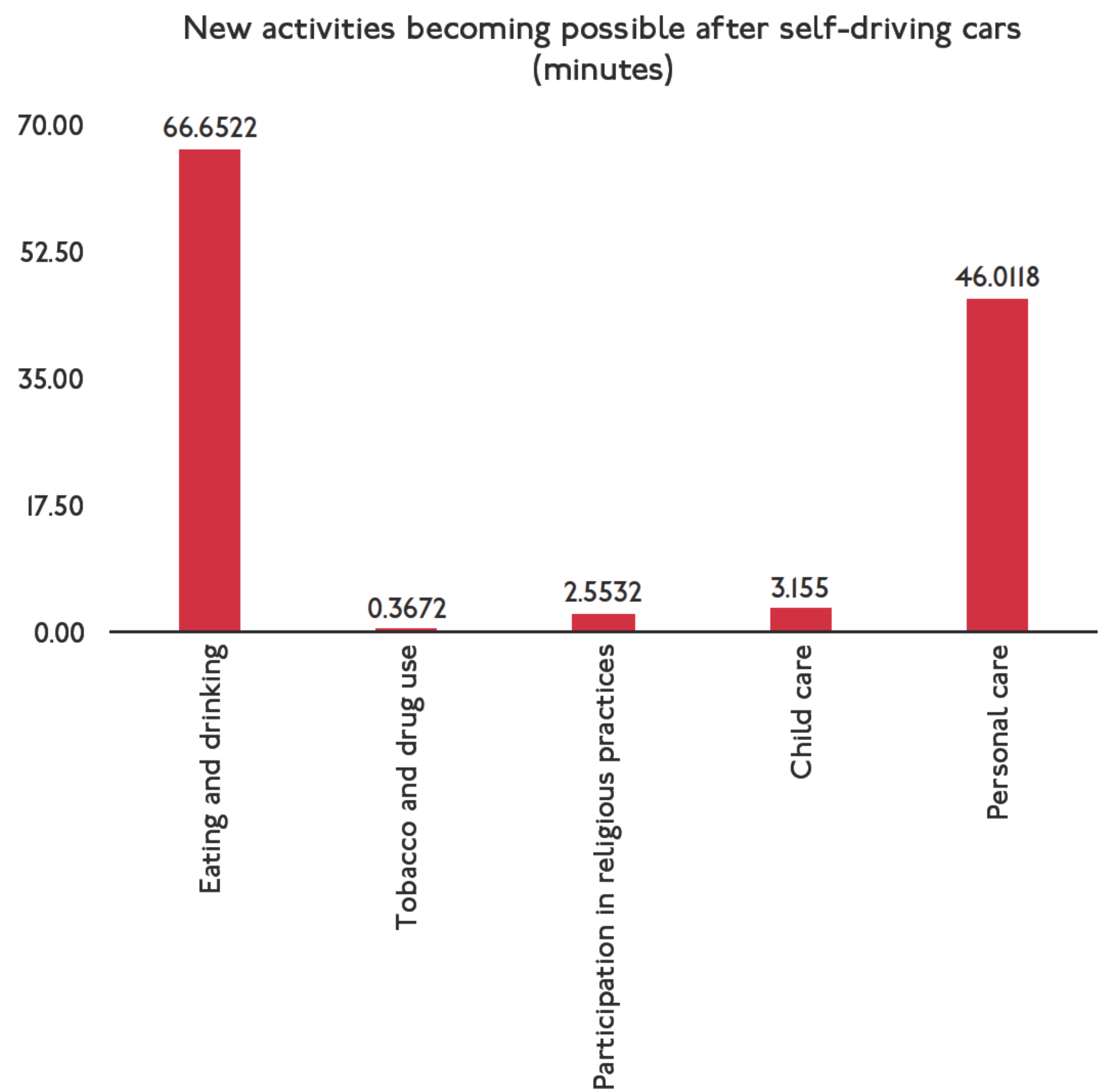


Tesla S

- Level 2, 2.5 Now (Tesla Auto-Pilot, etc.)
- Level 3 ("limited self-driving automation") autonomous vehicles will be on the market by 2020.
    - Cadillac SuperCruise 2017
- Level 4 will be available in 2025 and required in new US cars by 2030, and required for all cars by 2040.
- **In other words, human driven vehicles will eventually be prohibited on public roads (aside from special events).**

Tesla S

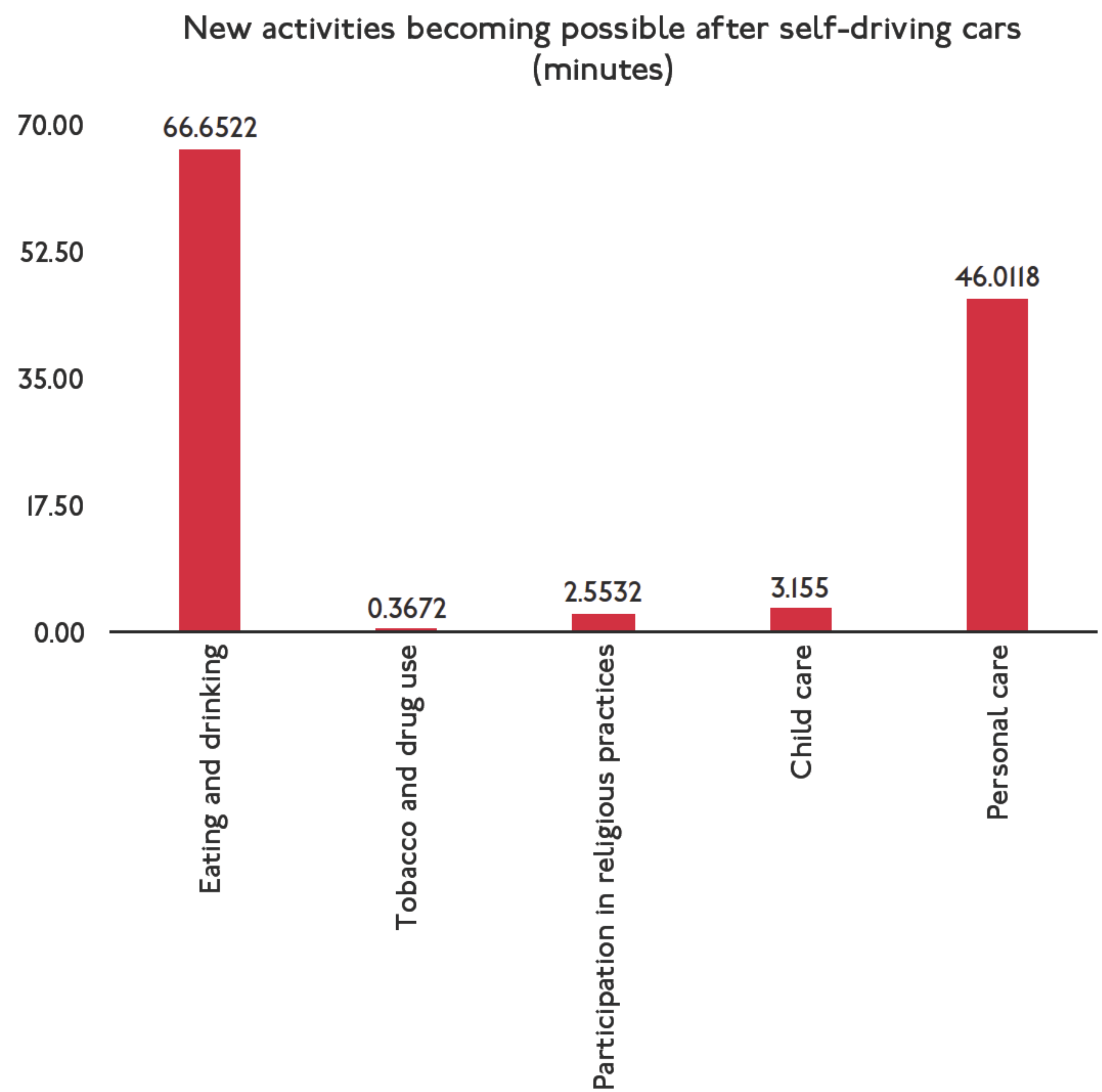
New Activities in Motion



Fan (2016)

New Activities in Motion

- A limited set of personal care activity including dressing & grooming, health-related self care, personal/private activities;



Fan (2016)

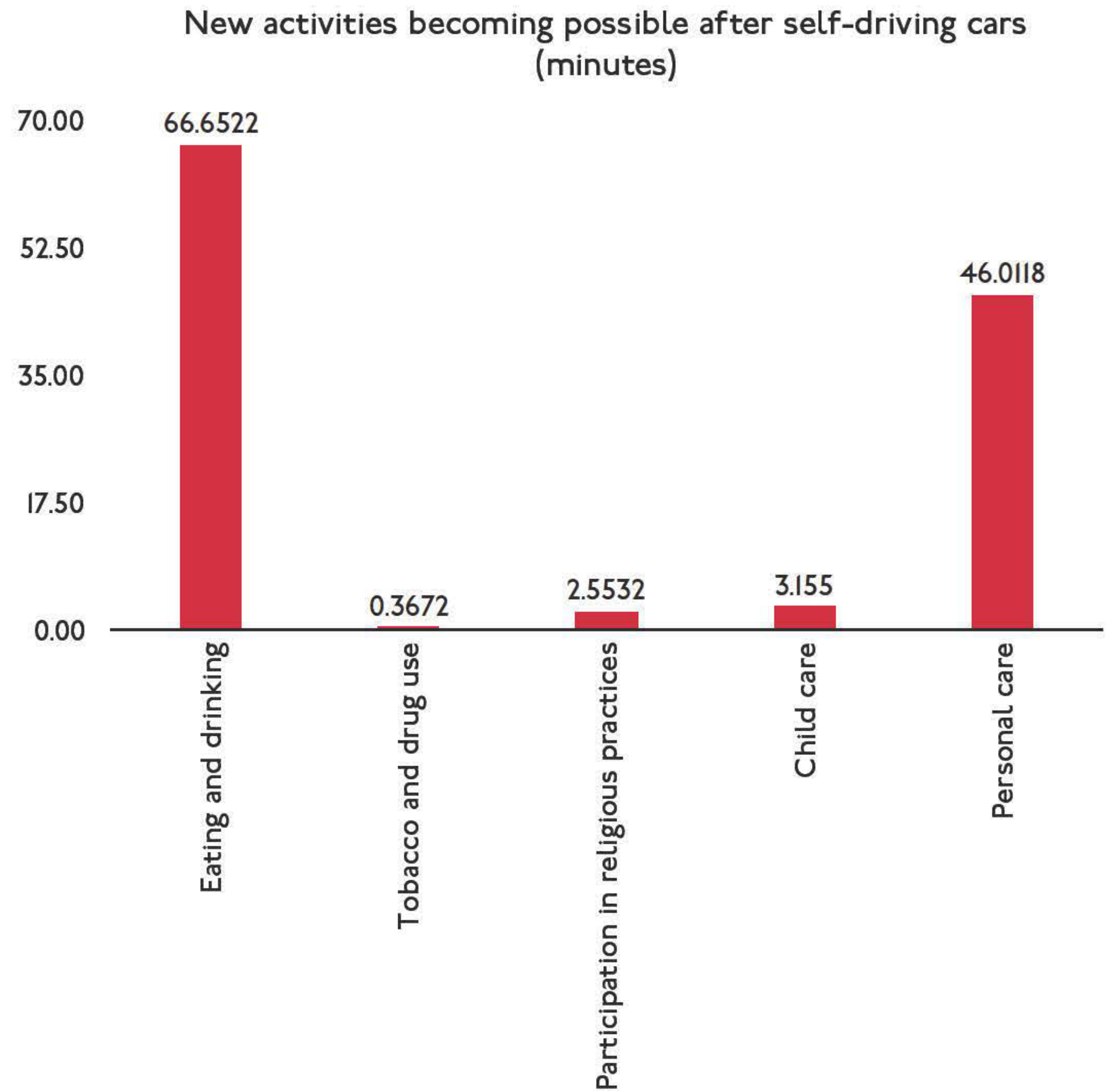
New Activities in Motion

New Activities in Motion

New Activities in Motion

New Activities in Motion

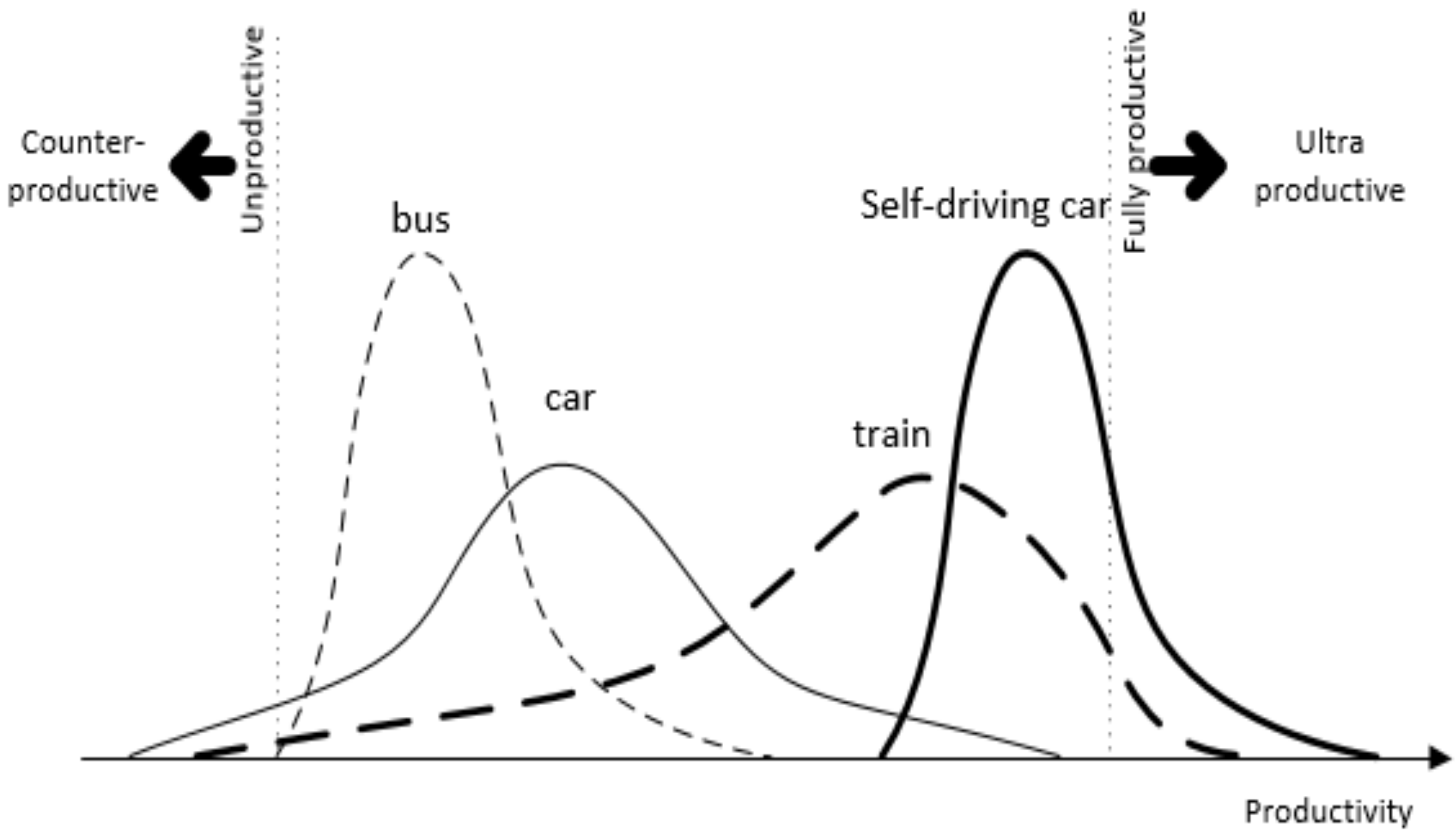
- A limited set of personal care activity including dressing & grooming, health-related self care, personal/private activities;
- A limited set of child care activities including reading to/with children, home schooling, and arts and crafts with children;
- Eating and drinking;
- Tobacco and drug use; and
- Participation in religious practices.



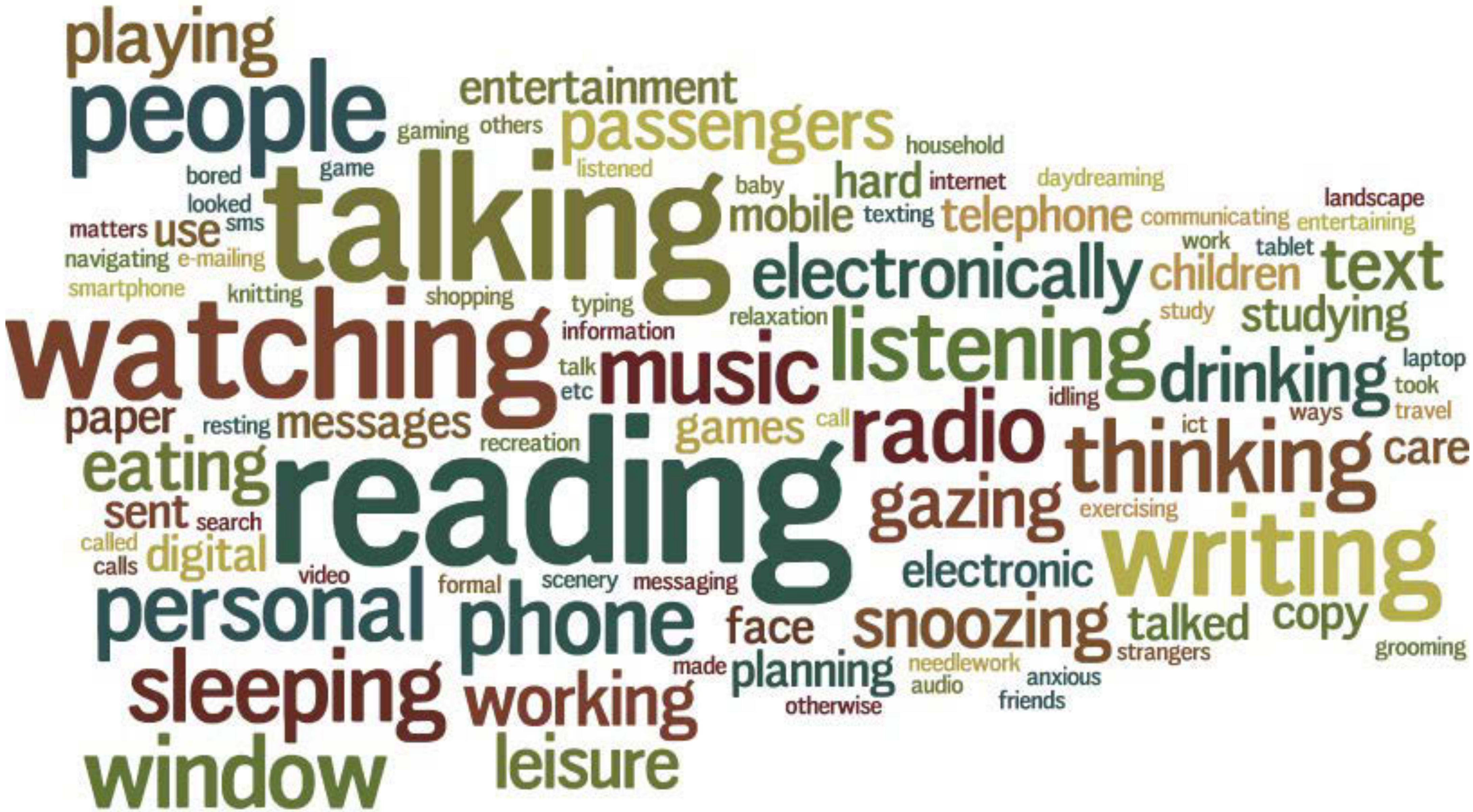
Fan (2016)

Impacts: Longer trip distances & durations

Mokhtarian and Salomon (2001): Excess travel is more likely to occur as people increase the perceived positive utility of activities



Fan (2016)


playing
people
entertainment
gaming
others
passengers
household
bored
game
listened
talking
looked
baby
hard
internet
daydreaming
landscape
matters
use
sms
mobile
texting
telephone
communicating
entertaining
navigating
e-mailing
work
tablet
smartphone
knitting
shopping
electronically
children
text
typing
relaxation
study
studying
watching
information
listening
laptop
talk
music
drinking
took
etc
idling
ways
travel
paper
resting
messages
call
radio
ict
games
recreation
thinking
care
eating
reading
gazing
sent
search
exercising
called
digital
calls
video
electronic
writing
formal
scenery
messaging
personal
phone
face
snoozing
talked
copy
made
planning
needlework
strangers
grooming
audio
anxious
sleeping
working
otherwise
friends
window
leisure

Fan (2016)

Connectivity

Types of Connectivity

Types of Connectivity

- Vehicle Condition (On-Star)

Types of Connectivity

Types of Connectivity

Types of Connectivity

Types of Connectivity

- Road Condition Information (Ice Patch)

Types of Connectivity

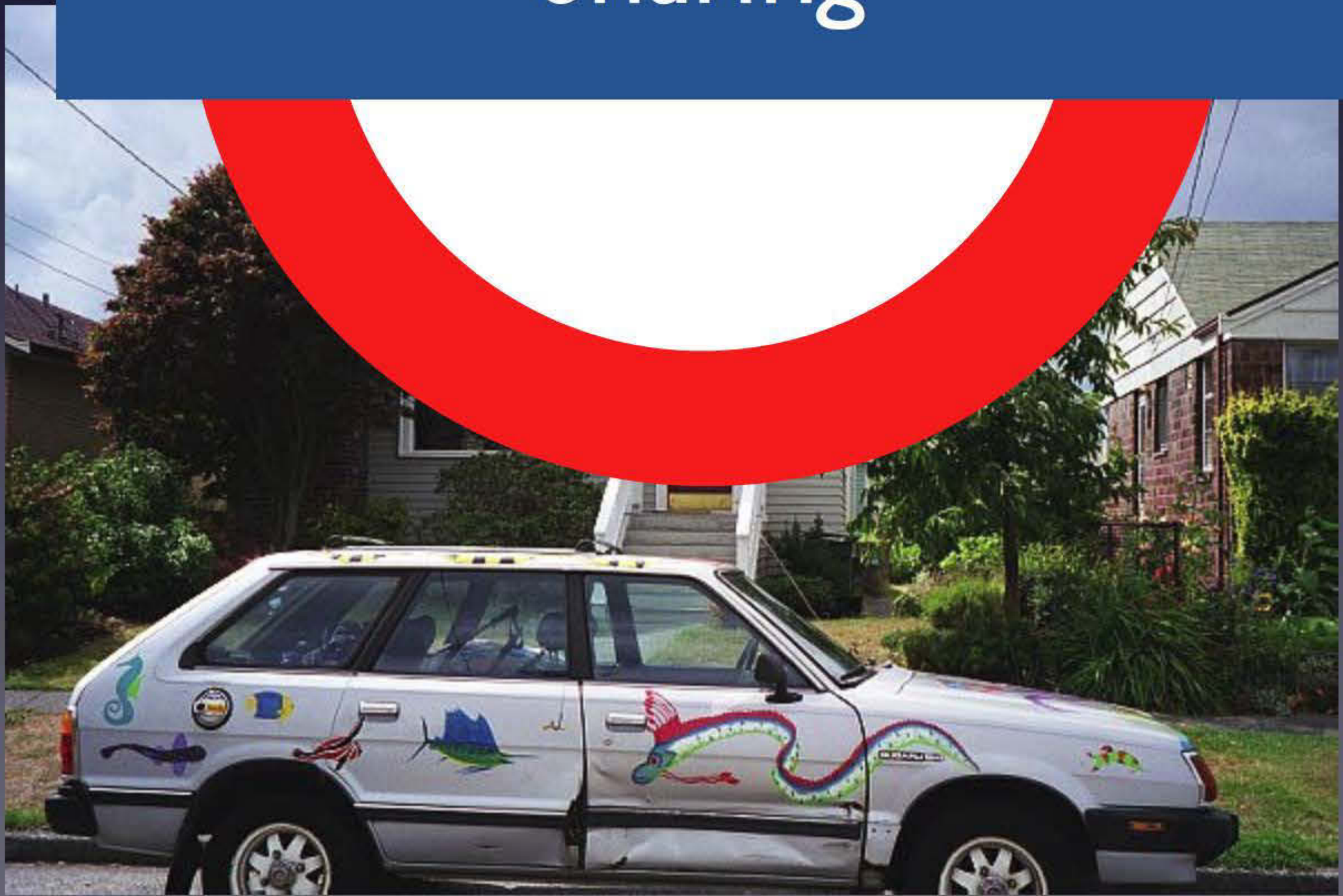
Types of Connectivity

Types of Connectivity

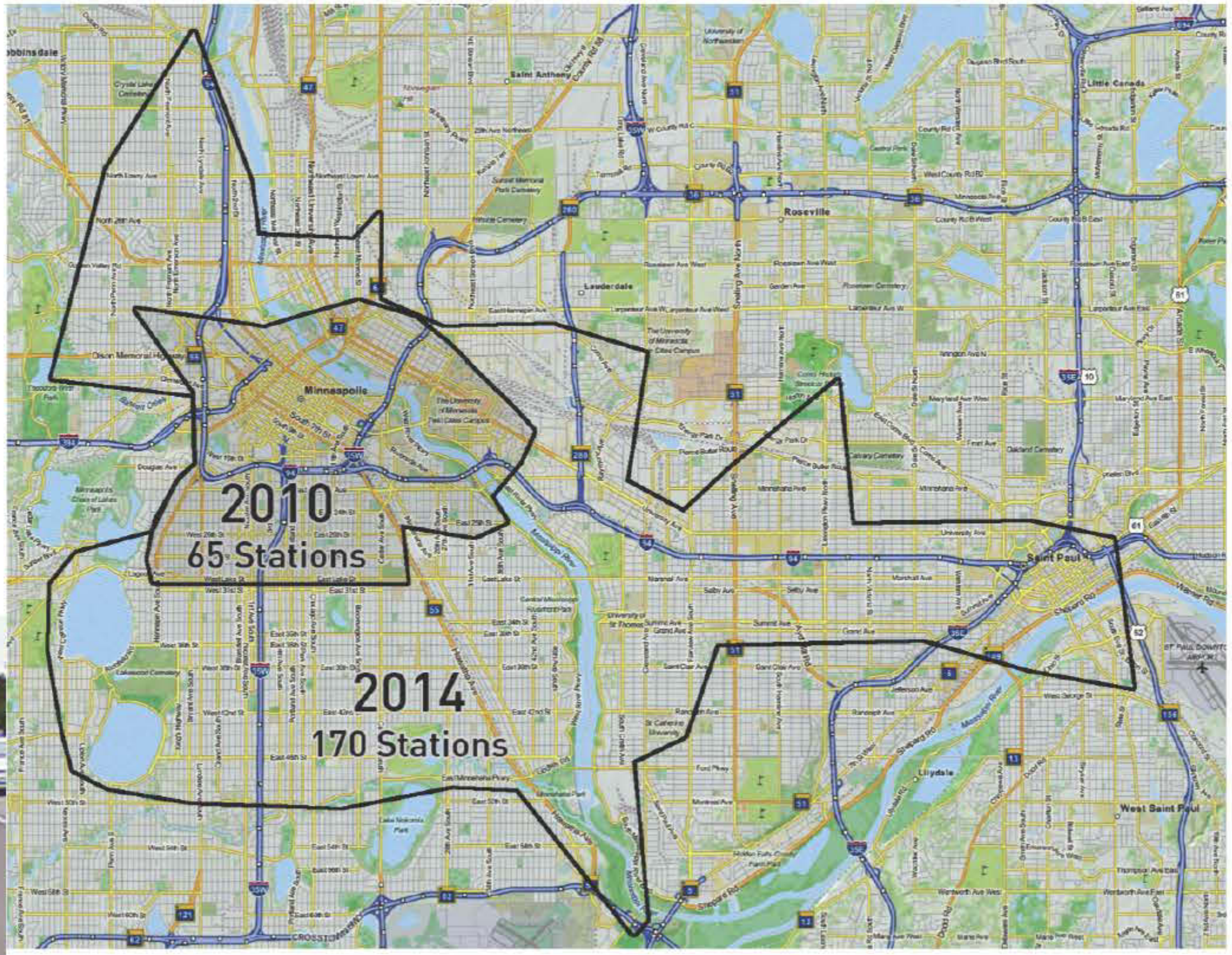
Types of Connectivity

Types of Connectivity

Sharing




STARBUCKS COFFEE
MaaS Transport

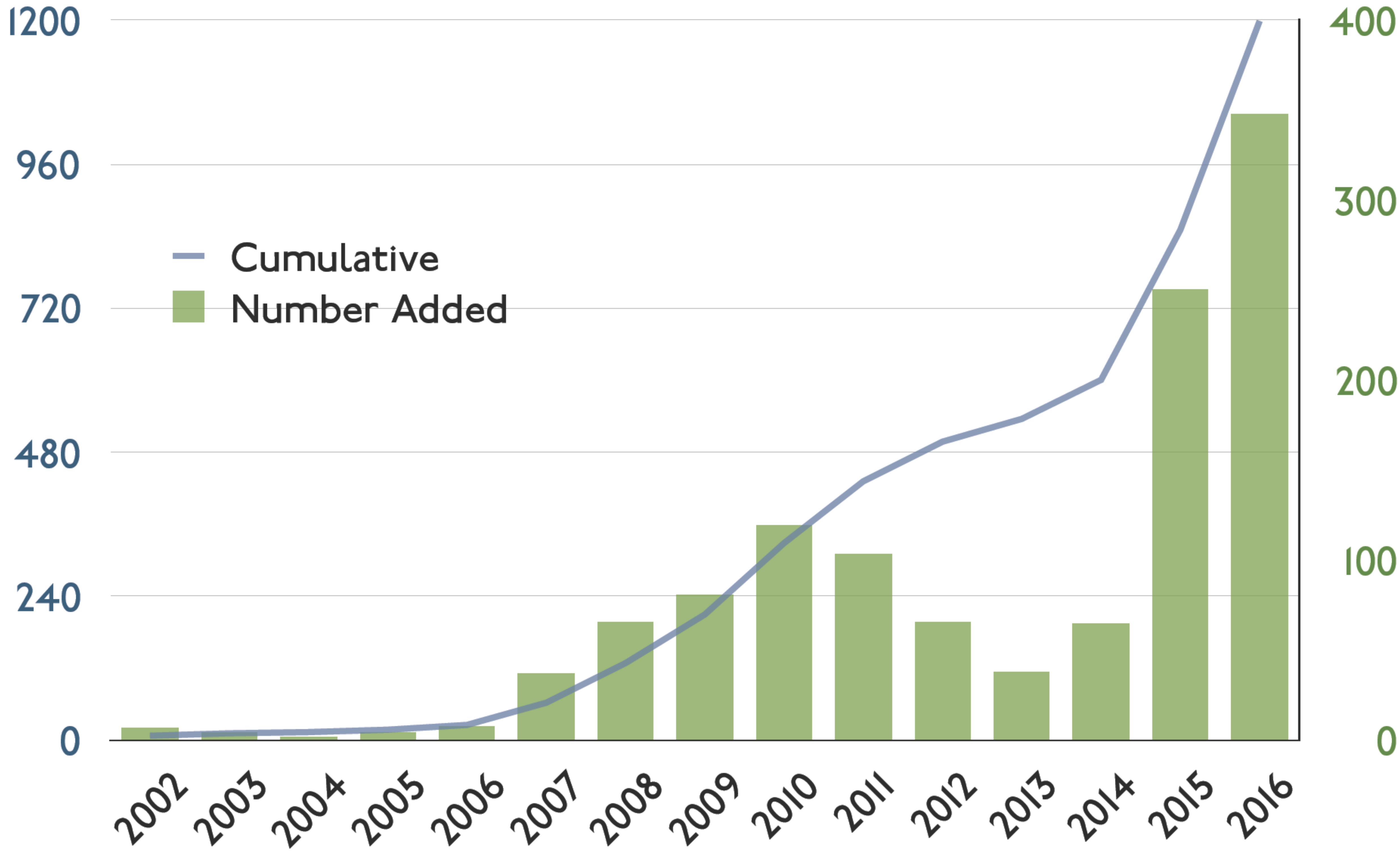


Comparing Nice Ride's service area in 2010, the first year of operation, and 2014, the most recent year of operation.

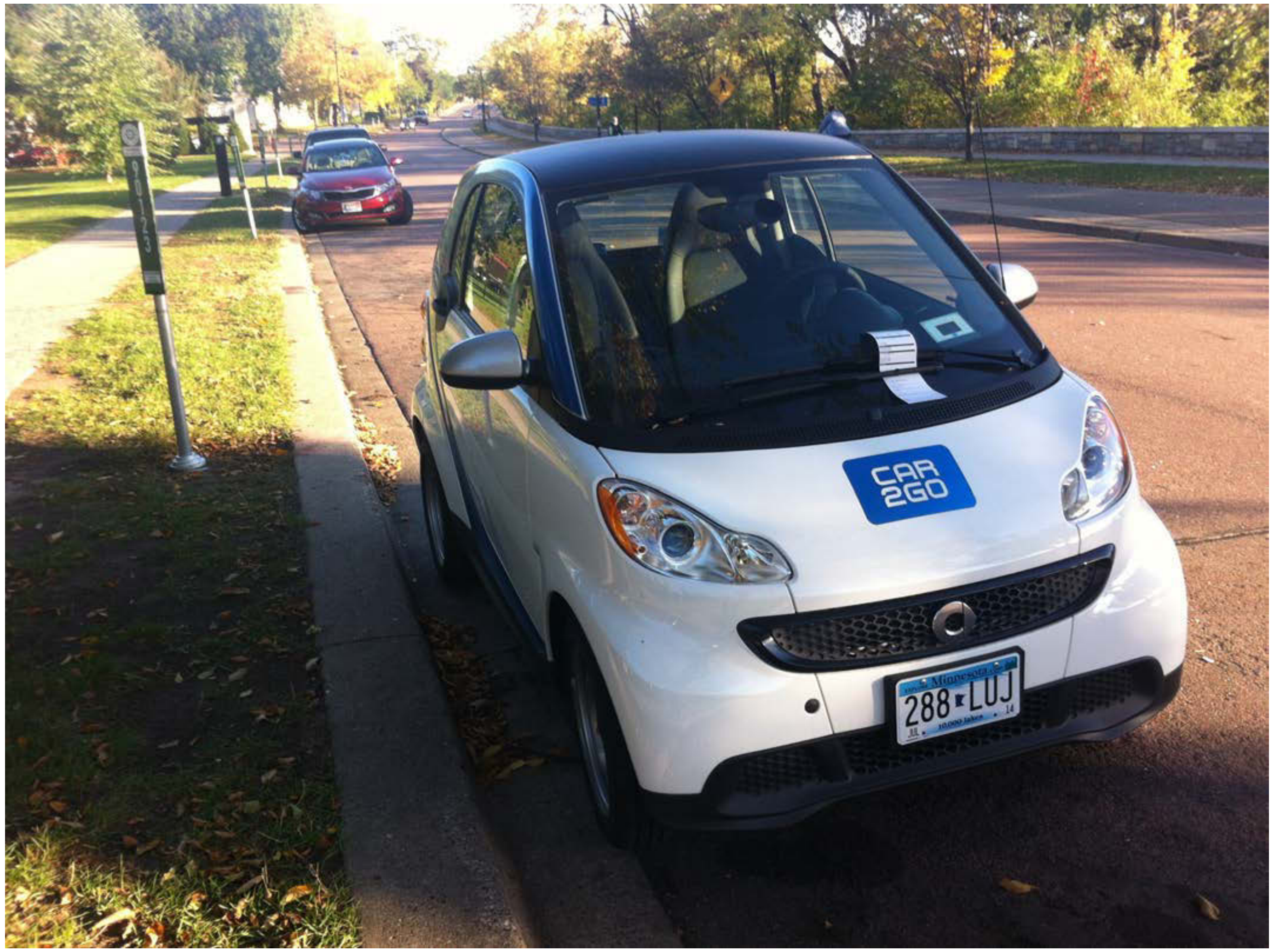
Source: NiceRide


24小时自助银行服务
交通银行
享骑电单车
享骑出行
xqchuxing
mobike
ofo
02160T1771

Figure 8.3 Growth of Bike Sharing Systems Globally

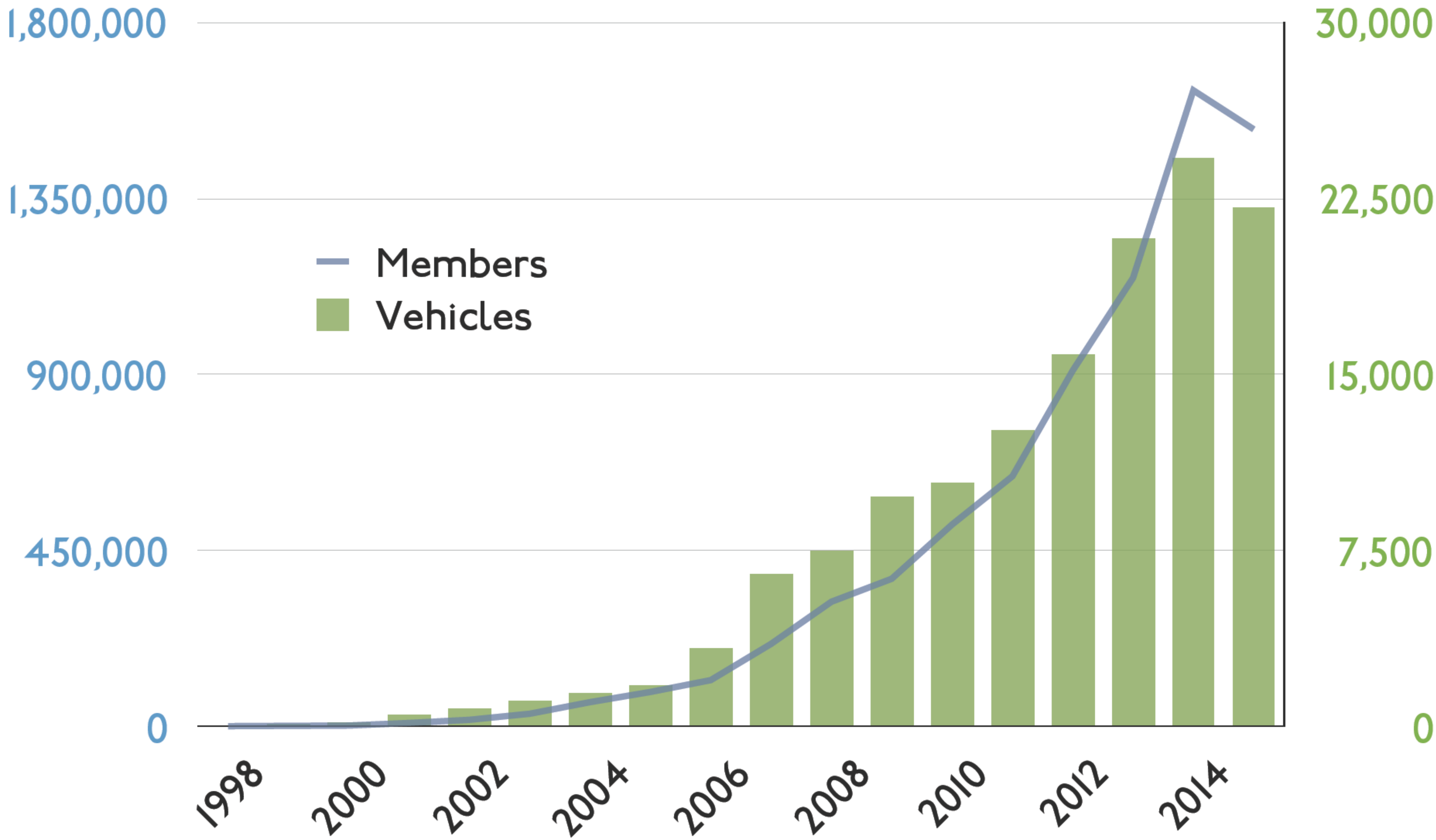


Source: McCarthy, Niall "Bikesharing Takes Off" Statista http://www.statista.com/chart/1148/bike-sharing-takes-off/ .



Car2Go | Smart Fortwo

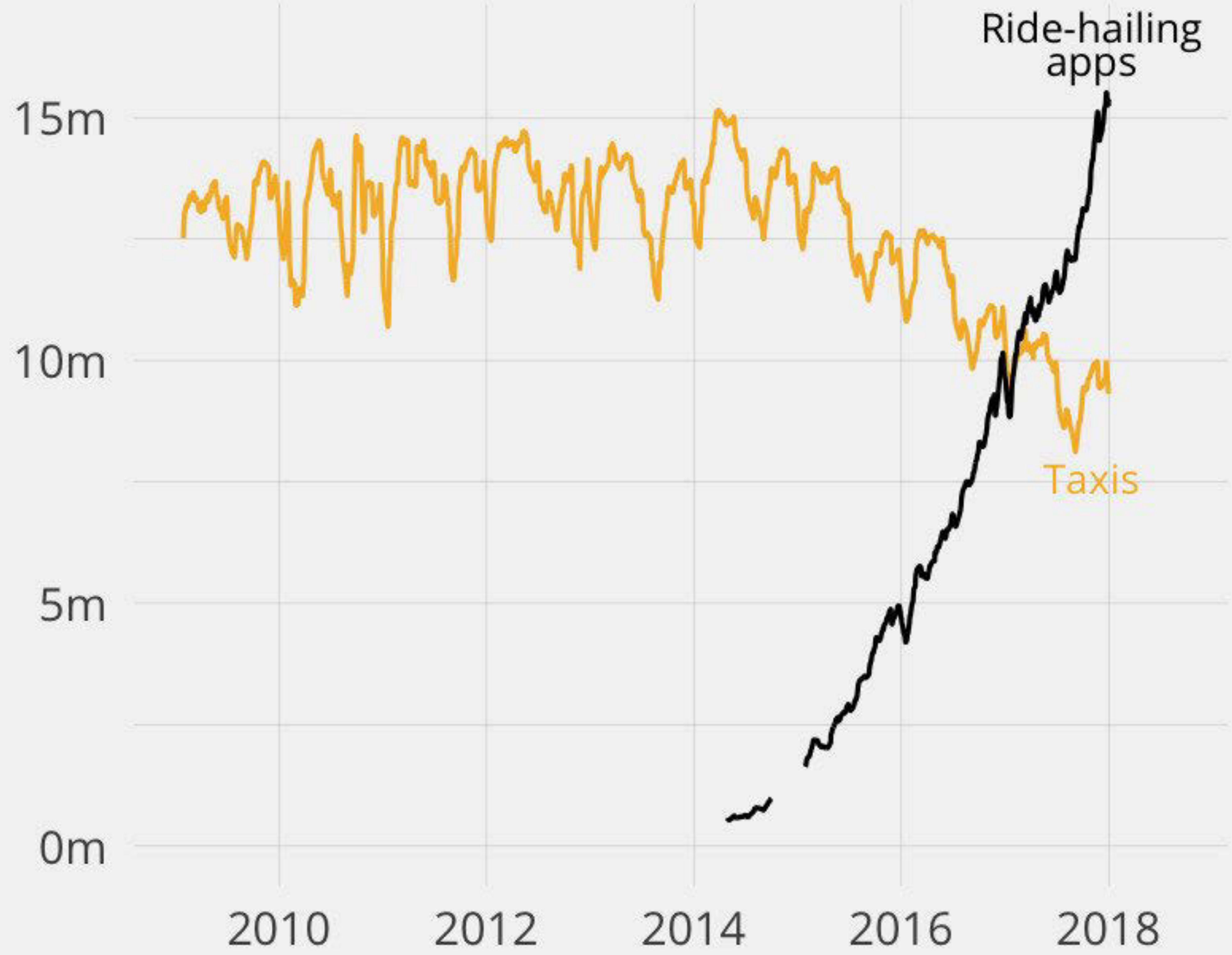
Figure 8.2 North American Carsharing Growth



Source: Shaheen and Cohen (2015)

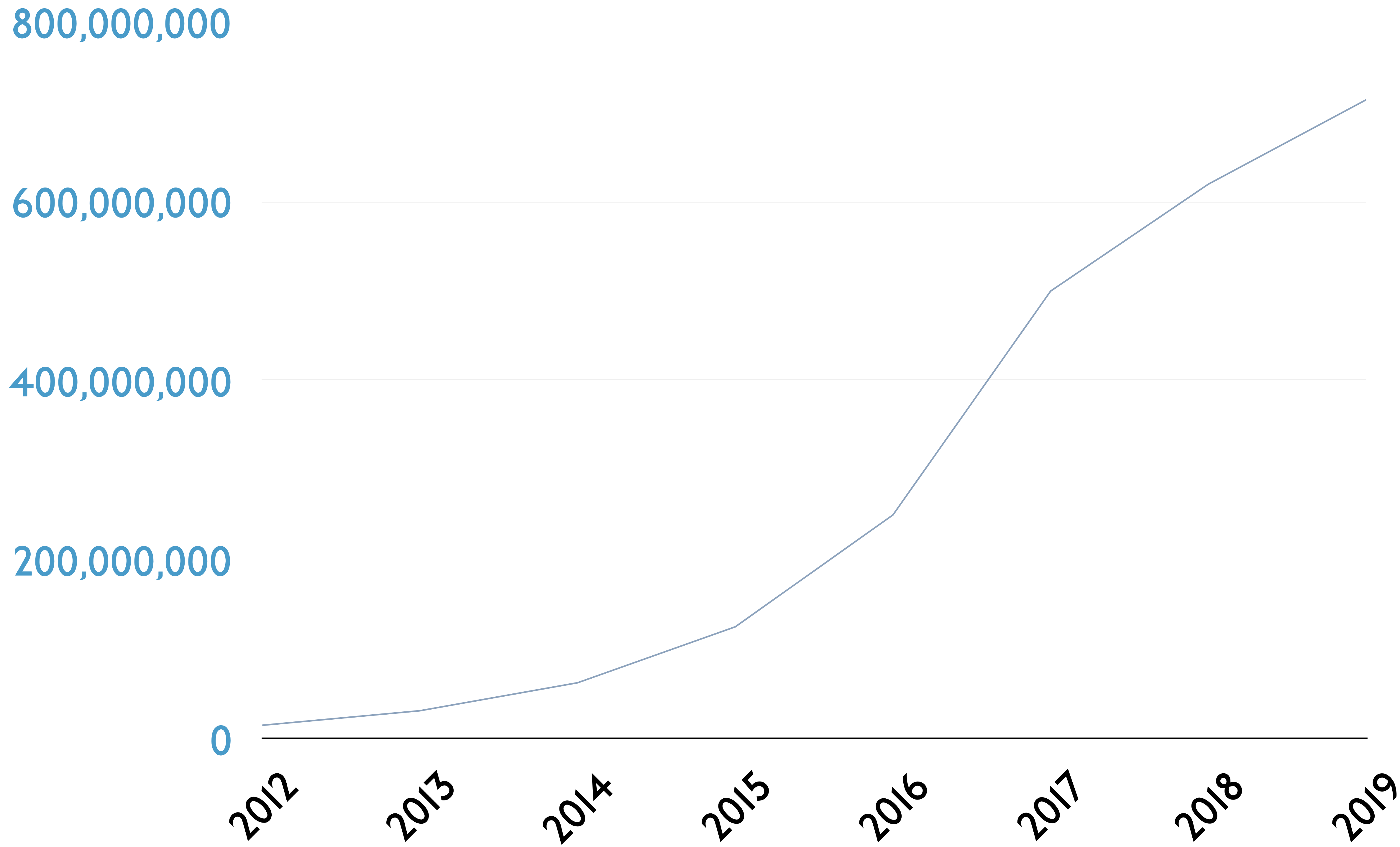
NYC Monthly Taxi Pickups

Trailing 28 days



Ride-hailing apps include Uber, Lyft, Juno, Via, and Gett; taxis include yellow and green
Data via NYC TLC
toddwschneider.com

Figure: Lyft's Rides Per Year (estimated)



CNBC, Lyft, various

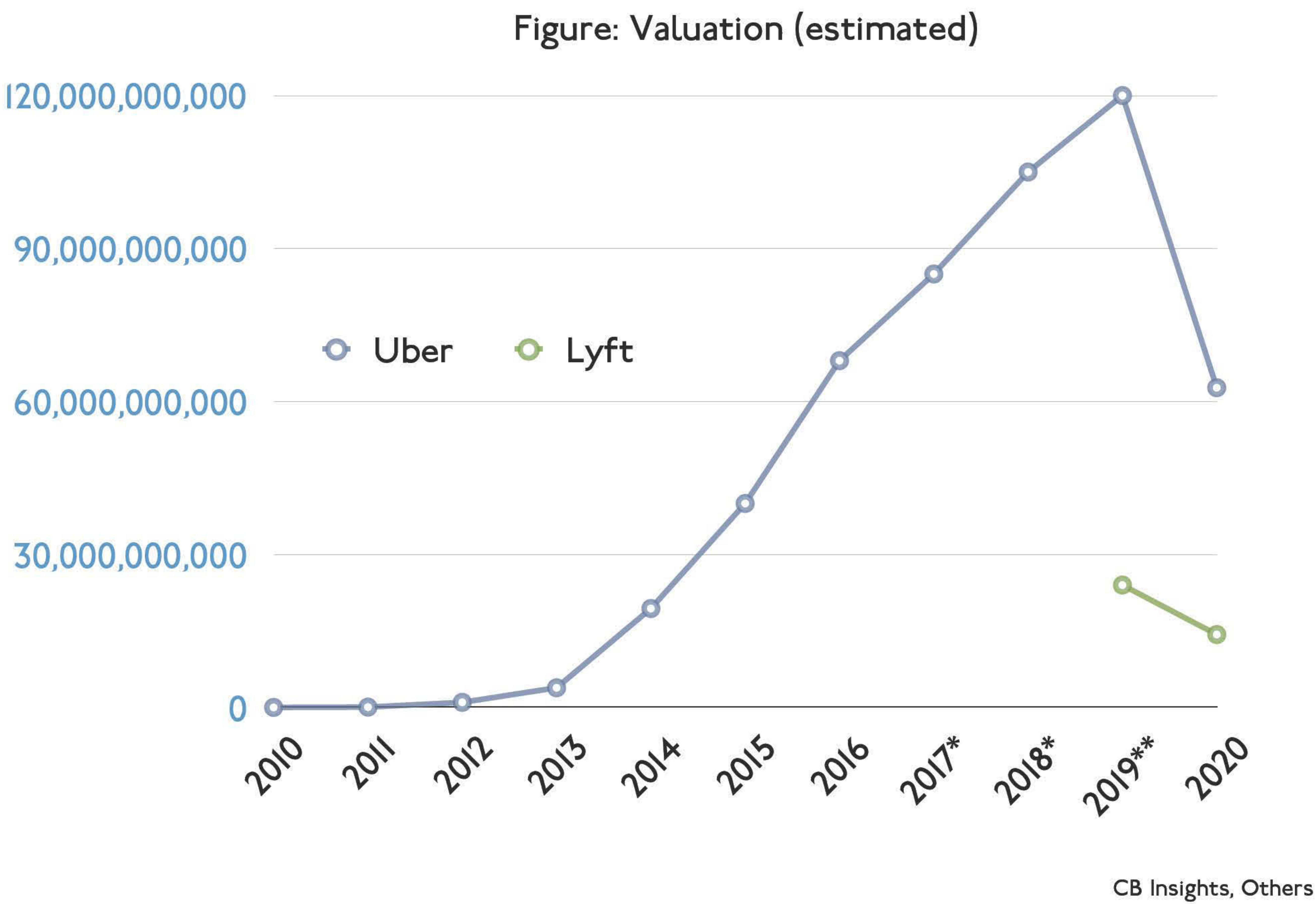


Figure: Valuation (estimated)
120,000,000,000
90,000,000,000
60,000,000,000
30,000,000,000
0
Uber
Lyft
2010
2011
2012
2013
2014
2015
2016
2017*
2018*
2019**
2020
CB Insights, Others

Cloud Commuting

Cloud Commuting

- Fleet (Taxi / Uber / 'Ride-sharing'/ `Ride-hailing' Model) (vs. Individual) Ownership

Cloud Commuting

Cloud Commuting

Cloud Commuting

Cloud Commuting

Cloud Commuting

- electrified so lowered vehicle capital and maintenance costs

Cloud Commuting

Cloud Commuting

Cloud Commuting

Cloud Commuting

Demassification

A Cambrian Explosion of Vehicle Forms

"Google Car"

Renault Twizy

G-Wiz Electric Vehicle (UK)

Shape-Sifting

MIT “Stackable City Car” Concept

Smaller

Smaller

Toyota iRoad

Smaller

GM Lean Machine

Toyota iRoad

Smaller

GM Lean Machine

Toyota iRoad

Gogoro


GMC
6JEY683
2BER02B

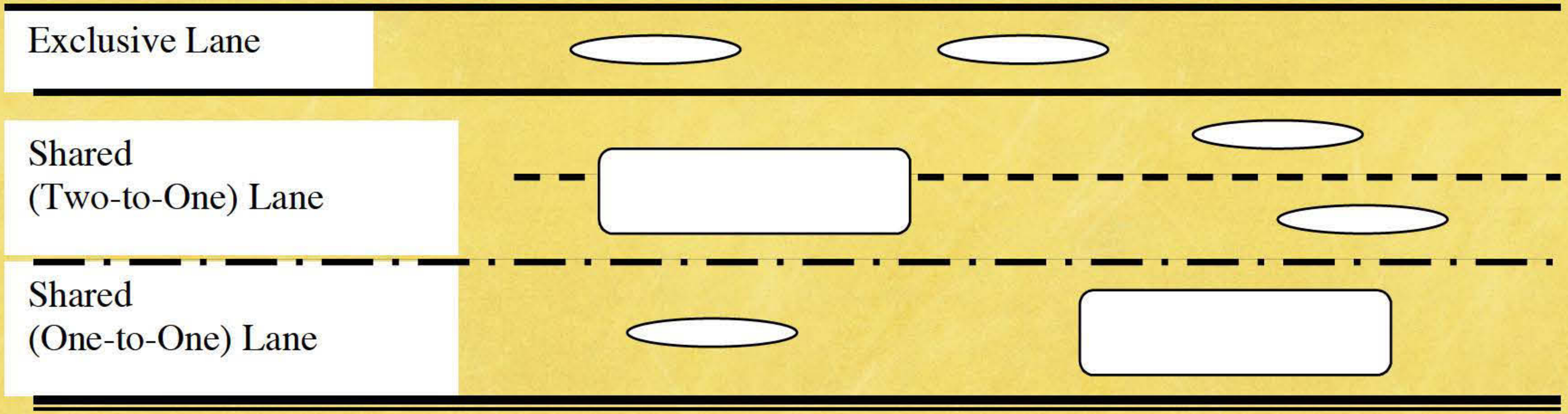
And Bigger

"Toyota Swagger"

with Fewer Wheels?

Ryno

eBikes



Alternative Vehicles, Alternative Highways


Delivery
POST
18 VR 86

Last Mile

Up and Out

SAEVs vs. PAEVs

SAEVs vs. PAEVs

Shared Autonomous
Electric Vehicles

SAEVs vs. PAEVs

Shared Autonomous
Electric Vehicles

Reduced per capita vehicle travel (higher per trip cost - no Fixed, high Variable cost)

SAEVs vs. PAEVs

Shared Autonomous Electric Vehicles

Reduced per capita vehicle travel (higher per trip cost - no Fixed, high Variable cost)

Some deadheading (driverless/passengerless to find next passenger)

SAEVs vs. PAEVs

Shared Autonomous
Electric Vehicles

Reduced per capita vehicle travel (higher per trip cost - no Fixed, high Variable cost)

Some deadheading (driverless/passengerless to find next passenger)

Less parking

SAEVs vs. PAEVs

Shared Autonomous Electric Vehicles

Reduced per capita vehicle travel (higher per trip cost - no Fixed, high Variable cost)

Some deadheading (driverless/passengerless to find next passenger)

Less parking

Private (Personal) Autonomous Electric Vehicles

SAEVs vs. PAEVs

Shared Autonomous Electric Vehicles

Reduced per capita vehicle travel (higher per trip cost - no Fixed, high Variable cost)

Some deadheading (driverless/passengerless to find next passenger)

Less parking

Private (Personal) Autonomous Electric Vehicles

Increased per capita vehicle travel (lower per trip cost, high Fixed, low Variable cost)

SAEVs vs. PAEVs

Shared Autonomous Electric Vehicles

Reduced per capita vehicle travel (higher per trip cost - no Fixed, high Variable cost)

Some deadheading (driverless/passengerless to find next passenger)

Less parking

Private (Personal) Autonomous Electric Vehicles

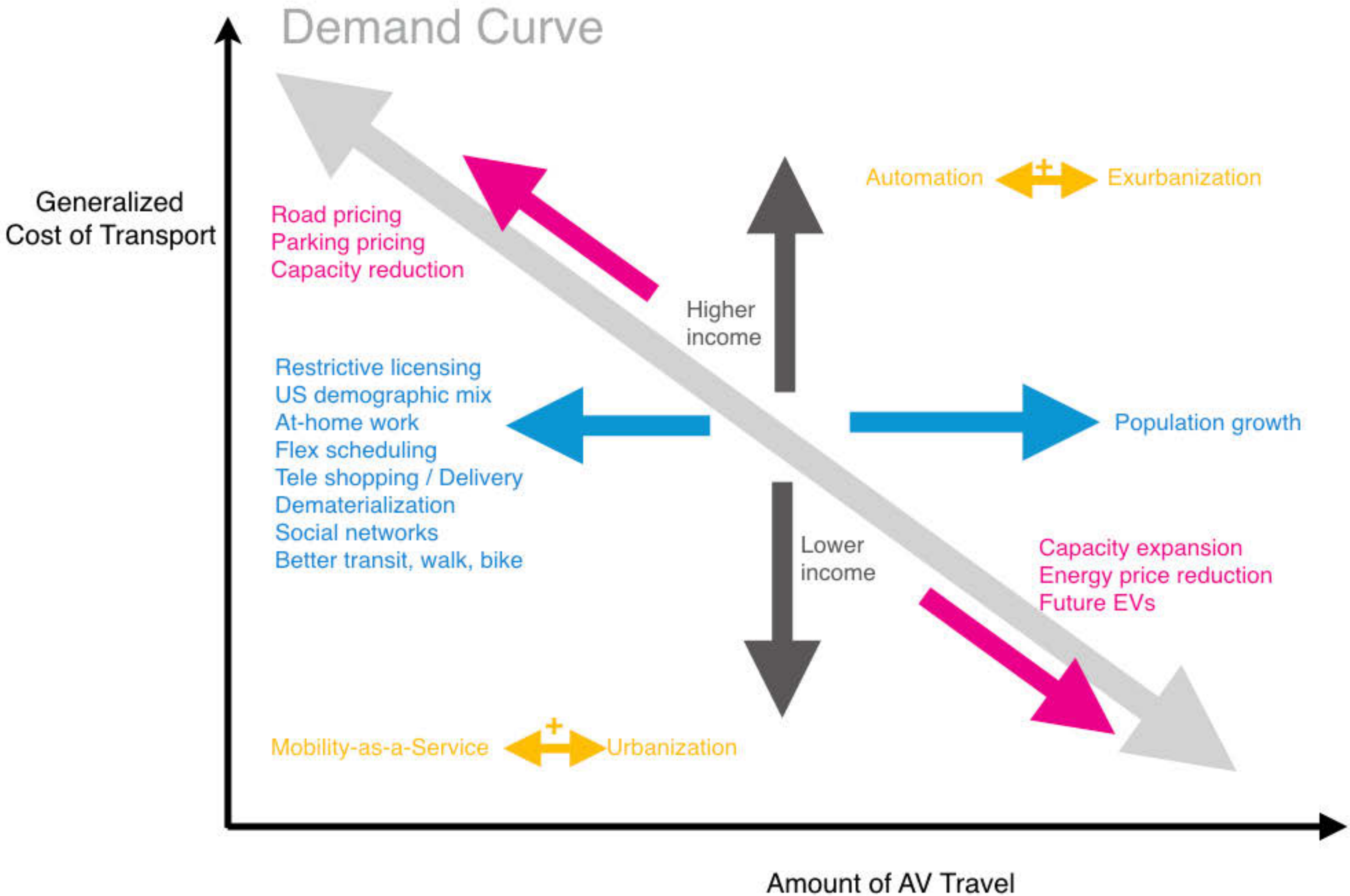
Increased per capita vehicle travel (lower per trip cost, high Fixed, low Variable cost)

Some deadheading (driverless/passengerless to find parking)

Land Use Consequences (MaaS + AVs)

Up and Out: The Future of Travel Demand and Where We Live

Figure 10.1: The future of transport demand



Up

- Up: Less vehicle ownership with increased use of MaaS in cities, raising the value of cities.

Up

Up

Up

Up

Up

Up

- The greater value in cities with the new more convenient technology leads to more and taller development. (Hence the use of the word “Up”.)


Out

- Out: More vehicle travel with increased exurbanization.


Out


Out


Out


Out

Out

- People will live farther "Out".

Adapting the Built Environment


Space Now Devoted
to Car Storage can
be Repurposed
ap


Chevron
Self
Self
Space Now Devoted to
Refueling can be Repurposed


Excess Space Now Devoted to Movement can be Repurposed
NO RIGHT TURN


Reduce, Reuse, (re)Cycle

Reduce, Reuse, Bicycle

- Most roads are under-used most of the time. There is ample capacity outside the peak.
- Most of the pavement is unused even at peak times; there are large gaps between vehicles both in terms of the headway between vehicles and the lateral spacing between vehicles. Americans drive 6 foot wide cars in 12 foot lanes, often on highways with wide shoulders.
- Most seats in most cars are unoccupied most of the time.
- Most cars contain far more weight than required to safely move the passenger. While bigger cars might be safer for the occupants, they are less safe for non-occupants. This is an inefficient arms race.
- Many roads are so wide we use them for storage of vehicles most of the day.
- There is excessive delay at traffic lights, especially during off-peak periods, wasting time and space.

Dimensions

- Vehicle width/ Lane width
- Vehicle weight
- Vehicle occupancy
- Traffic signals and stop signs

Figure 12.1 Narrowly marked street lane in Palermo, Italy.

Right-sizing Roads

- Five stages of repurposing. A Kübler-Ross model of grief felt by the motorist at the forthcoming loss of automobile roadspace for cycling facilities.

- **STAGE 1: DENIAL** applies to most communities across the US, whose residents refuse to acknowledge that street space will be or needs to be changing. Examples: Anytown, USA.

- **STAGE 2: ANGER** is exemplified by the so-called ”War on Bikes” and ”War on Cars” that are riveting cities trying to make modest changes, like replacing parking with bike lanes or designating ’bicycle boulevards’. Examples: New York, Washington DC, Toronto.

- **STAGE 3: BARGAINING** refers to desire to re-design select areas to reduce auto presence. Examples: St. Paul, Minnesota.

- **STAGE 4: DEPRESSION** builds on Bargaining as the perceived losers in the War on Cars (drivers) stop fighting the extension of non-auto infrastructure into full corridors. Examples: Minneapolis, Minnesota.

- **STAGE 5: ACCEPTANCE** means community-wide consensus to reduce auto space by removing on-street parking overall, installing parking in former vehicular lanes, or any of a series of other treatments (e.g., buffered bicycle lanes, bulb-outs). Examples: Davis, California and Portland, Oregon.

Figure 12.2. Installation of the street repurposing project in Boulder

Reuse

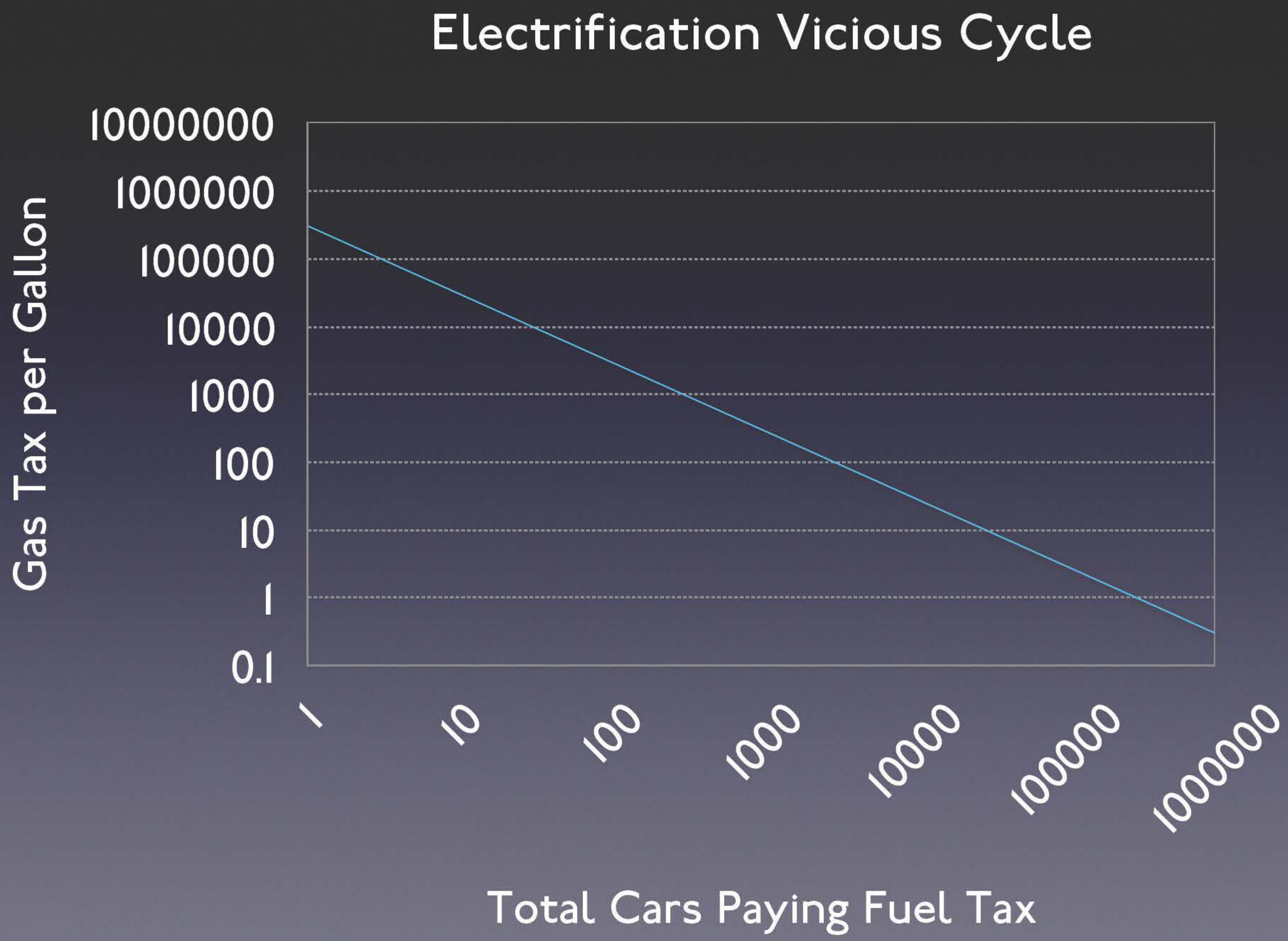
- Plastics
- Paint
- Plasticity


SE ARRIENDA
310 824 40 67
Z.E.R
XTC
GT

Bicycle


SE ARRIENDA
310 824 40 67
P
Z.E.R
GT

Pricing



Electrification Vicious Cycle
Gas Tax per Gallon
10000000
1000000
100000
10000
1000
100
10
1
0.1
1
10
100
1000
10000
100000
1000000
Total Cars Paying Fuel Tax

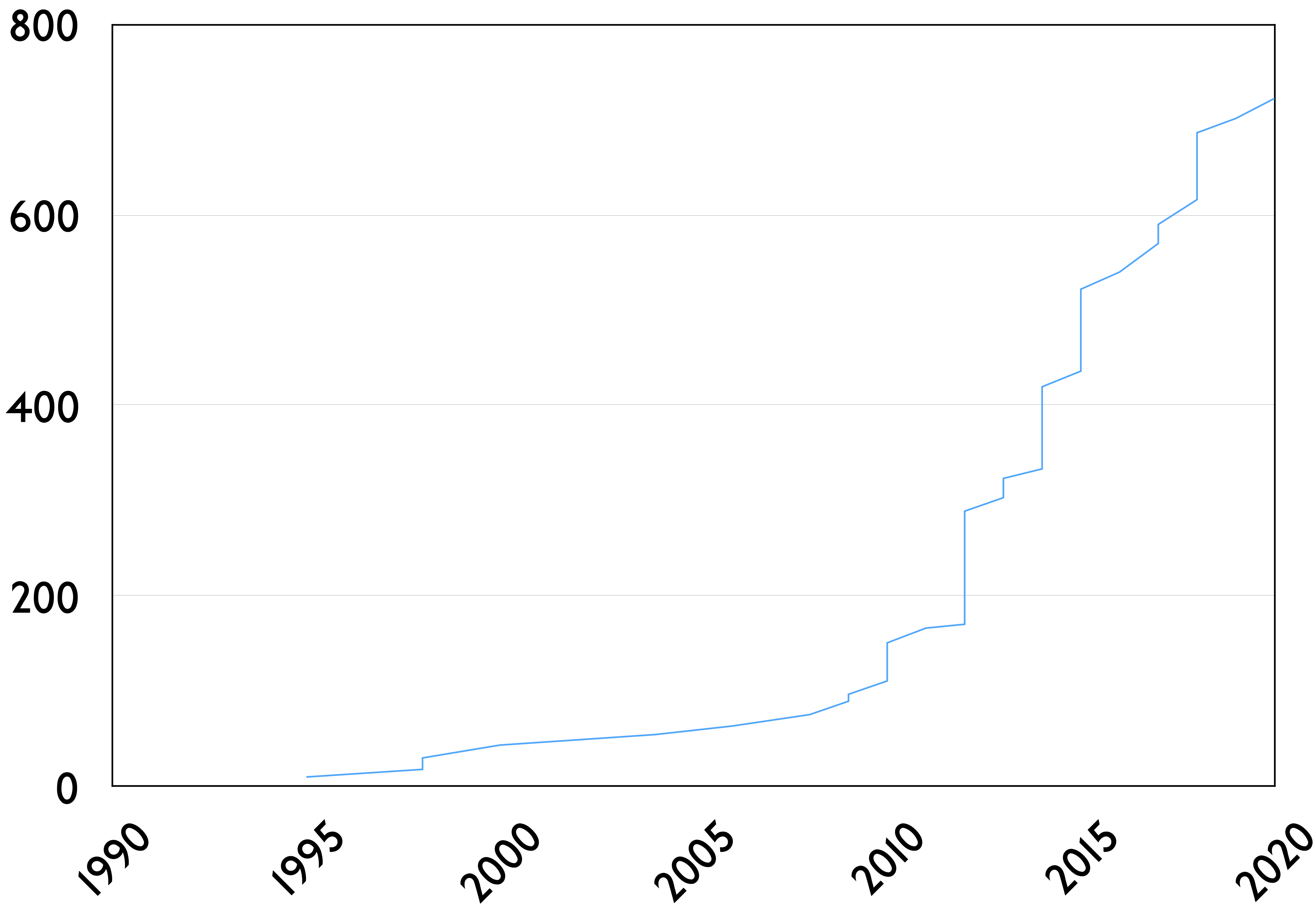
All congestion is unnecessary: Accelerating the end of traffic via pricing

- Fuel Tax
- Implementing Road Pricing One Electric Vehicle at a Time
- Networks of HOT Lanes
- Reservation Pricing
- Roads as a Public Utility

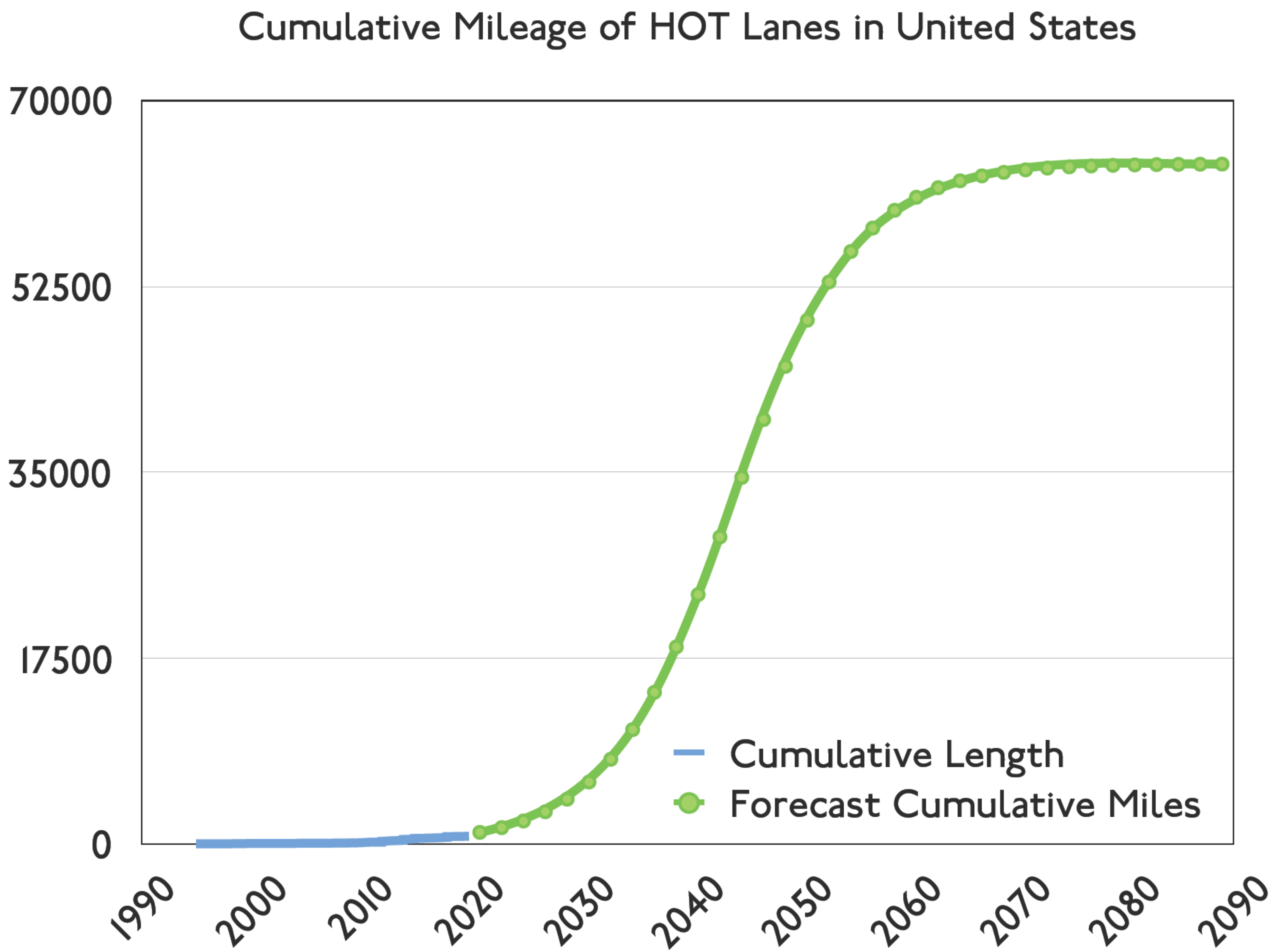
The fuel tax does not

- account for cost inflation in the road sector. (Unless indexed)
- account for rising fuel efficiency.
- pay for local roads.
- pay for pollution.
- pay for crashes, which are borne individually through worsened health and life outcomes, and socially through the health care system. (Pay as you go insurance does this, and is related to fuel tax in some places)
- raise revenue from vehicles that do not use gasoline for fuel.
- recover pavement damage from heavy vehicles. (NZ does this though)
- address congestion, which requires time of day differentiation. Traffic congestion is a problem. It is not getting measurably worse over the past two decades, but it is not getting obviously better.

Cumulative Mileage of HOT Lanes in United States



Source: Levinson (2016) Transportation Futures Project



Source: Levinson (2016) Transportation Futures Project

How to get to a replacement?

- EVs don't pay fuel tax, yet use roads.
- AVs may pay fuel tax, but don't pay driver's time, and may be person-less when traveling.
- Retaining the highway user fee principle requires charging AVs and EVs once a sufficient number make it relevant.
- Vary vehicle mileage charge for EVs and AVs and opt-ins (and eventually all vehicles) by location and time-of-day.


Redeeming Transport

Redeeming Transport

- How can we still get the gains of auto-mobility without the costs?
- Change from outside rather than inside (DOT follows, does not lead)

Policy Implication:

- Increased throughput per square meter of pavement (along with flattened demand) indicates fewer square meters of pavement are required.

Transport is Interesting, Again

In most industrialized countries, car travel per person has peaked and the automobile regime is showing considerable signs of instability. As cities across the globe venture to find the best ways to allow people to get around amidst technological and other changes, many forces are taking hold — all of which suggest a new transport landscape. Our roadmap describes why this landscape is taking shape and prescribes policies informed by contextual awareness, clear thinking, and flexibility.

Table of Contents

Network
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Lab

The End of Traffic and the Future of Access Levinson ◆ Krizek

The End of Traffic and the

Future of Access

A Roadmap to the New Transport Landscape

David M. Levinson ◆ Kevin J. Krizek

¿Questions?