



GETTING TO ZERO

*STRATEGIESTO RAPIDLY
DRIVE DOWN EMISSIONS*

HAL HARVEY

@hal_harvey

ENERGY INNOVATION
POLICY & TECHNOLOGY LLC



OUTLINE

- Doing the math on climate
- A “Four Zero” energy solution
- Options
 - The policy path
 - Venues and strategies



CLIMATE TRENDS: EXTREMES BECOME THE NORM

- Extreme weather is becoming the devastating new normal
- Climate change worsens drought, wildfires, floods, storms, invasive species

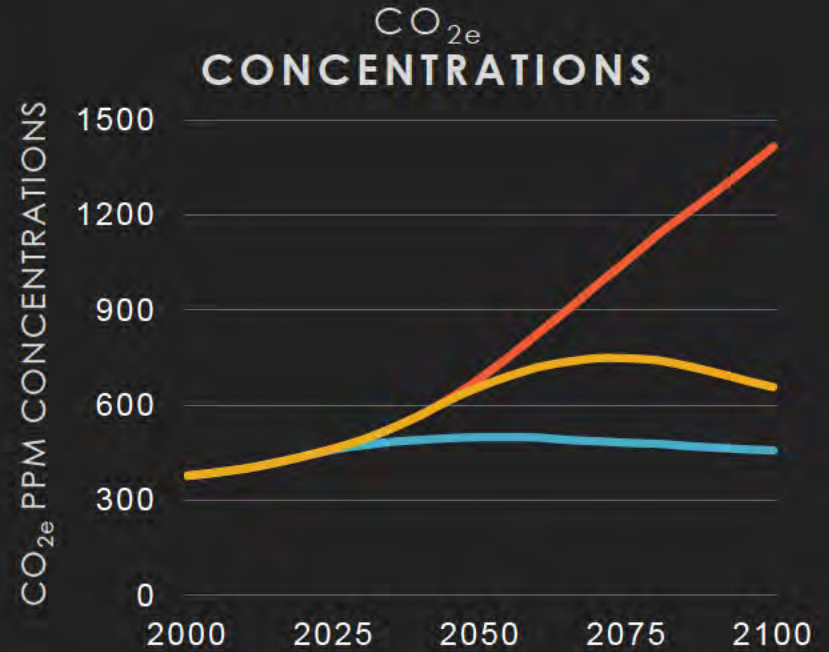
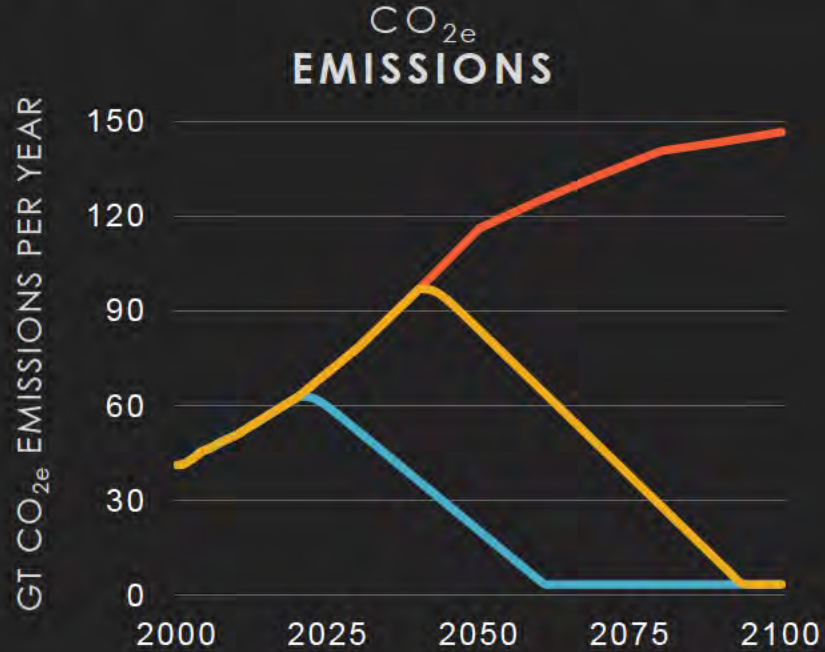


THE CLIMATE THREAT: RUNAWAY FEEDBACK LOOPS

- Methane release from melting tundra
- Wildfires
- Arctic sea ice minimums



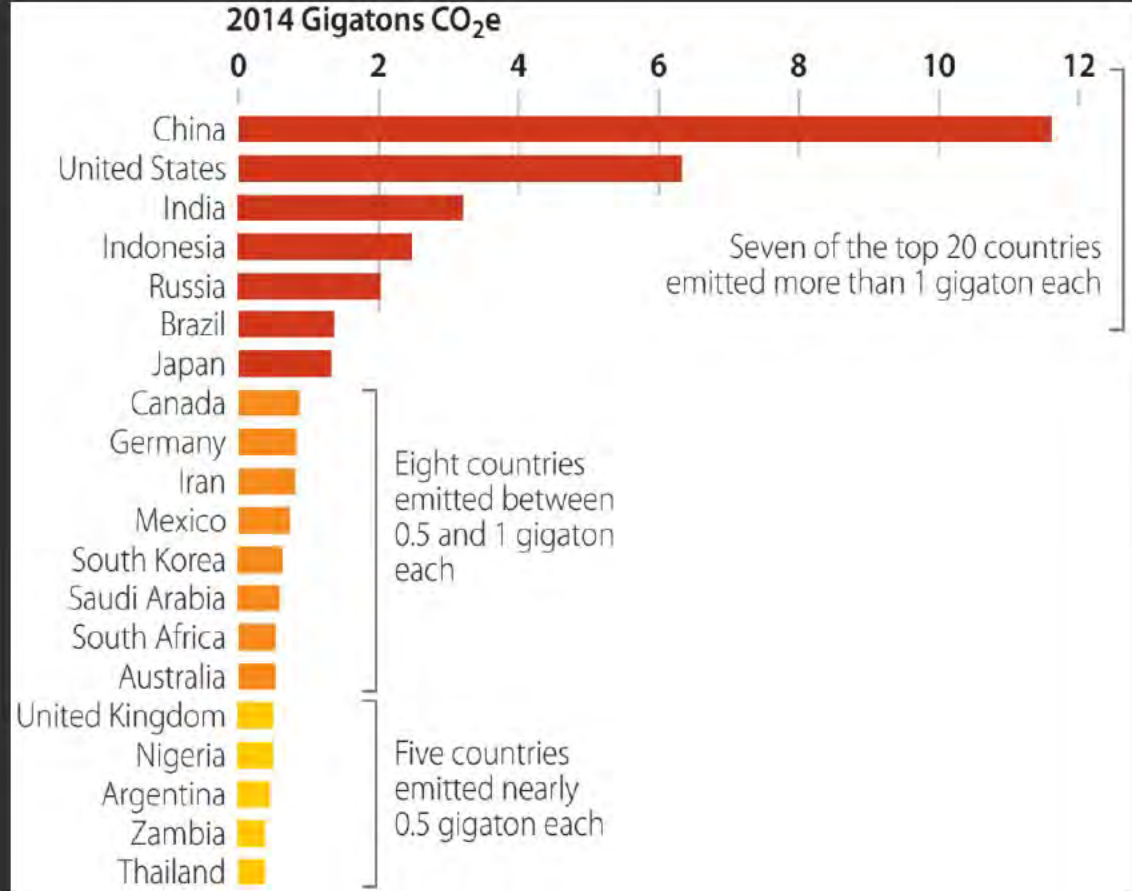
CLIMATE MATH: THE COST OF DELAY



■ BUSINESS AS USUAL ■ 450 PPM ■ 650 PPM

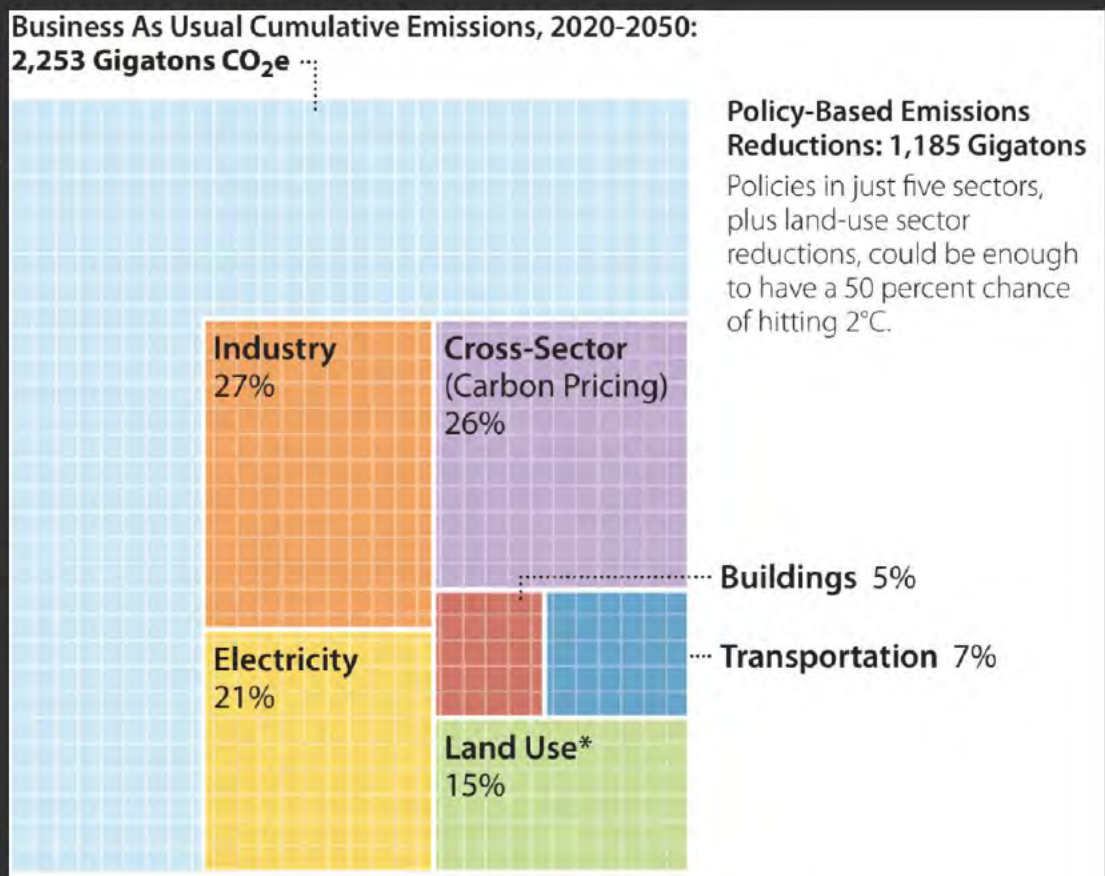
20 COUNTRIES MATTER THE MOST

- 20 countries generate nearly 75% of global emissions
- Win there, and win on climate



4 SECTORS MATTER THE MOST

- Policies in four sectors – plus carbon pricing – could cut emissions enough to keep warming below 2°C
- Let's get to zero in all of them



*Land-use emissions are calculated separately in this book, as explained in chapter two.

DECARBONIZING FOUR SECTORS IS KEY



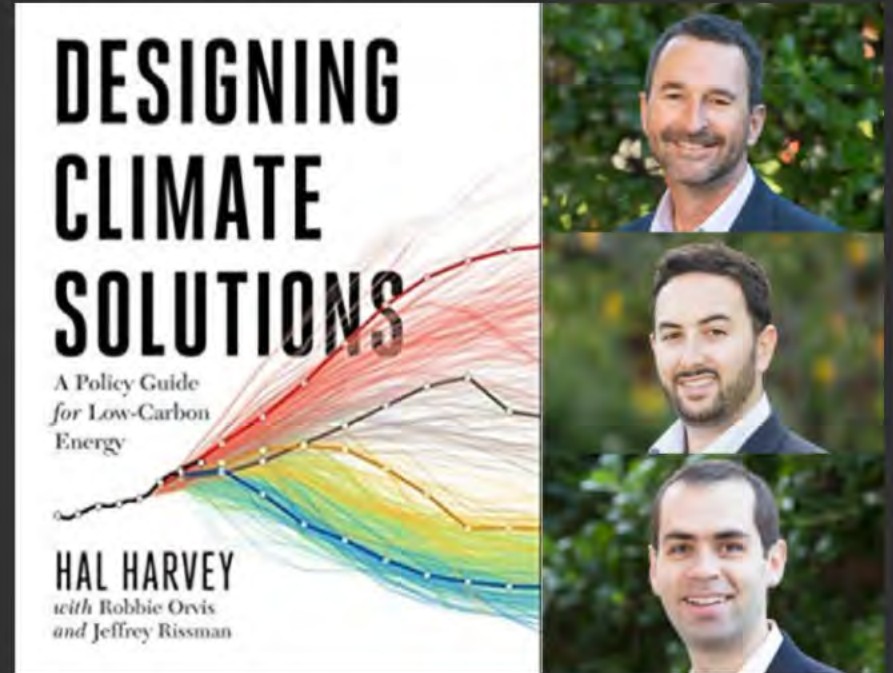
MOVE CAPITAL FROM BROWN TO GREEN— REQUIRES POLICY

- Cash flow exists
- \$5 trillion in global cash flow for energy; \$6 trillion for infrastructure setting consumption
- Redirect money from fossil fuels to clean energy



SUMMARY SO FAR

1. Extremes become the norm,
2. Systems can runaway due to natural feedback loops
3. Delay is fatal
4. 20 countries matter most
5. Four sectors (plus agriculture) must be changed.
6. Policy is required



1. CLIMATE TRENDS

IMPACTS ARE ACCELERATING, TIME IS SHORT

2. A FOUR ZERO SOLUTION

SMART POLICY IN 4 SECTORS, 20 COUNTRIES

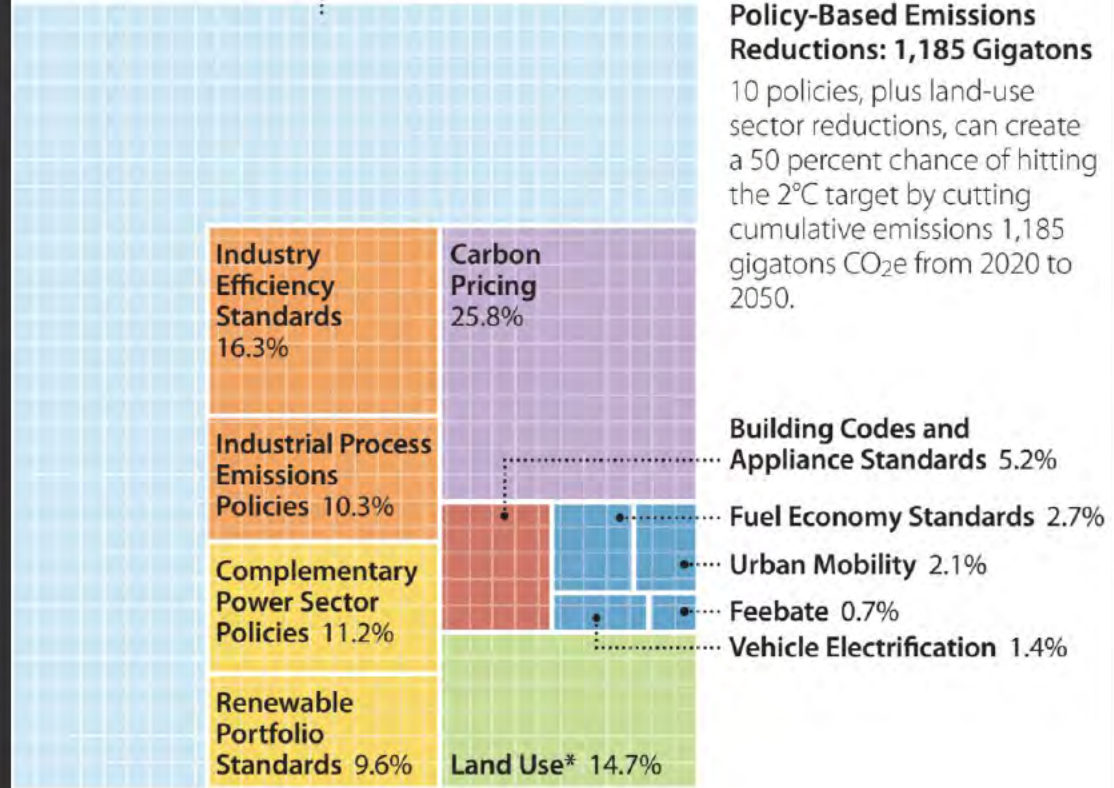
3. NEXT STEPS ON THE POLICY PATH

SPEED, SCALE, VENUE

POLICY IS REQUIRED

- Well-designed policies, properly implemented, can generate necessary emissions reductions at *speed* and *scale*
- Hundreds of policies exist; about a dozen actually work

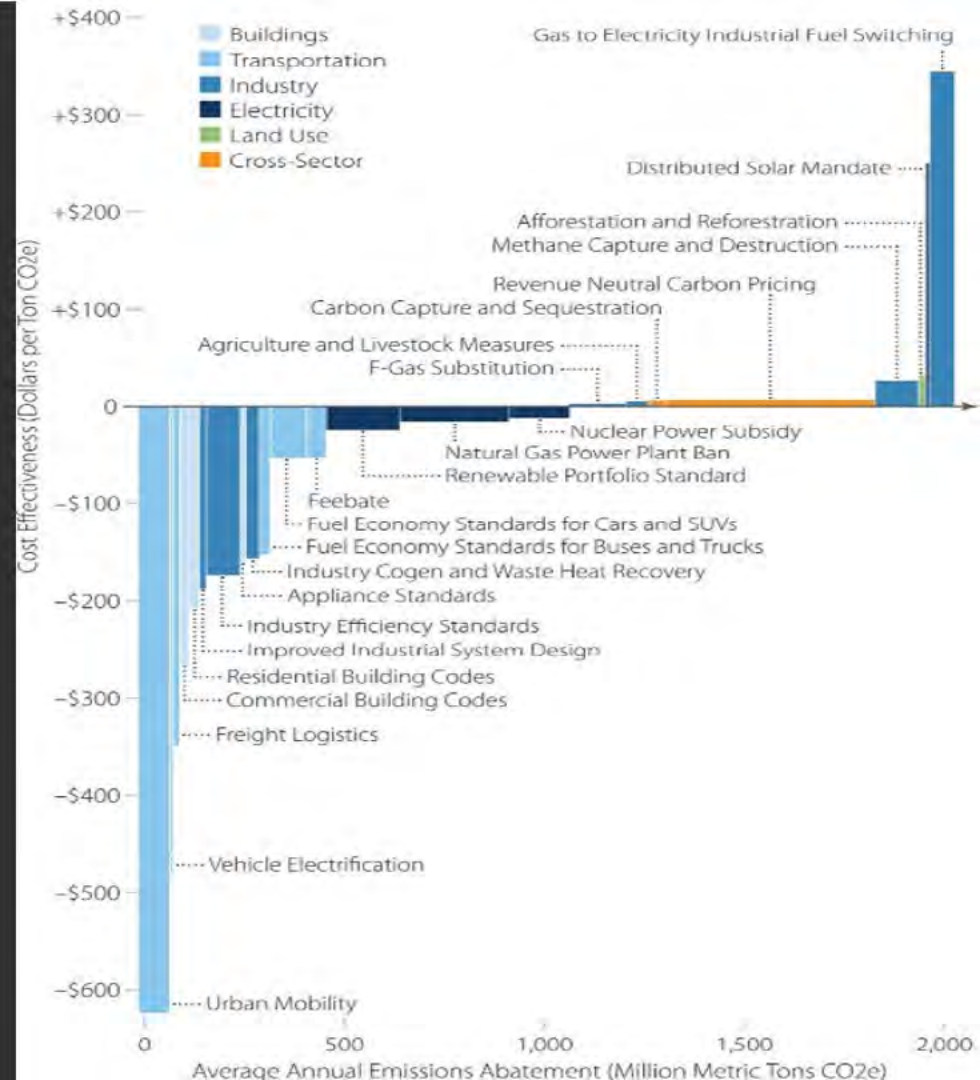
Business As Usual Cumulative Emissions, 2020-2050:
2,253 Gigatons CO₂e



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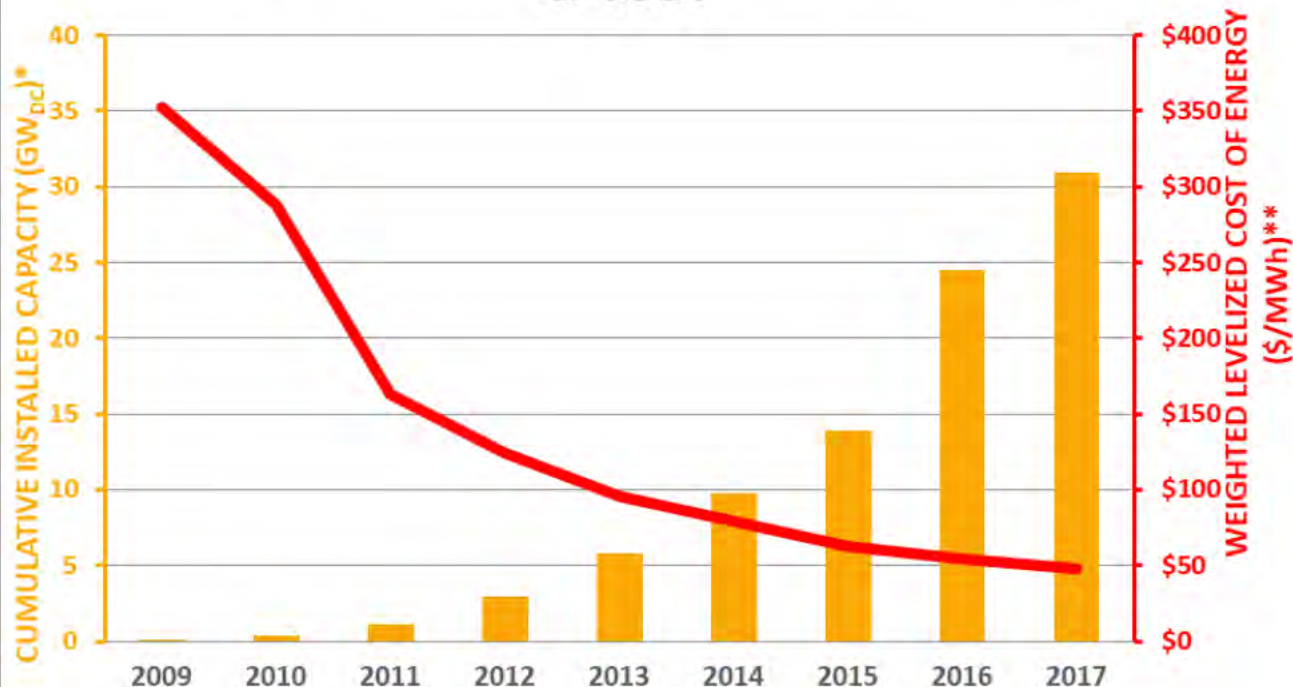
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ZERO-CARBON GRID: SOLAR PV

U.S. UTILITY-SCALE SOLAR PV DEPLOYMENT & COST



* Utility-scale capacity data - LBNL Utility-Scale Solar data set (2009-2016); GTM/SEIA Solar Market Insight Report (2017)

**LCOE - Lazard's Levelized Cost of Energy Analysis (2009-2017), technology-weighted avg. of high/low

ZERO-CARBON GRID: ONSHORE WIND

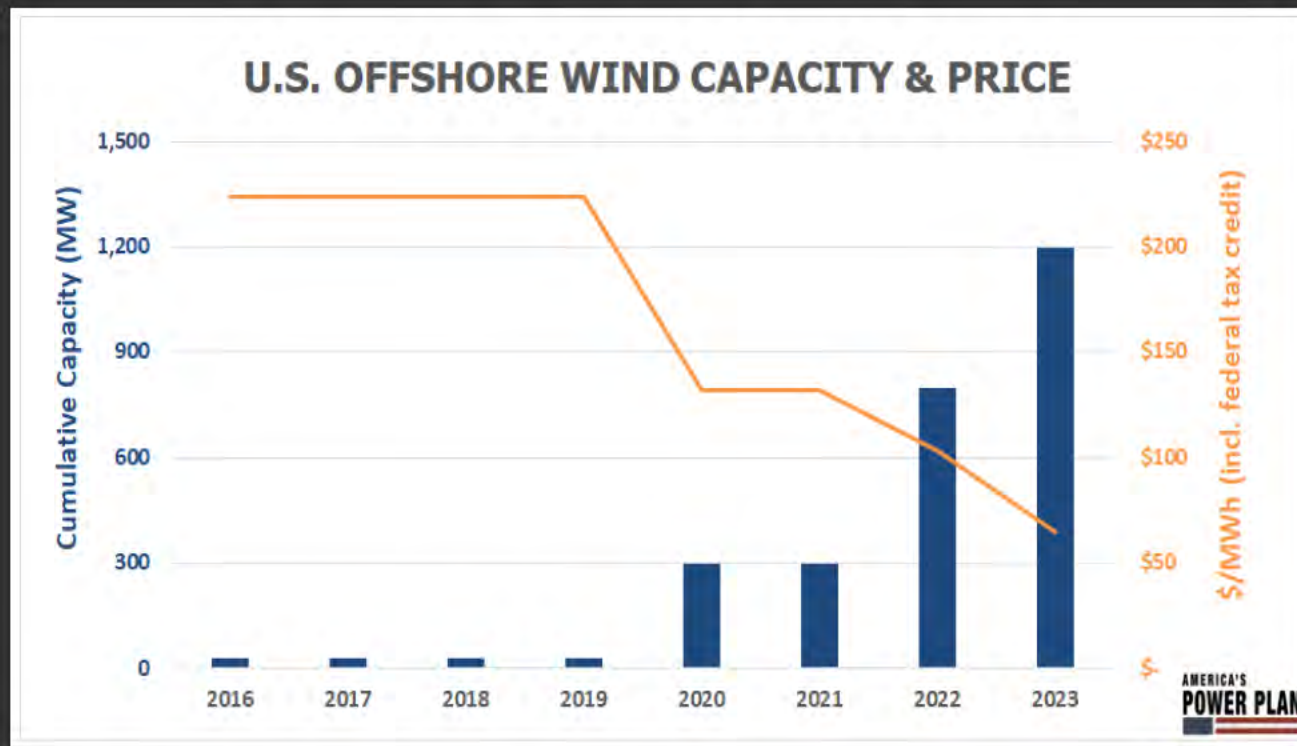
U.S. ONSHORE WIND DEPLOYMENT & COST



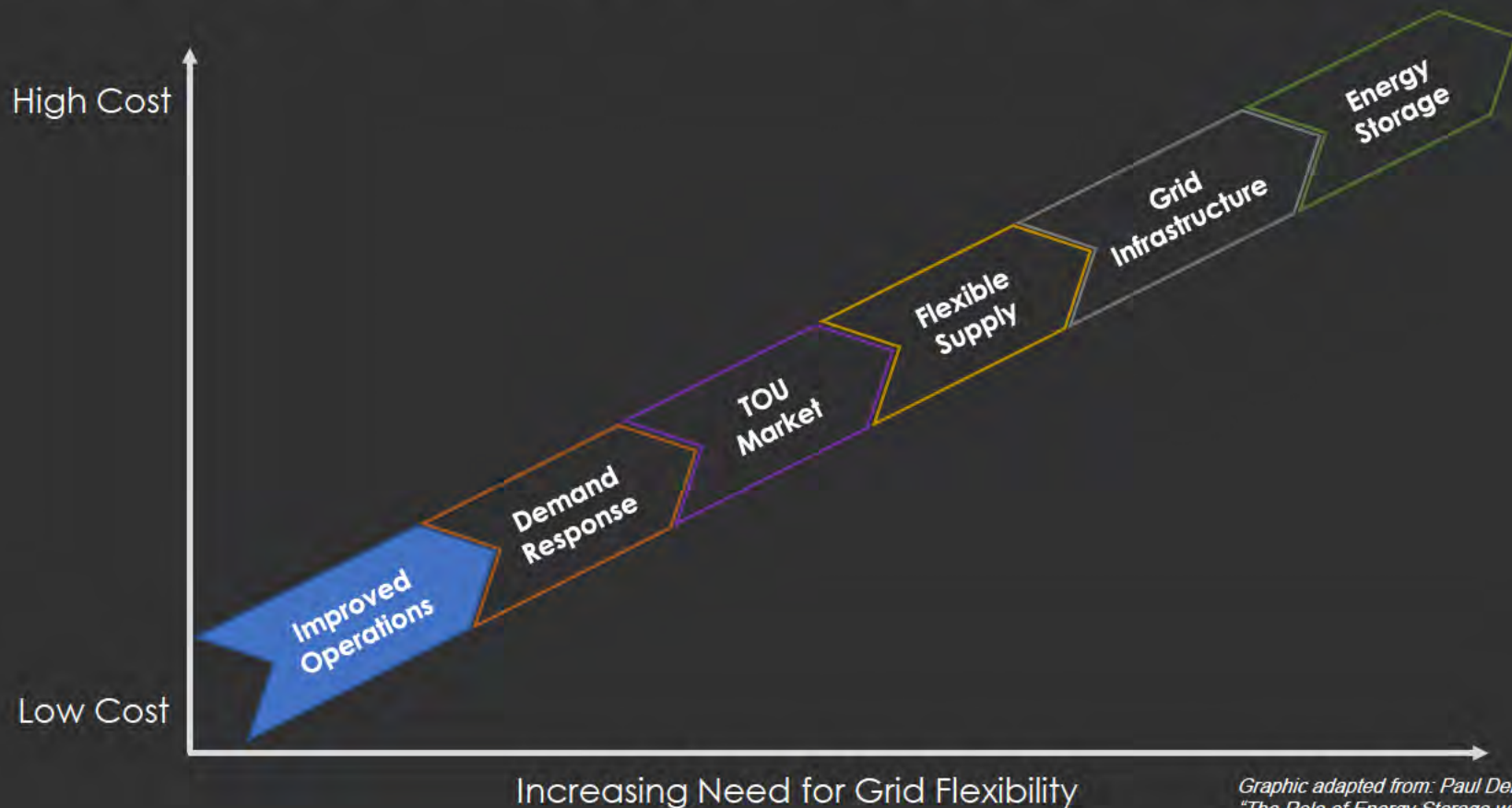
*Annual & Cumulative Capacity - LBNL Wind Technologies Market Report (2017) & AWEA market reports (2017)

**LCOE - Lazard's Levelized Cost of Energy Analysis (2009-2017), avg. of high/low figures

ZERO-CARBON GRID: OFFSHORE WIND

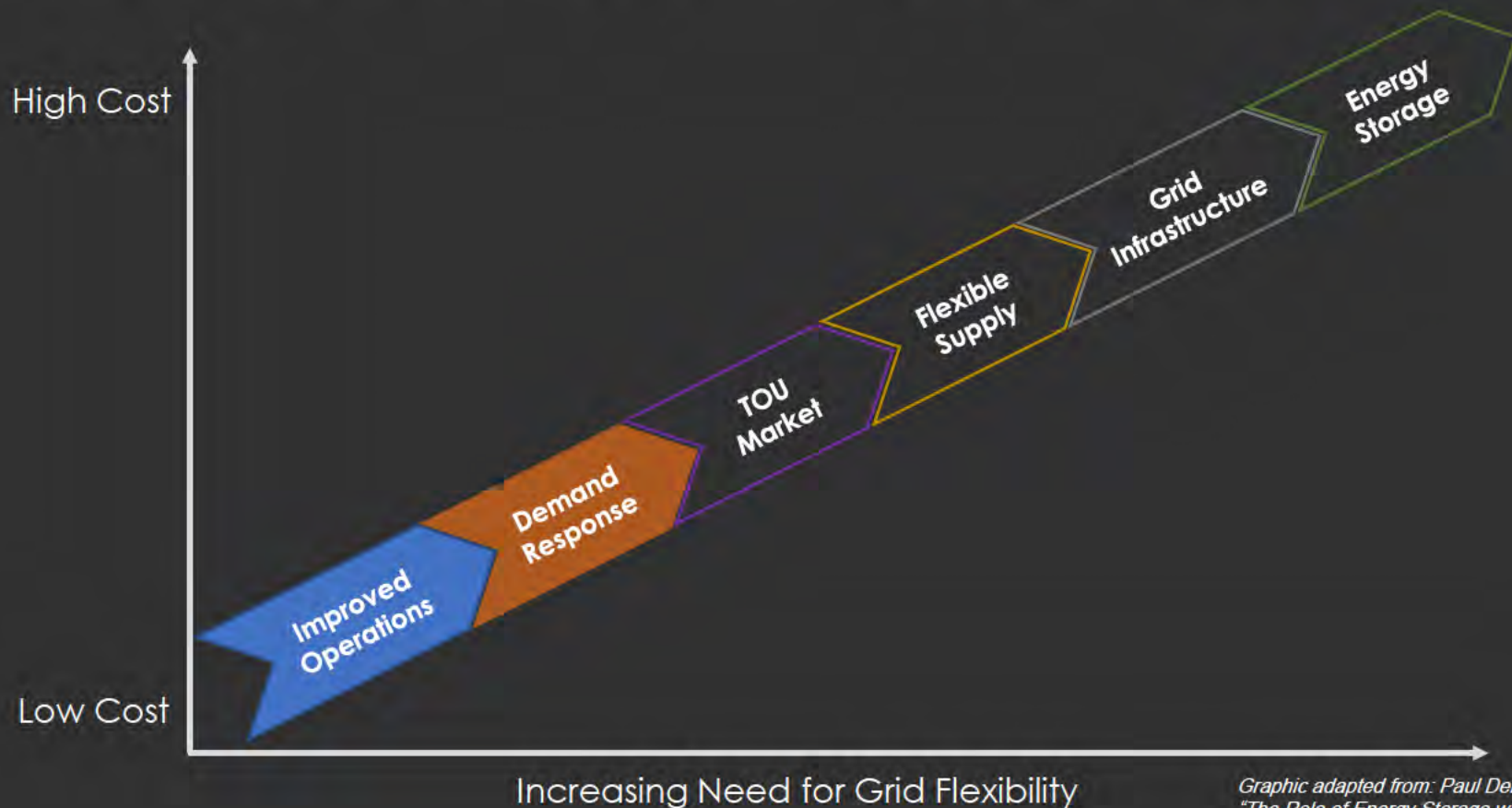


ZERO-CARBON GRID: GRID FLEXIBILITY



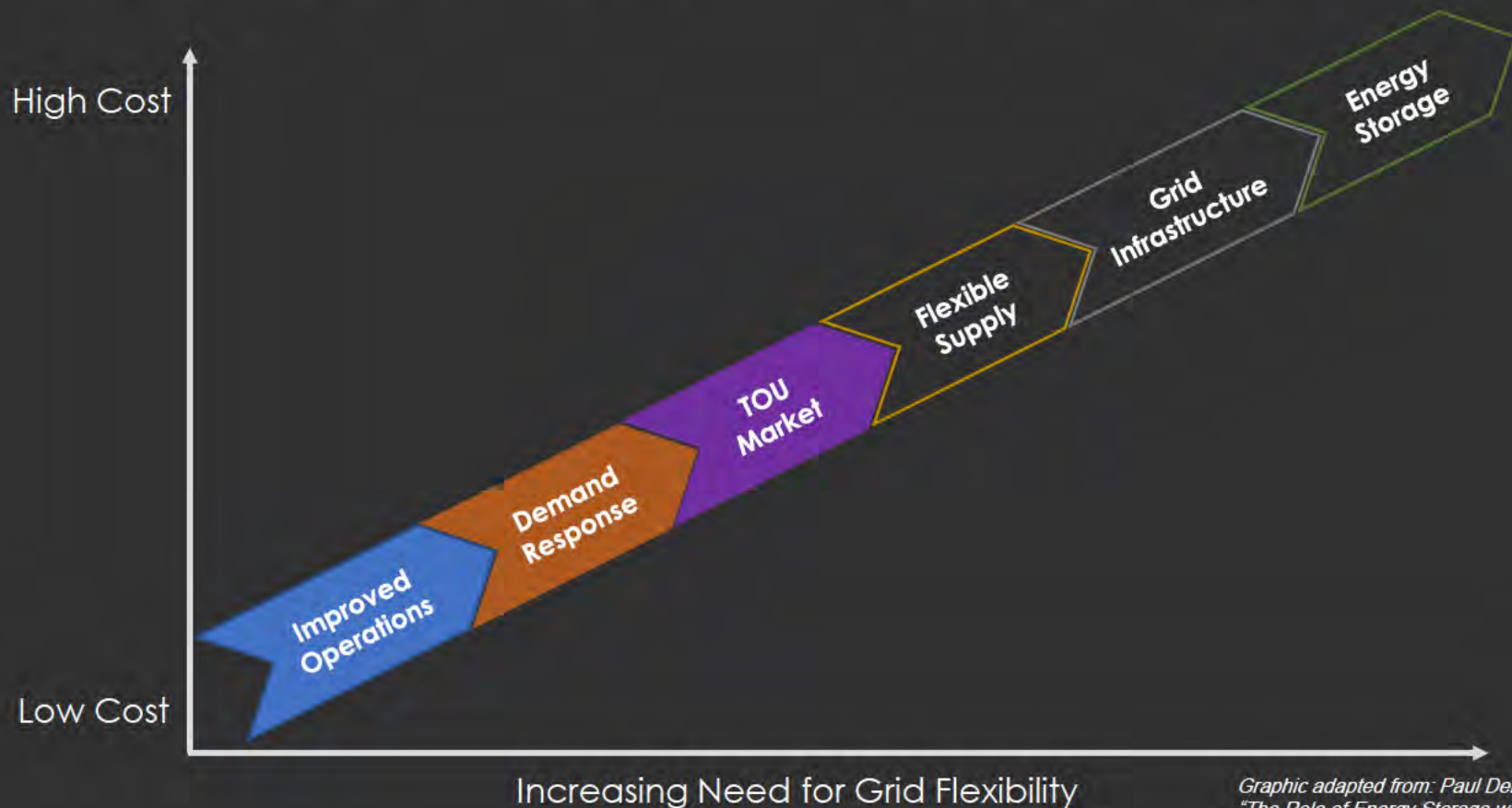
*Graphic adapted from: Paul Denholm et al.,
"The Role of Energy Storage with Renewable
Electricity Generation" (NREL, January 2010).*

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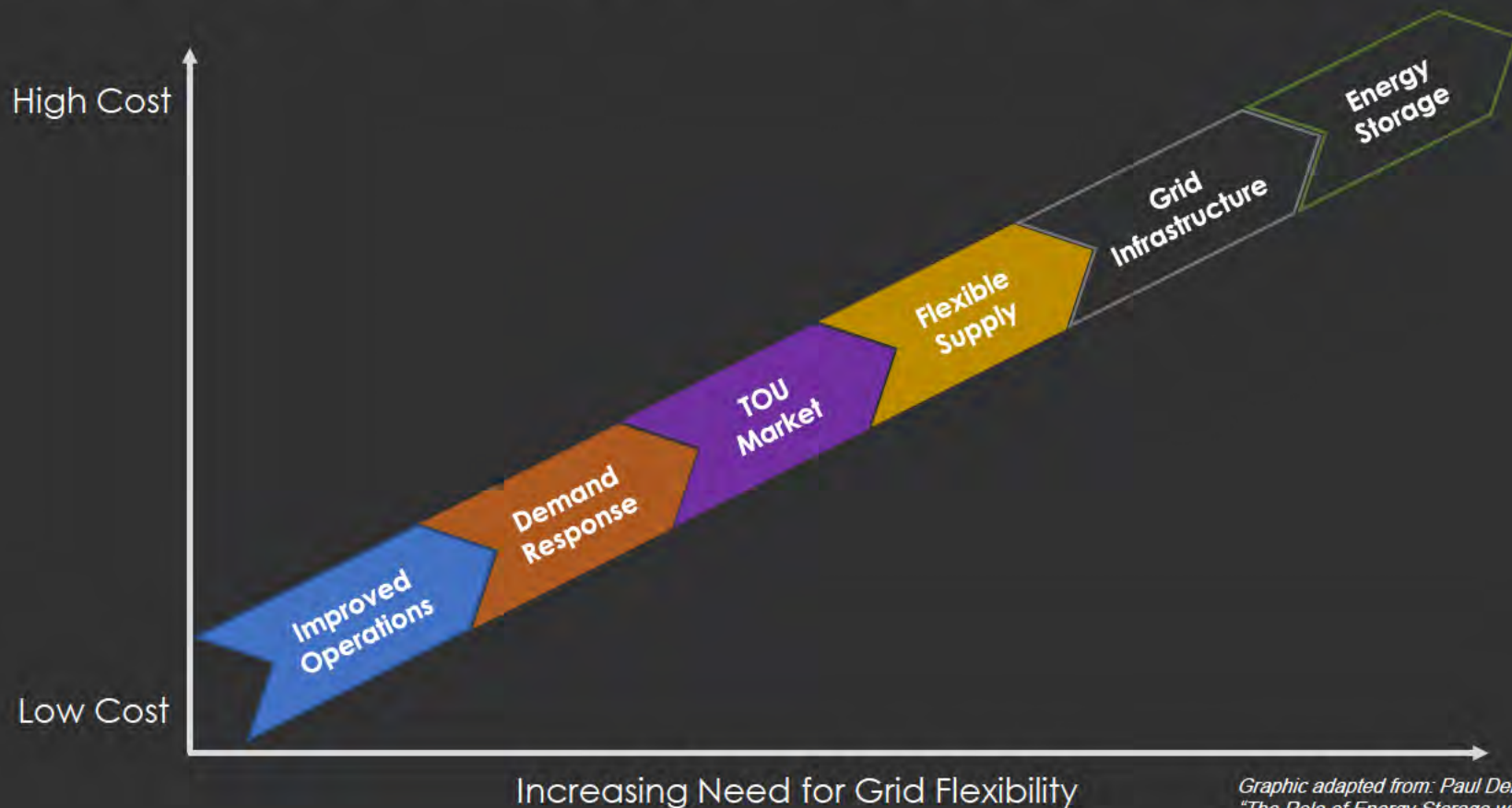
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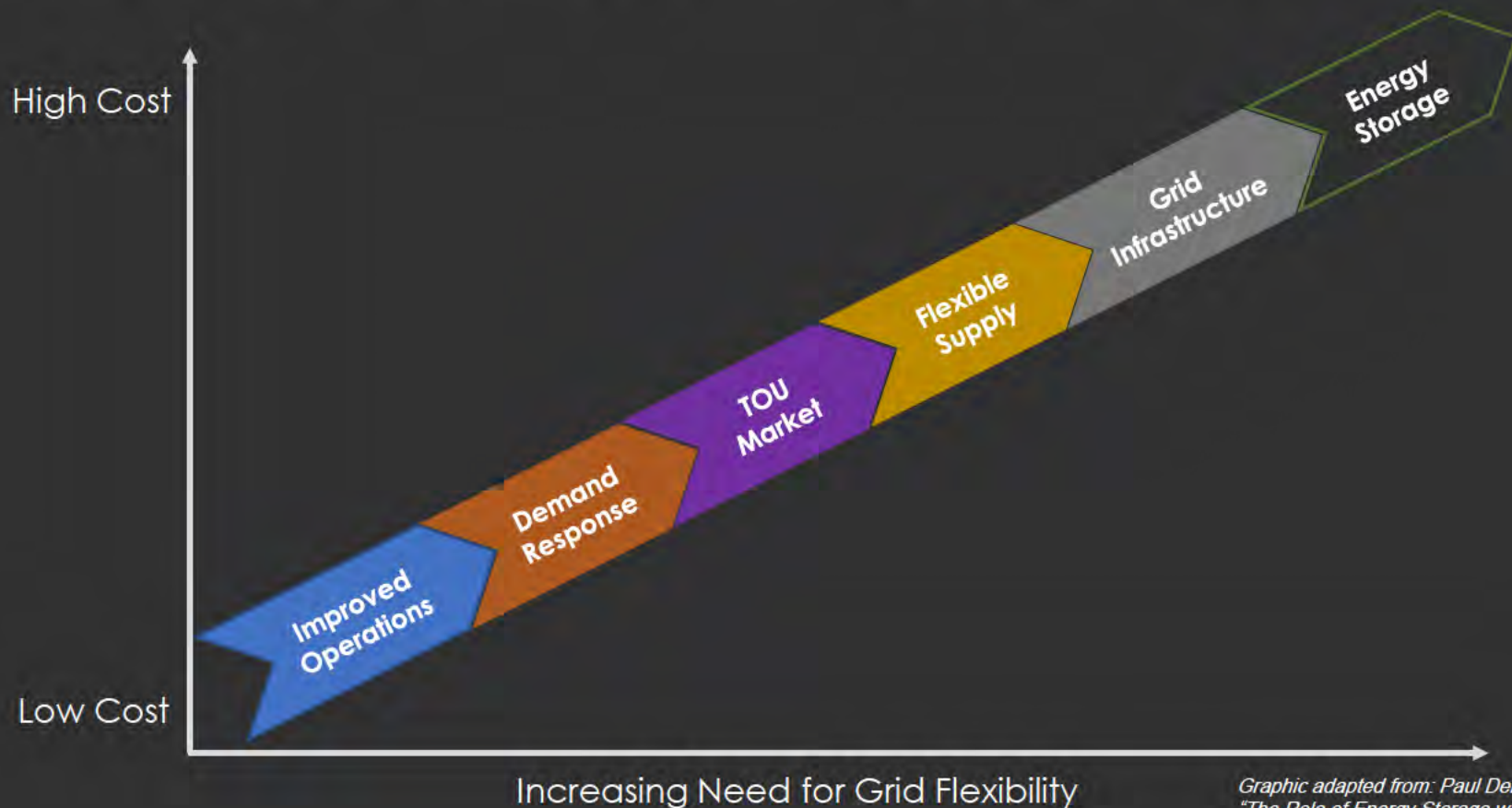
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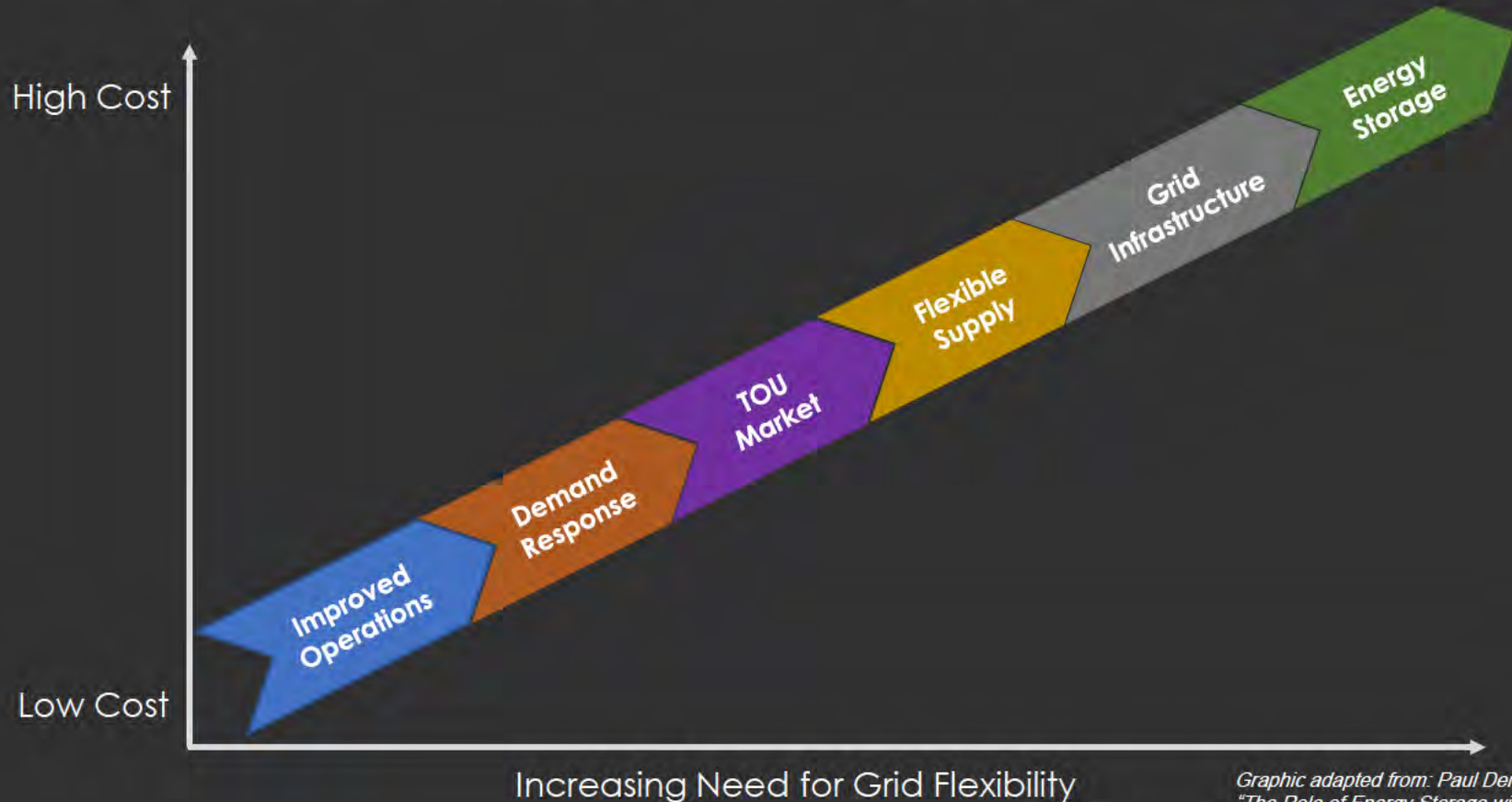
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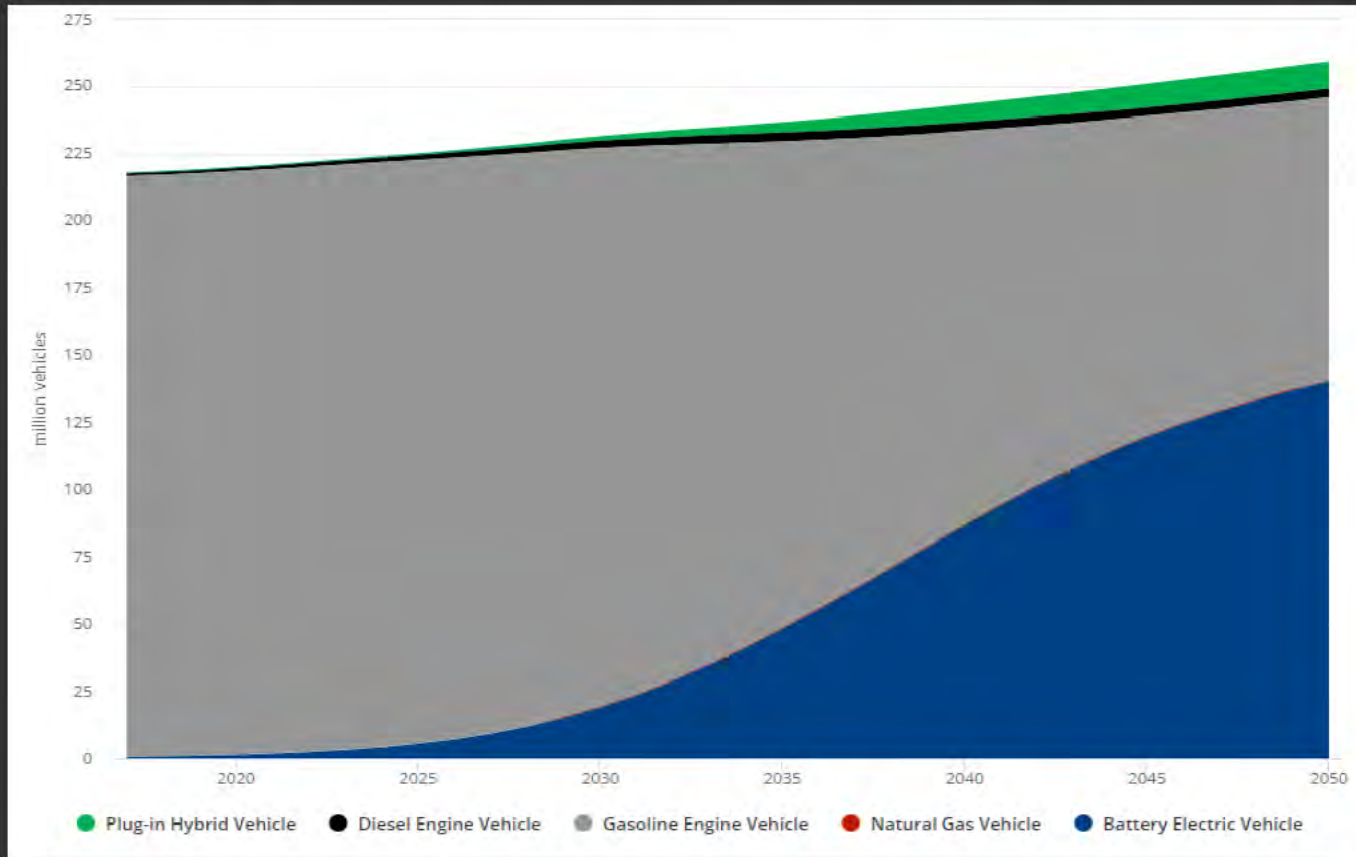
ZERO-CARBON GRID: POLICIES



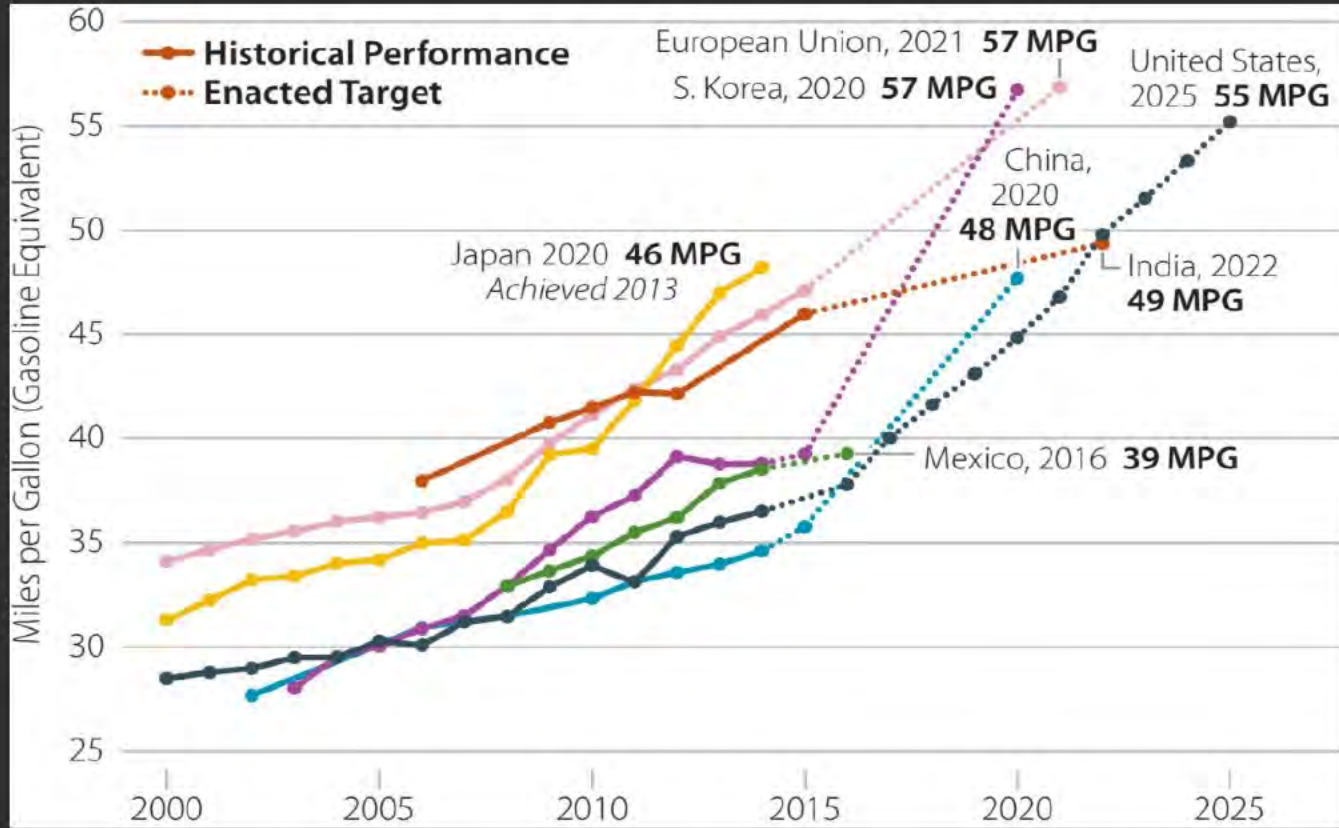
Value grid flexibility

Renewable Portfolio Standards

ZERO-EMISSIONS VEHICLES: EV FLEET



ZERO-EMISSIONS VEHICLES: FUEL STANDARDS



ZERO-EMISSIONS VEHICLES: LIGHT-WEIGHTING

- Improved aerodynamics
- Low-resistance tires
- Demass with advanced materials + design
- Reduced auxiliary loads
- More efficient transmissions + engines
- Hybridization



ZERO-EMISSION VEHICLES: POLICIES



Zero-emission vehicle (ZEV) mandate

Fuel efficiency/emissions standards featuring
continuous improvement



ZERO NET-ENERGY BUILDINGS: LOW-E GLASS

Heat 100%

Light 100%

U.V. 100%

Sound 100%

OUTSIDE



INSIDE

74% enters

80% enters

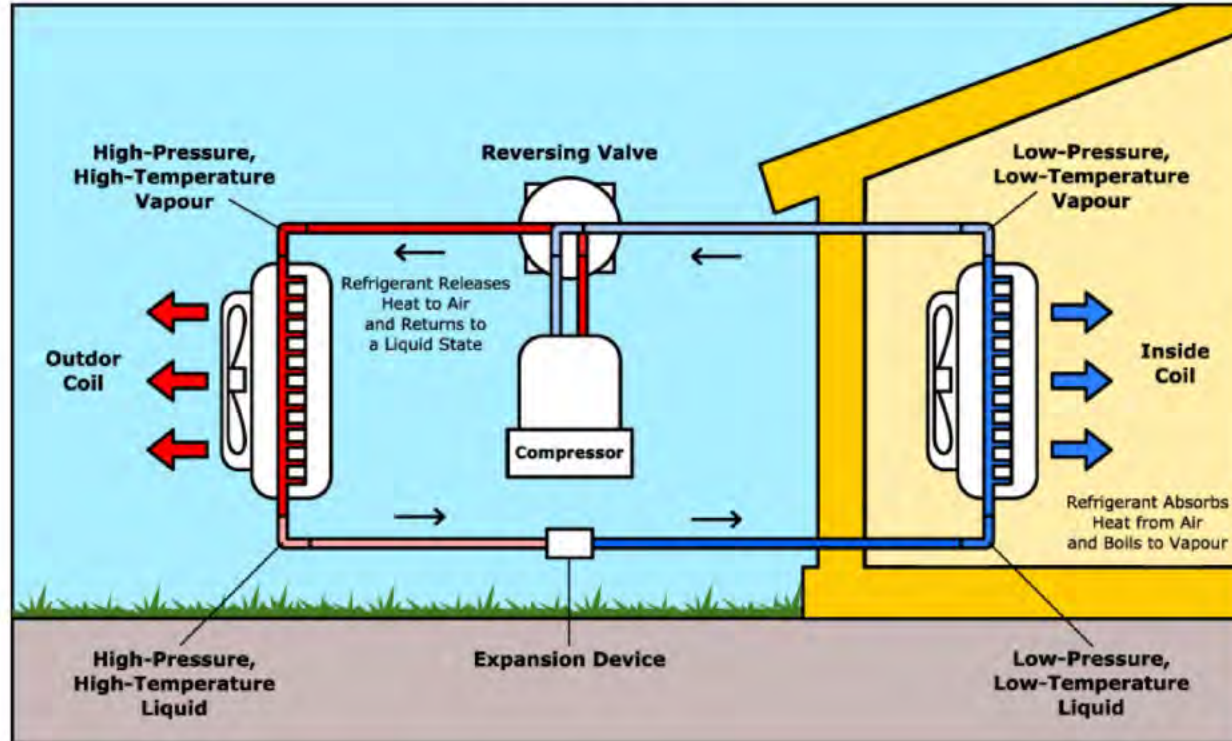
52% enters

20% enters

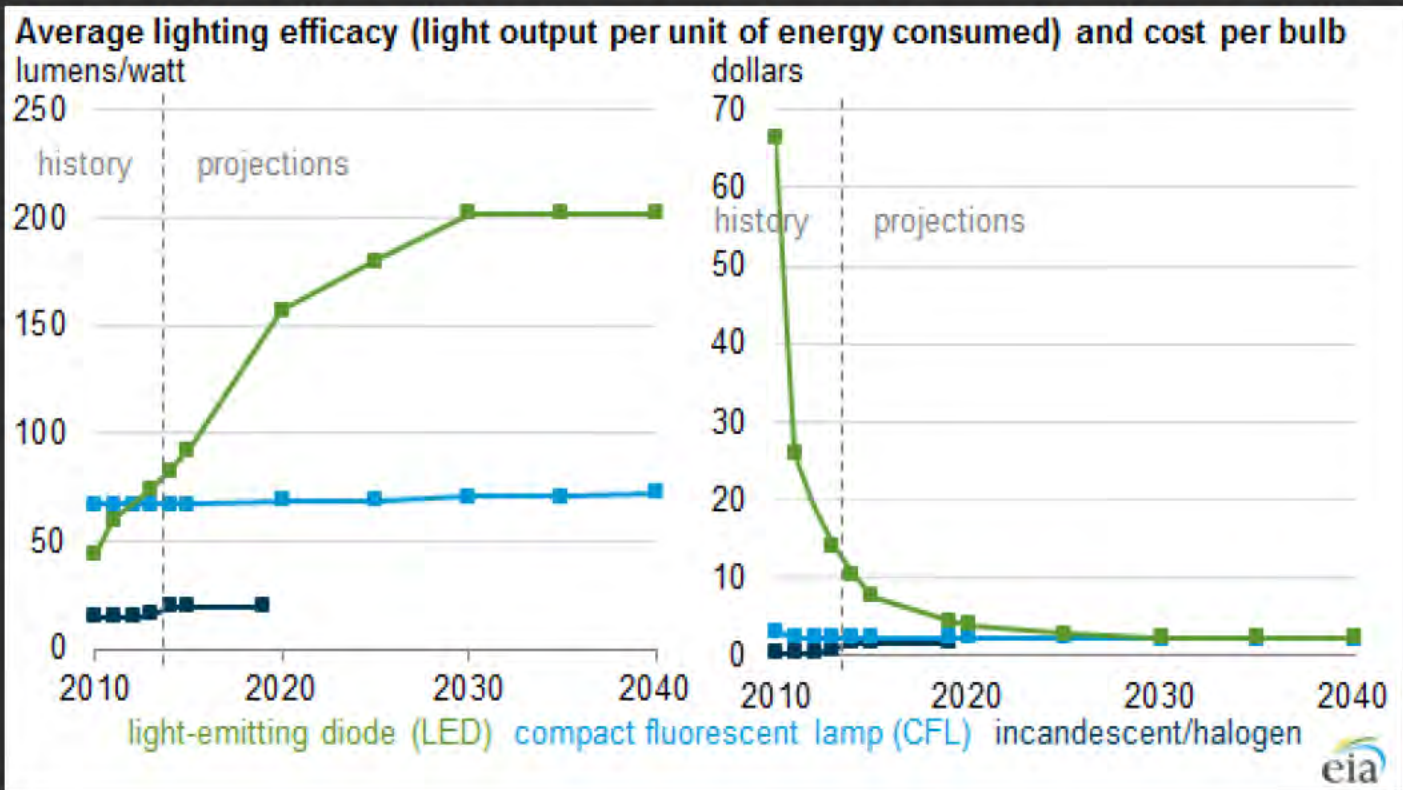
54% heat loss reduction

ZERO NET-ENERGY BUILDINGS: LOW-E GLASS

Air Source Heat Pumps Cooling Cycle



ZERO NET-ENERGY BUILDINGS: LED LIGHTING



ZERO NET-ENERGY BUILDINGS: APPLIANCES (REFRIGERATOR EXAMPLE)



ZERO NET-ENERGY BUILDINGS: OPTIMIZE HEATING/COOLING

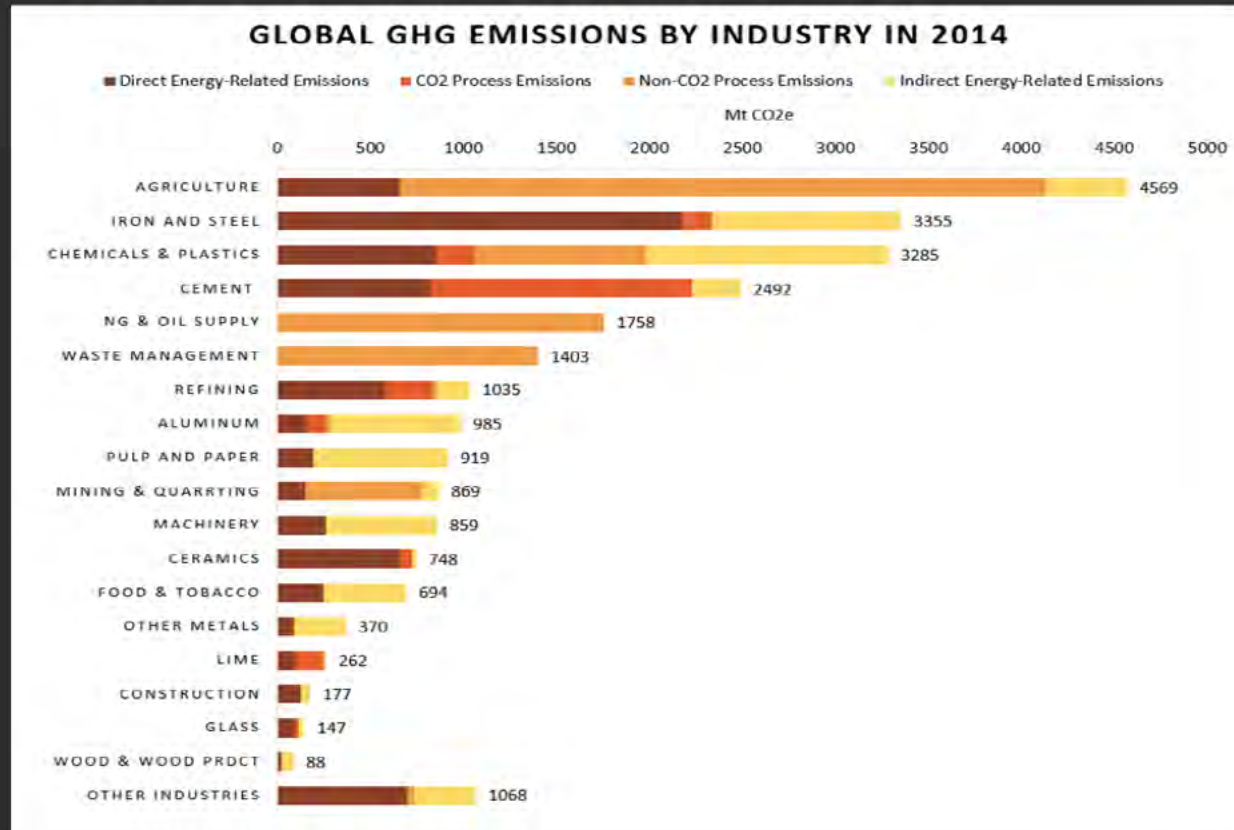


ZERO NET-ENERGY BUILDINGS: POLICIES



Building codes, appliance standards featuring
continuous improvement

ZERO-WASTE MANUFACTURING: CARBON INTENSITY STANDARD



ZERO-WASTE MANUFACTURING: TECHNOLOGY

- Device efficiency
- System efficiency
- Additive manufacturing
- Green chemistry



ZERO-WASTE MANUFACTURING: POLICY



Carbon pricing system

Efficiency standards for devices

Carbon intensity standard for products

1. CLIMATE TRENDS

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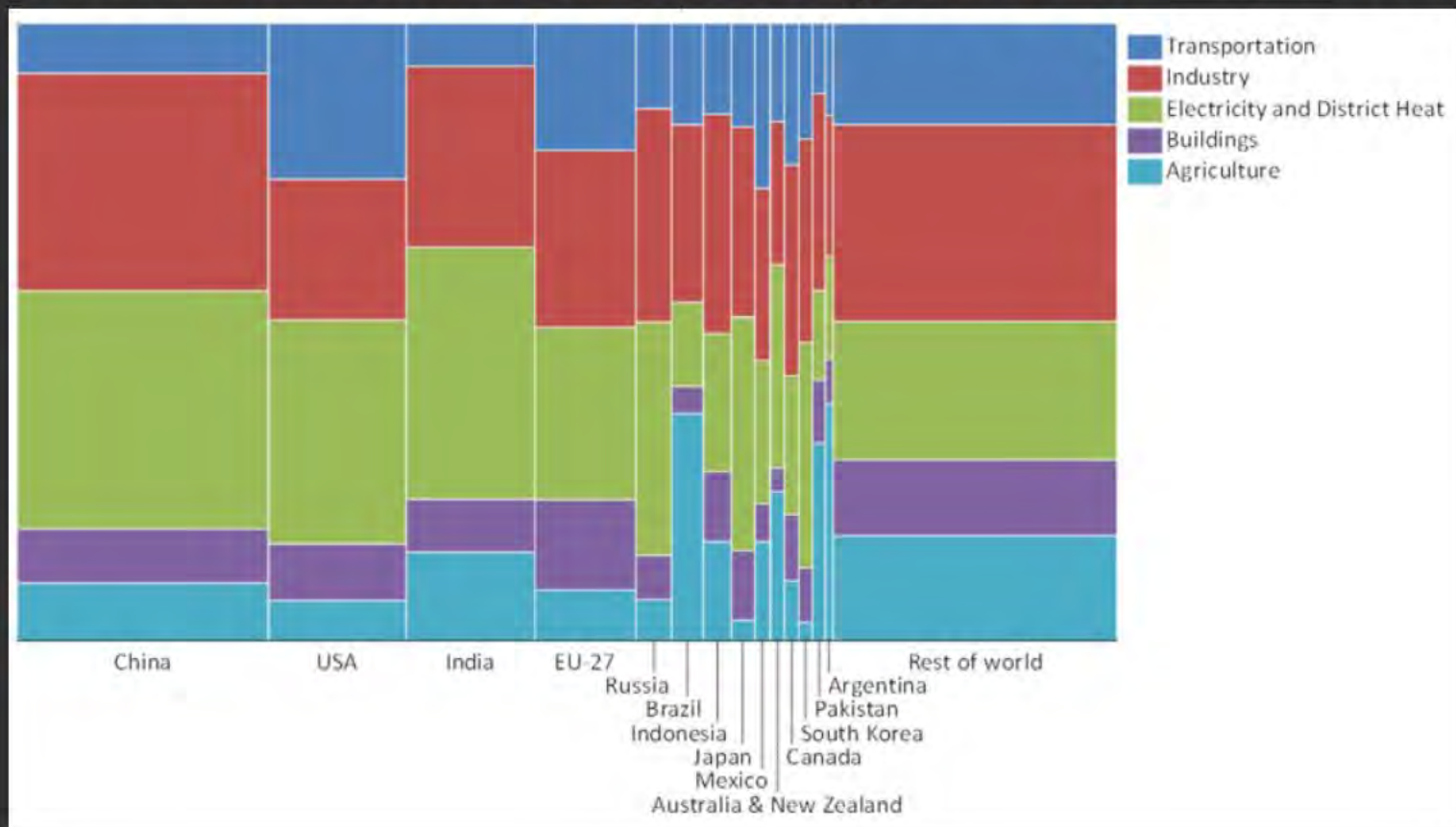
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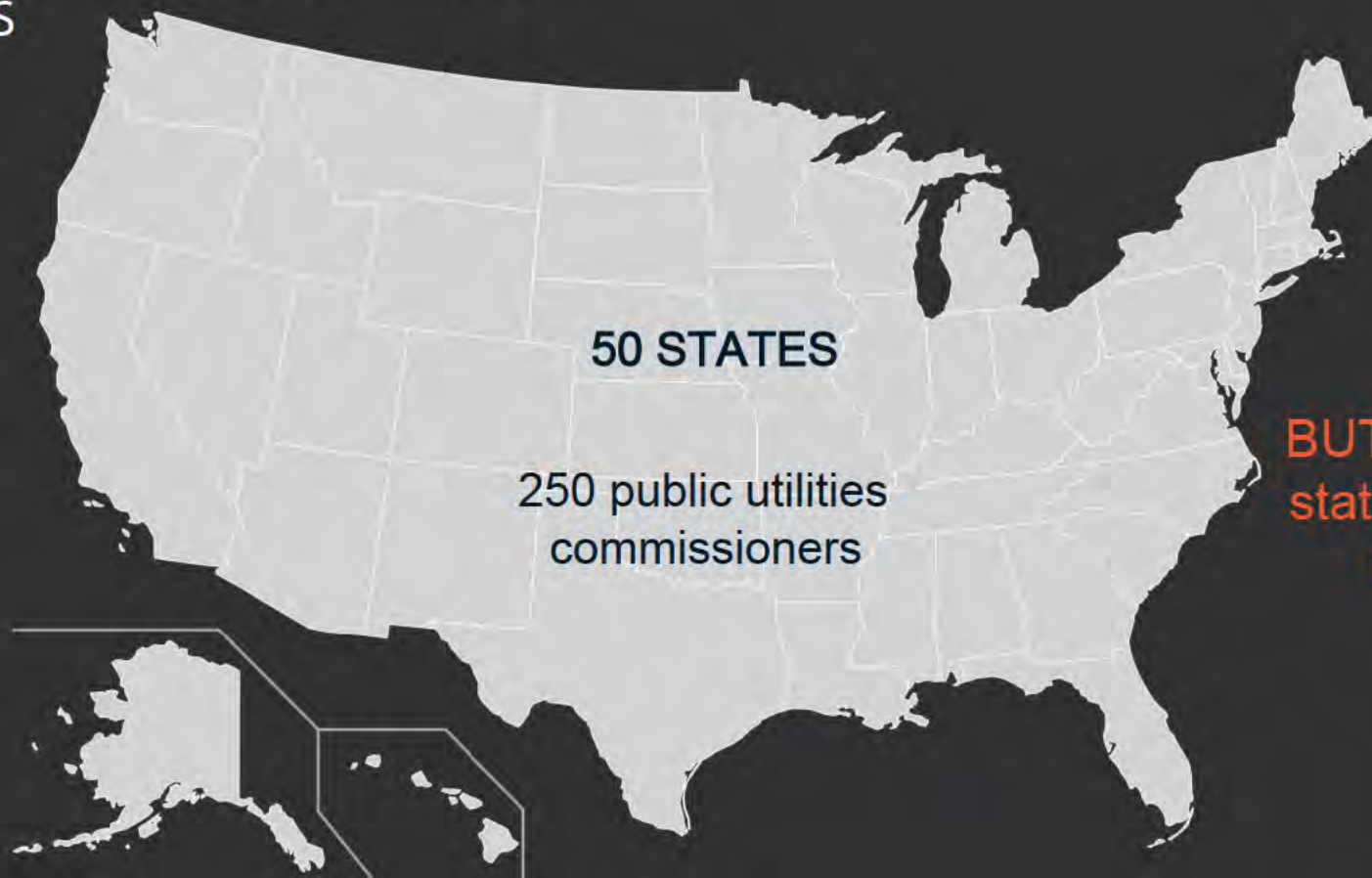
SPEED, SCALE, VENUE

THE RIGHT STRATEGY: BIGGEST OPPORTUNITIES, SPEED + SCALE



INFLUENCER MATH

PUCS



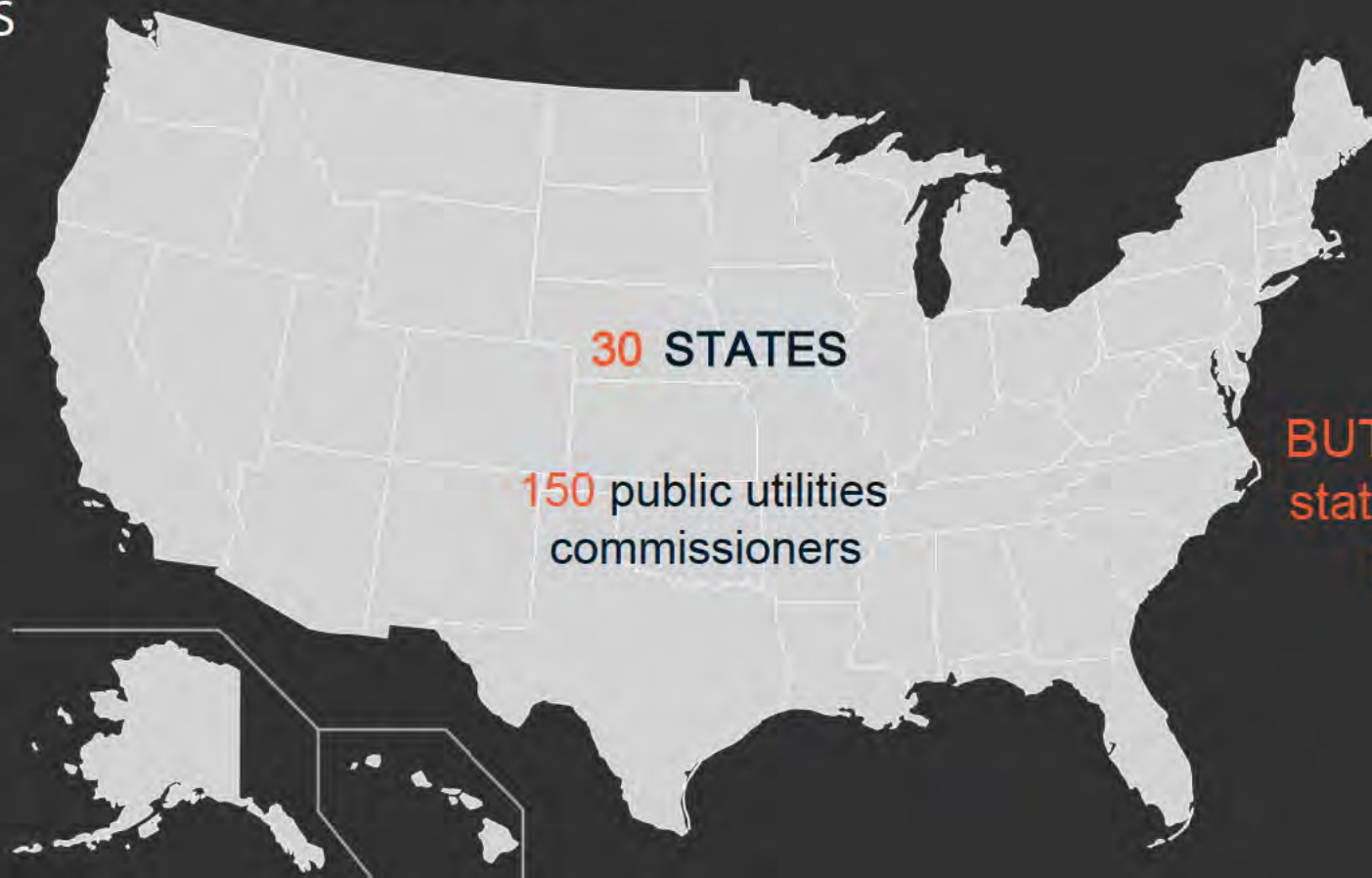
50 STATES

250 public utilities
commissioners

**BUT... only 30
states matter
to win**

INFLUENCER MATH

PUCS



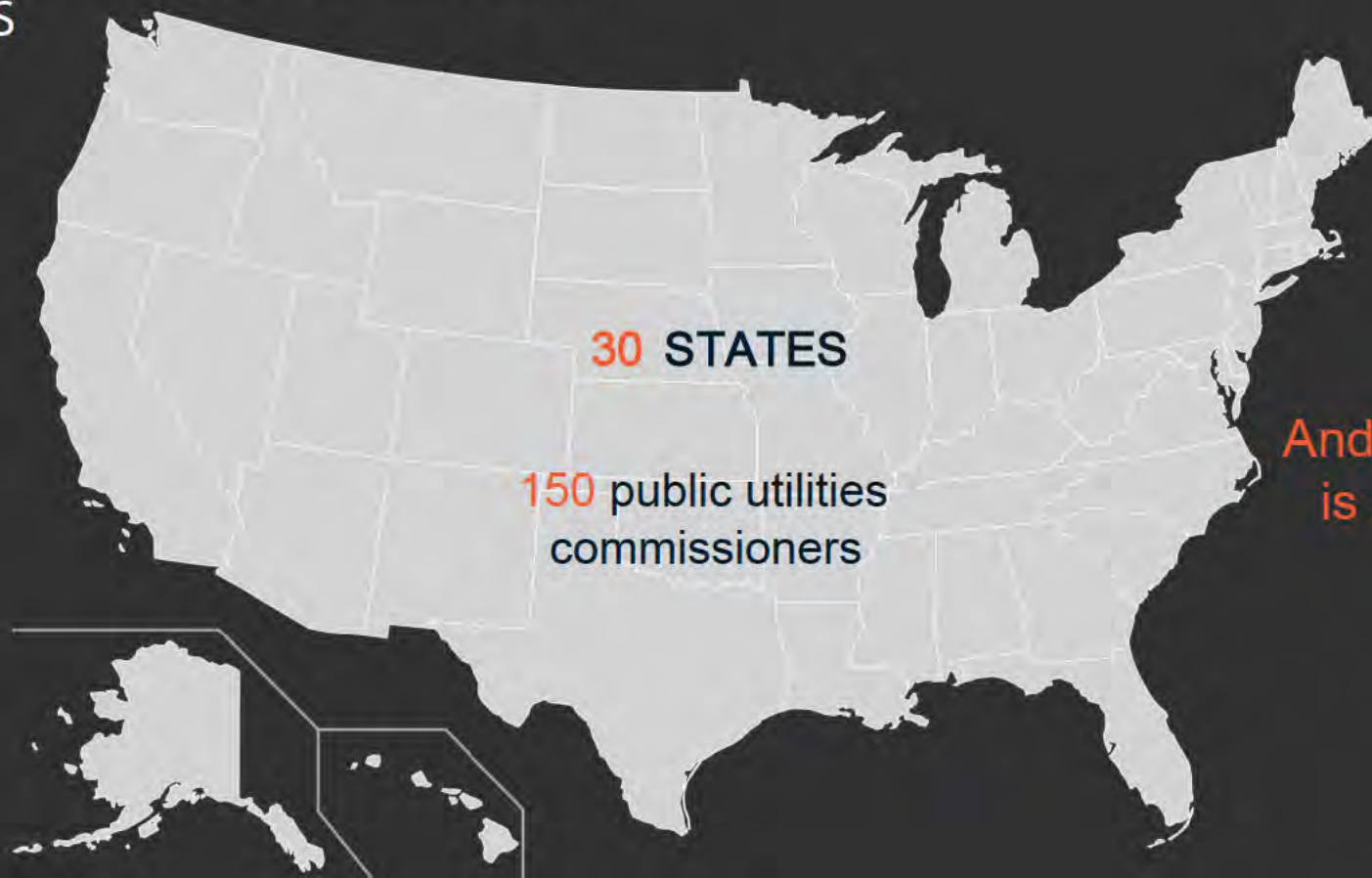
30 STATES

150 public utilities
commissioners

**BUT... only 30
states matter
to win**

INFLUENCER MATH

PUCS



30 STATES

150 public utilities
commissioners

And a 3-2 vote
is sufficient

INFLUENCER MATH

PUCS



90

public utilities
commissioners

And a 3-2 vote
is sufficient

INFLUENCER MATH

PUCS

HOW TO WIN

- Know the technological, economic, and political landscape
- Be serious about time, funds, and intensity

You can flip a PUC from brown to green



INFLUENCER MATH



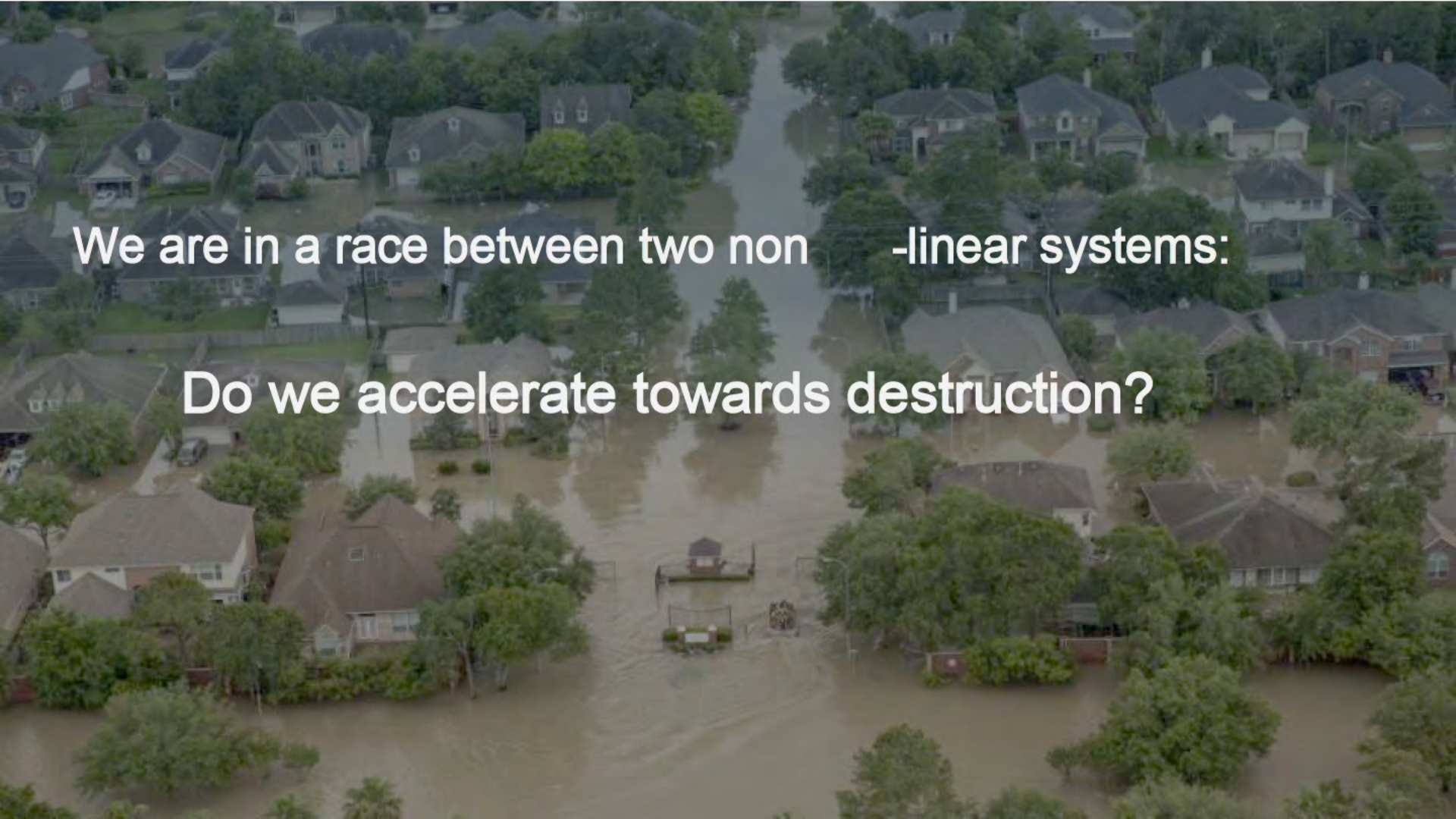
FOLLOW THIS DISCIPLINE FOR:

Utilities

Cars/trucks

Buildings

Industry



We are in a race between two non-linear systems:

Do we accelerate towards destruction?

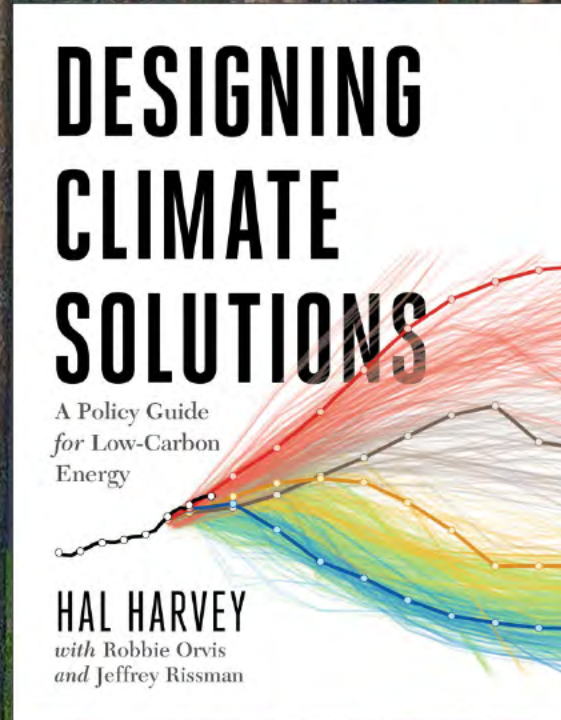
An aerial photograph of a vast solar farm in a desert. The solar panels are arranged in neat, parallel rows that stretch across the sandy terrain. The perspective is from a high angle, looking down at the panels. The text "Or low -carbon prosperity?" is overlaid in the center of the image in a white, sans-serif font.

Or low -carbon prosperity?

@hal_harvey
@EnergyInnovLLC

Hal Harvey
www.energyinnovation.org

THANK YOU



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