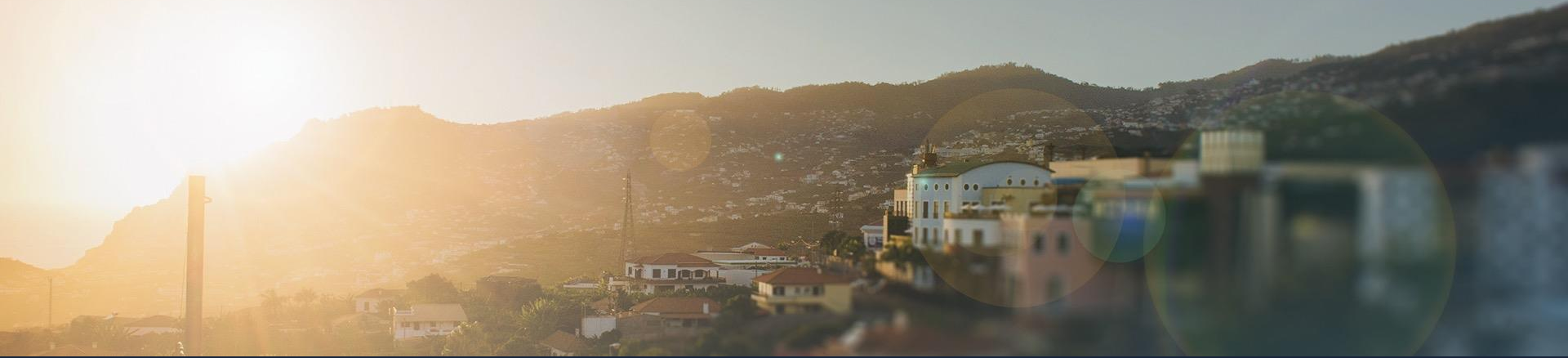


# Mexico & the Clean Energy Revolution



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## Entrepreneur & Investor: Solar and Bitcoin



Max Webster

**versionone**

**Bright**

Yale

- 
- I. Challenges of a Generation**
  - II. Exponential Technologies**
  - III. Solar Energy**
  - IV. Storage (Batteries)**
  - V. EVs (Autonomous Fleets)**
  - VI. What does this mean for me?**

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# I. Challenges of a Generation

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# Climate Change





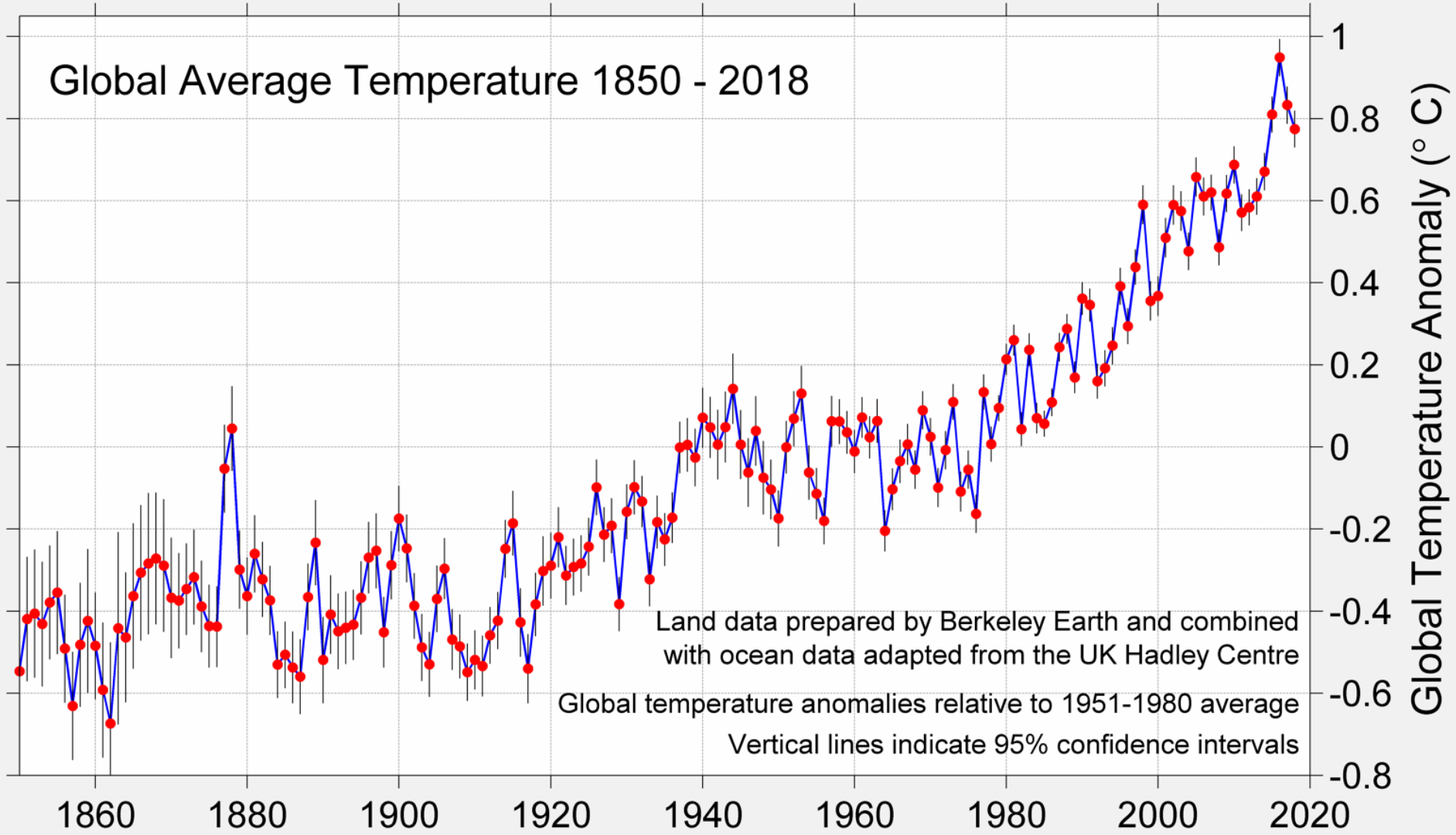




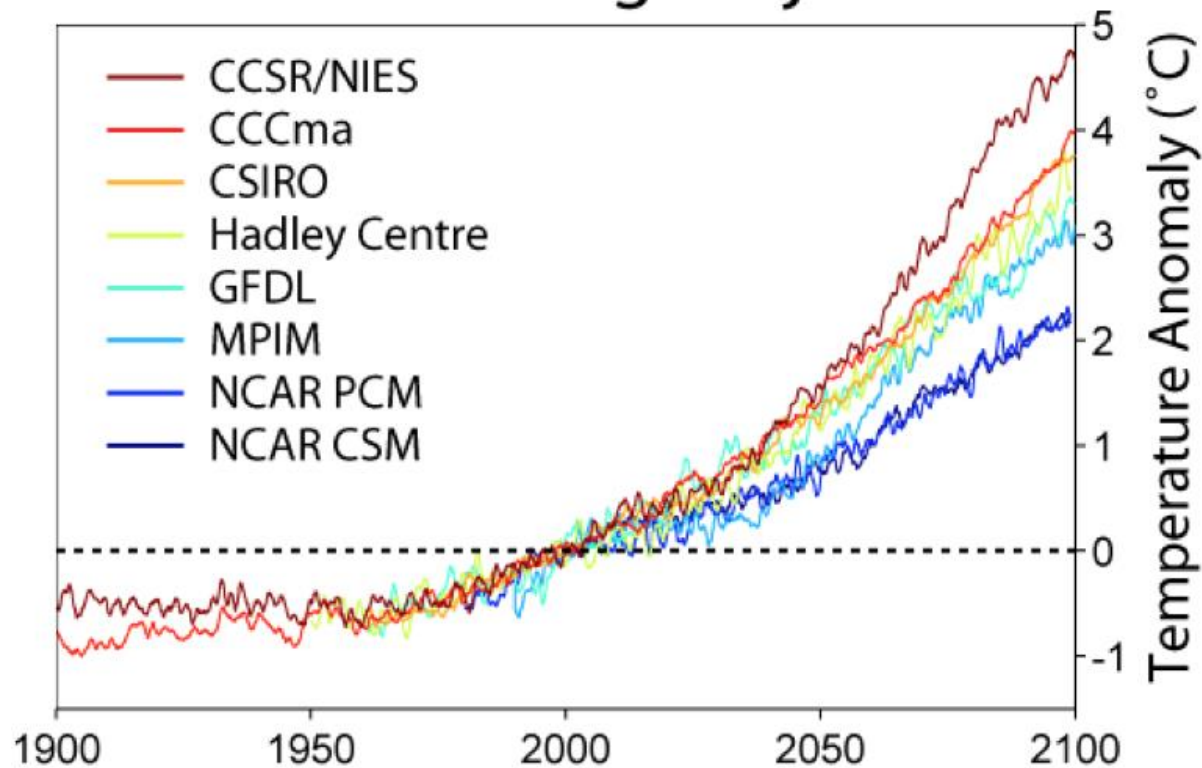




# Global Average Temperature 1850 - 2018



# Global Warming Projections



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# Energy Poverty





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# Air Pollution





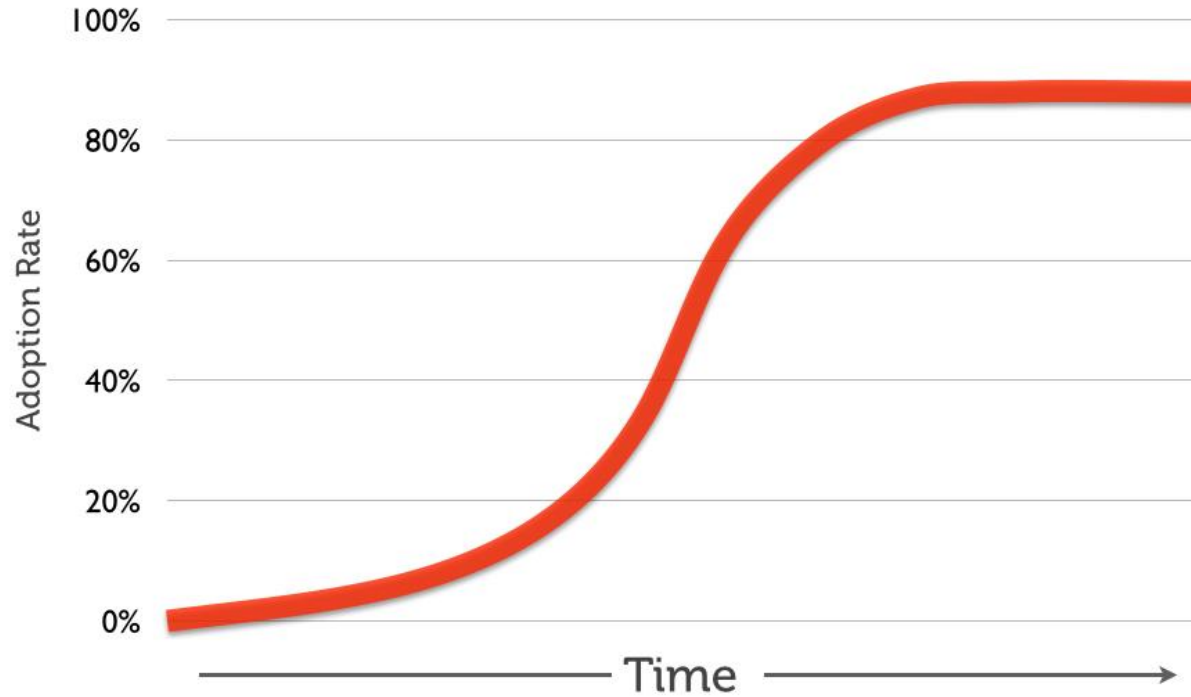


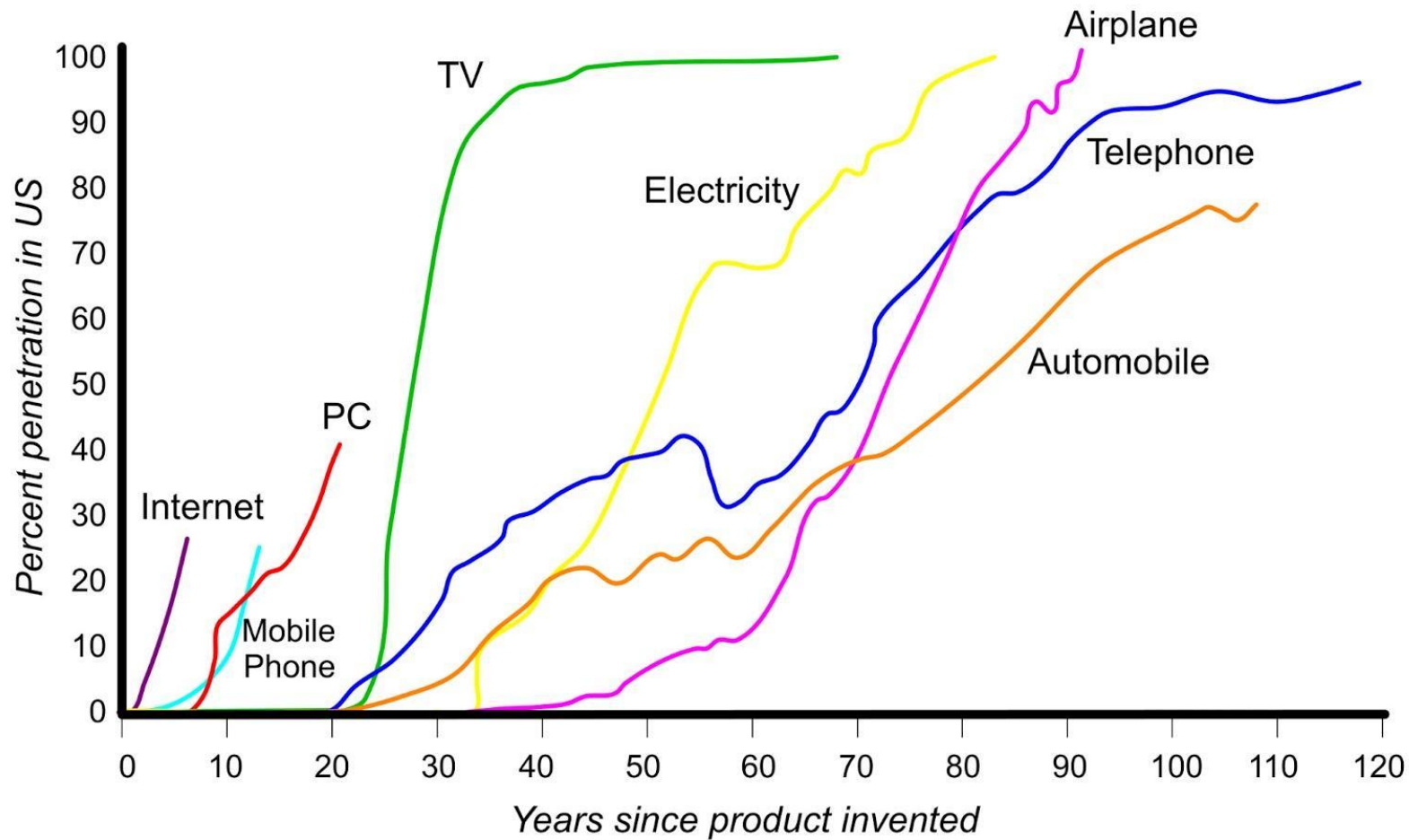


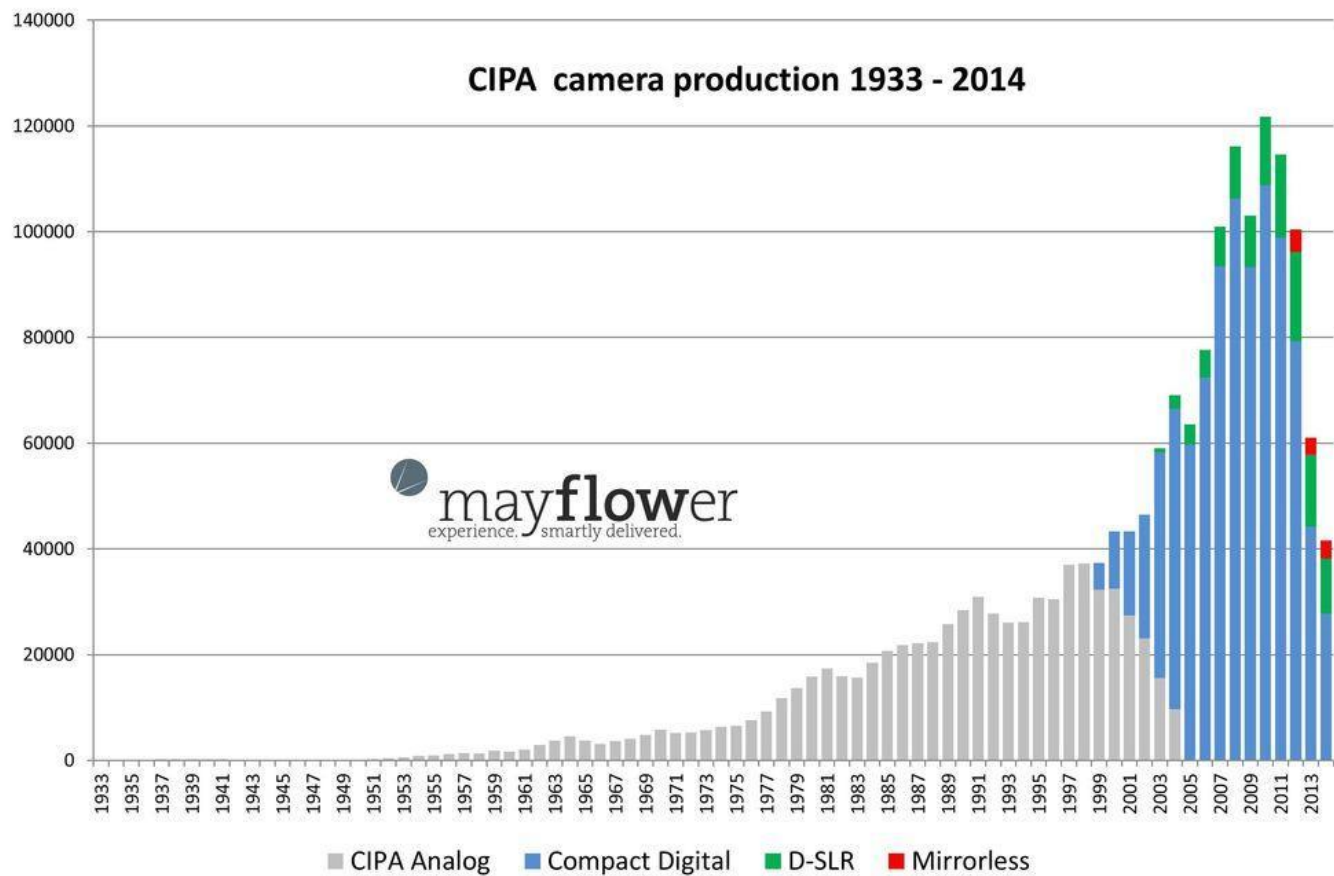
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## II. Exponential Technologies

## — S-Curve Adoption Model









## Exhibit I

Price of Model T, 1909-1923 (Average list price in 1958 dollars)

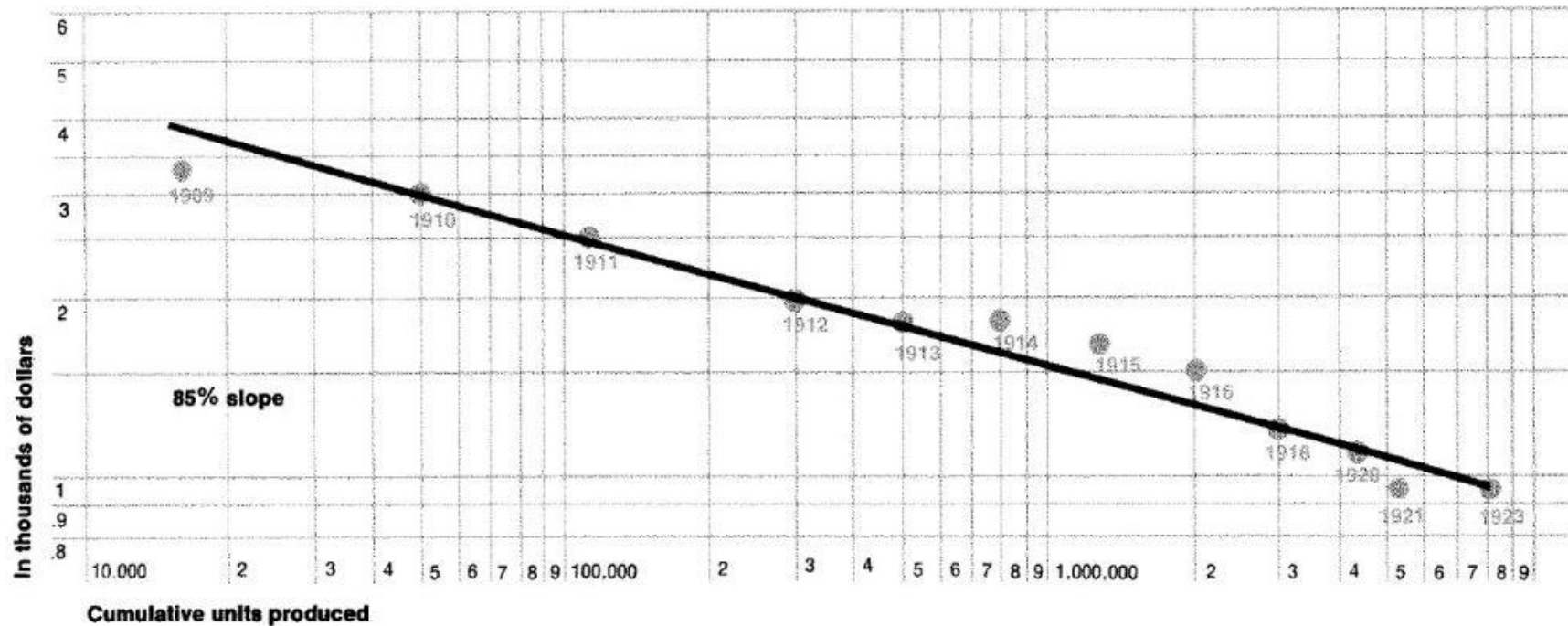
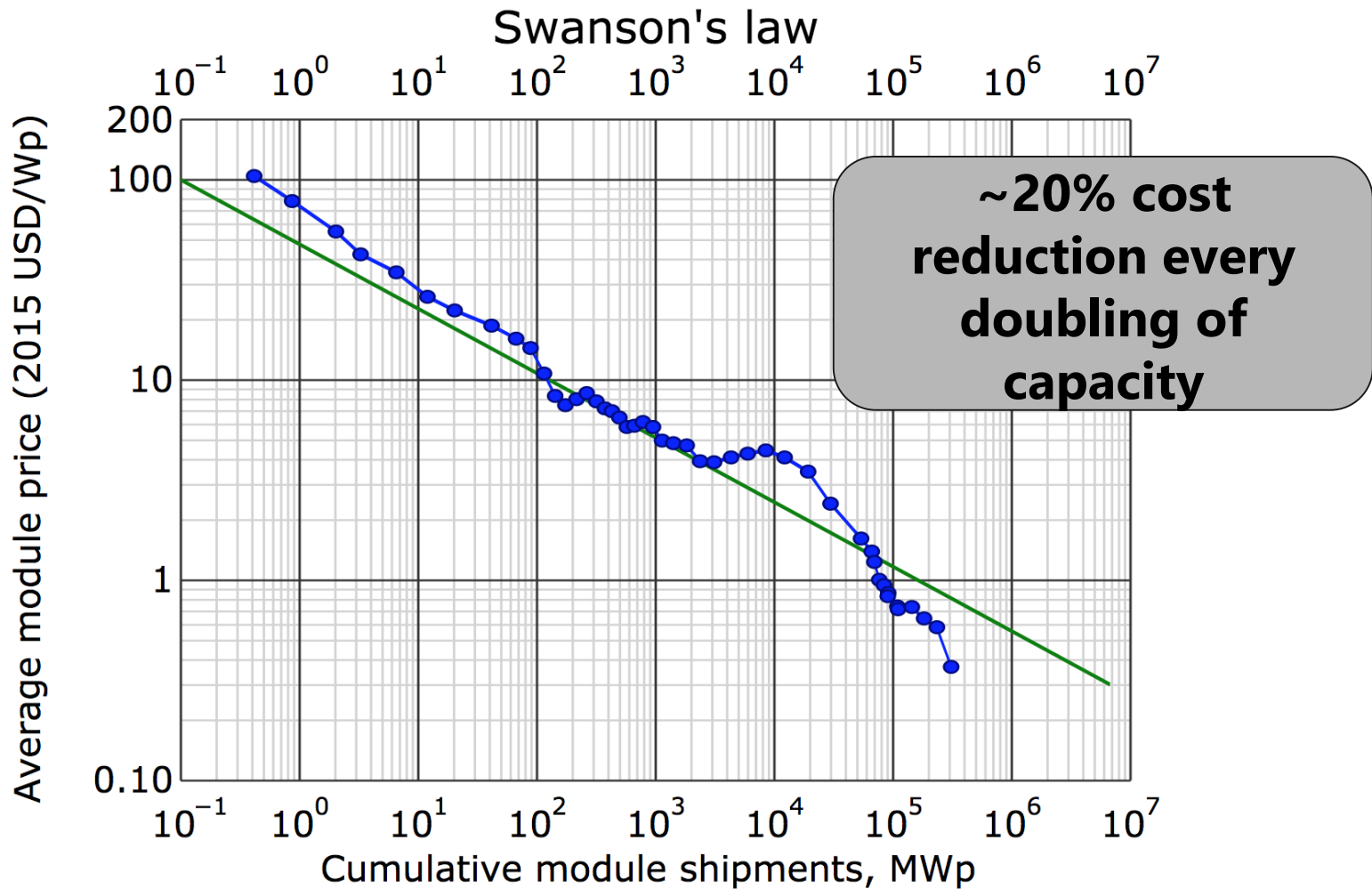


Figure 1. The price of the Ford Model T from 1909-1923[2].

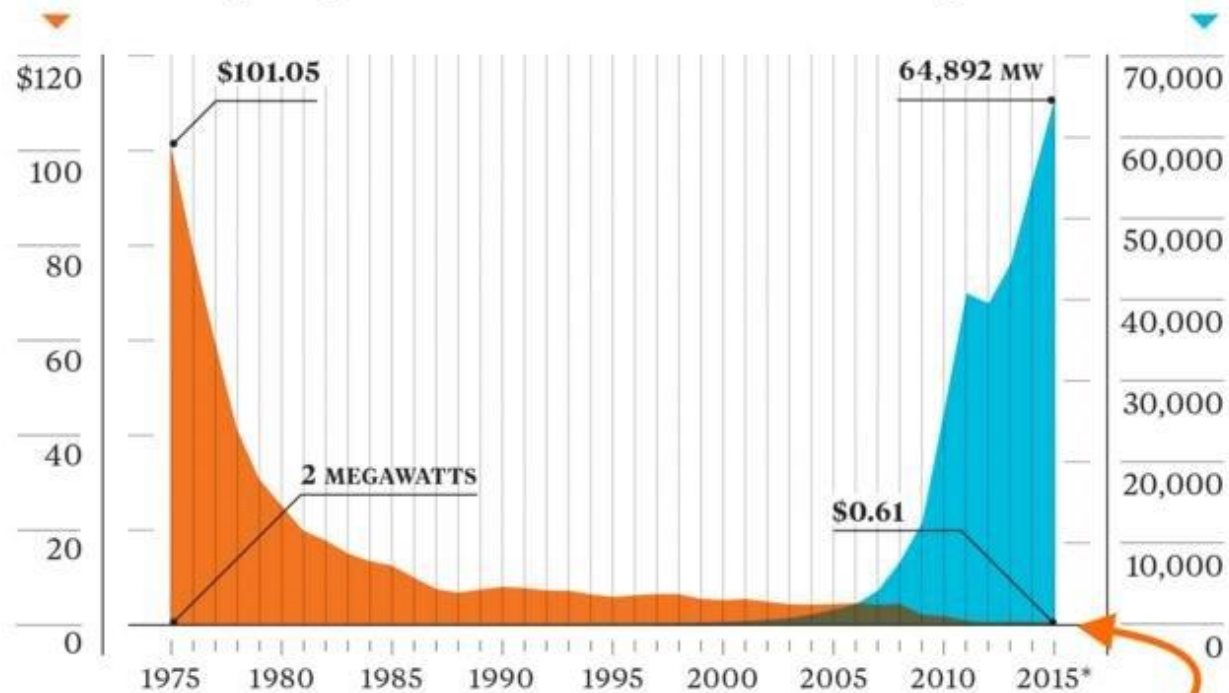
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## III. Solar Energy



Price of a solar panel per watt

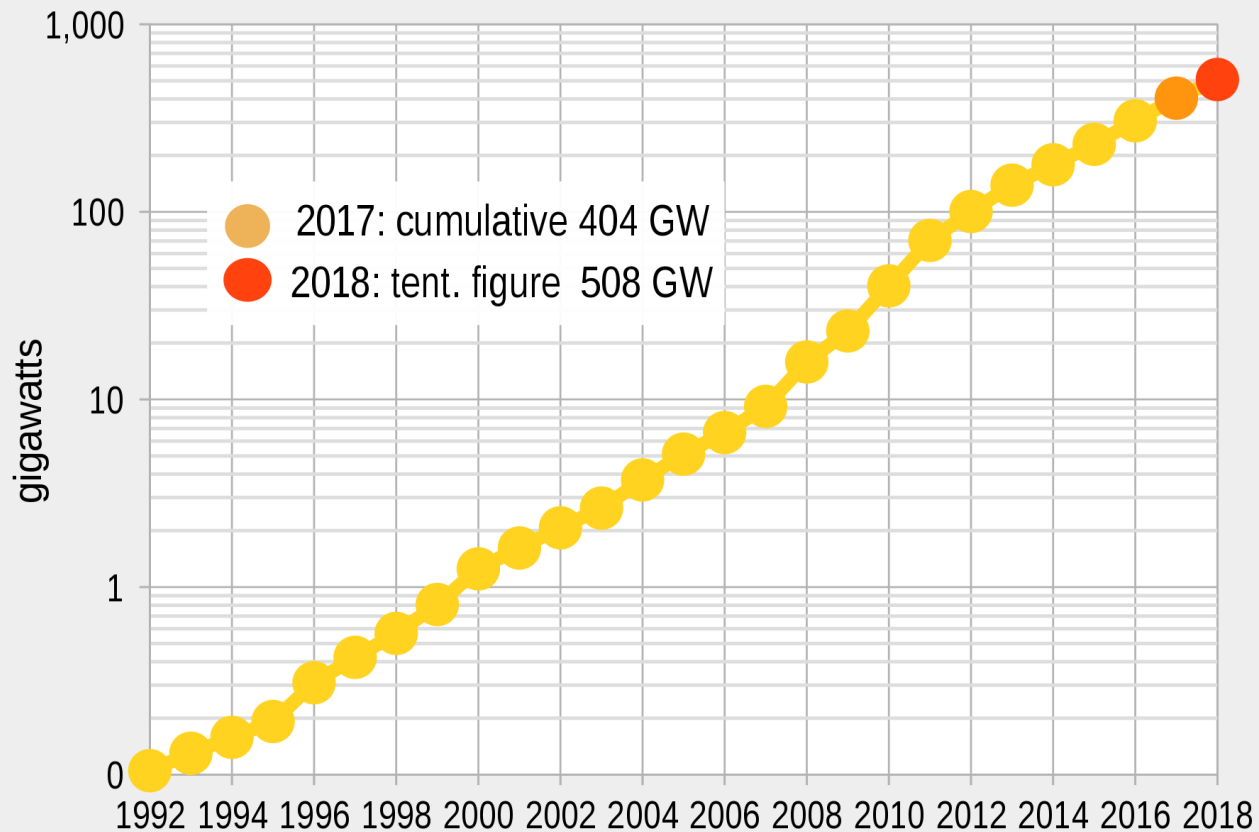
Global solar panel installations



\*Estimate. Sources: Bloomberg, Earth Policy Institute, [www.earth-policy.org](http://www.earth-policy.org)

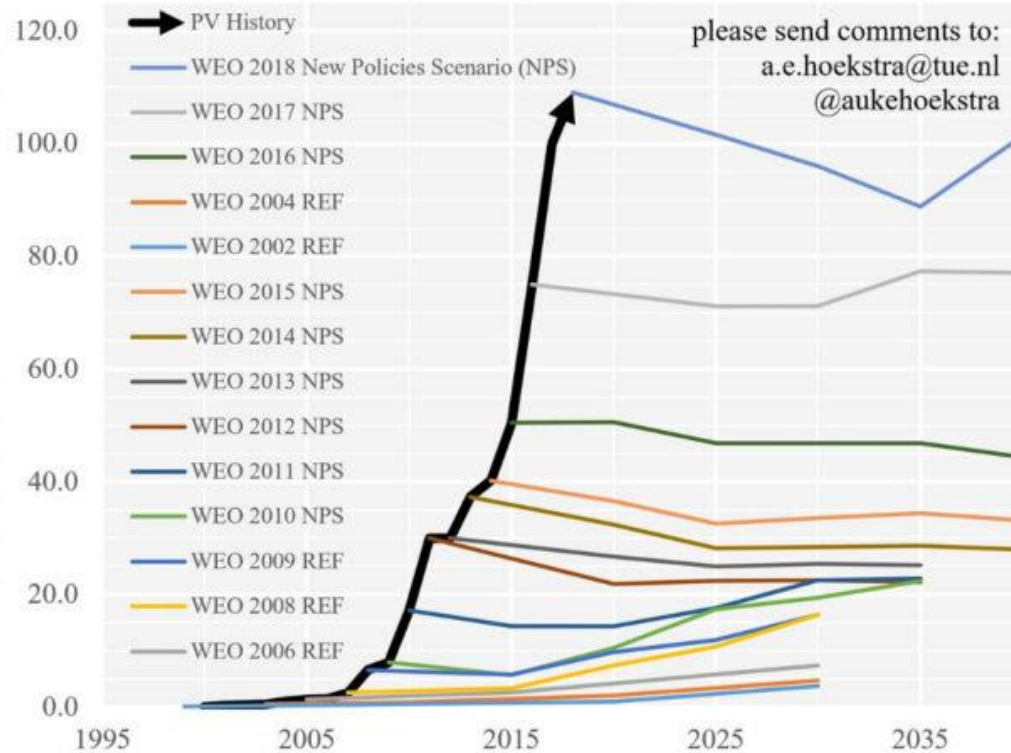


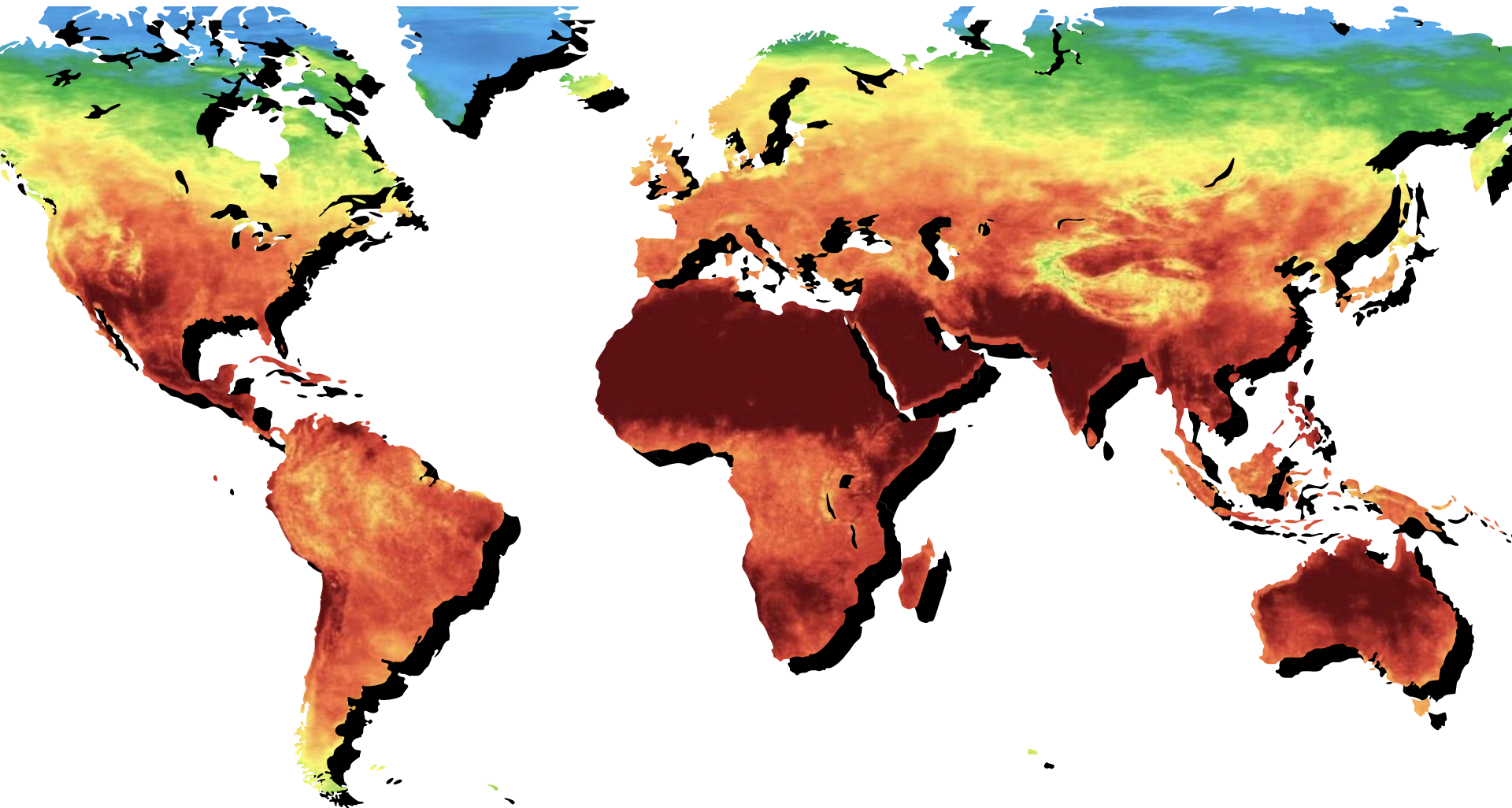
## Exponential Growth of Solar PV (in GW)



## Annual PV additions: historic data vs IEA WEO predictions

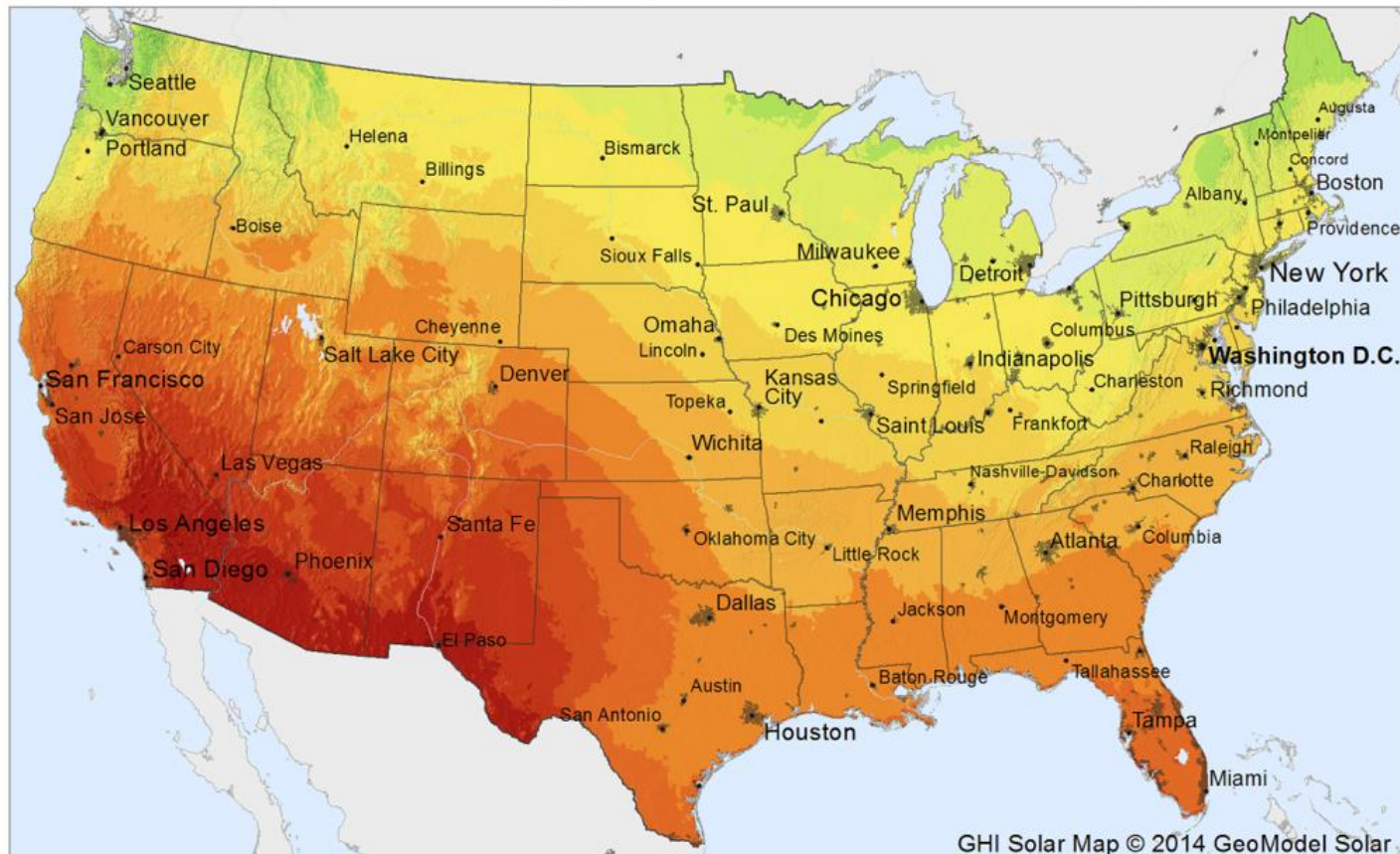
In GW of added capacity per year - source International Energy Agency - World Energy Outlook





# Global Horizontal Irradiation (GHI)

## USA Mainlands



Average annual sum, period 1999-2013



0 200 400 km



# Global Horizontal Irradiation (GHI)

Mexico



**solargis**  
<http://solargis.info>

Average annual sum, period 1999-2013



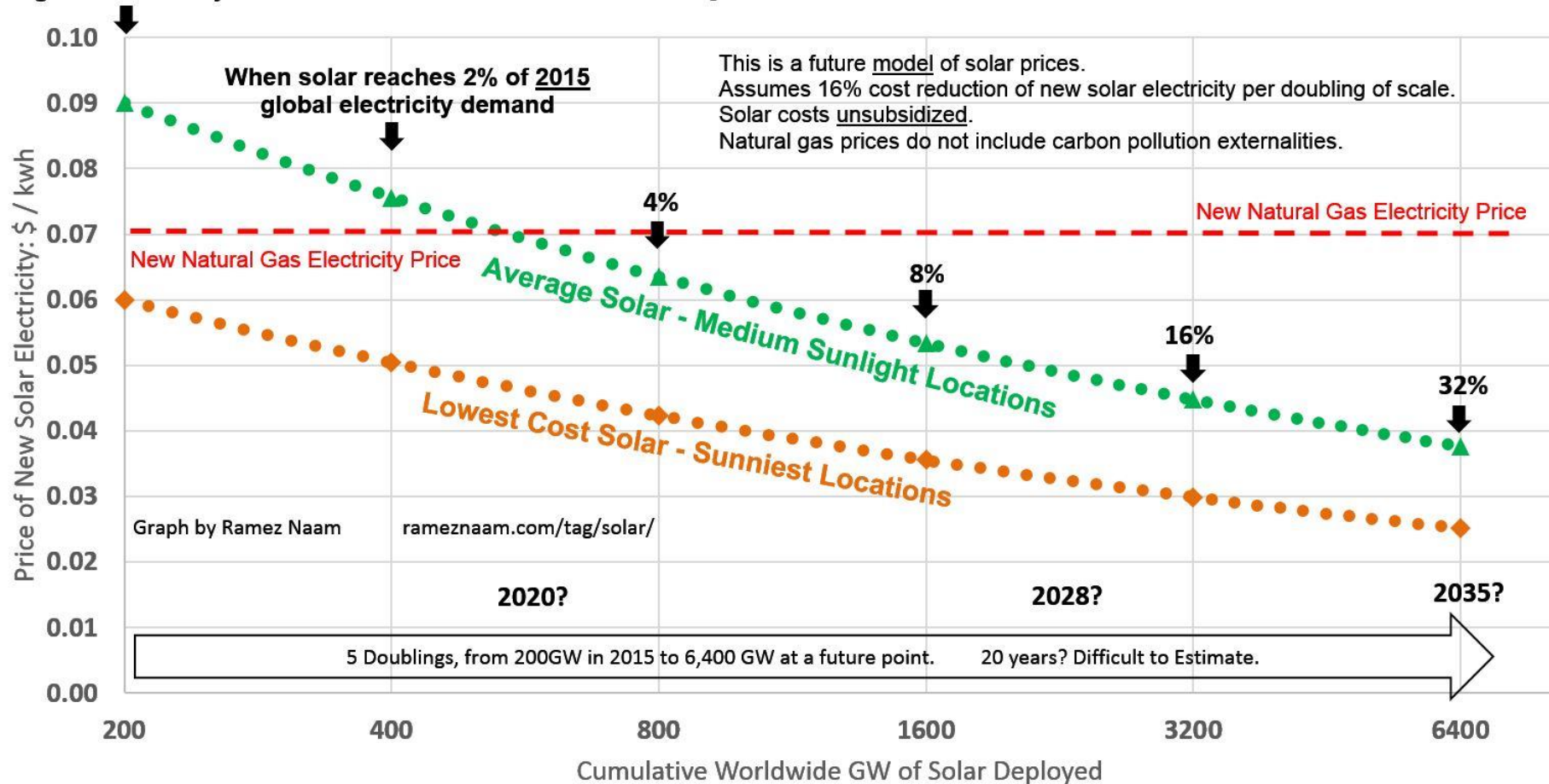
< 1550   1700   1850   2000   2150   2300 > kWh/m<sup>2</sup>

0   200 km

GHI Solar Map © 2014 GeoModel Solar

**2015: Solar is 1% of global electricity**

# How Cheap Can Solar Get?





# Record Low Solar Prices

Abu Dhabi = 2.42 c/kWh

Chile = 2.1 c/kWh

Los Angeles = 2 c/kWh

Mexico = 1.92 c/kWh

Brazil = 1.75 c/kWh

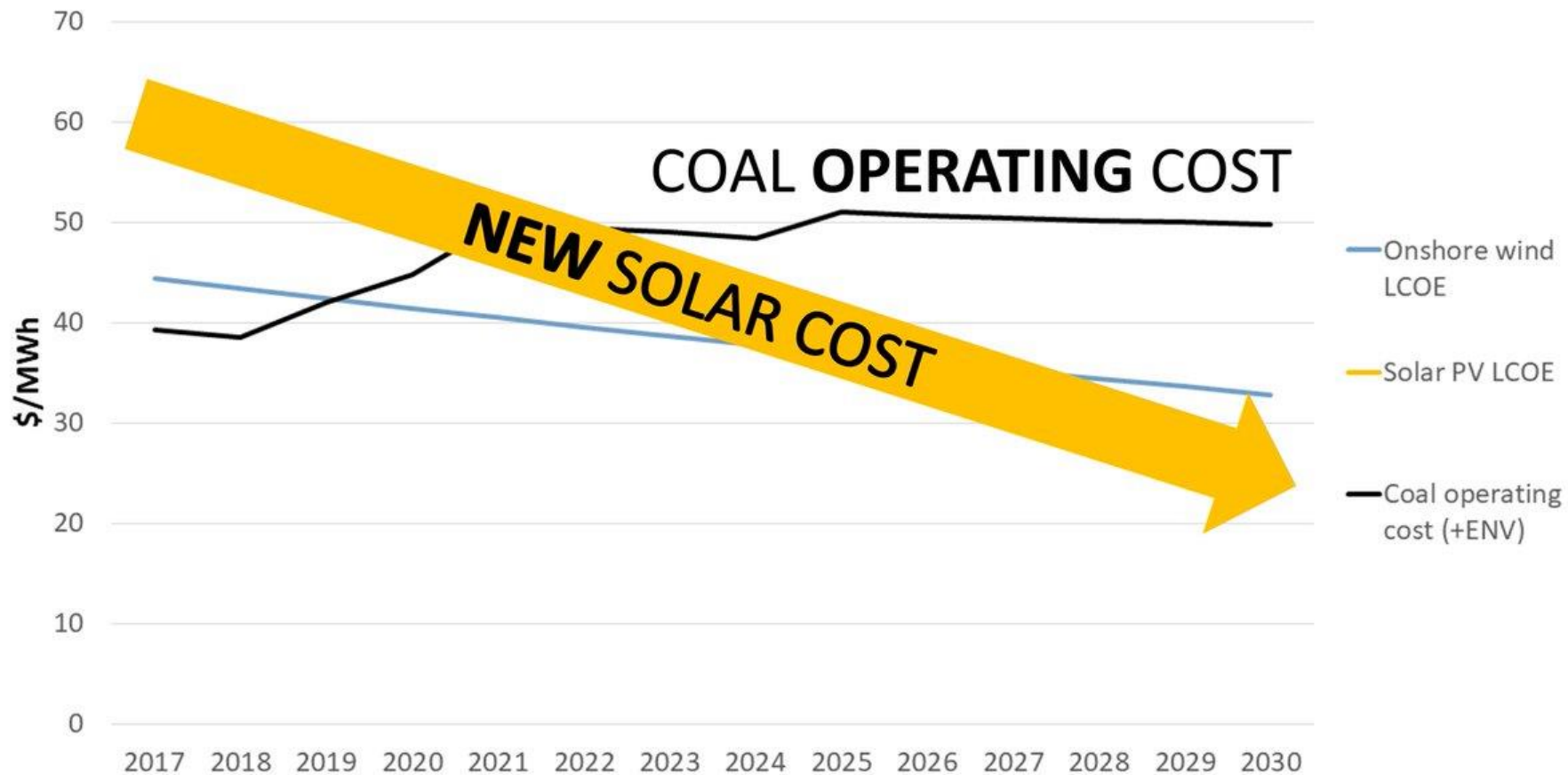
Saudi Arabia = 1.7 c/ kWh

Portugal = 1.65 c / kWh

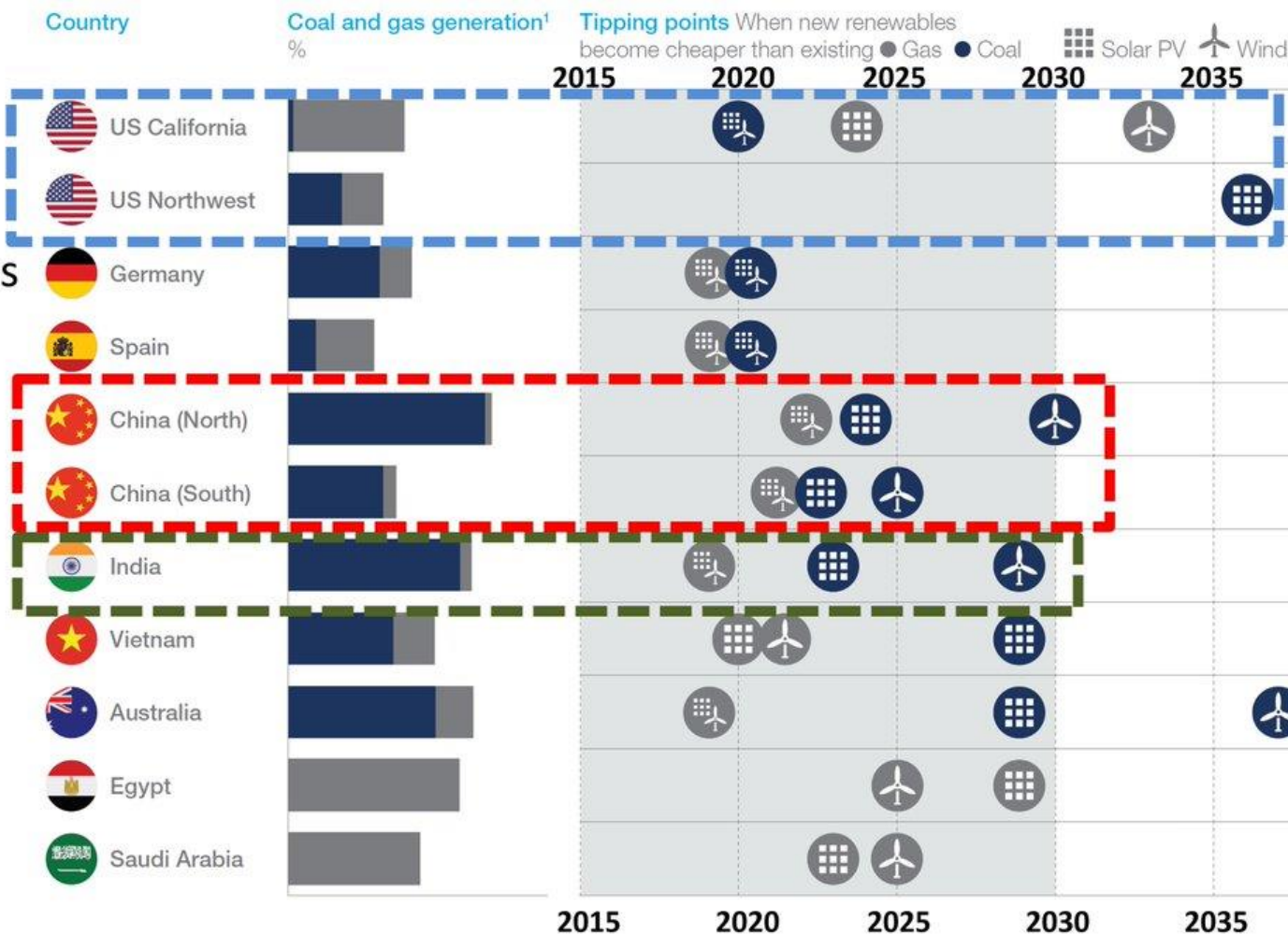
## **New wind and solar will be cheaper than existing coal and nuclear by the early 2020s**

First, the headline numbers. Here are the costs Robo anticipates “early in the next decade”:

- Unsubsidized new wind: 2.0-2.5 cents per kilowatt-hour
- Unsubsidized new solar: 3.0-4.0 cents per kilowatt-hour
- Variable operating costs of existing coal or nuclear plants: 3.5-5.0 cents per kilowatt-hour



New renewables cheaper than existing coal and gas almost everywhere by 2030



CHARGE AHEAD —

## Florida utility to close natural gas plants, build massive solar-powered battery

The battery bank will be significantly larger than the world's current biggest battery.

MEGAN GEUSS - 3/29/2019, 12:15 PM

## Utility CEO: new renewables will be cheaper than existing coal plants by the early 2020s

Energy execs sound more like wild-eyed hippies every day.

By David Roberts | @drvox | david@vox.com | Jan 29, 2018, 3:00pm EST

## Even in Indiana, new renewables are cheaper than existing coal plants



# *China Cancels 103 Coal Plants, Mindful of Smog and Wasted Capacity*

## **Mexico's Record Solar Prices Fall Below the Average Cost of Energy From Gas and Coal**

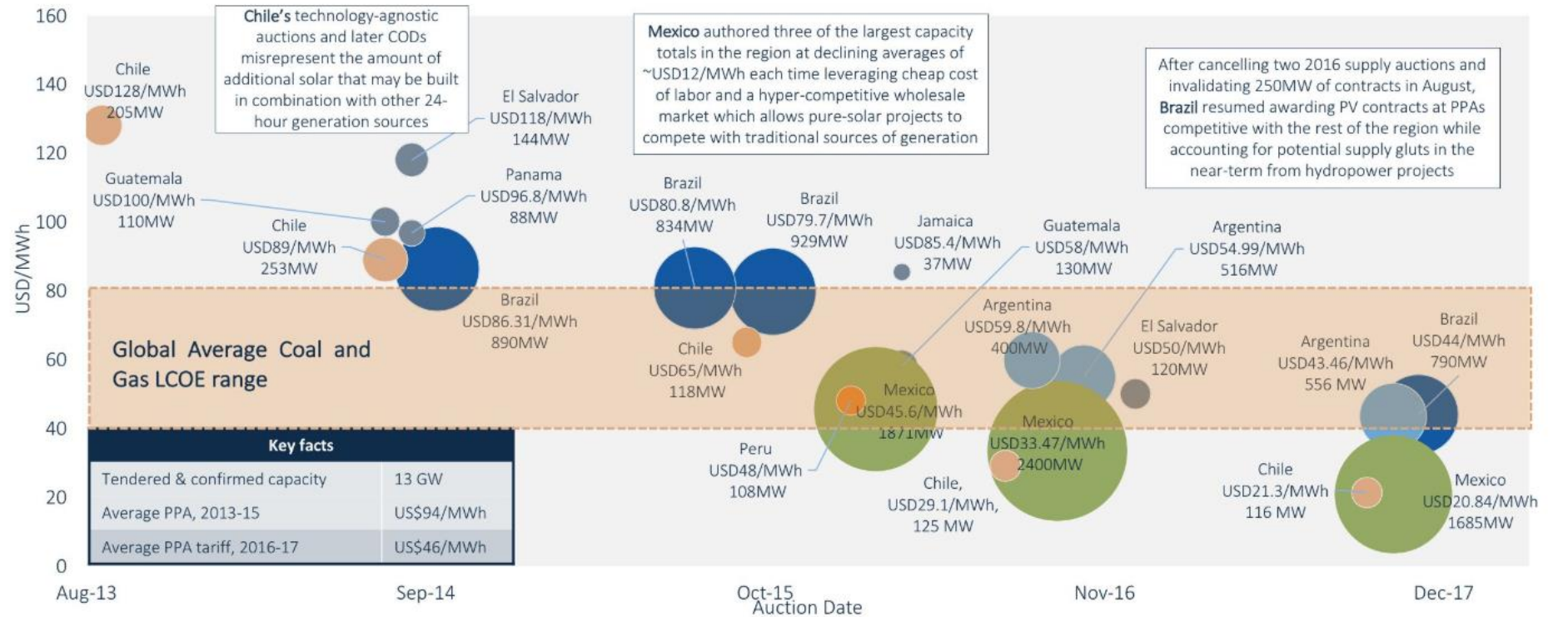
## **India Cancels Plans For Huge Coal Power Stations Thanks To Record Low Solar Energy Prices**

by Andrea D. Steffen 🕒 October 29, 2019



# Mexico's Recent Average Bid Push PV Beyond Cost-Competitive Range with Coal and Gas

Latin America & Caribbean Tendered Projects by Bid Price and Capacity, 2013-2017



Source: GTM Research Global Solar Demand Monitor Q4 2017

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# Can politics derail the energy revolution?

A photograph of Donald Trump at a campaign event. He is wearing a dark blue suit, a white shirt, and a blue and white striped tie. He is holding a large black sign with white text that reads "TRUMP DIGS COAL". The sign has a small line of text at the bottom: "Paid for by Donald J. Trump for President, Inc.". In the background, a large crowd of people is visible, many holding up their phones to take pictures. Some people are wearing "TRUMP" hats. The scene is lit with bright stage lights.

**TRUMP  
DIGS  
COAL**

Paid for by Donald J. Trump for President, Inc.

**TRUMP  
PENCE**





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## IV. Storage (batteries)





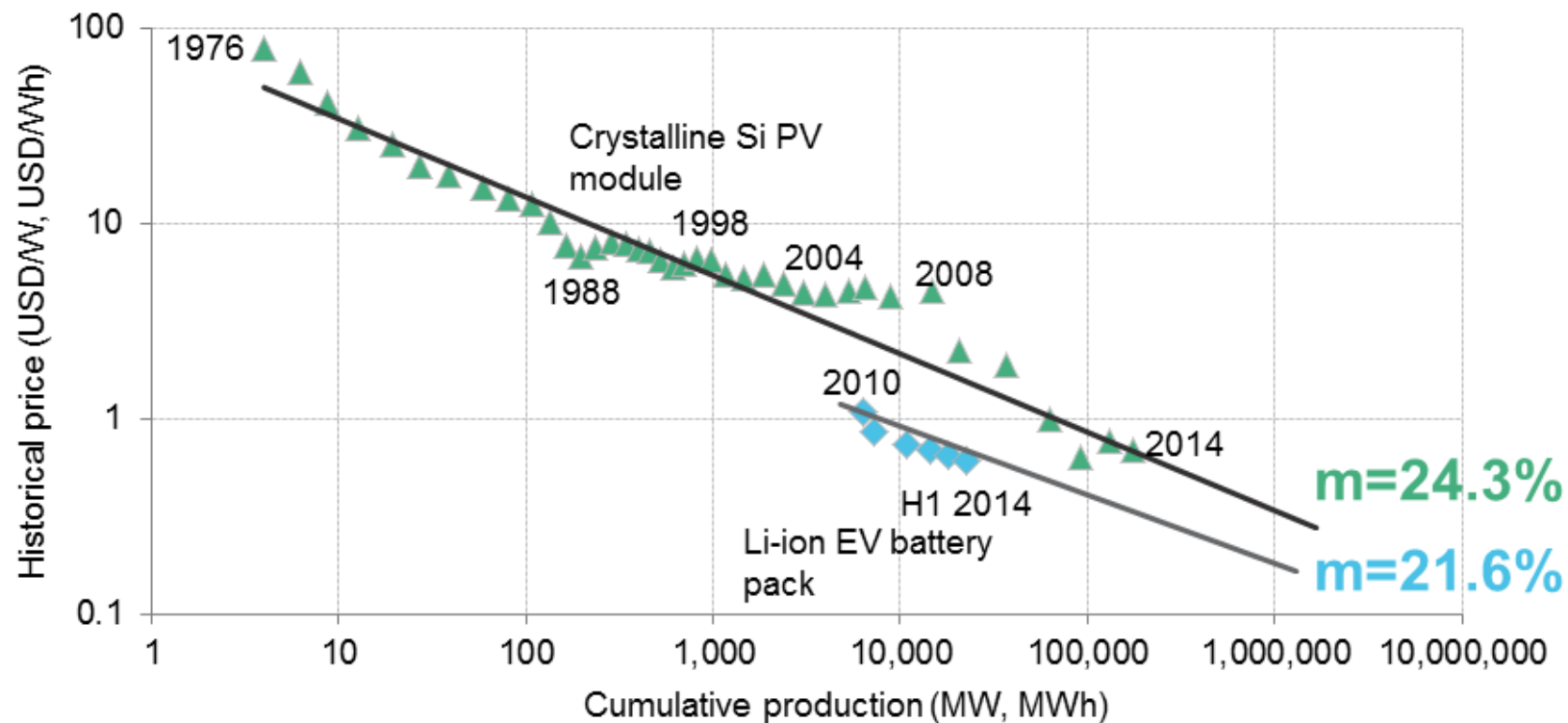
BATTERY  
PRICES  
FALL

TAP INTO  
NEW  
MARKETS

INCREASED  
BATTERY  
DEMAND

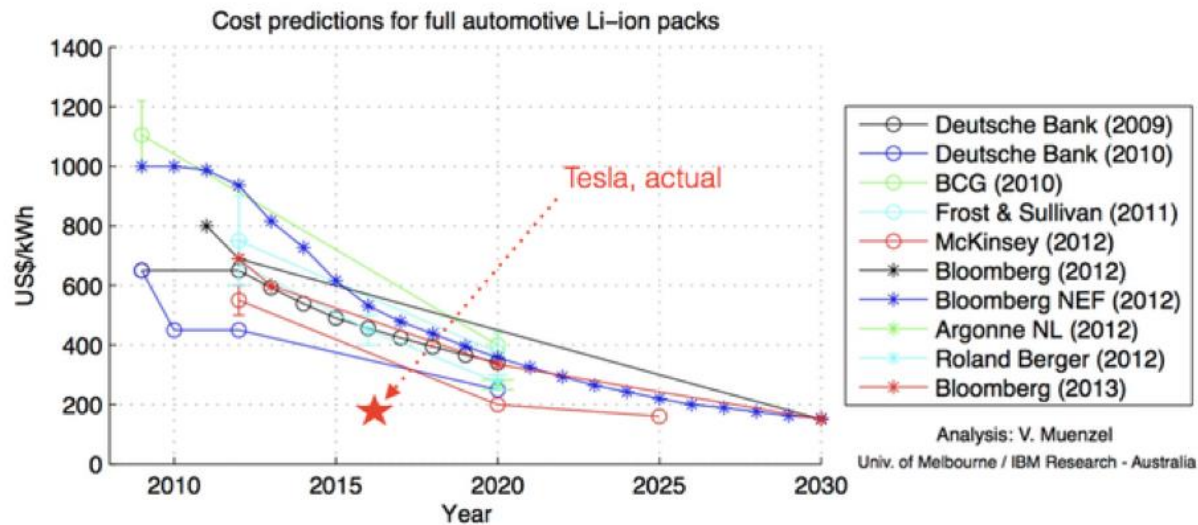


# LITHIUM-ION EV BATTERY EXPERIENCE CURVE COMPARED WITH SOLAR PV EXPERIENCE CURVE

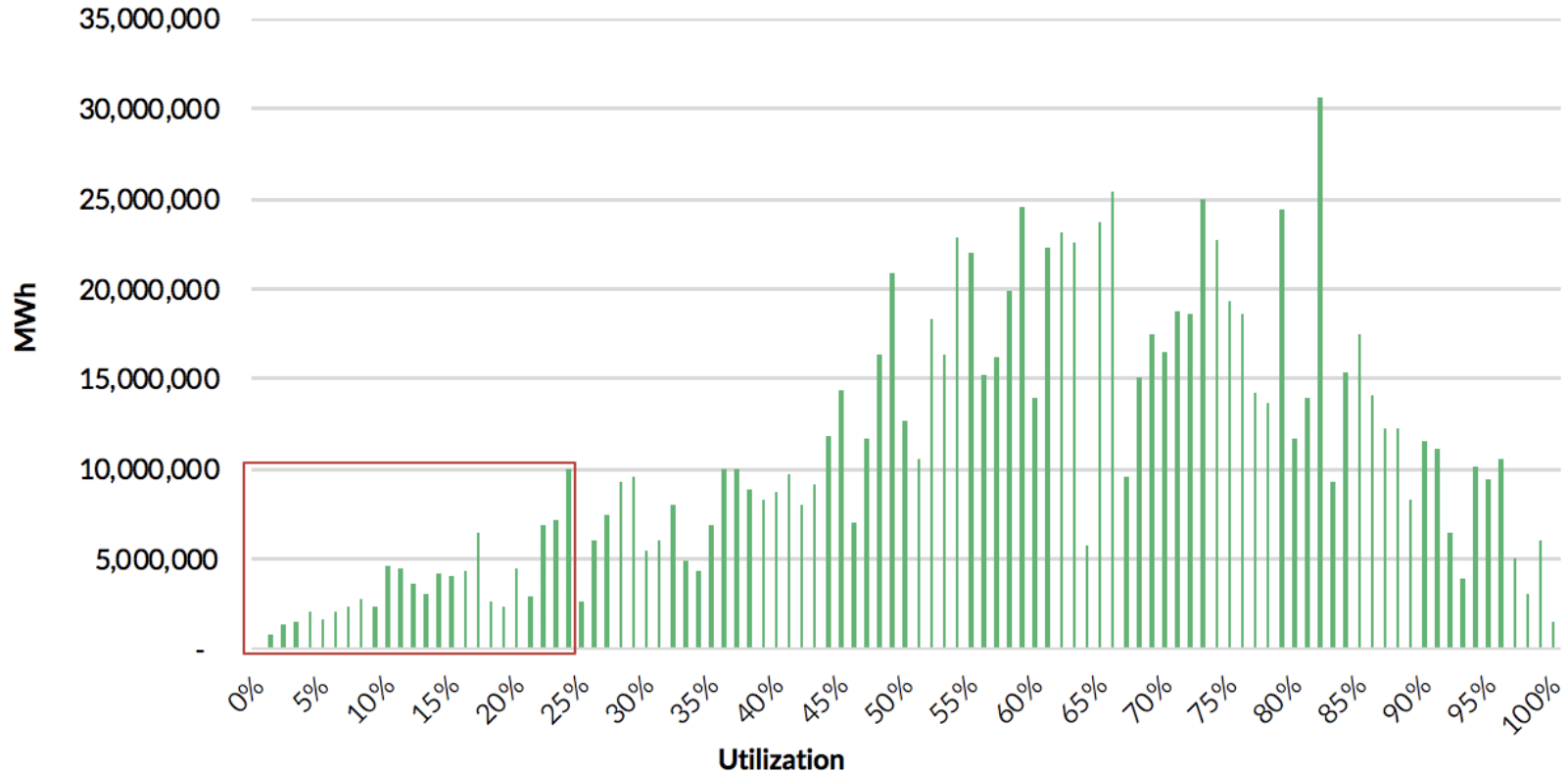


Note: Prices are in real (2014) USD.

Source: Bloomberg New Energy Finance, Maycock, Battery University, MIT



## Distribution of U.S. Natural Gas Generation by Utilization



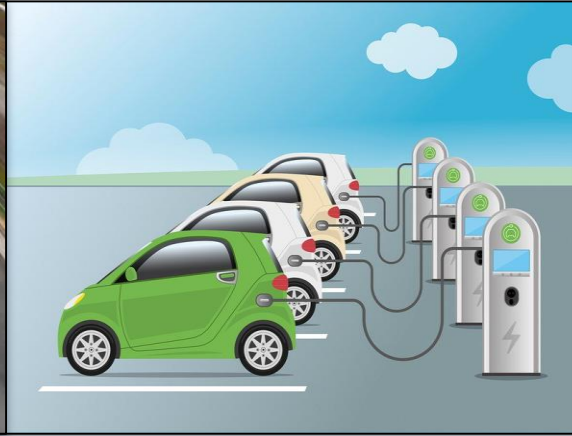
Source: ARK Investment Management LLC, 2019; Energy Information Administration (EIA)

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## **V. EVs (Autonomous Fleets)**

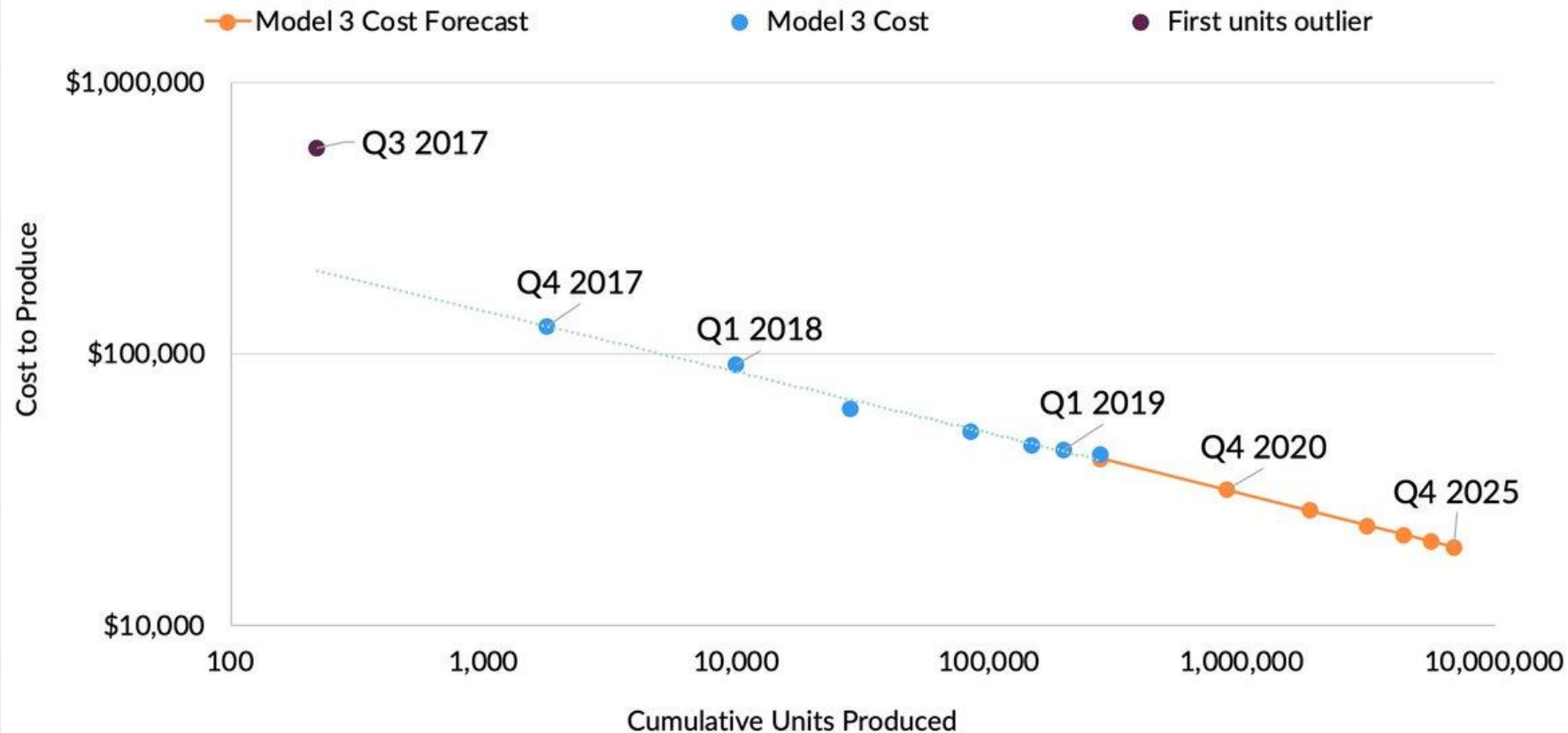
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## Convergence: Autonomous, EVs, Ridesharing

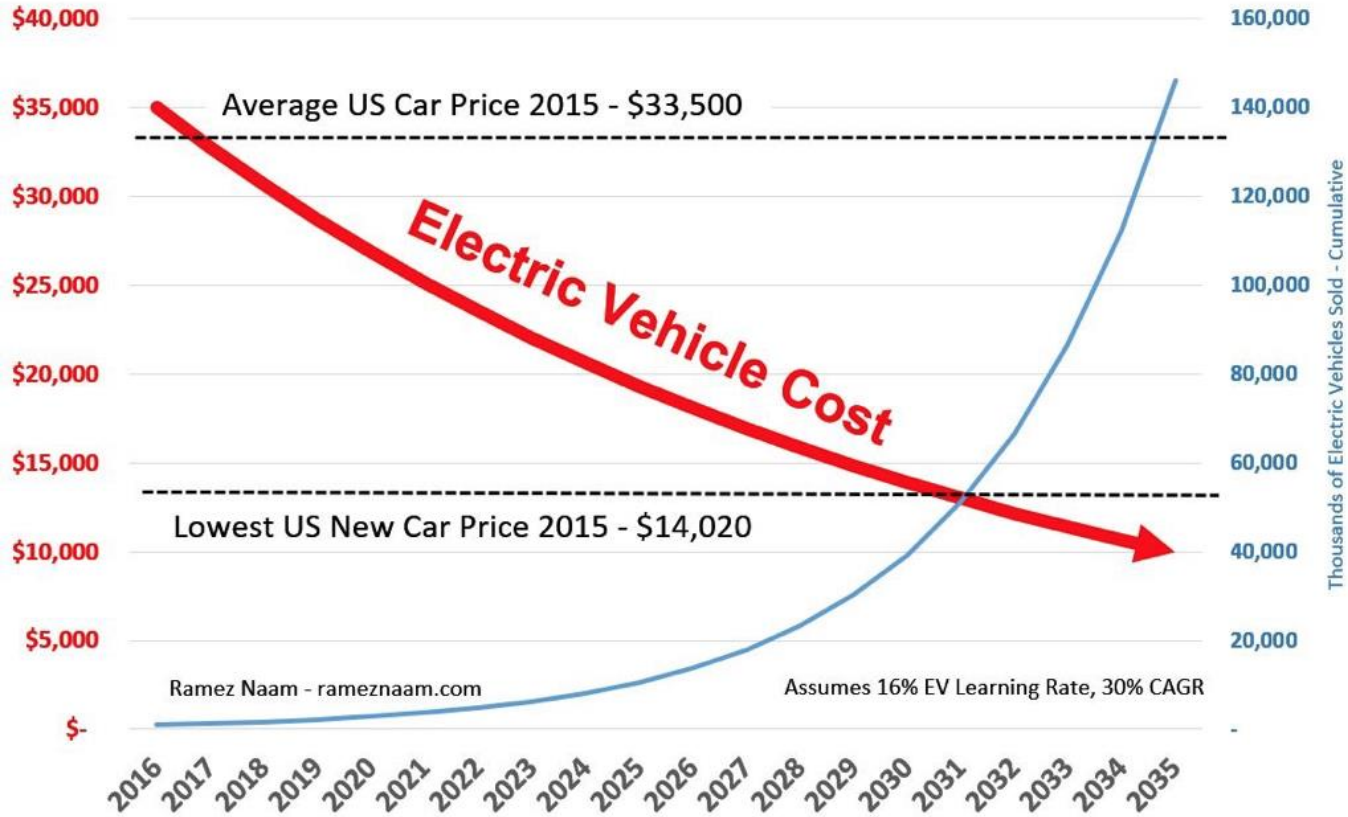




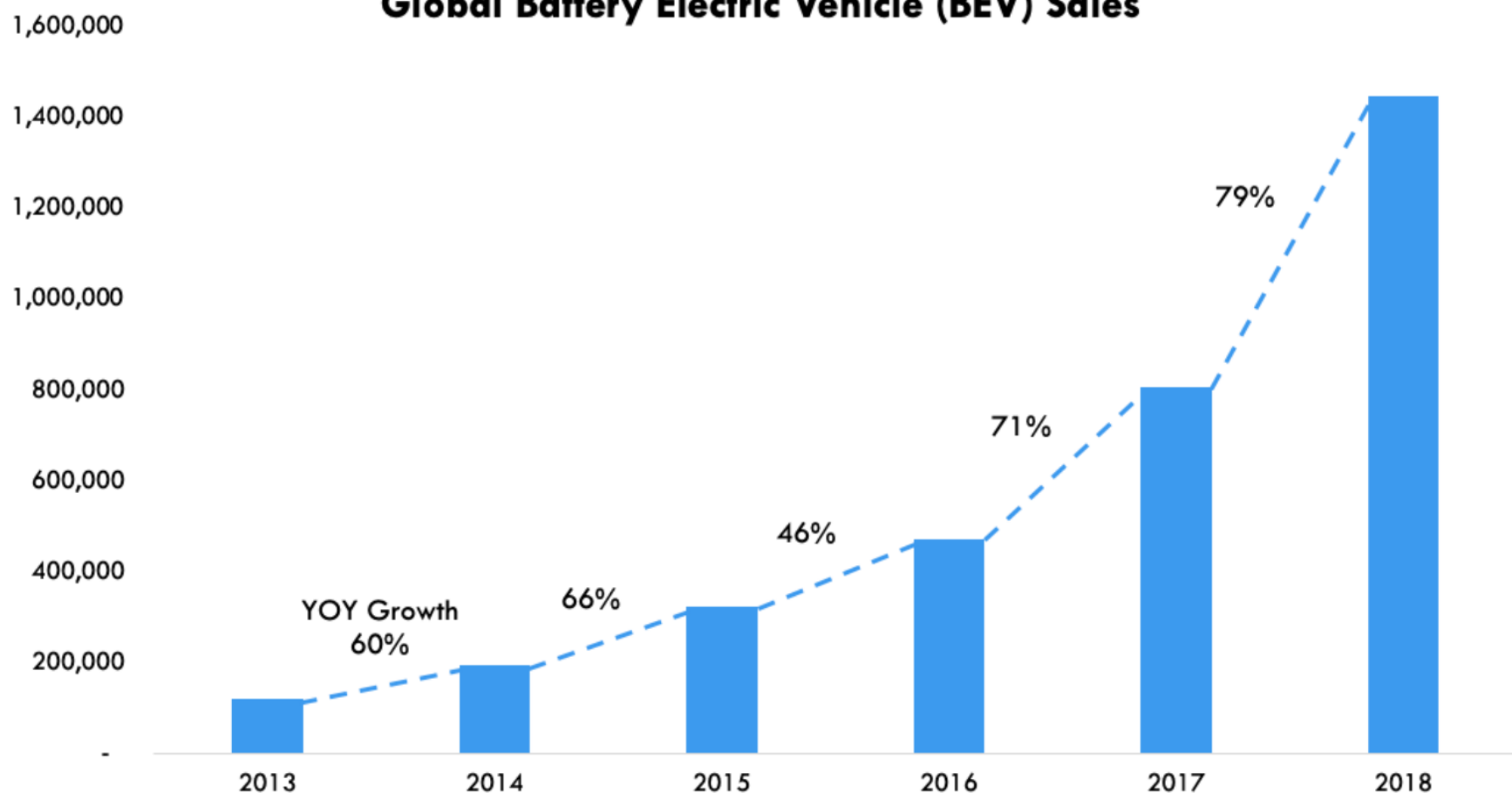
## Model 3 Cost Decline Curve



# Cost of 200 mile range EV



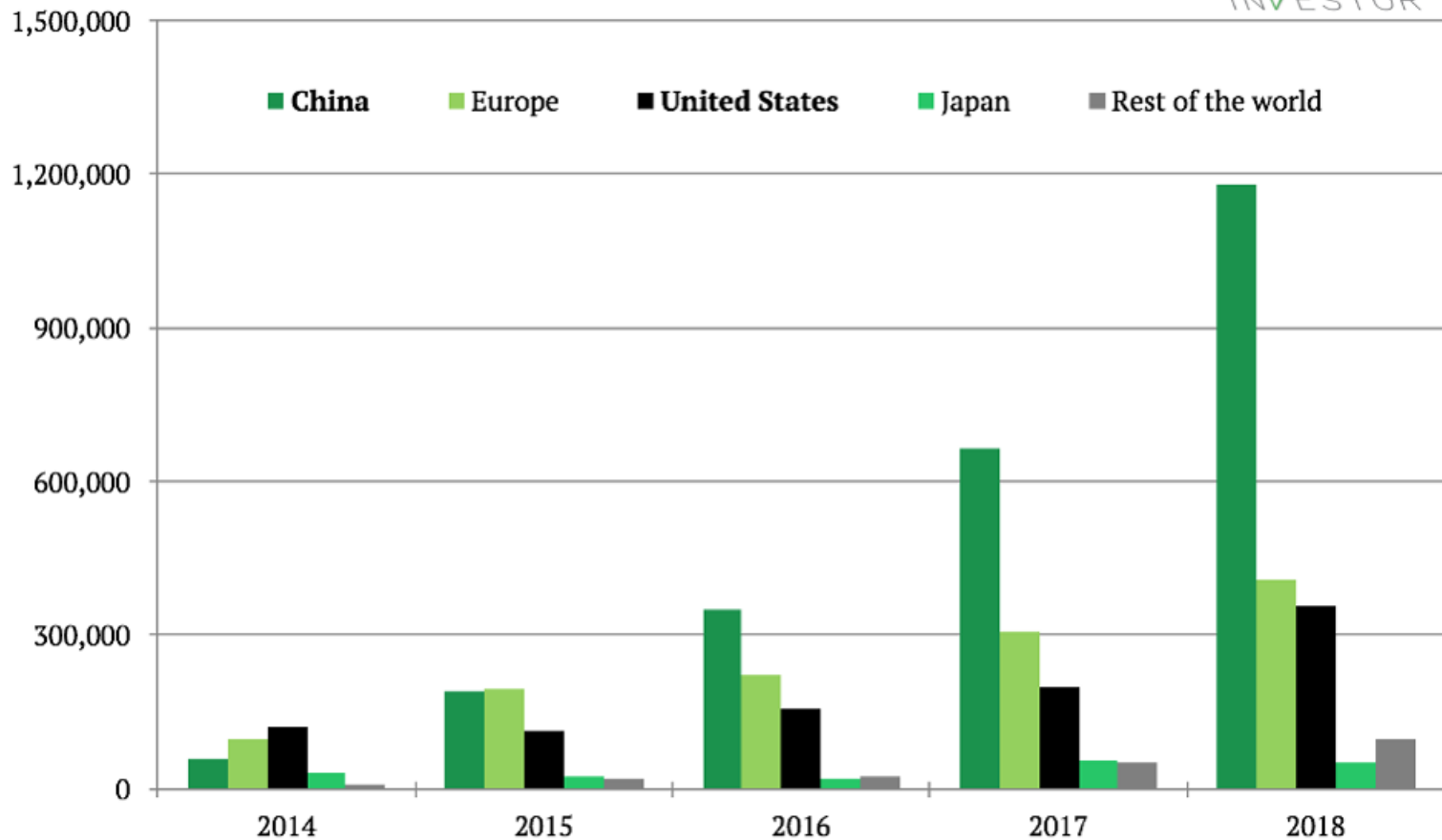
## Global Battery Electric Vehicle (BEV) Sales



Source: ARK Investment Management LLC, 2019 | [ark-invest.com](http://ark-invest.com); Data from: [EVvolumes.com](http://EVvolumes.com)

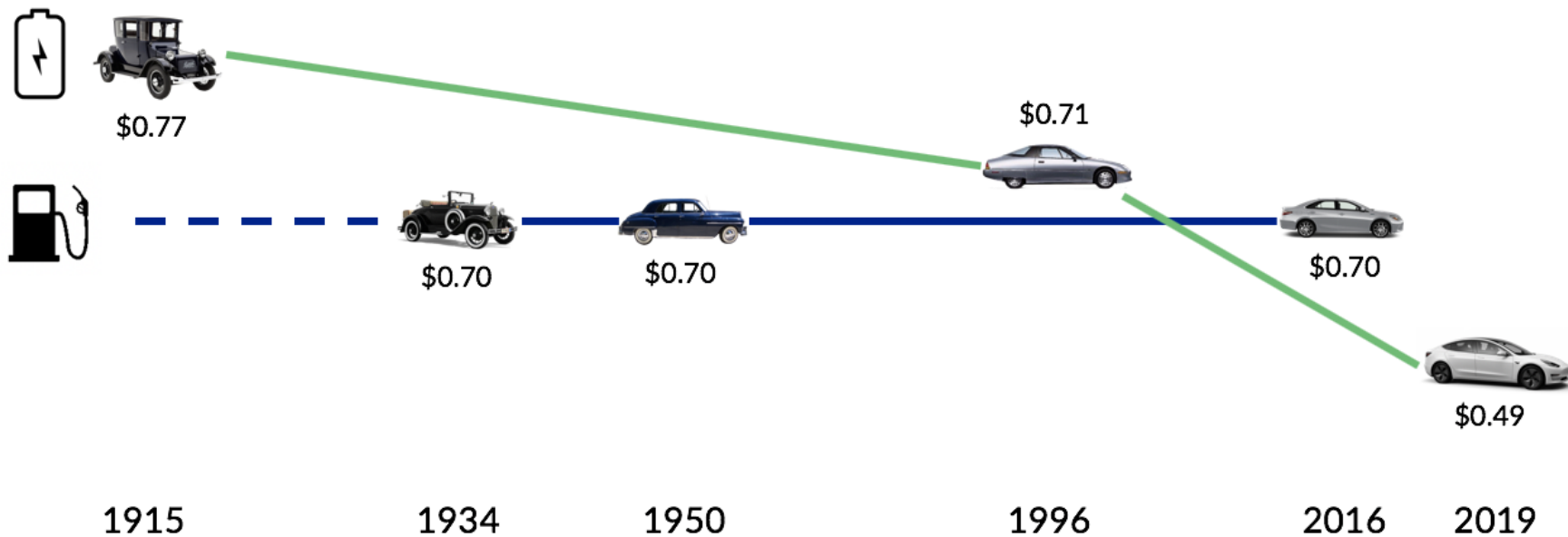
## Global Electric Car Sales, 2014-2018

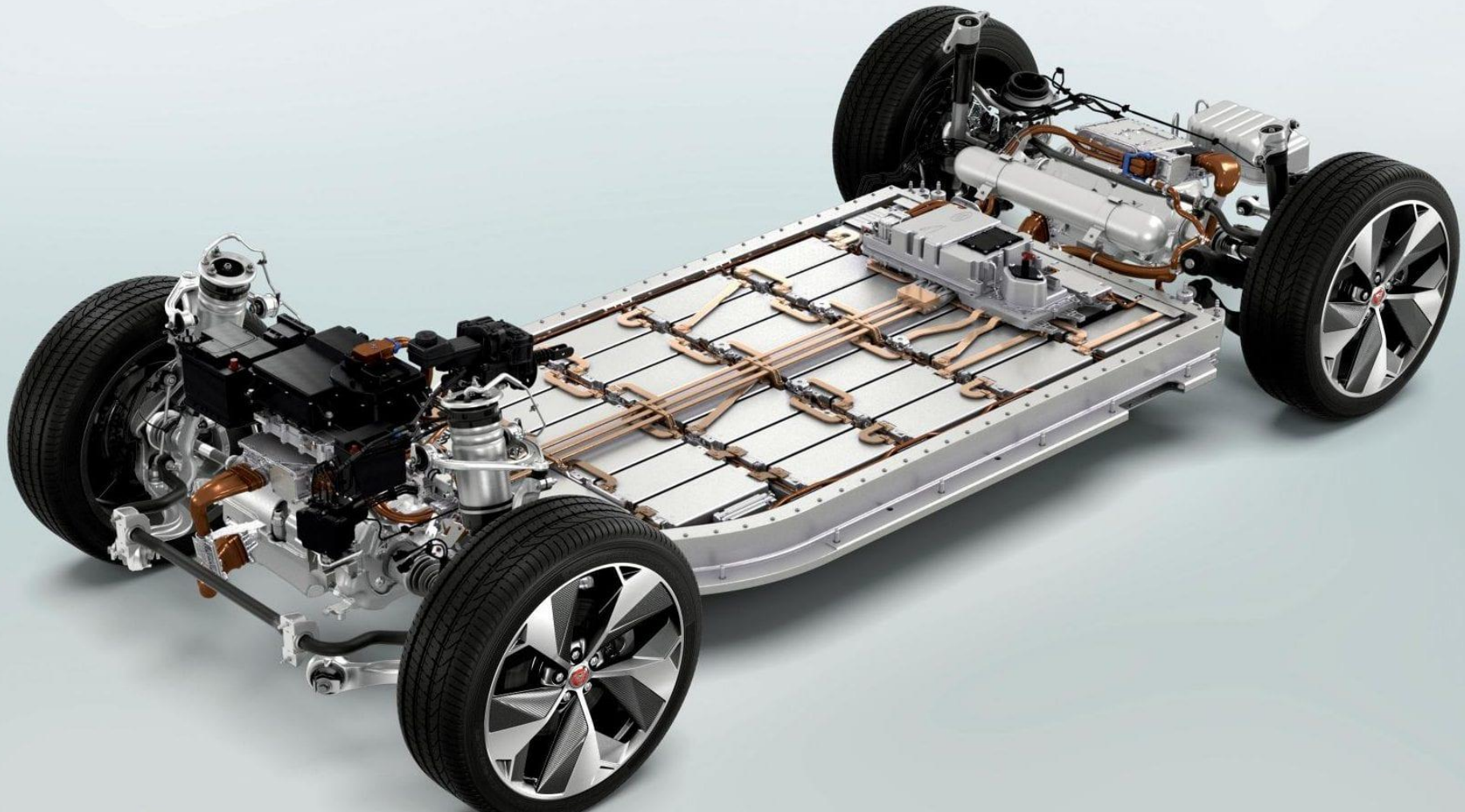
DISRUPTION  
INVESTOR



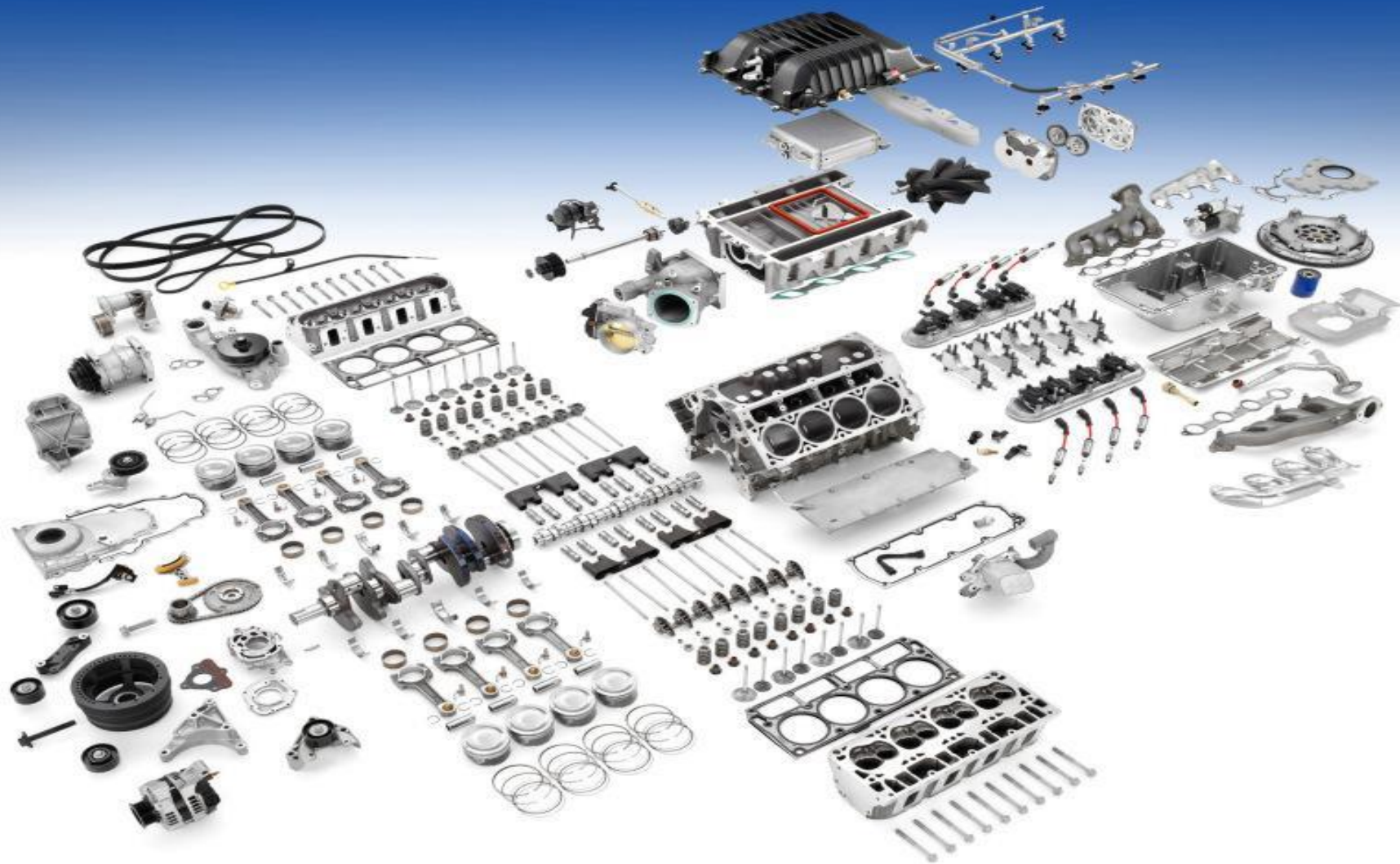
# Cost Per Mile of a Personally Owned Vehicle

(2019 Dollars)



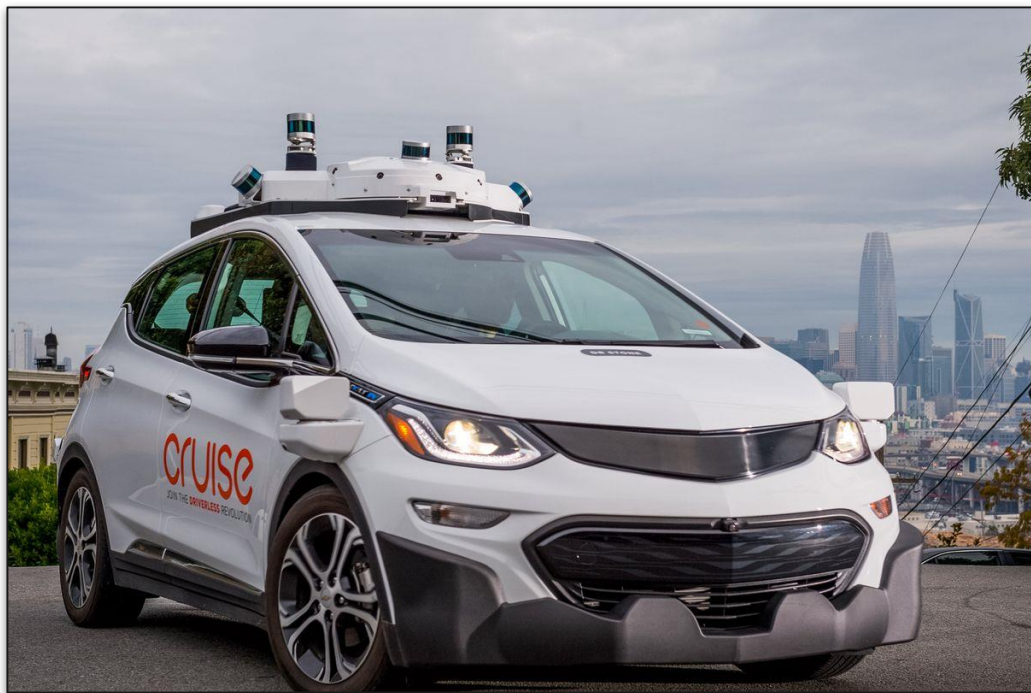




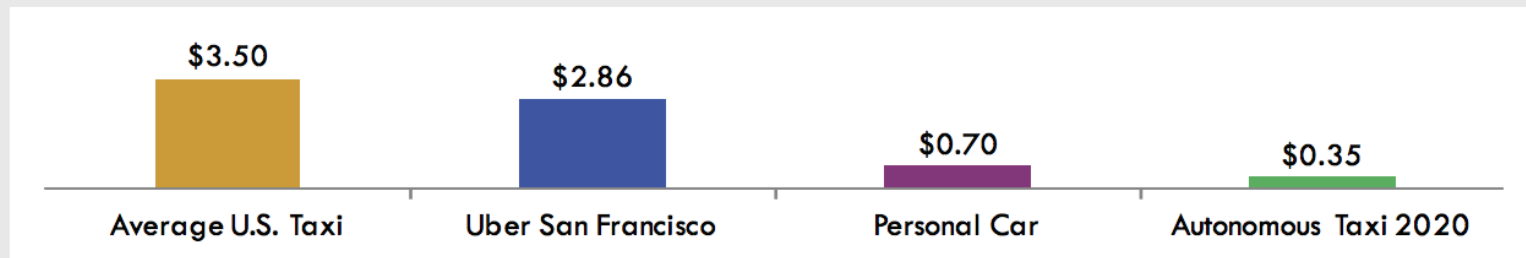






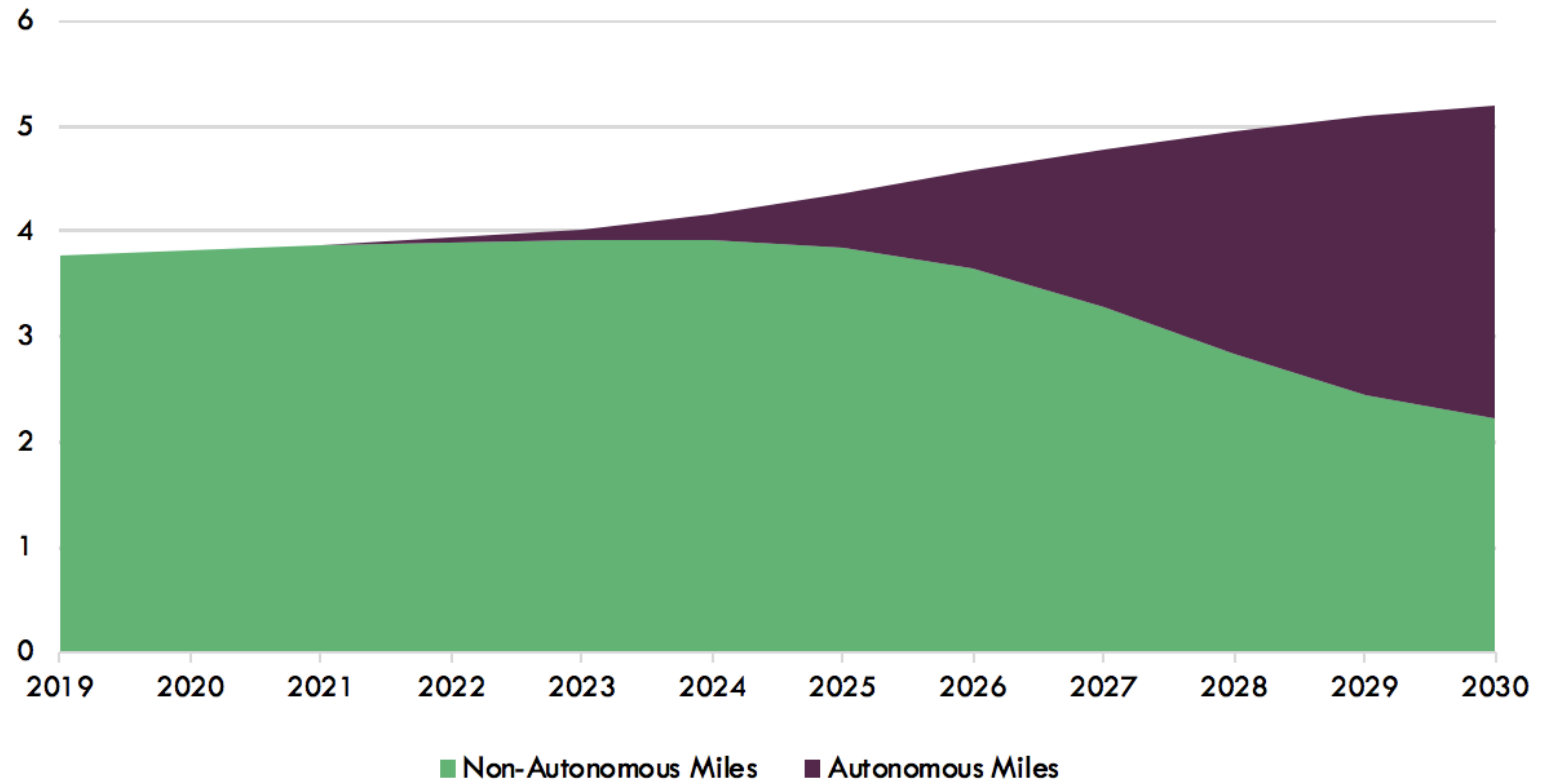


**FIGURE 7**  
**All-In Cost Per Mile of Vehicle Services**



Source: ARK Investment Management LLC

## US Vehicle Miles Traveled (Trillions)



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**VI. What does this mean for me?**

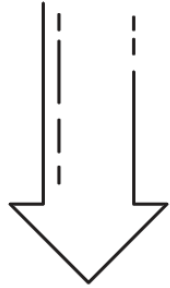
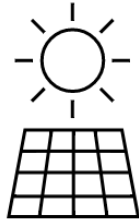


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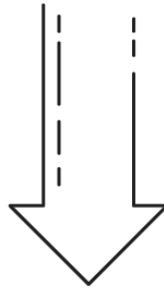
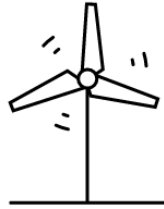
**Solar + Efficiency + Storage =**  
**Lowest cost**  
**Biggest impact**  
**Most autonomy / flexibility**  
**(Prosumer)**

## Technology cost-declines since 2010

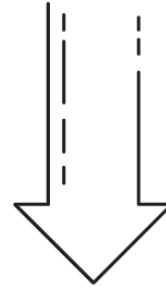
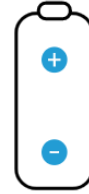
(Source: BloombergNEF)



**85%**

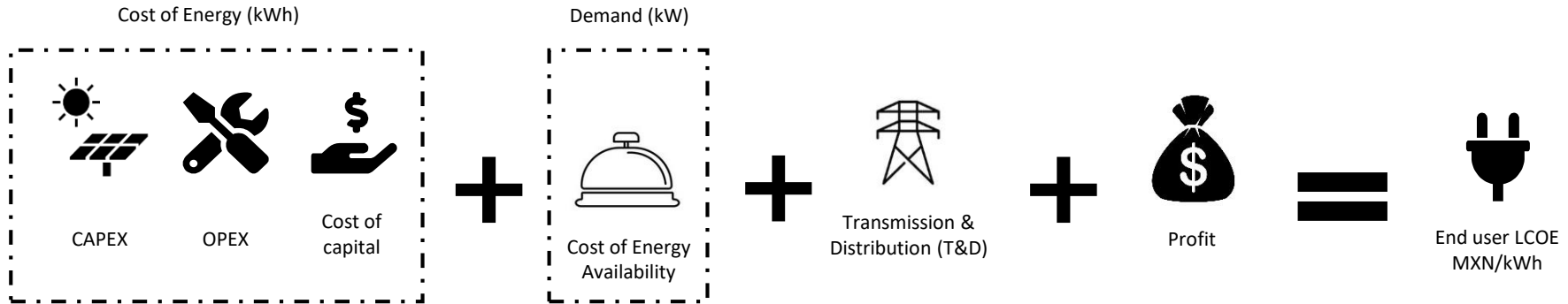


**49%**

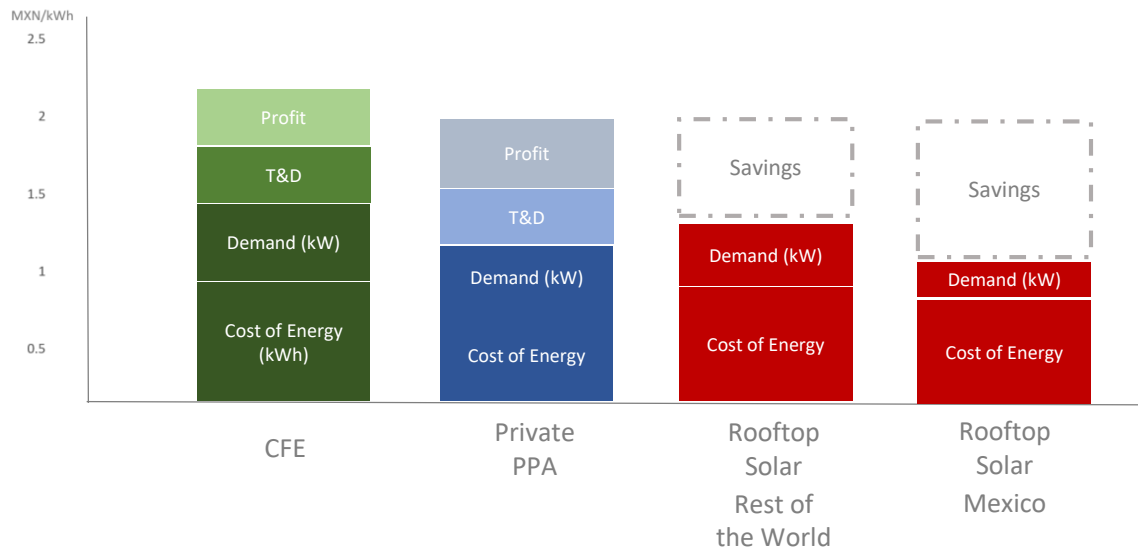


**85%**

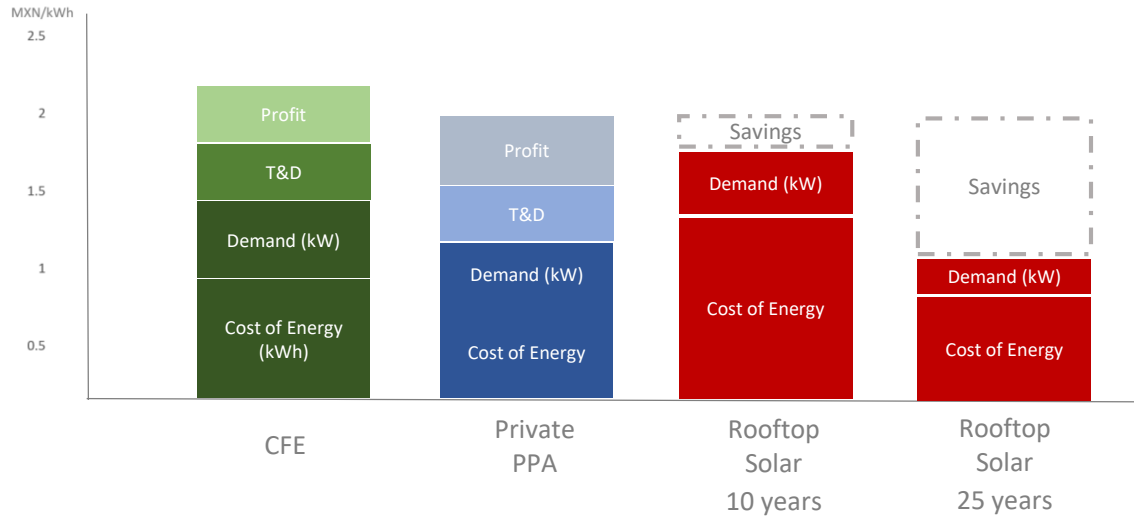
# Levelized cost of electricity break down (LCOE)



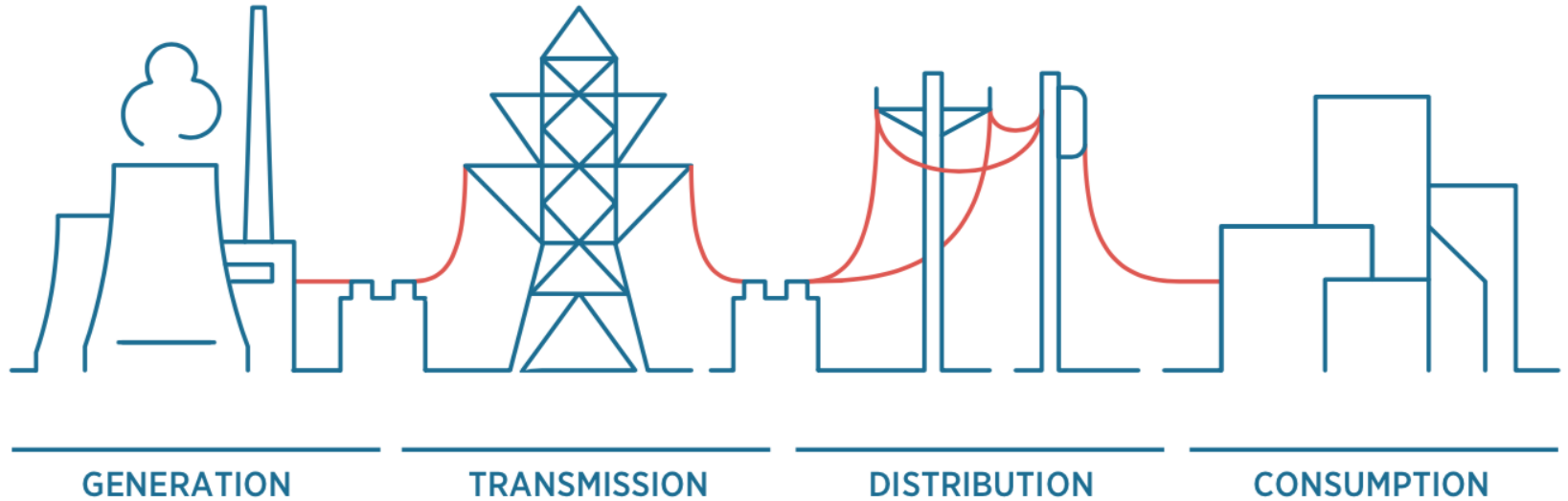
# End user LCOE by source comparison



# End user LCOE by source through time



## TRADITIONAL ELECTRICITY SUPPLY CHAIN



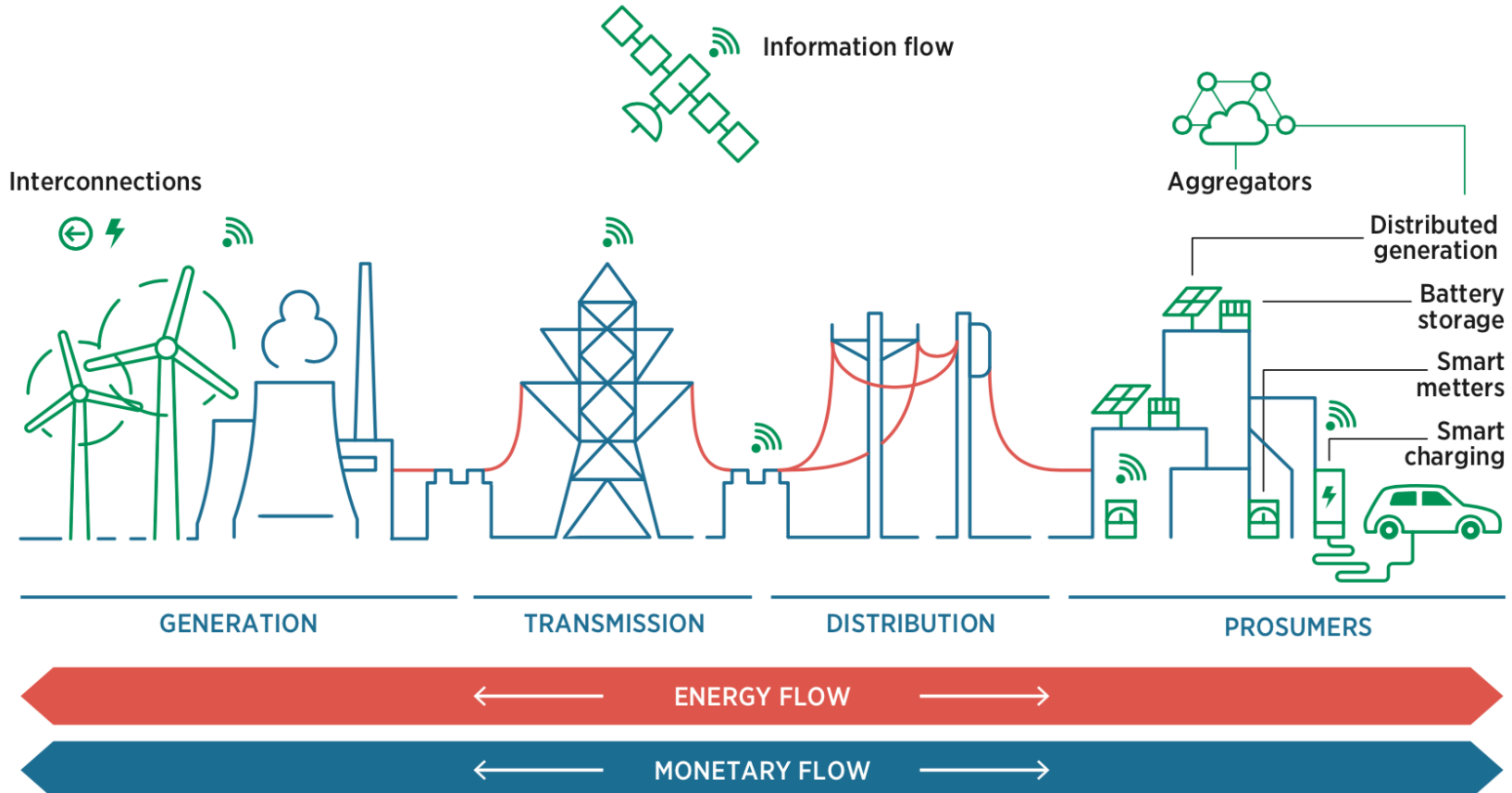
ENERGY FLOW



MONETARY FLOW



## NEW PARADIGM OF THE ENERGY SUPPLY CHAIN



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**Alvaro Migoya**  
**amigoya@zolarity.com.mx**

**maximilian.webster@gmail.com**  
**@MaxAWebster**