

Private and Confidential



CLIMATE IMPACT OF ENERGY STORAGE

Radiant Value Management, LLC

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Climate Impact of Energy Storage

A revolution in climate change mitigation

Opportunity

- Electric vehicles have zero tailpipe emissions and enable autonomous and shared mobility
- Grid-level and behind-the-meter storage enables greater renewable resource integration
- 79% cost deflation of lithium-ion battery storage since 2010 is driving rapid market adoption
- *Impact Investing is growing exponentially worldwide as more funds focus on this niche.*
: John Bogle, Founder of Vanguard Group
- Energy storage enables virtually all other ‘green’ technologies and helps realize decades of environmental investing.

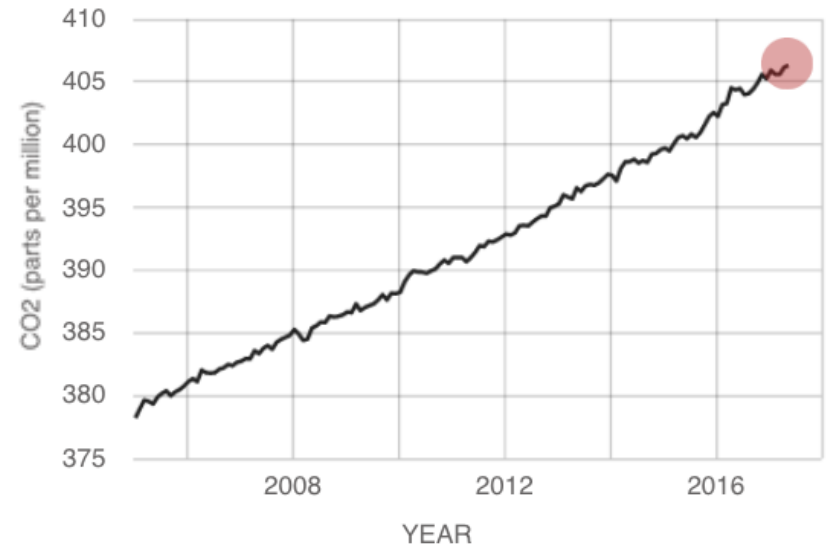
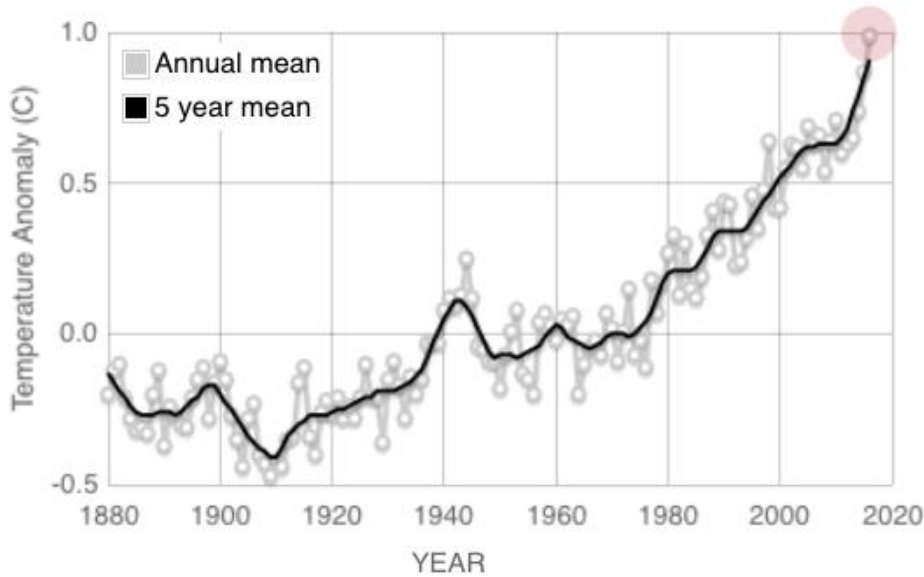
Who We Are

- Experienced investment managers in public/private energy, resource and industrial businesses
- Multi-disciplinary advisory board experienced in energy, investing, banking and turnaround situations
- Lithium experts in process development, capital markets, banking and turnaround situations



Energy is at the Forefront of the Climate Struggle

All tools at hand need to be deployed

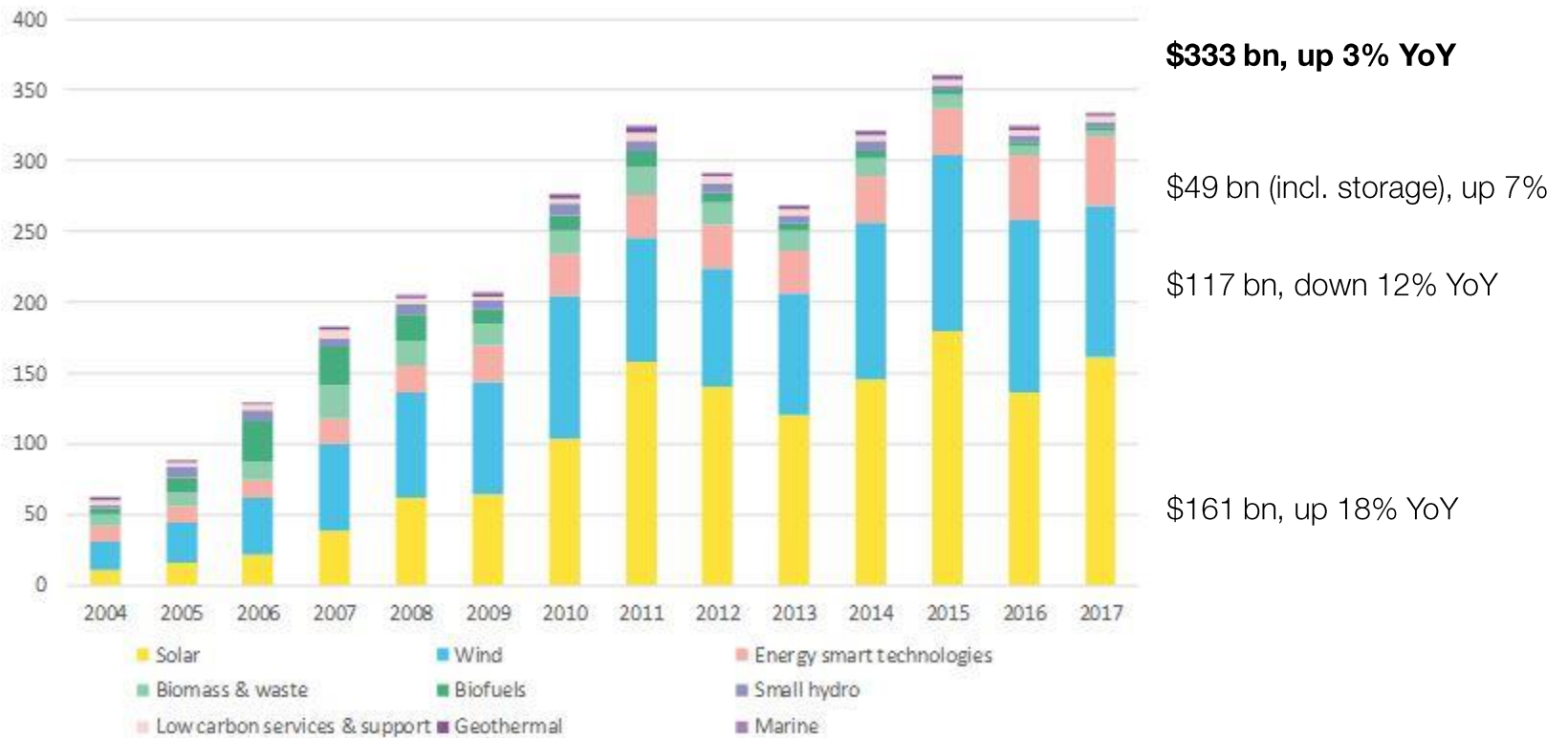


Source: NASA



Clean Energy Investments are Up Despite Massive Unit Cost Declines

\$2.5 trillion invested since 2010



Source: Bloomberg New Energy Finance (excludes hydro power)

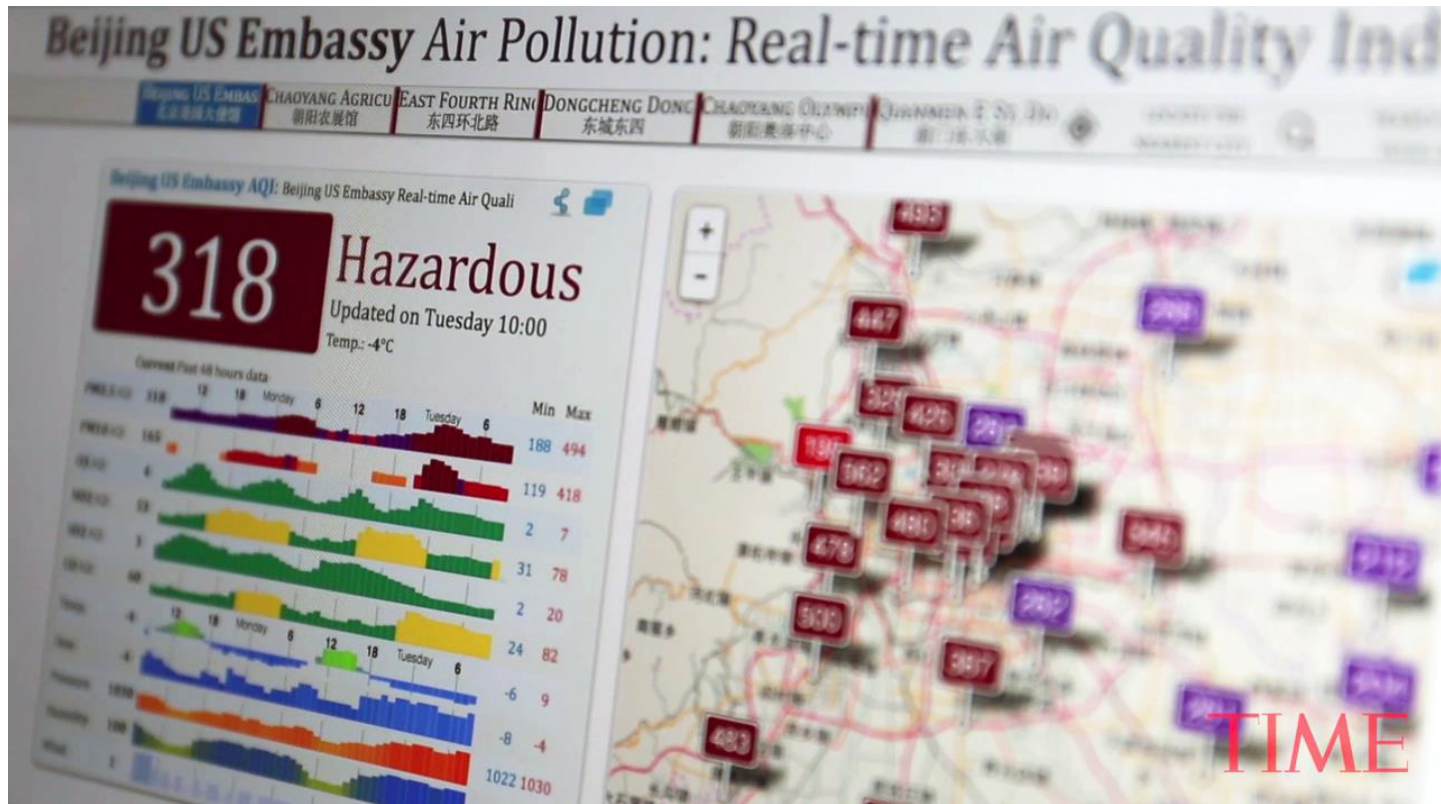


FUTURE MOBILITY

**Clean Transportation Beyond Carbon
and Paris Goals**



Electric Vehicles have Zero Tailpipe Emissions *Most important driver for growing cities of the world*



Source: Beijing Air Quality Index, TIME

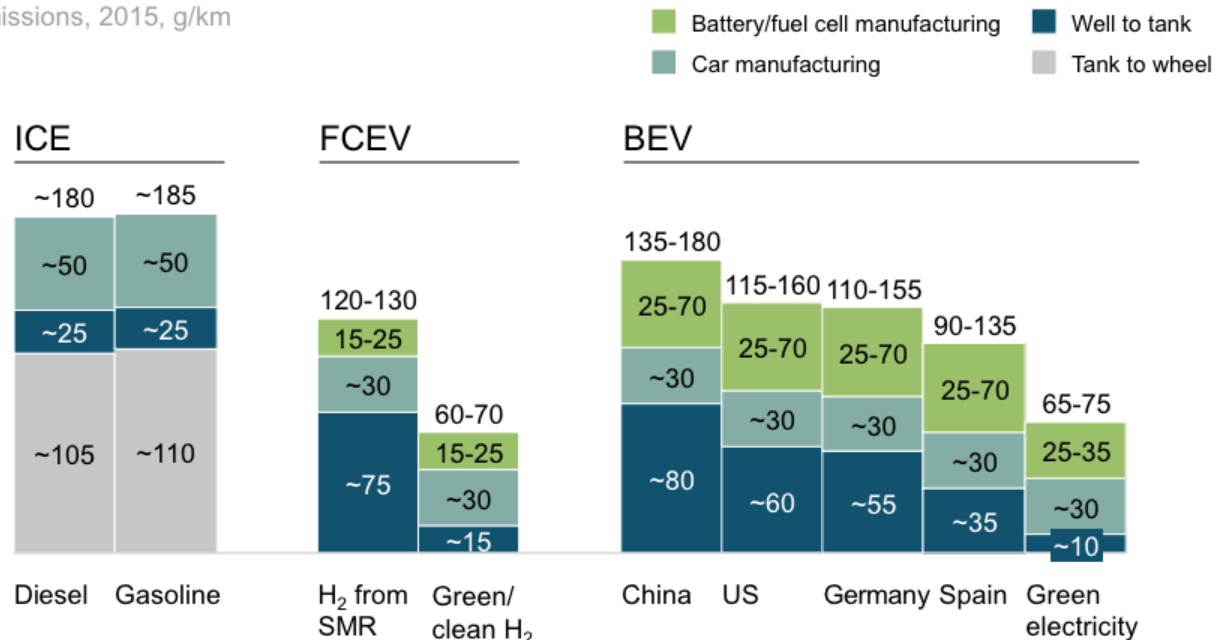
- Combustion engines emit many harmful compounds like $PM_{2.5}$, PM_{10} , NO_x , SO_x and CO_x



Electric Vehicles Cut Full-cycle Emissions

Despite higher emission intensity of powertrain construction

CO₂ emissions, 2015, g/km

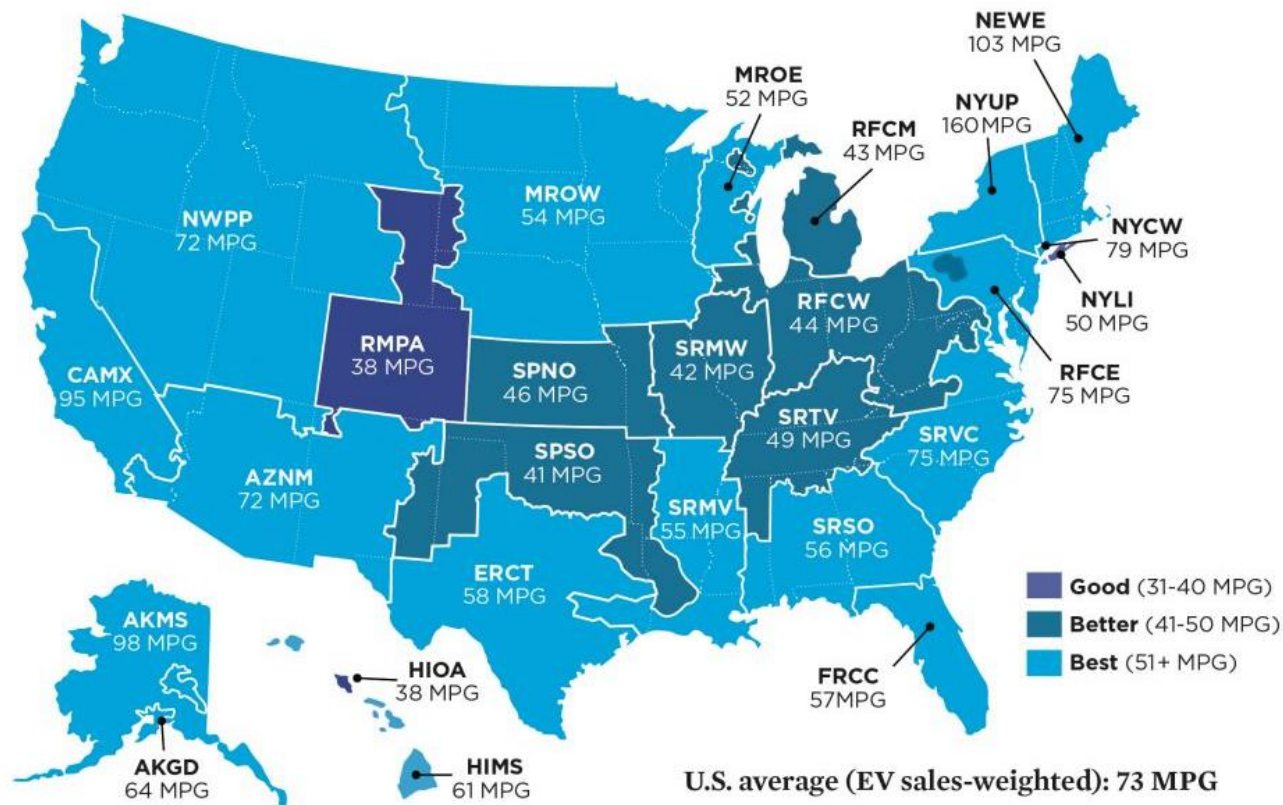


Source: Scaling-up, Hydrogen Council (2017)

- ICE = Internal Combustion Engine
- FCEV = Fuel Cell Electric Vehicle
- BEV = Battery Electric Vehicle (Lithium-ion)
- SMR = Steam Methane Reformation

Fuel Economy-Equivalent Ratings for EVs by U.S. Grid Region

How good depends on the source of electricity

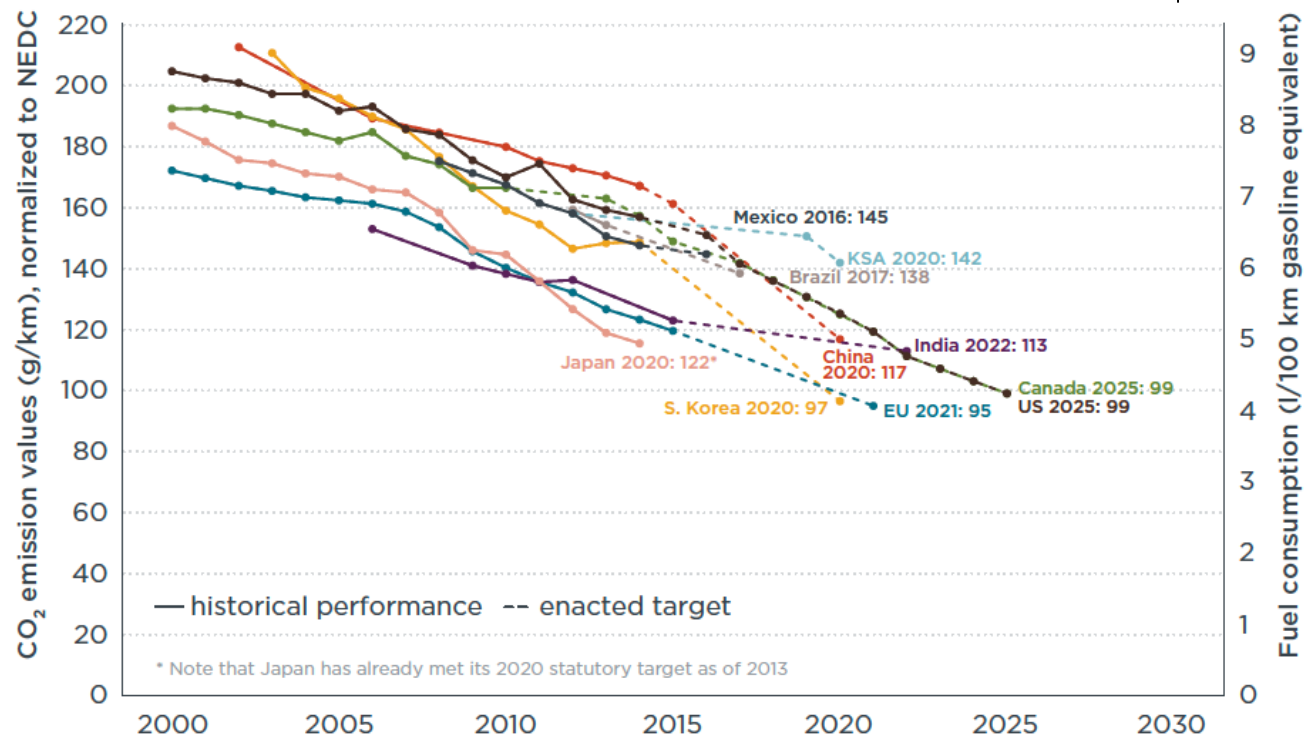


Source: Union of Concerned Scientists, May 2017

Electrification is Necessary to Meet Emissions Regulations

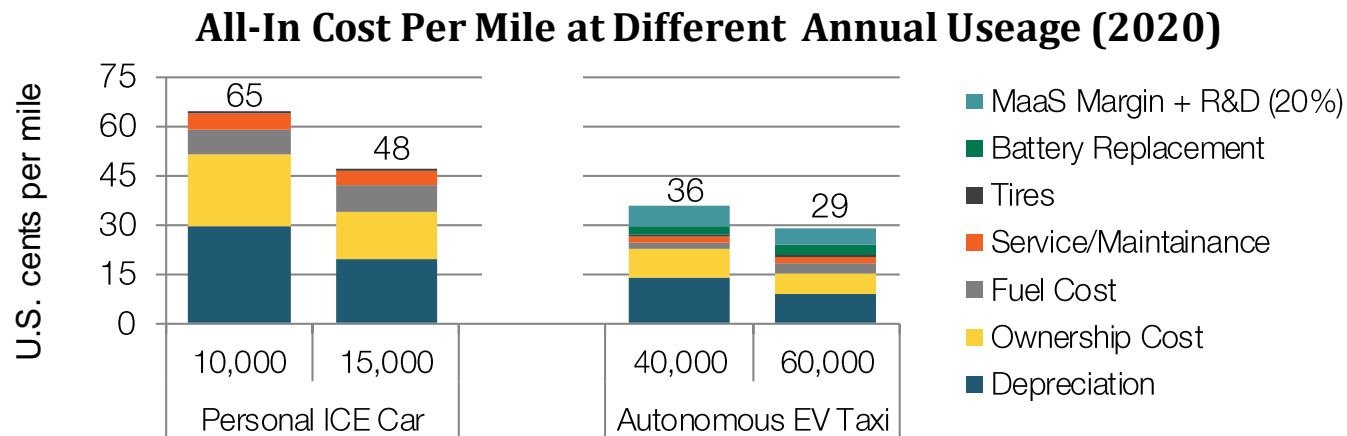
After a century of tinkering, ICEs are hard-pressed to adopt

Source: International Council on Clean Transportation



- Increasing number of countries, states and cities have policies for phasing out fossil fuel cars
- Diesel emissions scandal pulled the plug on Europe's switch towards diesel
- Paris Declaration on Electro-Mobility and Climate Change calls for 20% of all road vehicles electrified by 2030 and 50% by 2050 (COP 21)

Electric Vehicles Enable Autonomy and Better Sharing *Resultant higher utilization drives down costs and per-mile emissions*



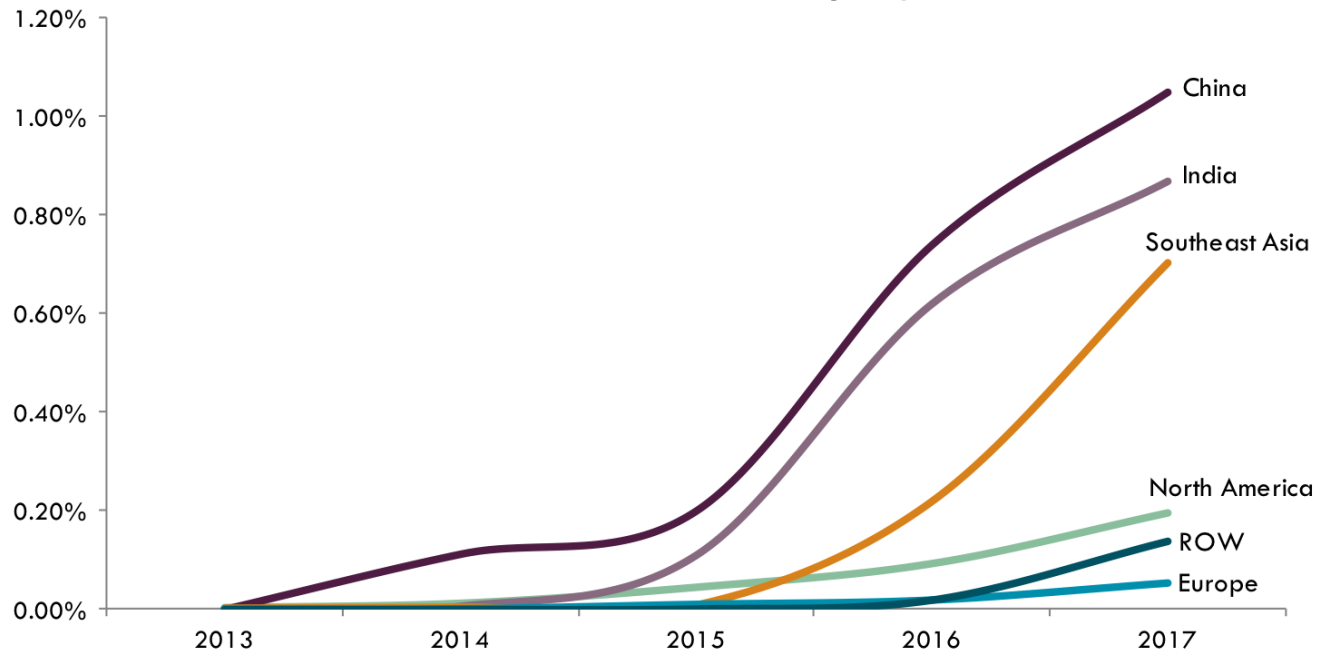
Source: AAA Your Driving Costs 2016 (small sedan), EIA (2016 all sector retail electricity), EPA (fuel economy for model year 2015), and Radiant Value analysis

- Individually owned vehicles are used merely 4–5% of the time
- Electric vehicles are cheaper to operate and easier for robots to control
- At 4x the utilization of personal cars, unsubsidized autonomous taxis could cut all-in costs by ~40%

Electric Mobility-as-a-Service May Leapfrog Personal Ownership

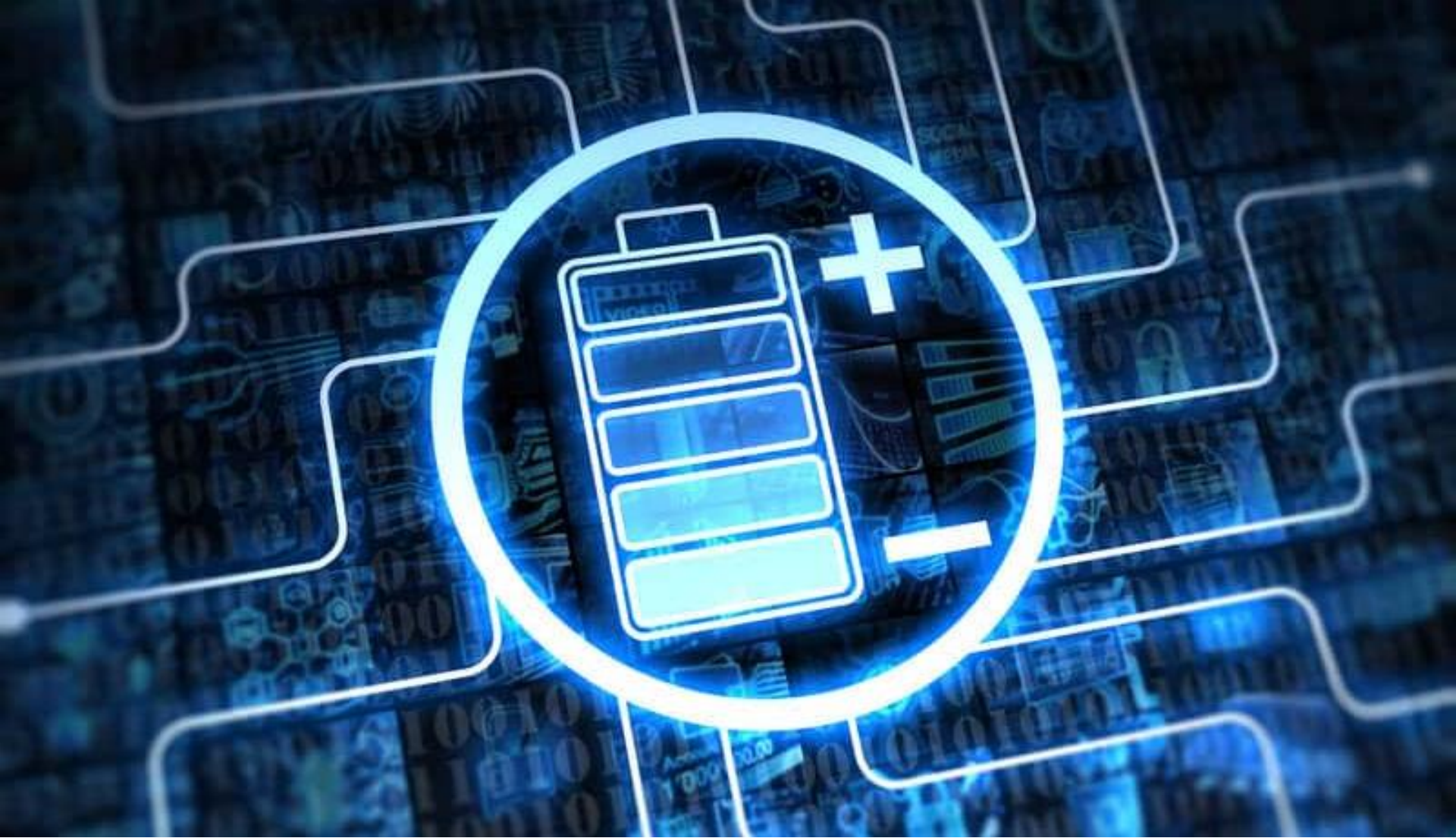
Auto industry to change more in the next 20 years than it did over the last 100

Mobility-As-A-Service Miles as a % of Total Vehicle Miles Traveled by Region



Source: ARK Investment Management LLC (who annualized the first quarter volume estimates from Hillhouse Capital)

- 2005–2015 vehicle fleet CAGR: 17.8% for China and 10.8% for India (3.7% global)
- Emerging markets much quicker to choose MaaS over personal cars
- High vehicle-cost-to-income ratio and % of population without a driving license



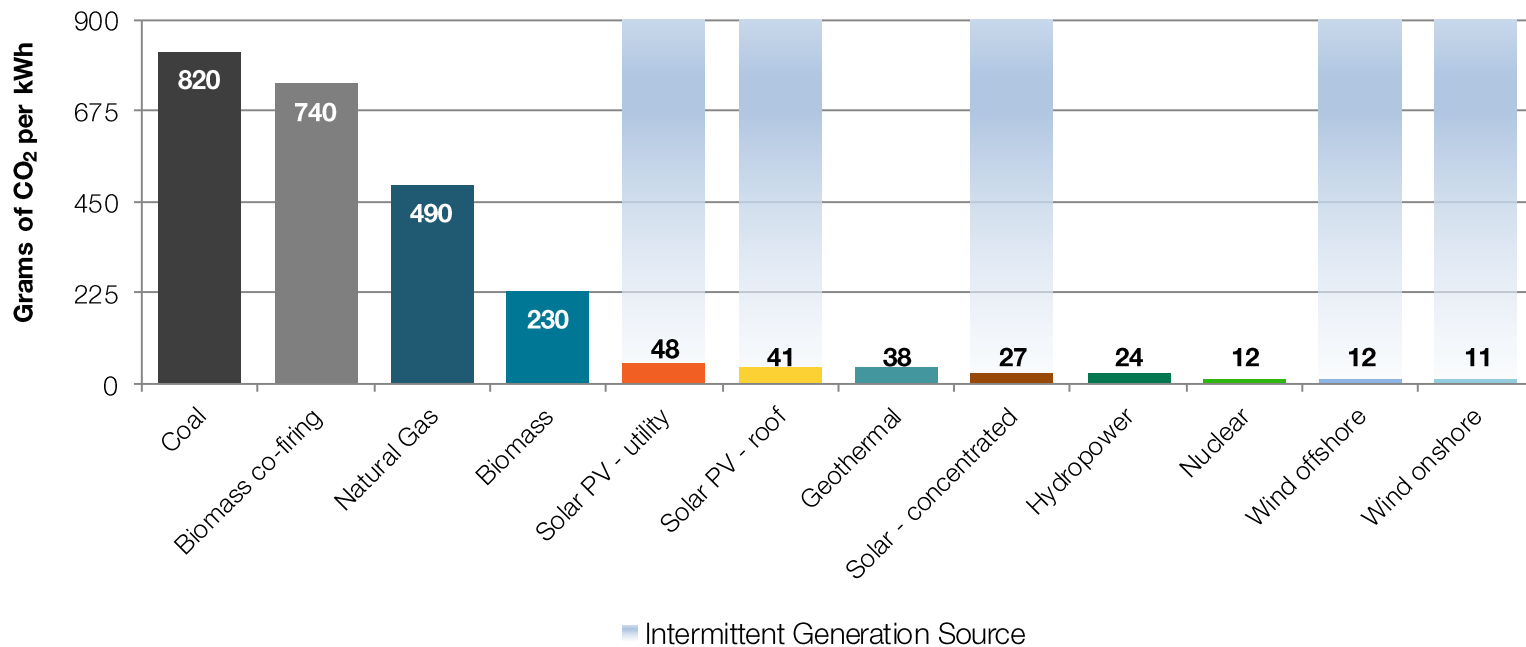
RENEWABLE INTEGRATION

**Intermittent Renewable Generation
Needs Energy Storage**



Most Low-Carbon Resources Are Intermittent

Electricity and heat production accounts for 1/4 of global GHG emissions



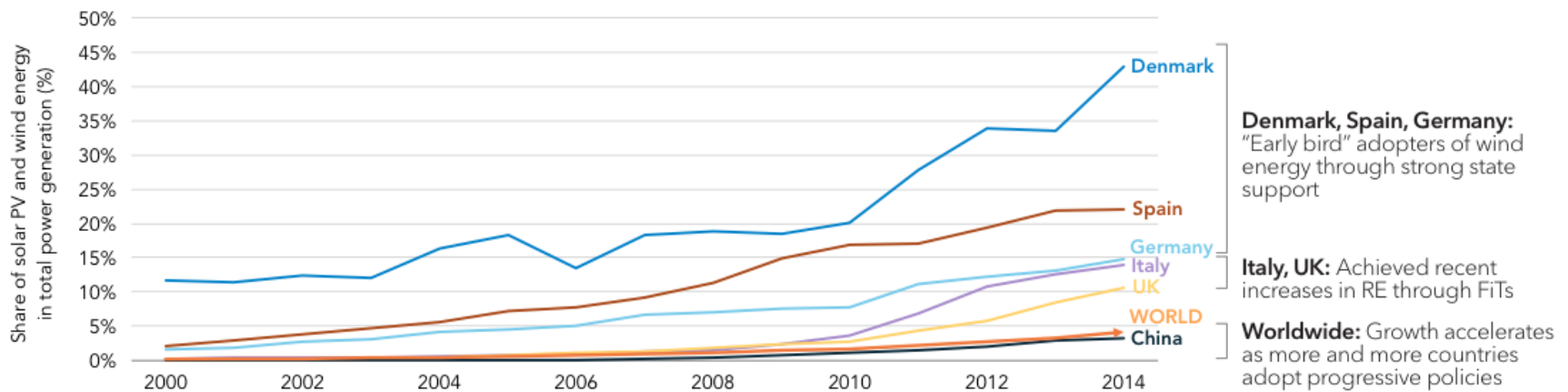
Source: Intergovernmental Panel on Climate Change
2014 Assessment, Annex III Table A.III.2

- Fossil fuels played three major roles in the energy mix: bulk generation, dispatchable generation and provision of flexibility



Renewable Energy Ramp Up

Initial uptake has been dependent on subsidies, but economics catching up fast



Source: New Climate Institute (Data from IEA)

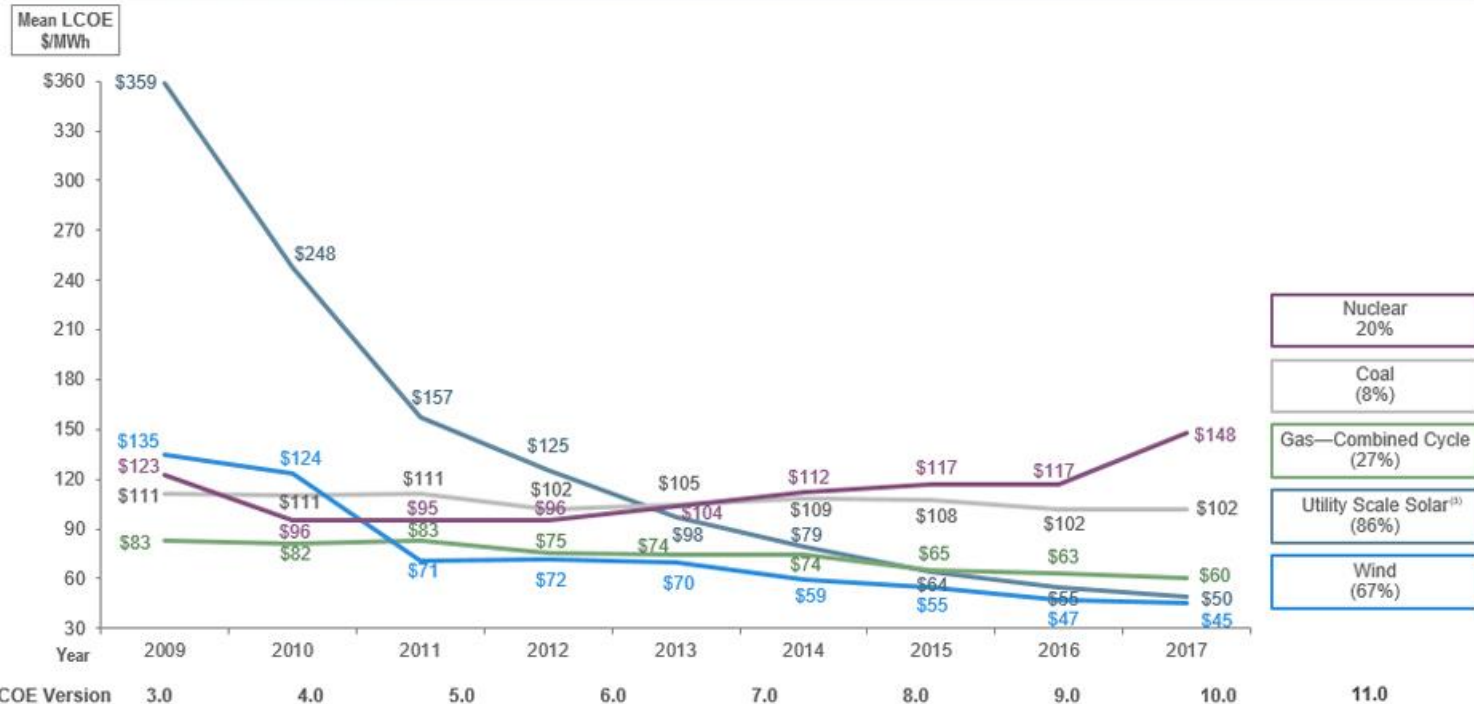
- RE = Renewable Energy
- FiT = Feed-in Tariff

Renewable Power Cost Declines Have Been Dramatic

Some renewables' full-lifecycle costs now below conventionals' operating cost alone

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.

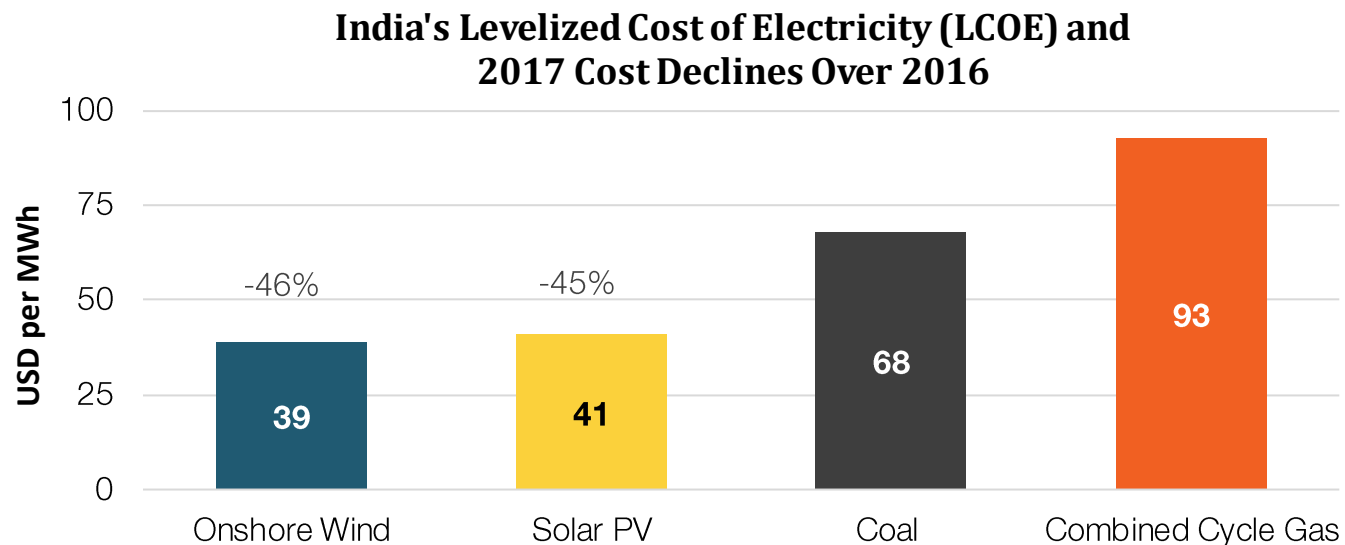
(1) Primarily relates to North American alternative energy landscape, but reflects broader/global cost declines.

(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.

India's Renewable Electricity Cheaper Than Fossil Fueled Options

An avalanche of new capacity is ready to be installed



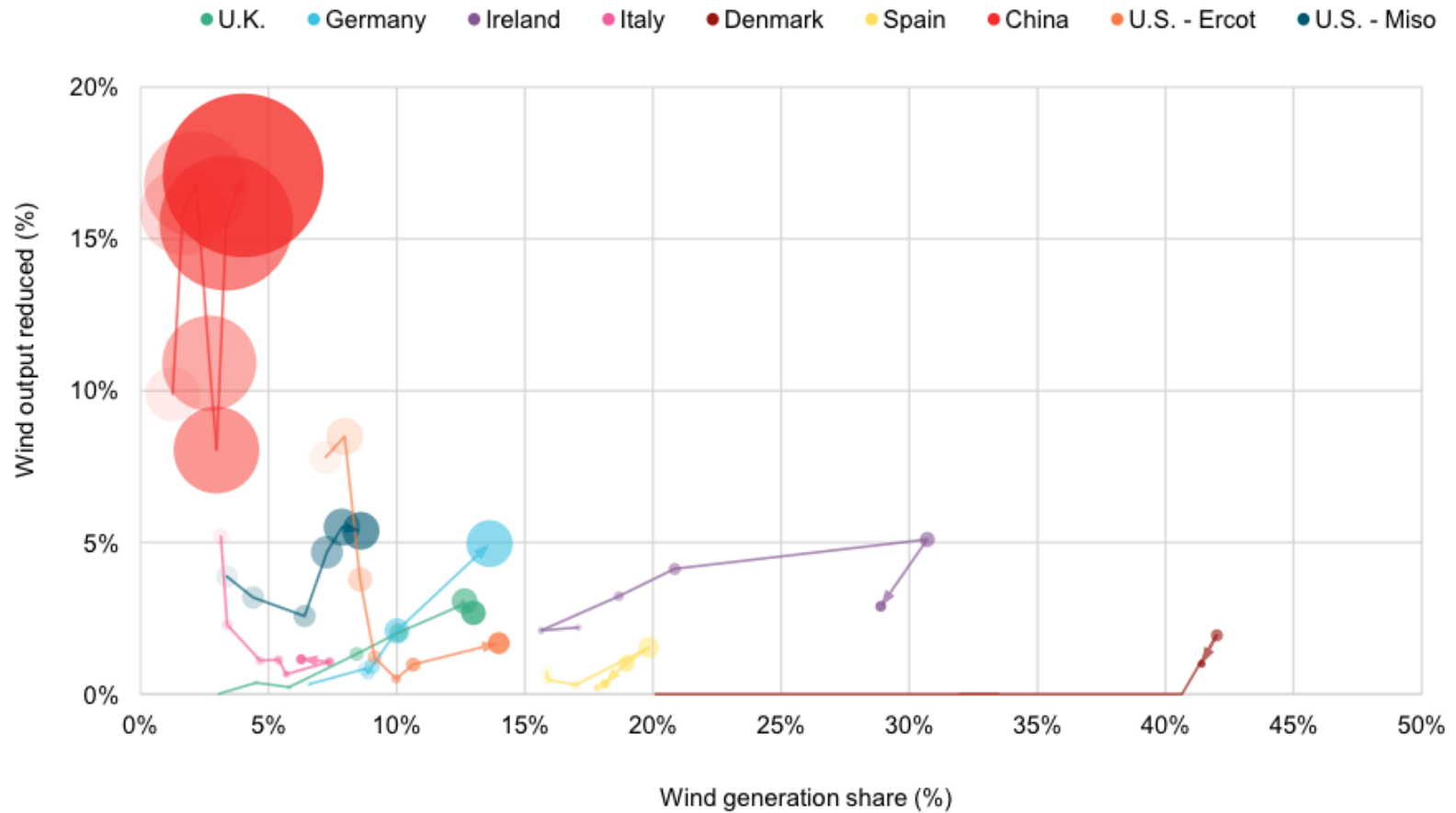
Source: Bloomberg New Energy Finance

- In many markets, unsubsidized renewable resources are becoming cheaper than conventional sources



Wind Generation Curtailment

The inability to dispatch renewable power 'at will' creates bottlenecks



Source: Bloomberg New Energy Finance, NEA, ENTSO-E, U.S. DOE

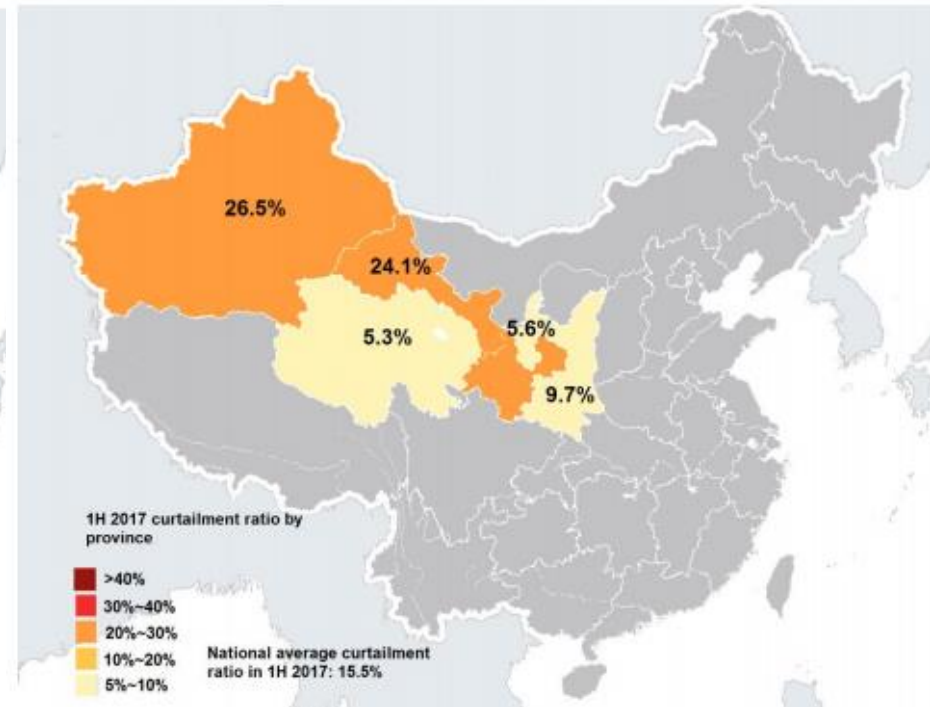
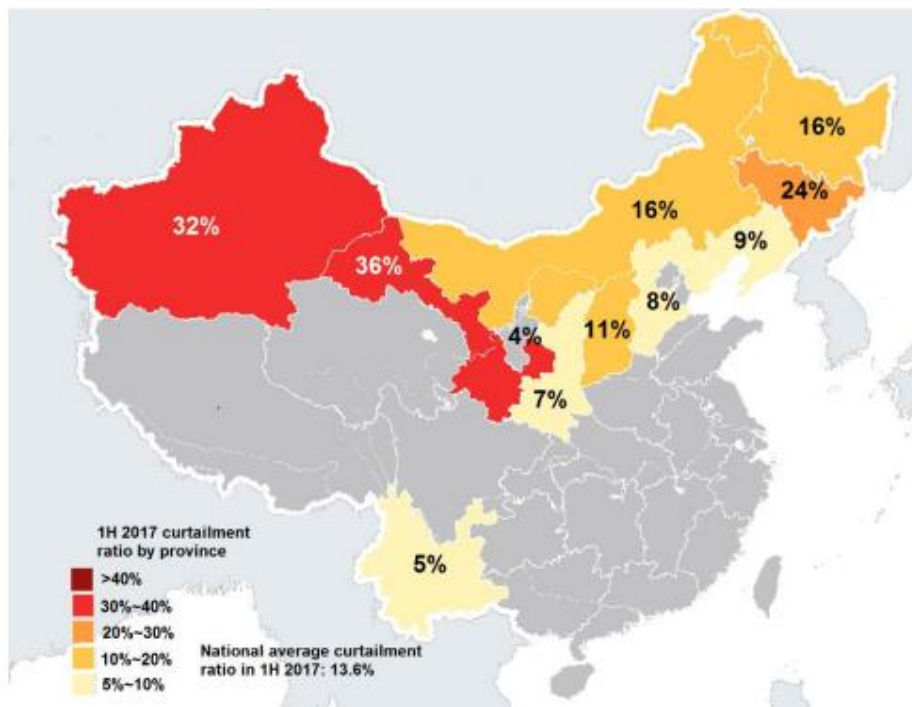


China's Wasted Renewable Generation

National curtailment rates were 17% for wind and 20% for solar in 2016

1H 2017 wind curtailment ratio in China

1H 2017 solar curtailment ratio in China



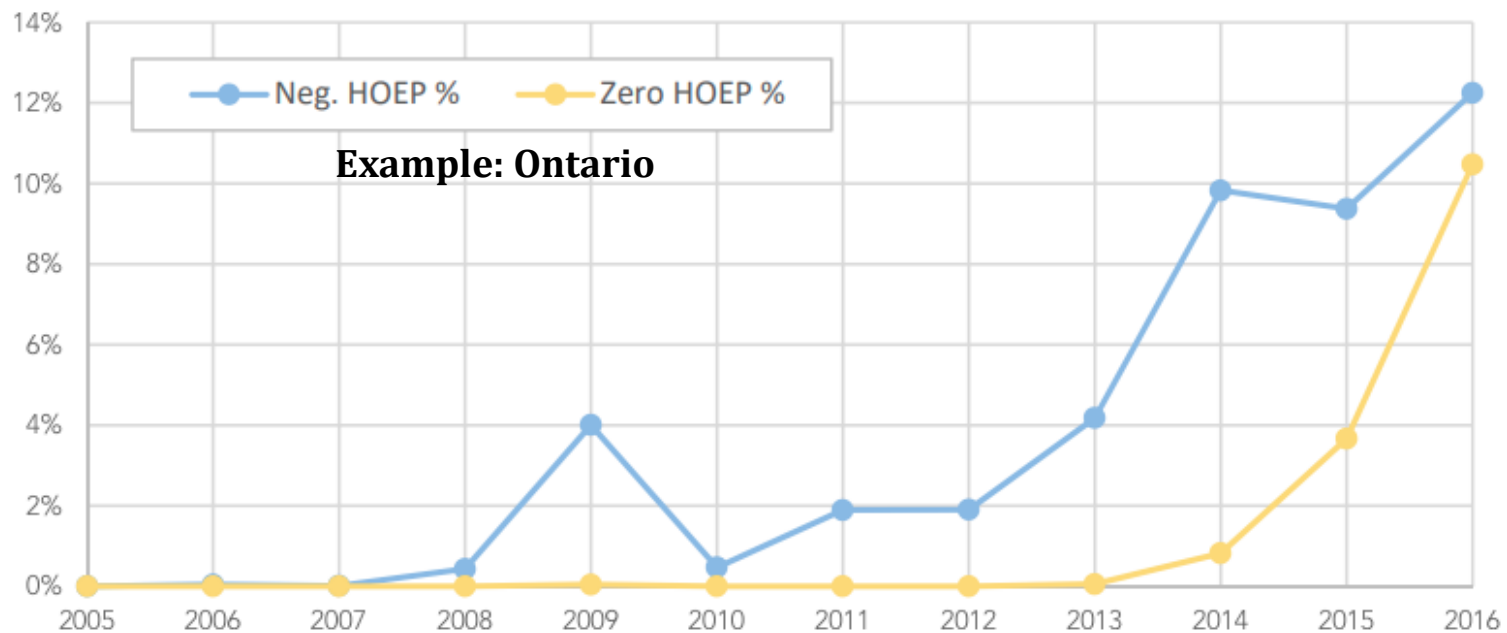
Source: Bloomberg New Energy Finance (NEA)

- Improved inter-regional transmission and market flexibility will alleviate incentive-driven overbuild
- Energy storage will help reduce renewable curtailment



Increased Renewables Pose a Threat to Grid Stability

Zero and negatively priced hours of energy production (HOEP) growing



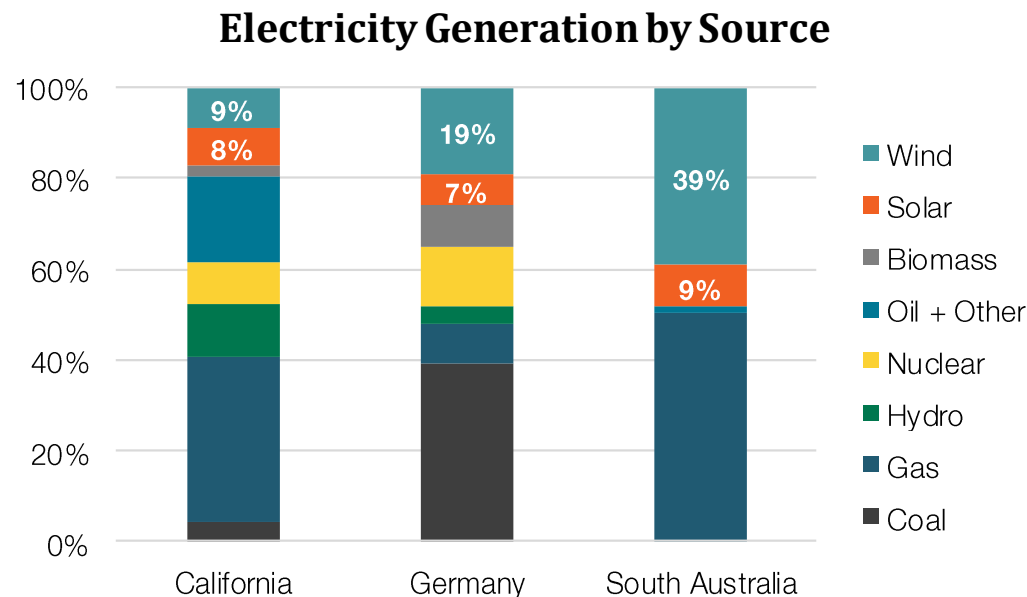
Source: Metrolinx Hydrail feasibility

- Unsubsidized low-carbon nuclear power cannot compete with negative sales prices and is shutting down due to renewable growth
- Wasted renewable electricity can be harnessed with energy storage while stabilizing the grid



Electric Grids Under Pressure

Counties/areas with high intermittent generation are struggling to cope



Source: Fraunhofer Institute for Solar Energy Systems (2017), California Energy Commission (2016), Australian Energy Market Operator (2016-2017)

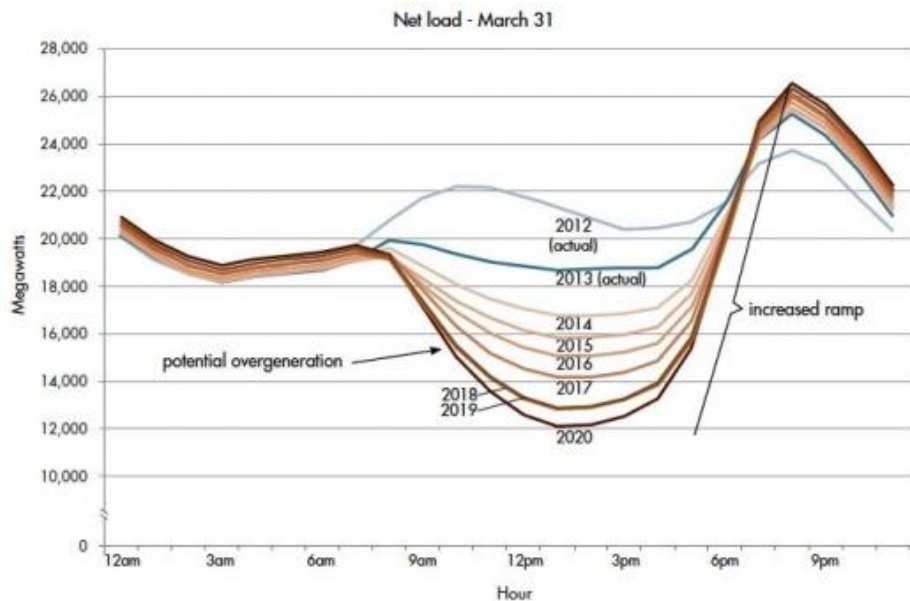
- South Australia suffered widespread power outage in 2016, where Tesla installed a large battery
- German power grid nearly collapsed in 2017 when wind and solar contribution dipped below 5%
- California has relied on natural gas to balance growing intermittent resources, but the massive Aliso Canyon gas leak (2015/2016) has diminished public support



Integrating Solar Power: The Duck Curve

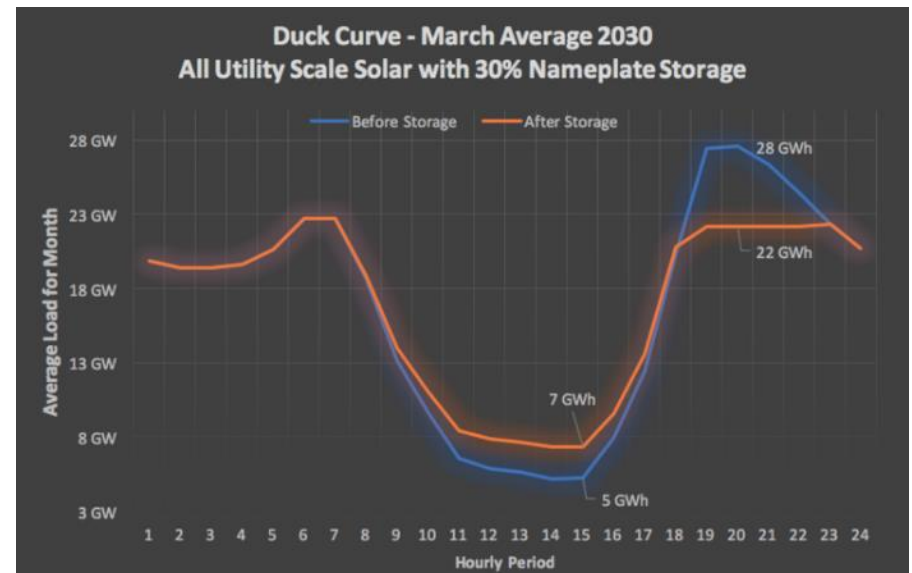
Daily electricity demand net of solar generation

Problem in California



Source: California Independent System Operator, 2013

Proposed Solution with Storage



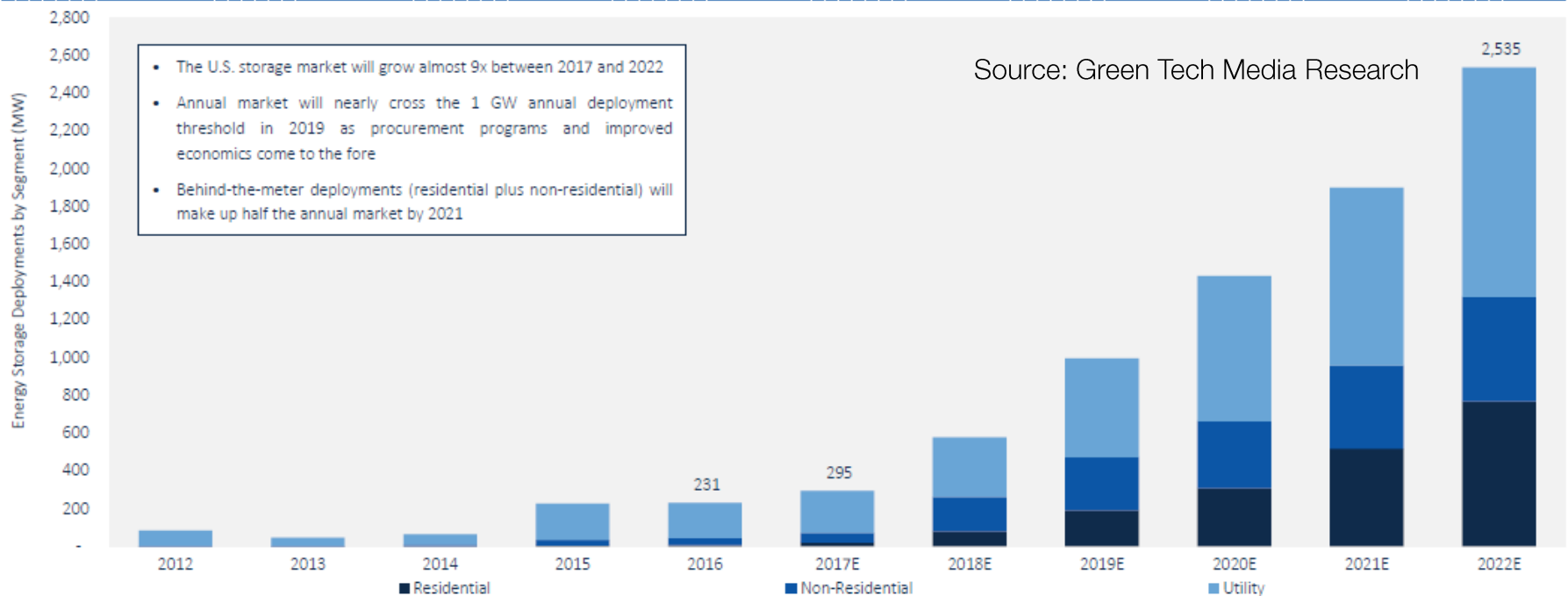
Source: Strategen Consulting, 2017

- Due to high solar capacity, net electricity demand dips during daylight hours
- Over generation causes solar curtailment and rapid ramp-up increases gas 'peaker' plant use
- Storage solves both problems and lowers the investments needed for peak grid capacity

Grid-Storage: Long-Term Potential

All U.S. gas 'peaker' plants to be uneconomic vs. storage by 2025: GS and GTM

U.S. Annual Energy Storage Deployment Forecast, 2012-2022E (MW)



- Electricity storage is near non-existent – sub-0.1% of global electricity was stored
- Lithium-ion 94% of energy storage deployment since 4Q2014: GTM/ESA US Energy Storage Monitor
- Grid storage could be biggest battery end-use beyond 2030



Radiant Value Management, LLC

Operating money management since 2015

We invest in the dislocations created in energy and in the storage revolution. Energy storage costs' dramatically decline over the last decade has allowing uses to expand rapidly. The pace of change creates market inefficiencies, which are our opportunities. We aim to invest ahead of bottlenecks, vertically and horizontally across energy, industrial and resource value chains.

One of our focus areas is lithium-ion batteries, which are becoming faster, better, and cheaper than competing technologies. Lithium-ion dominates personal electronic devices, and is in the process of disrupting the auto industry. The price of Electric Vehicles becoming cost-competitive with fossil fuel cars will create new business models like autonomous ride sharing. Energy storage will also become increasingly important as inherently intermittent renewable generation becomes economic without subsidies.



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Disclosures

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