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Legal Pathways to Deep Decarbonization in the United States

ALEC

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US 2050 Vol. 1
Technical Report
pathways to
deep decarbonization
in the United States
IDDRI
SUSTAINABLE DEVELOPMENT SOLUTIONS NETWORK

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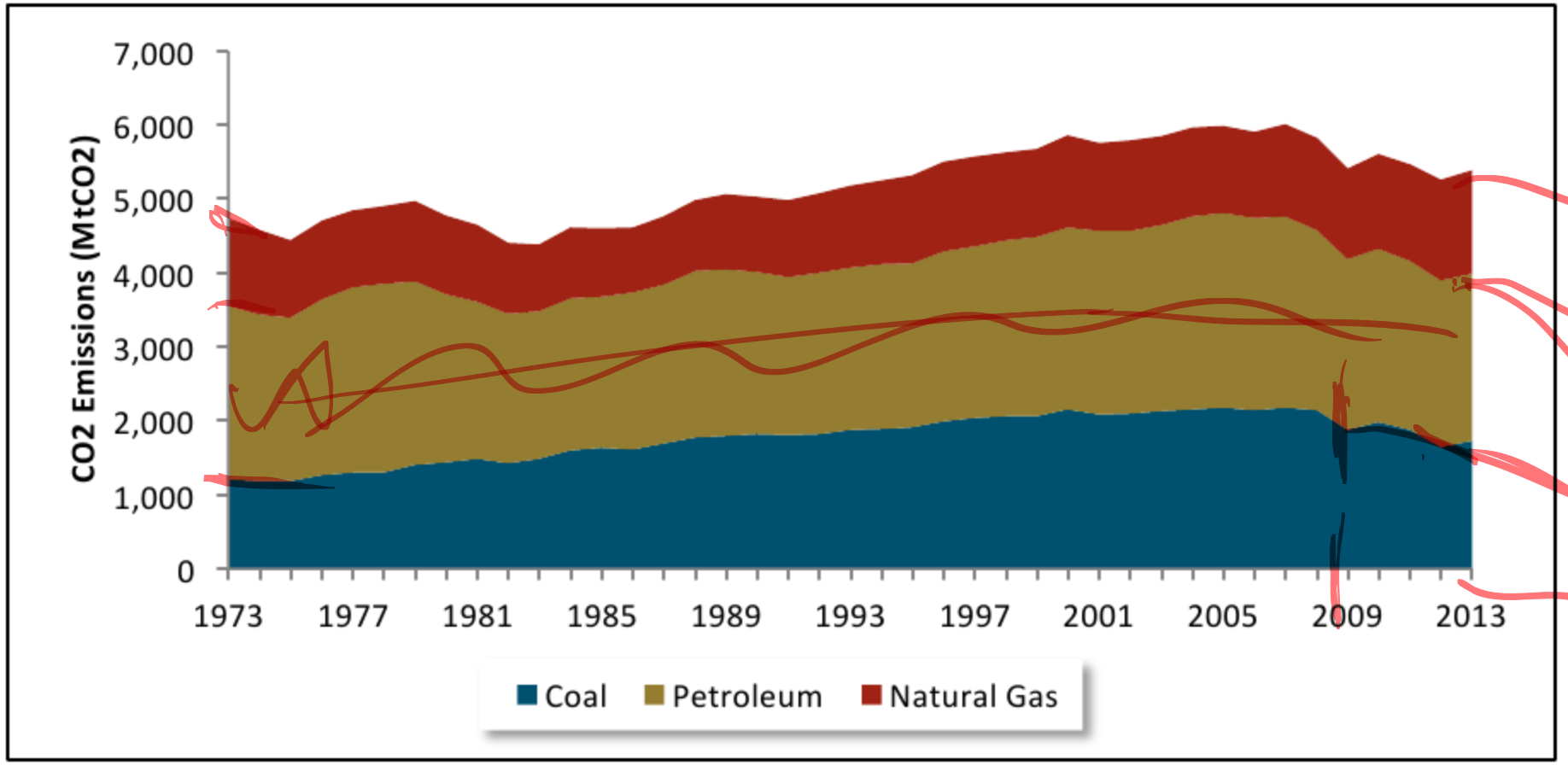
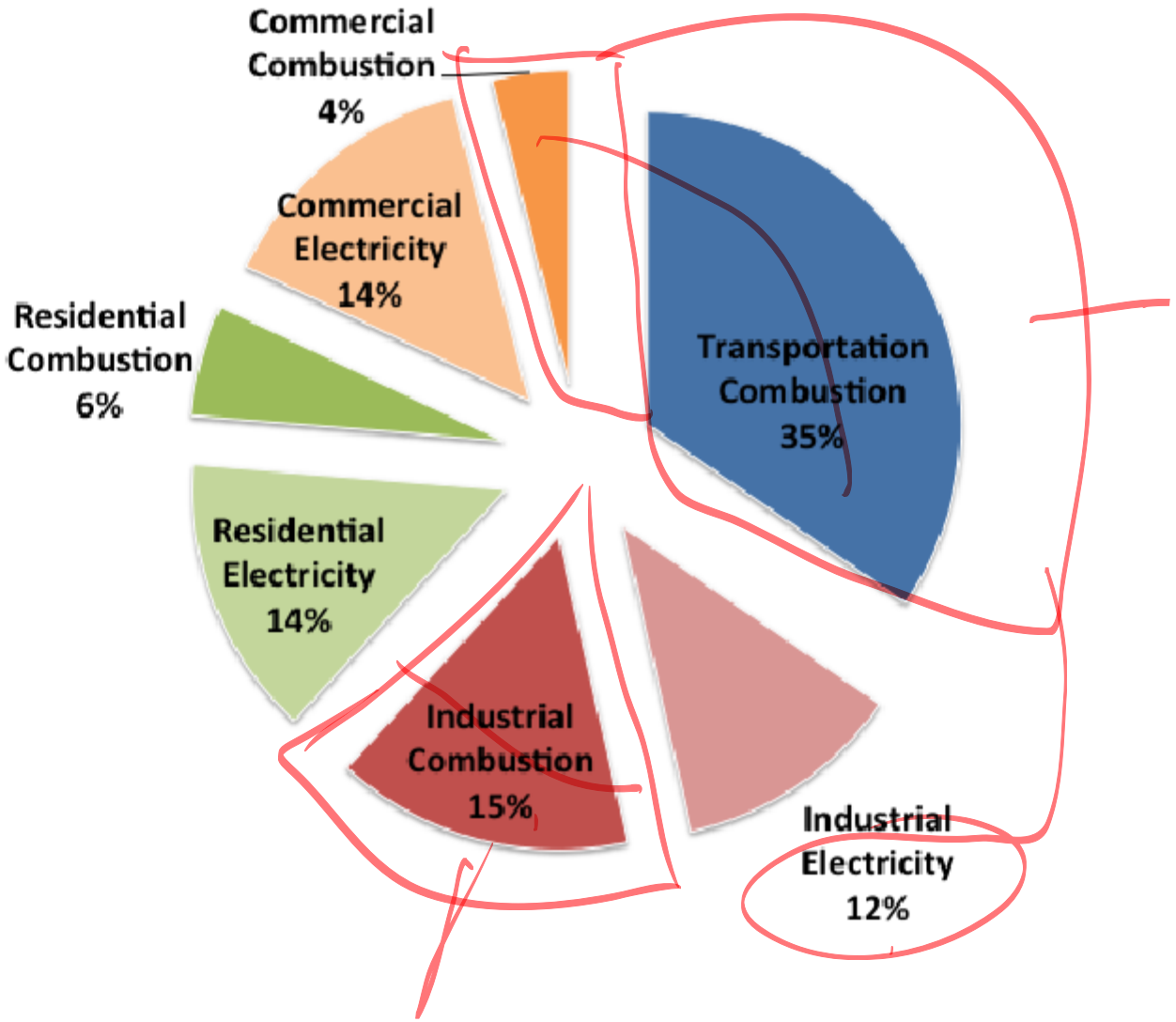
Gas is a higher % now and coal is lower.

Figure 2. U.S. CO_2 Emissions from Fossil Fuel Combustion by Fuel Source, 1973–2013



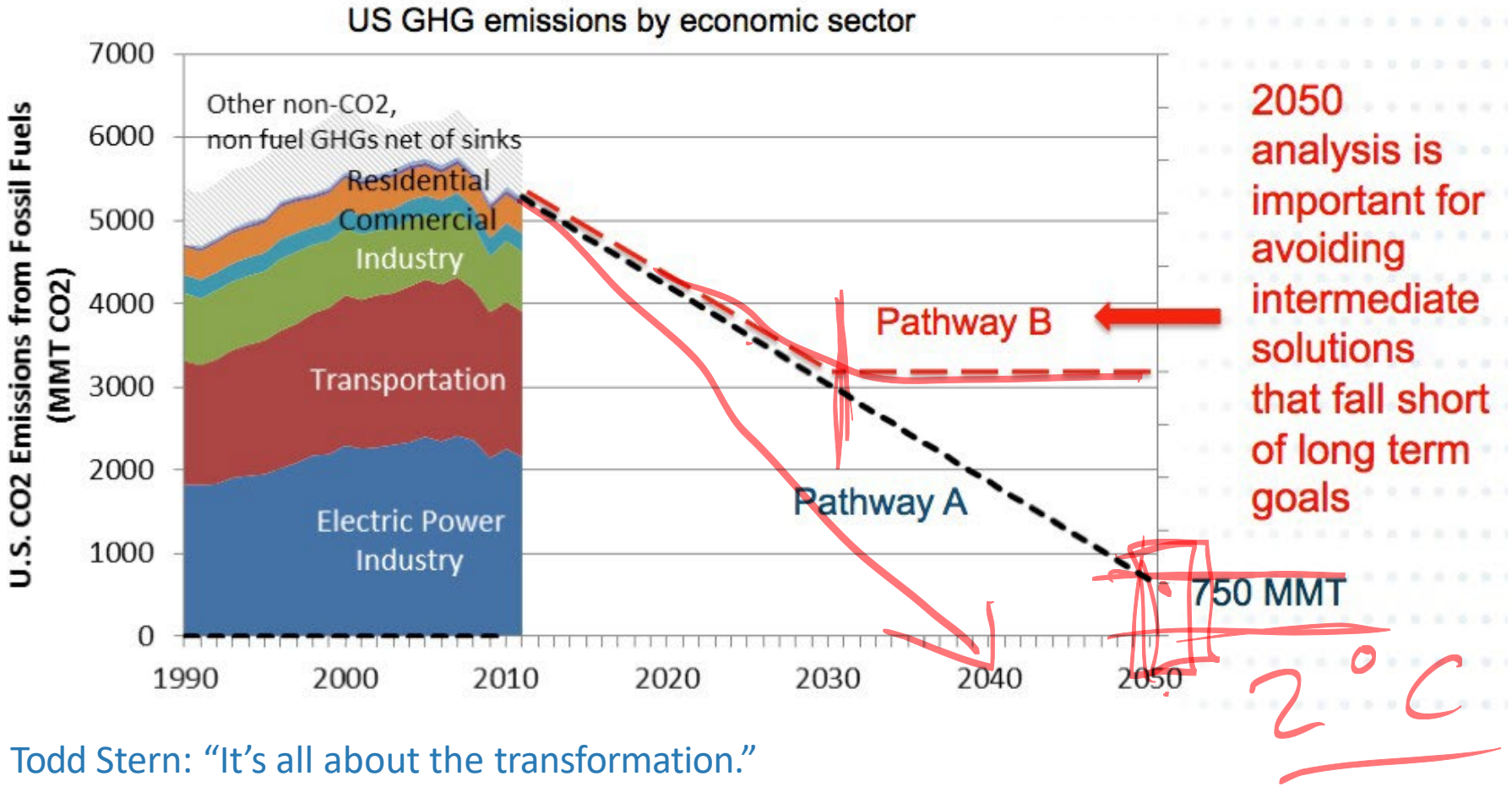
Source: EIA , March, 2014 Monthly Energy Review

Figure 3. U.S. CO_2 Emissions from Fossil Fuel Combustion, with Electricity Emissions Allocated to End Use, 2012



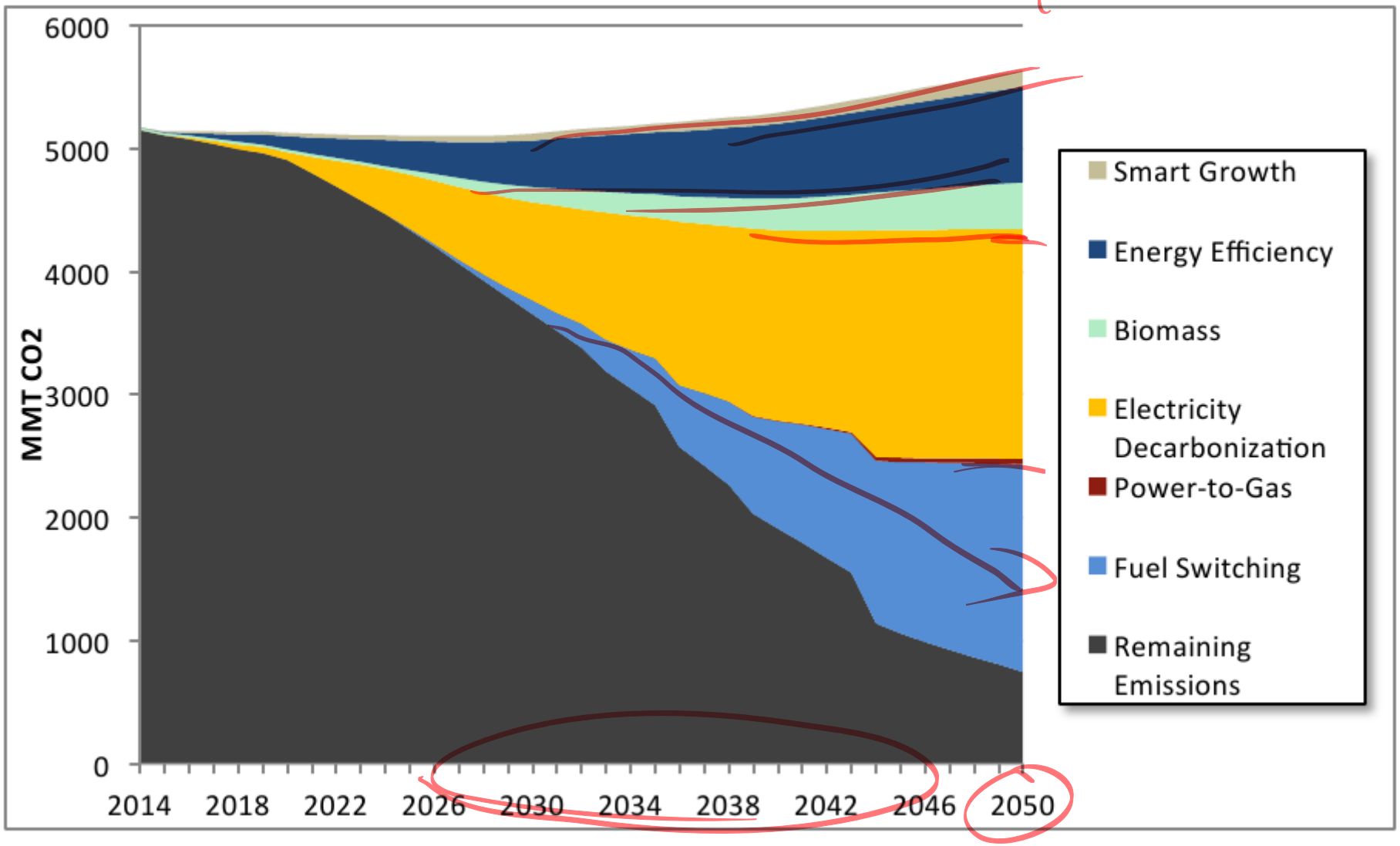
Source: U.S. EPA 2014

Avoiding emissions dead ends

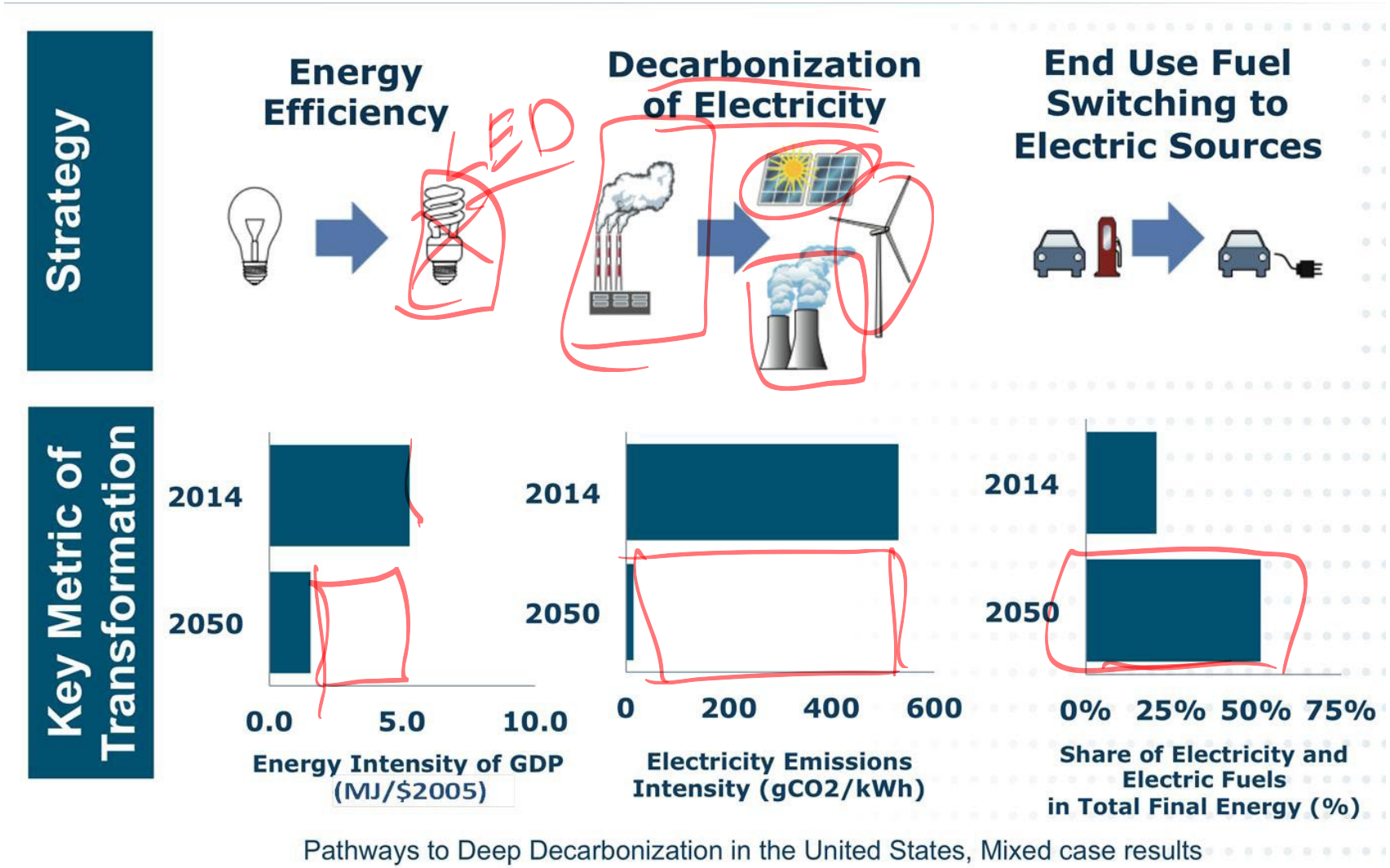


Todd Stern: “It’s all about the transformation.”

Figure 10. Decarbonization Wedges for the U.S., Mixed Case



Three Pillars of Deep Decarbonization



Pathways to Deep Decarbonization in the United States, Mixed case results

Table 6. Key Decarbonization Measures by Sector and Decarbonization Strategy

Strategy and Sector	Measures
Energy Efficiency Strategies	
Residential and commercial energy efficiency	• Highly efficient building shell required for all new buildings • New buildings require electric heat pump HVAC and water heating • Existing buildings retrofitted to electric HVAC and water heating • Near universal LED lighting in new and existing buildings
Industrial energy efficiency	• Improved process design and material efficiency • Improved motor efficiency • Improved capture and re-use of waste heat • Industry specific measures, such as direct reduction in iron and steel
Transportation energy efficiency	• Improved internal combustion engine efficiency • Electric drive trains for both battery and fuel cell vehicles (LDVs) • Materials improvement and weight reduction in both LDVs and freight

EV

Energy Supply Decarbonization Strategies	
Electricity supply decarbonization	• Different low-carbon generation mixes with carbon intensity <50 gCO_2 /kWh that include renewable, nuclear, and CCS generation
Electricity balancing	• Flexible demand assumed for EV charging and thermal building loads • Flexible intermediate energy production for hydrogen and power-to-gas processes to take advantage of renewable overgeneration • Hourly/daily storage and regulation from pumped hydro • Natural gas w/CCS
Pipeline gas supply decarbonization	• Synthetic natural gas from gasified biomass and anaerobic digestion • Hydrogen and SNG produced with wind/solar over-generation provides smaller but potentially important additional source of pipeline gas
Liquid fuels decarbonization	• Diesel and jet-fuel replacement biofuels • Centralized hydrogen production through electrolysis • Centralized hydrogen production through natural gas reformation w/CCS

Fuel Switching Strategies	
Petroleum	• LDVs to hydrogen or electricity • HDVs to LNG, CNG, or hydrogen • Industrial sector petroleum uses electrified where possible, with the remainder switched to pipeline gas
Coal	• No coal without CCS used in power generation or industry by 2050 • Industrial sector coal uses switched to pipeline gas and electricity
Natural gas	• Low carbon energy sources replace most natural gas for power generation; non-CCS gas retained for balancing in some cases • Switch from gas to electricity in most residential and commercial energy use, including majority of space and water heating and cooking

Multiple Feasible Technology Pathways Exist

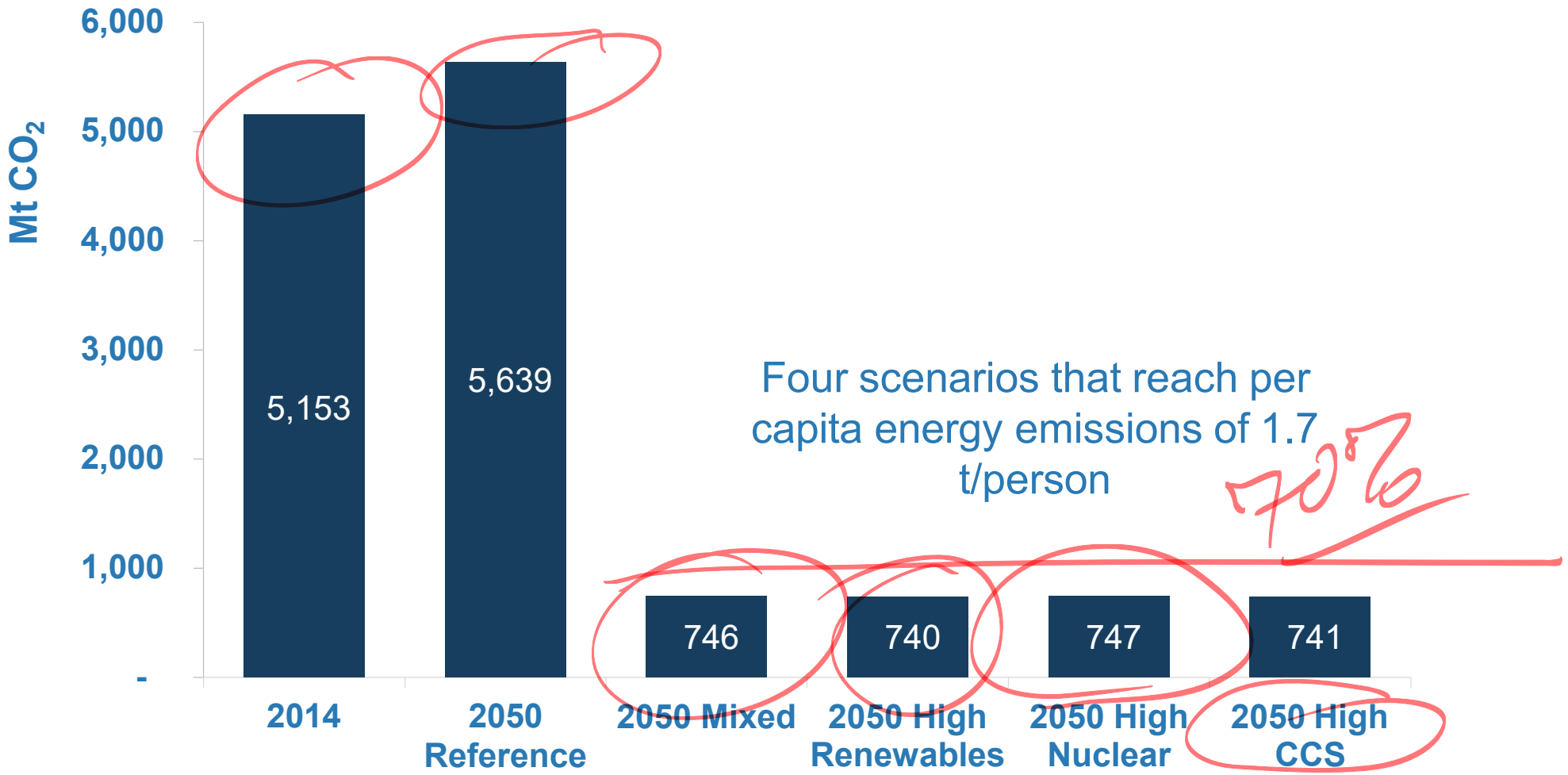


Figure 39. Mixed Case Regional Per Capita CO_2 Emissions Intensity (Tonnes CO_2 Per Person)

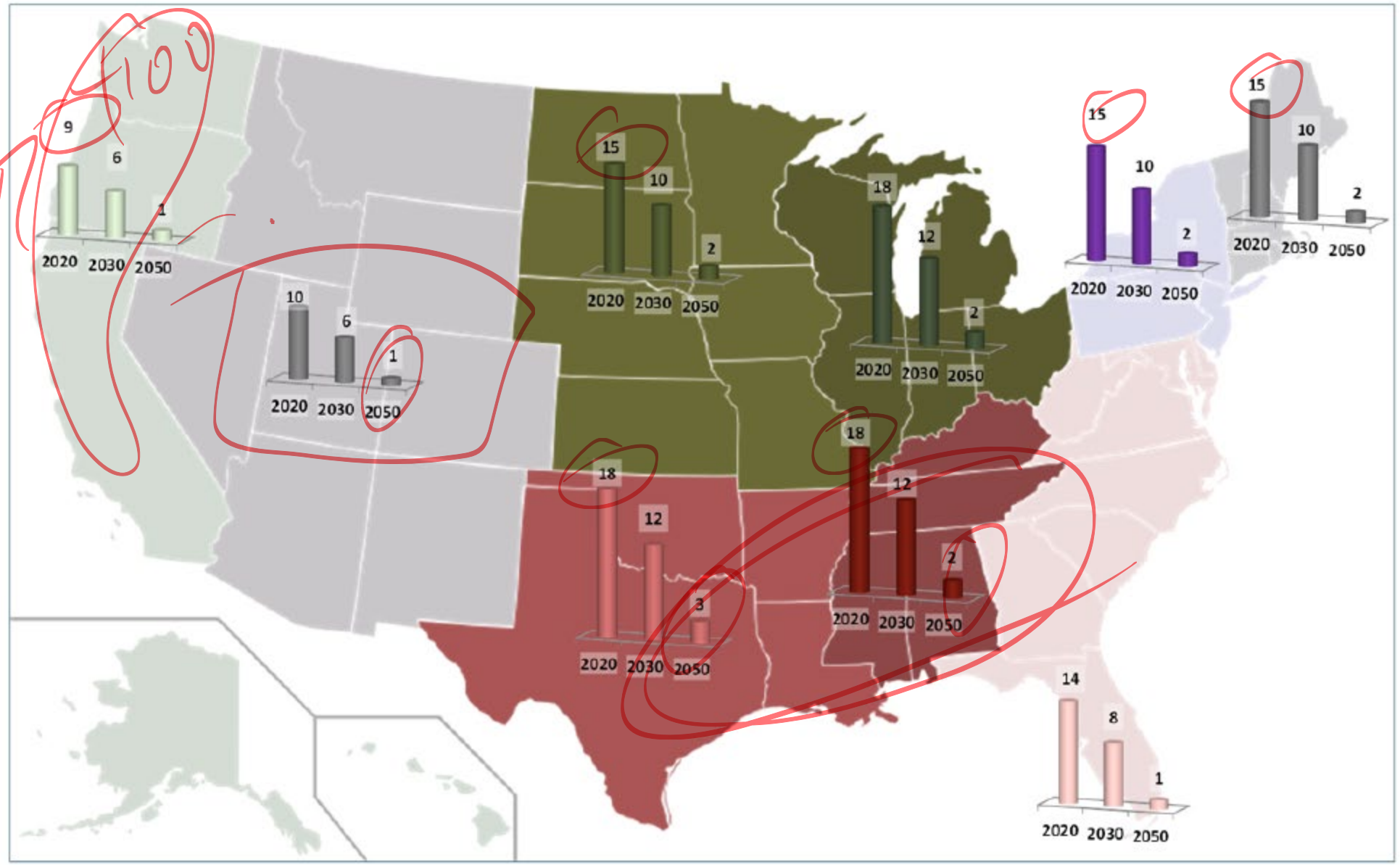


Figure 11. Indicative Metrics for the Three Main Decarbonization Strategies, Mixed Case Compared to 2014

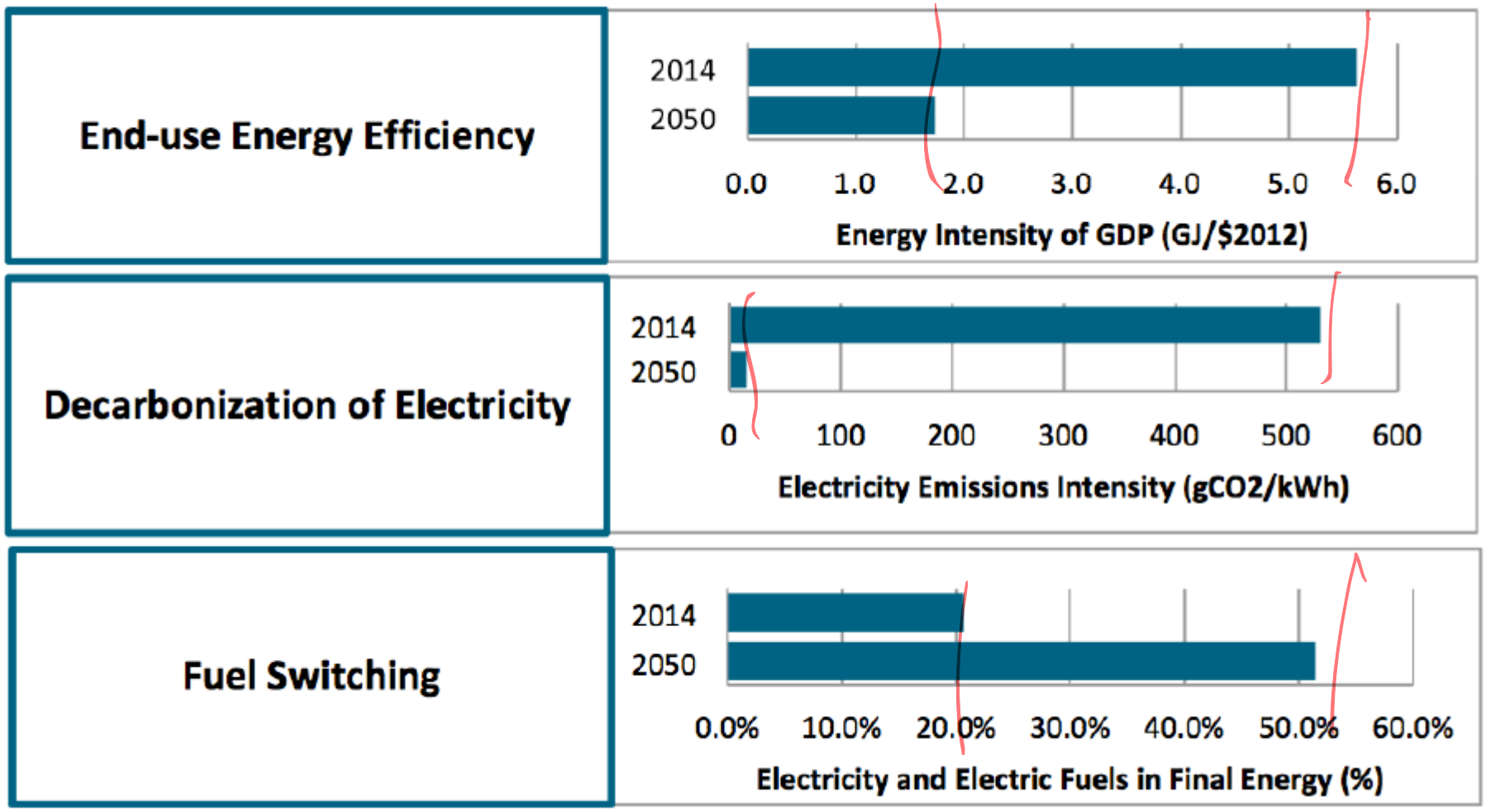
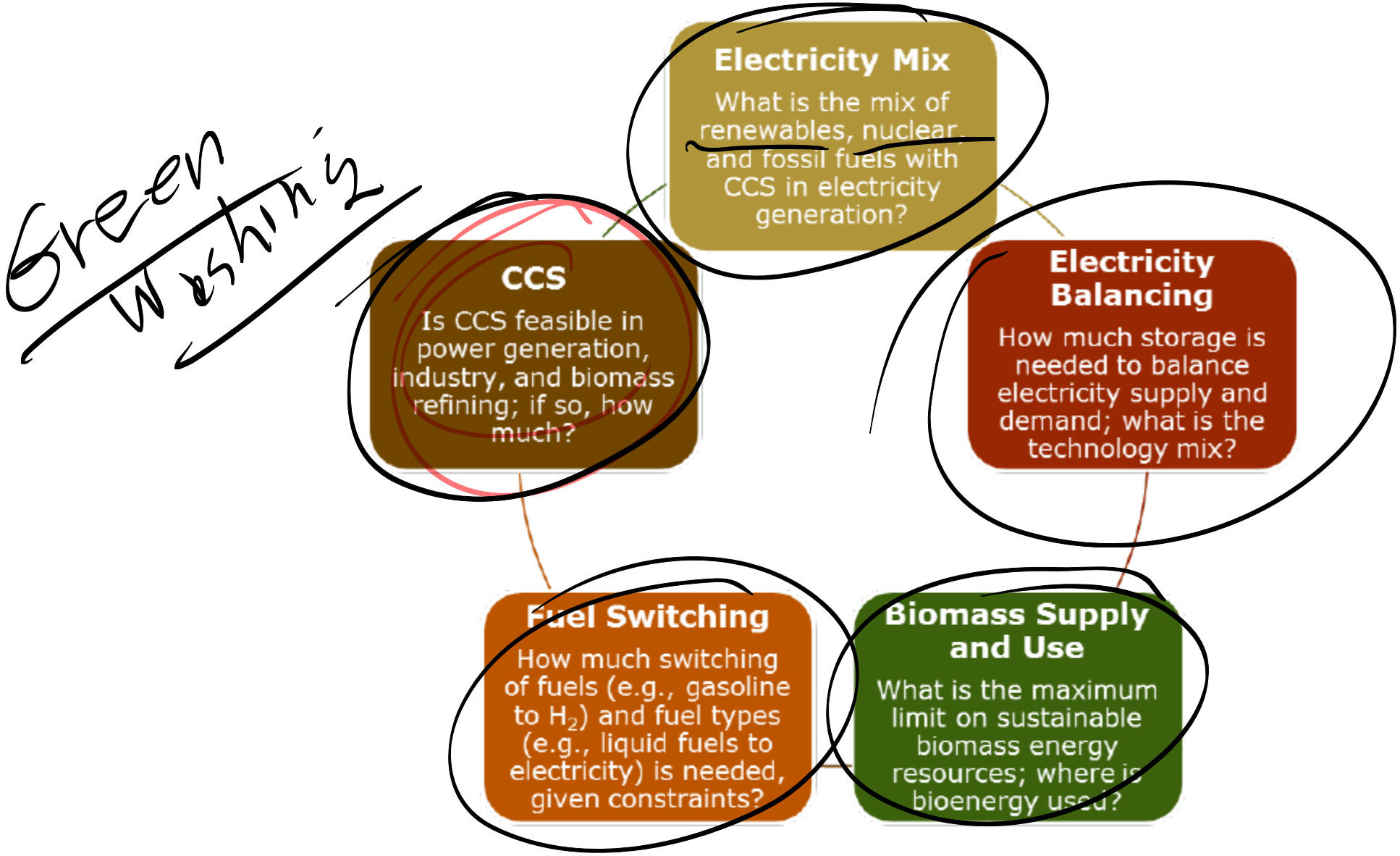


Figure 6. Pathways Determinants: Critical Elements that Determine the Features of a Low Carbon Energy System

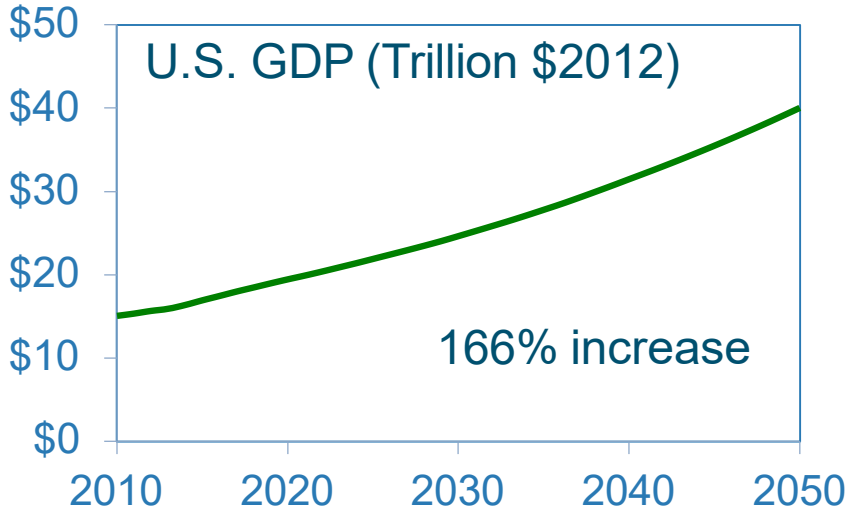


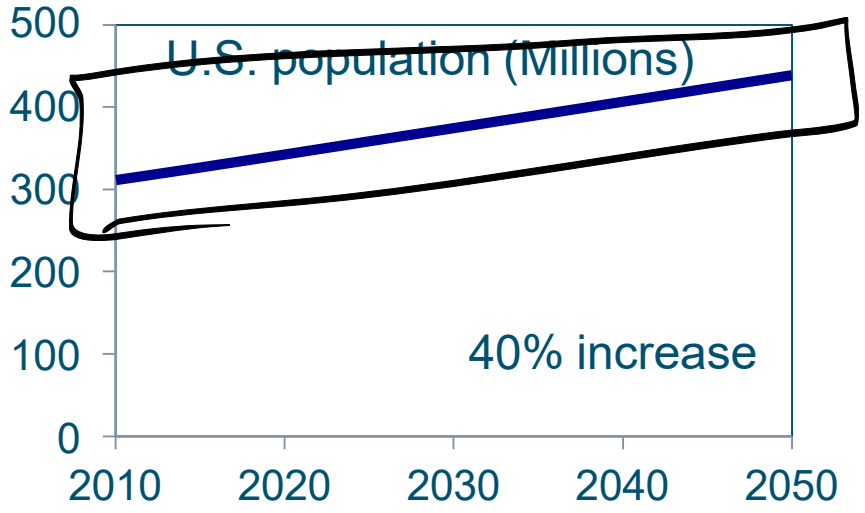
80% Reduction Goal by 2050 is Technically Feasible and Would Cost Only 1% of US GDP

- Almost complete decarbonization of electricity by 2050
- Double electricity generation through massive program of renewables construction
- More than double the efficiency with which energy is used
- Switching most end uses that require liquid fuels to electricity, especially passenger cars and space heating and cooling
- Requires deployment of roughly 300 million alternative fuel vehicles by 2050

Scenario Design Constraints

- Infrastructure inertia
- Electric reliability
- Same energy services as EIA forecast
- Technology is commercial or near-commercial
- Environmental limits (biomass, hydro)

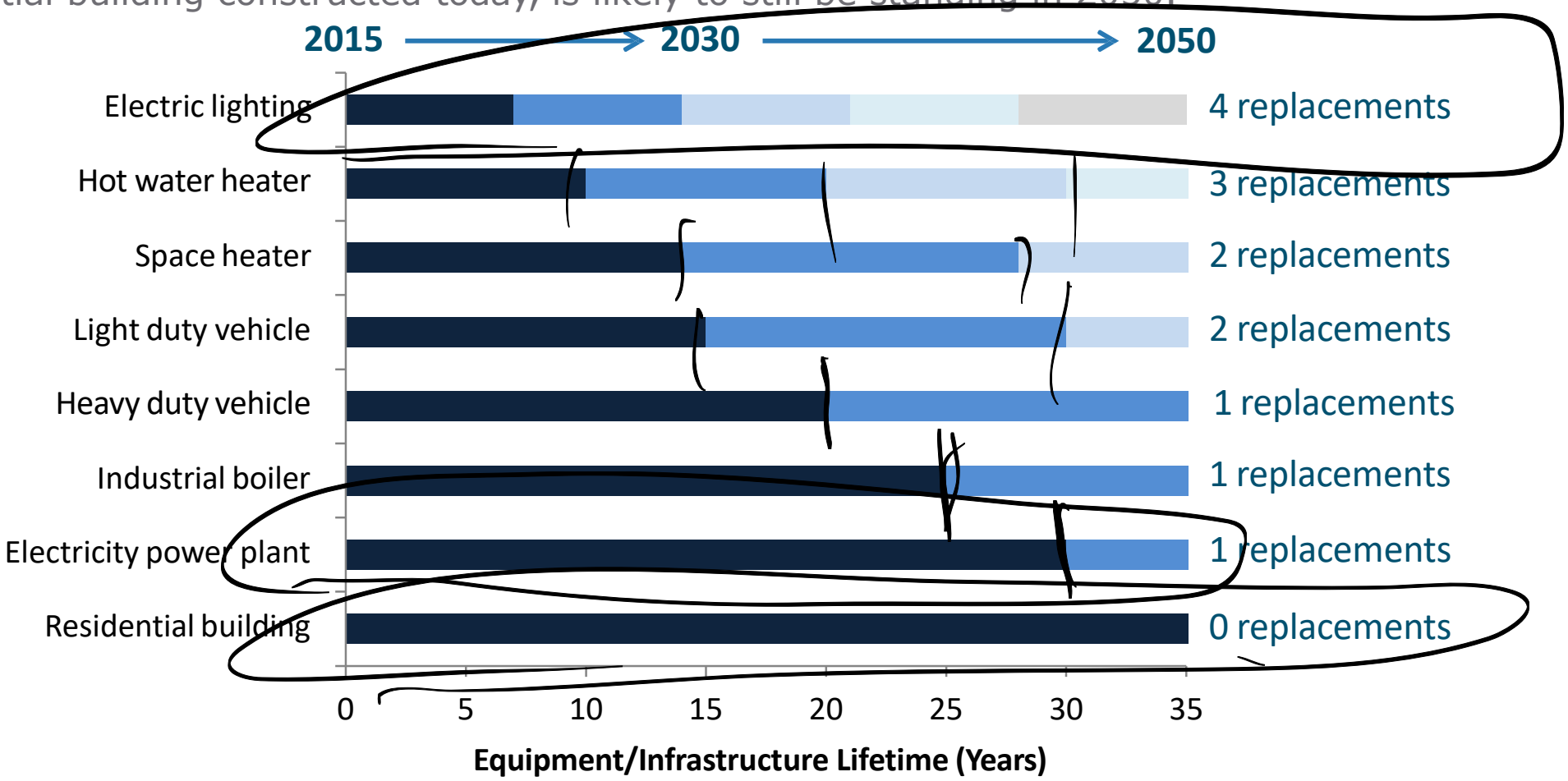




U.S. National Energy Modeling System and 2013 Annual Energy Outlook reference case

Early Retirement Not Required…
But Timely Replacement Is

- A car purchased today, is likely to replaced at most 2 times before 2050.
  A residential building constructed today, is likely to still be standing in 2050.



Key Findings on Legal Pathways

- Legal tools are available to decarbonize U.S.
  - Available, but necessarily politically acceptable
- More than 1,500 specific recommendations for federal, state, local and private action
- Wide variety of types of tools; some are regulatory, but most are not
- These tools would create economic, social, environmental, and security benefits in addition to reducing GHG emissions

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Twelve types of legal tools

- Additional regulation
- Reduction or removal of legal barriers
- Market-leveraging approaches
- Removal of incentives for fossil fuel use
- Tradable permits or allowances
- Information/persuasion
- Facilities and operations
- Infrastructure development
- Research and development
- Insurance
- Property rights
- Social equity

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Legal Pathways

Energy efficiency, conservation, fuel switching

- Light duty vehicles
- Heavy duty vehicles and freight
- Transportation demand and mode shifting
- Aviation
- Shipping
- Lighting, appliances and other equipment
- Old buildings
- New buildings
- Industrial sector

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Legal Pathways

Electricity decarbonization

- Utility-scale renewables
- Distributed renewables
- Transmission, distribution and storage
- Nuclear
- Hydropower
- Phasing out fossil fuels in electricity sector

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Legal Pathways

Fuel decarbonization

- Production and delivery of low-carbon gaseous fuels
  - Hydrogen?
- Production and delivery of bioenergy fuels
  - Fuel from biomass or algae production

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Legal Pathways

Carbon capture and negative emissions

- Carbon capture, sequestration, utilization
- Direct air capture
- Agriculture
- Forestry

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Legal Pathways

Non-CO2 climate pollutants

- Black carbon - melts Ice
- Methane
- Fluorinated gases
- Nitrous oxide

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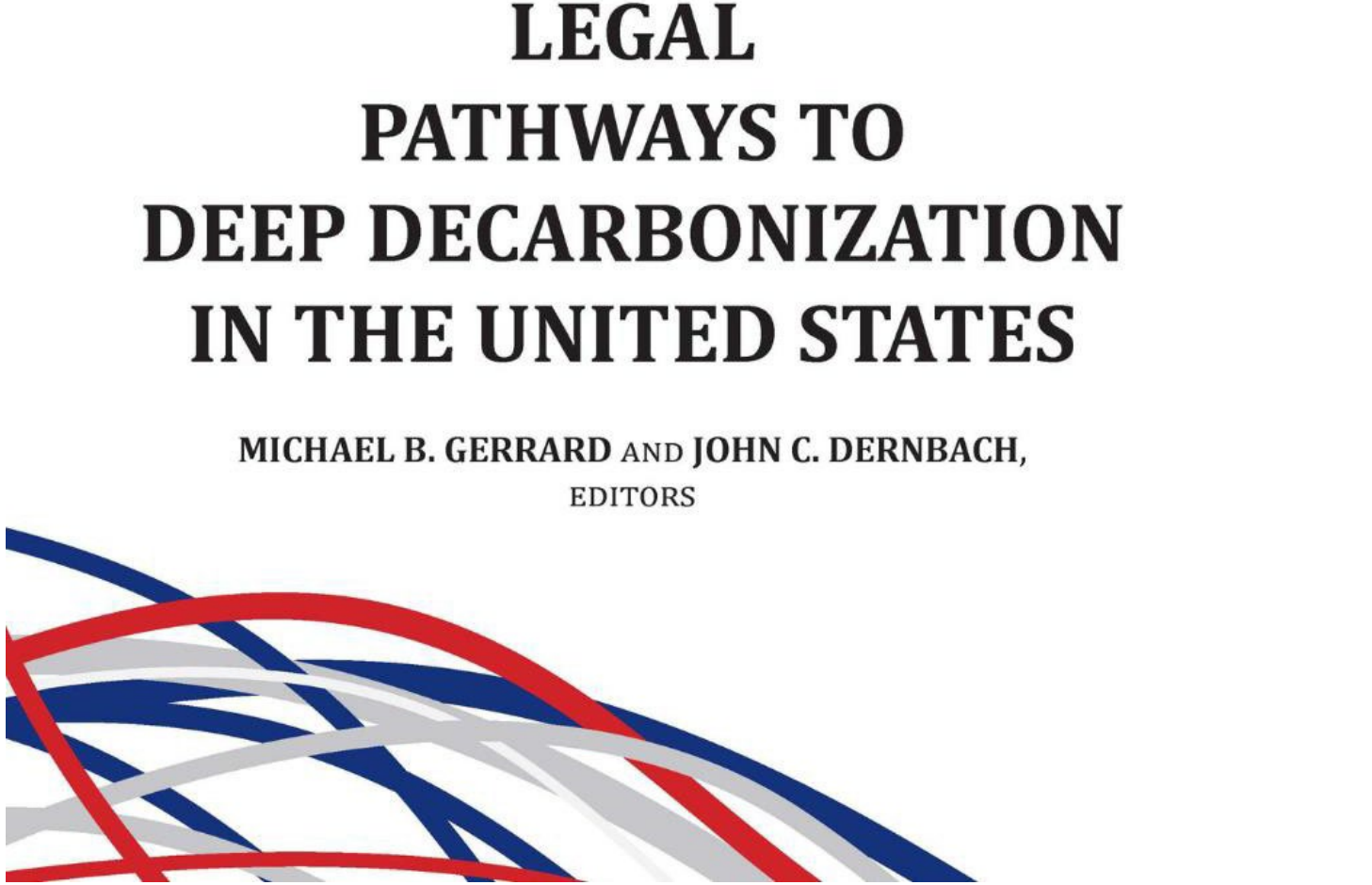
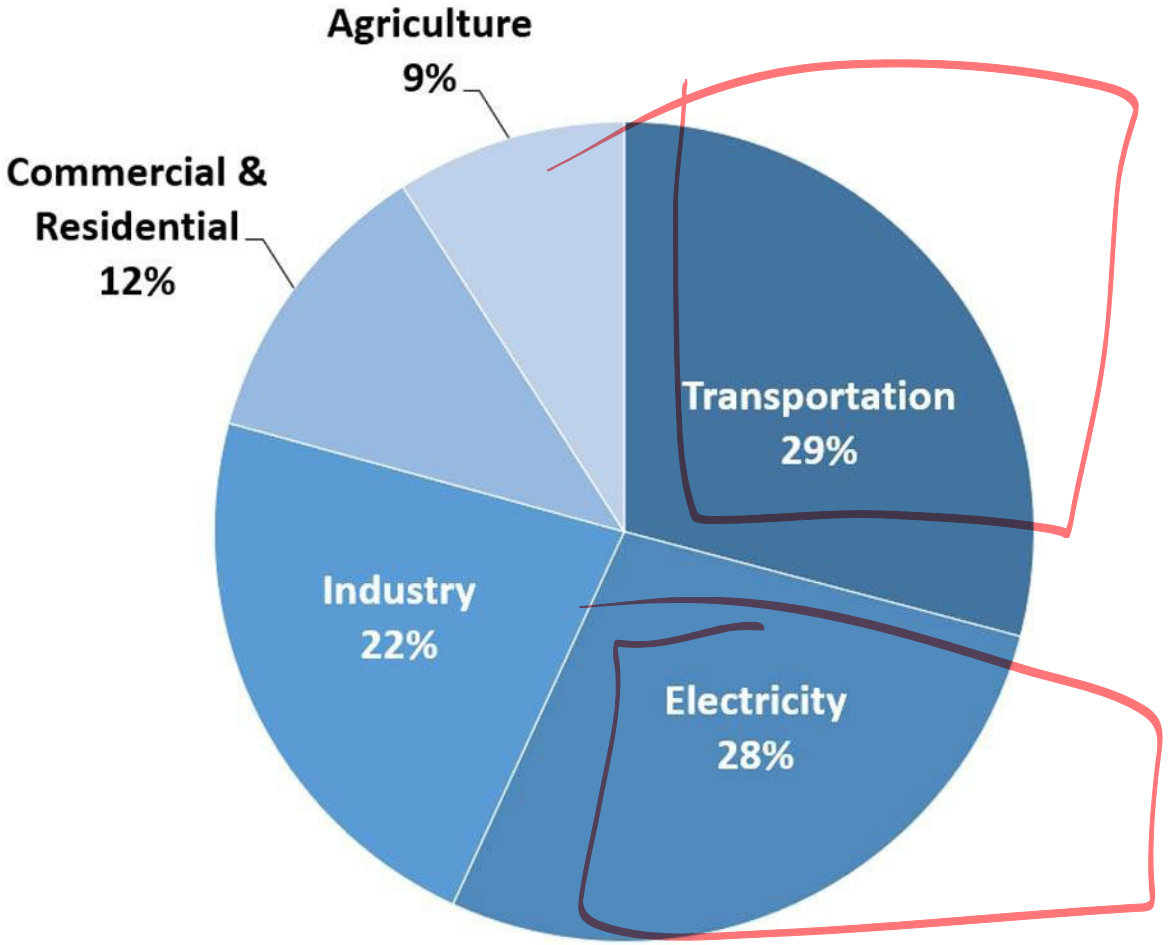
Transportation: Light-Duty Vehicles

Professor Amy L. Stein
University of Florida
Levin College of Law



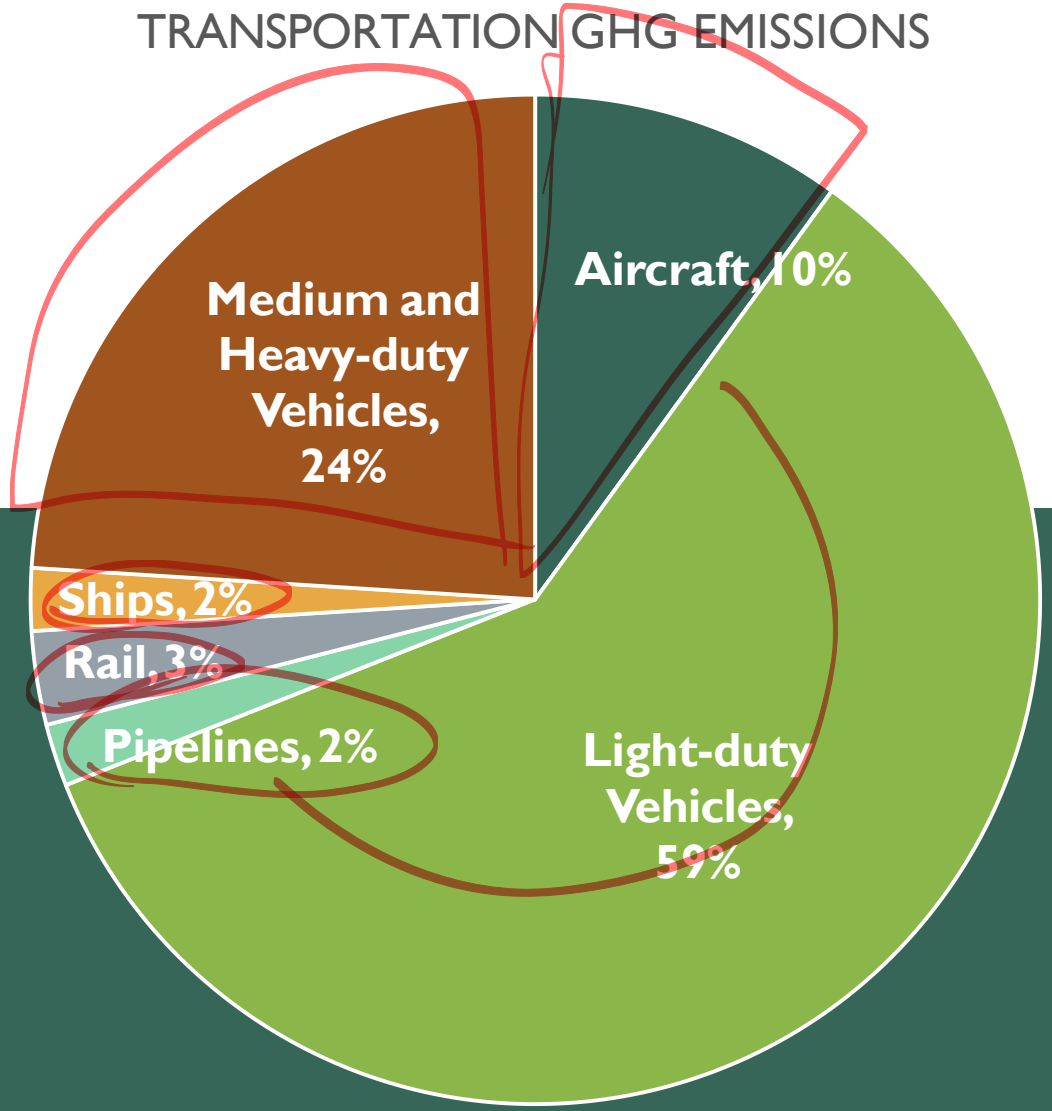
Total U.S. Greenhouse Gas Emissions by Economic Sector in 2017



U.S. Environmental Protection Agency (2019). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2017

THE TRANSPORTATION SECTOR ISTHE LARGEST CONTRIBUTOR OF GHG EMISSIONS

TRANSPORTATION GHG EMISSIONS



LIGHT-DUTY VEHICLES ARE THE LARGEST SOURCE OF TRANSPORTATION GHG EMISSIONS

U.S. Environmental Protection Agency (2019). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2017

DDPP GOALS

Reduce greenhouse gases by at least 80% from 1990 levels by 2050

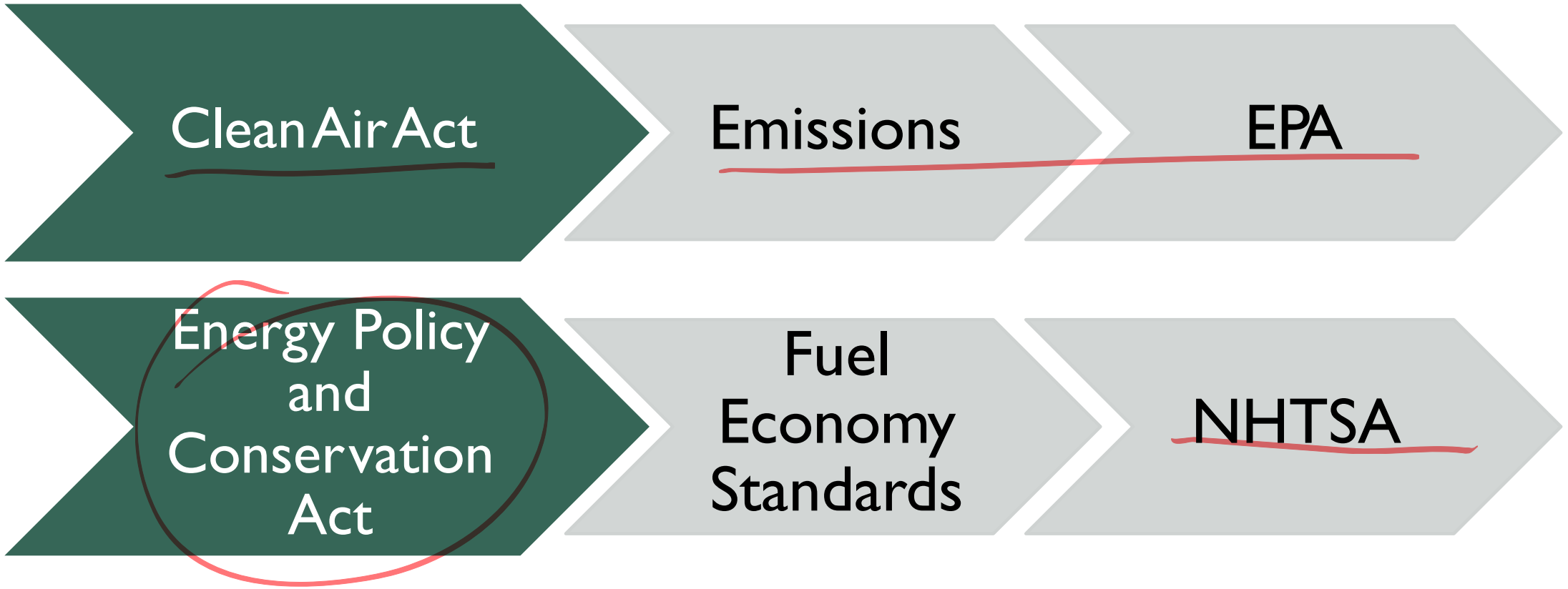
- DDPPTransportation Goal #1:
  - Increase fuel economy standards in excess of 100 mpg

- DDPPTransportation Goal #2:
  - Deploy 300 million alternative fuel vehicles

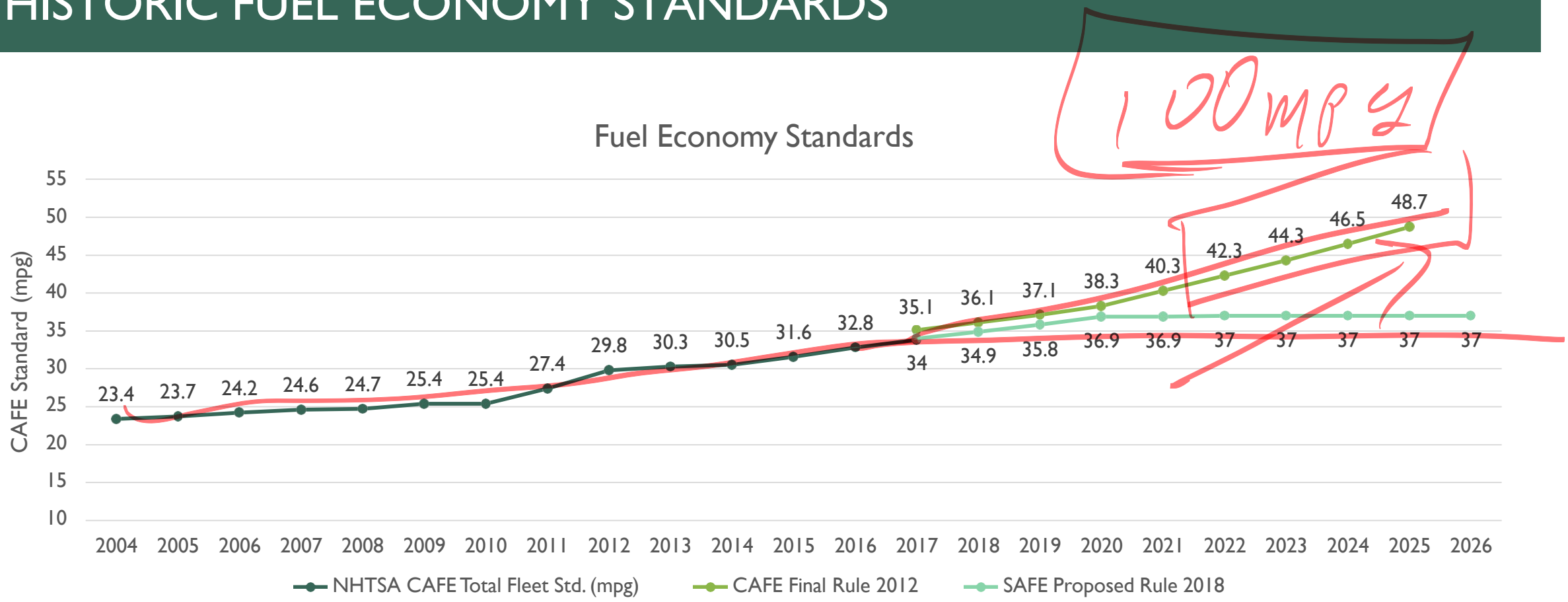
GOAL #1

INCREASE FUEL ECONOMY STANDARDS IN EXCESS OF 100 MPG

GOAL #1: INCREASE FUEL ECONOMY STANDARDS BIFURCATED LEGAL AUTHORITY



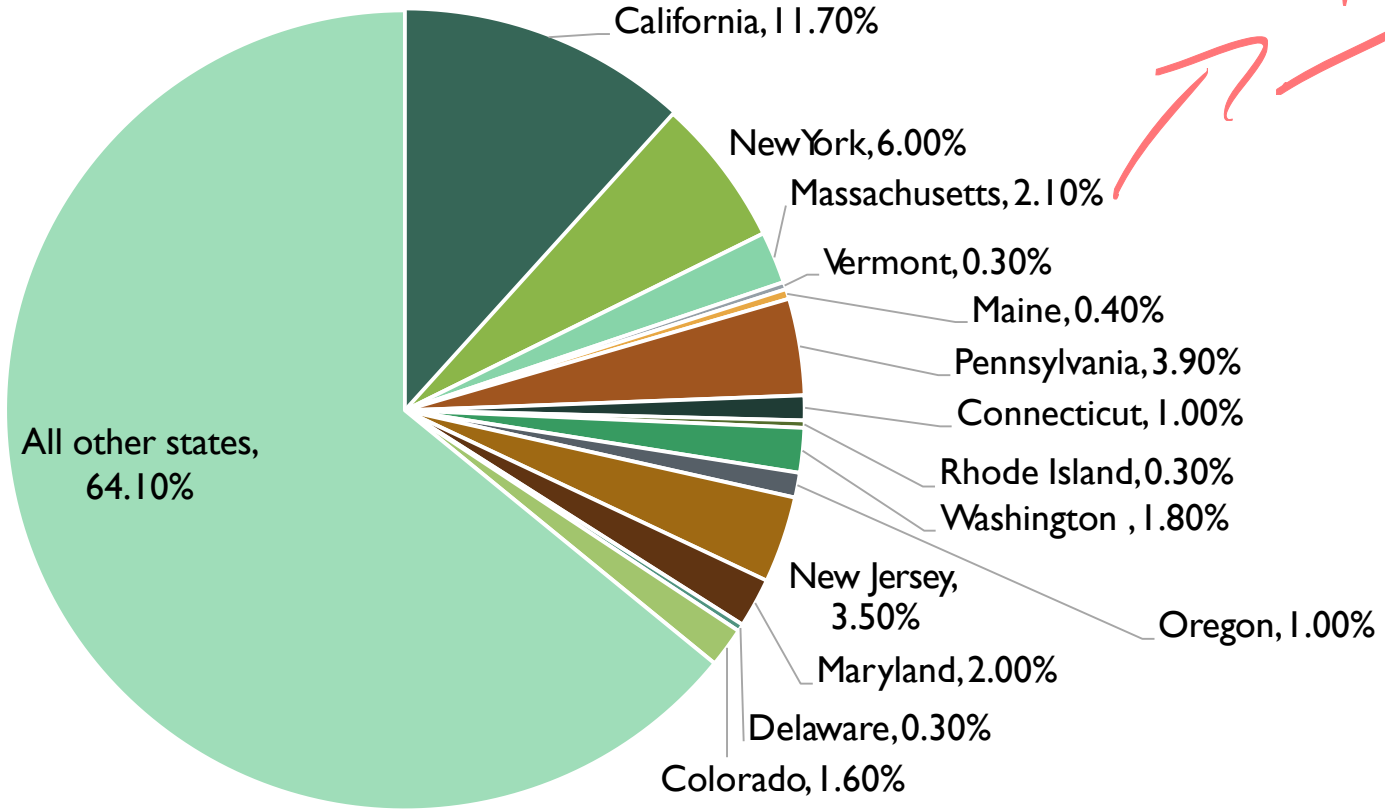
GOAL #1: INCREASE FUEL ECONOMY STANDARDS
HISTORIC FUEL ECONOMY STANDARDS



https://one.nhtsa.gov/cafe_pic/CAFE_PIC_fleet_LIVE.html (using all MY years,Total Fleet, Fleet Standards)
https://www.govinfo.gov/content/pkg/FR-2012-10-15/pdf/2012-21972.pdf (CAFE Final Rule 2012)
https://www.govinfo.gov/content/pkg/FR-2018-08-24/pdf/2018-16820.pdf (SAFE Proposed Rule 2018)

GOAL #1: INCREASE FUEL ECONOMY STANDARDS FEDERALISM 101

ZEV State Shares of U.S. New LDV Sales



STATES THAT HAVE ADOPTED THE CA EMISSIONS STANDARDS REFLECT 46% OF NEW LDV SALES

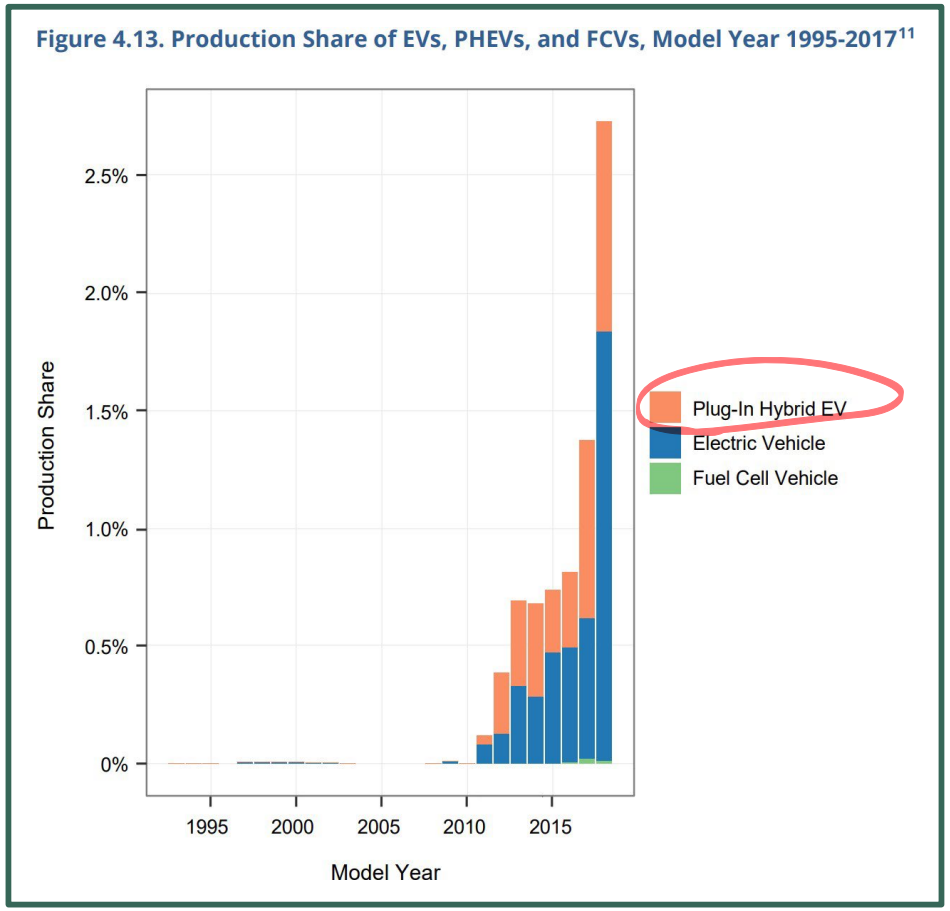
States that have Adopted California's Vehicle Emissions Standards under Section 177 of the Federal Clean Air Act, CALIFORNIA AIR RESOURCES BOARD (last updated Sept. 27, 2019) https://ww2.arb.ca.gov/resources/documents/states-have-adopted-californias-vehicle-standards-under-section-177-federal

GOAL #2

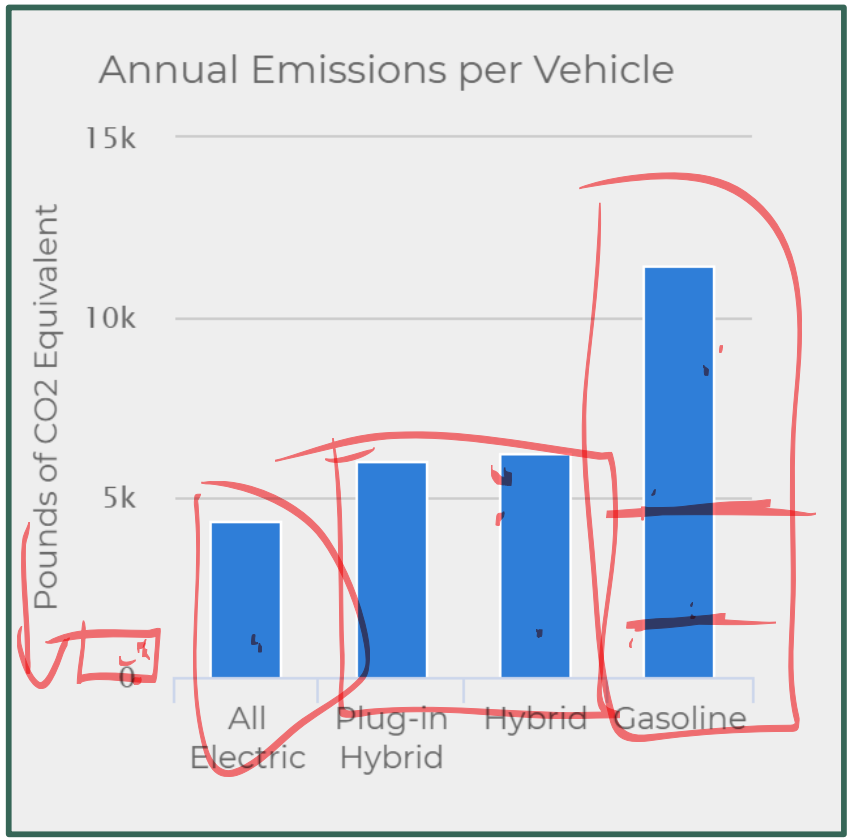
DEPLOY 300 MILLION ALTERNATIVE FUEL VEHICLES

EV

GOAL #2: DEPLOY 300 MILLION ALTERNATIVE FUEL VEHICLES

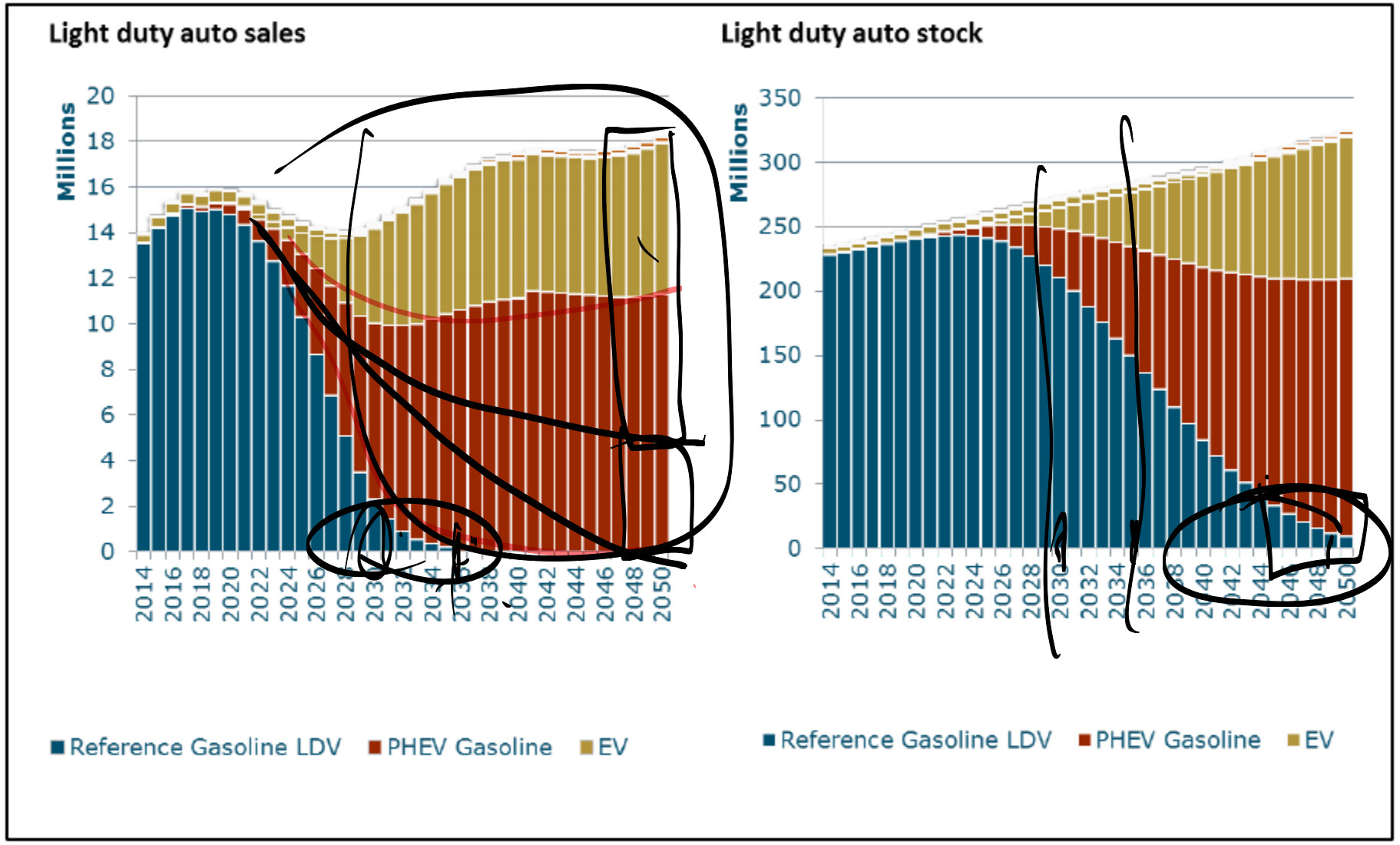


The 2018 EPA Automotive Trends Report: Greenhouse Gas Emissions, Fuel Economy, and Technology since 1975, EPA (last visited Nov. 21, 2019) https://nepis.epa.gov/Exe/ZyPDF.cgi/P100W5C2.PDF?Dockey=P100W5C2.PDF



Emissions from Hybrid and Plug-In Electric Vehicles: National Average, U.S. DEPT. OF ENERGY (last visited Nov. 21, 2019) https://afdc.energy.gov/vehicles/electric_emissions.html

Figure 5. Stock-rollover Example in PATHWAYS: Light Duty Auto Sales and Stock by Model Year



PHEV - plug-in hybrid electric vehicles

GOAL #2: DEPLOY 300 MILLION ALTERNATIVE FUEL VEHICLES
PATHWAY #2: FACILITATE INFRASTRUCTURE DEVELOPMENT

- Workplace Charging
- Home Charging
- Charging Corridors

ChargePoint Station

- *ChargePoint ElectricVehicle Charging Corridors: United States of America*, UNITED NATIONS: CLIMATE CHANGE, https://unfccc.int/climate-action/momentum-for-change/ict-solutions/chargepoint-electric-vehicle-charging-corridors

ACTION ITEMS

- Maintain 54.5 mpg fuel economy standard for 2025 and ramp up by 2050
- View EVs as grid assets (rise in EVs=rise in electricity demand, V2G programs)
- Work with electric utilities to capitalize on charging patterns and rates
- Maximize EV climate impacts through cleaner electricity resources
- Investments (e.g. infrastructure, education, and battery technologies)
- Harness government purchasing power for EVs
- Plan ahead (provide funding for pilot studies on distribution grid pressures from EVs, secure lithium supply, prepare for lithium battery disposal)
- Think creatively (battery recycling, resale markets, Cash for Clunkers-type program, smart city design, autonomous vehicles, EV-Ready building codes, decouple highway revenues from gas taxes)

Environmental and Energy Study Institute
Briefing to the House Select Committee on the Climate Crisis

LEGAL PATHWAYS TO DEEP DECARBONIZATION IN U.S. AGRICULTURE

PETER LEHNER
MANAGING ATTORNEY

EARTHJUSTICE

CLIMATE CHANGE HARMS AGRICULTURE

EXTREME WEATHER

- Hurricanes and storms increase in frequency and severity
- Hurricane Maria: $780M in ag losses
- CAFO overflows

PESTS, WEEDS, DISEASES

- More optimal living conditions for pests, parasites and fungi
- Invasive species expand and spread
- Reduced resilience to disease outbreak

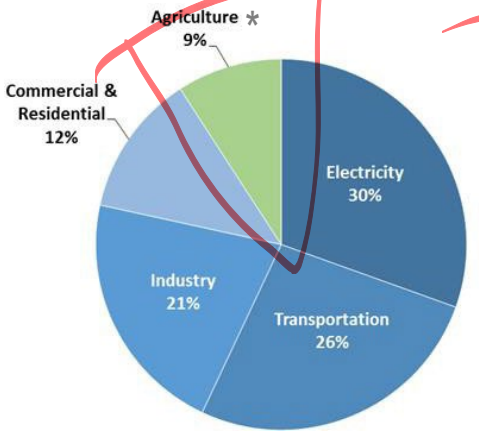
HEAT WAVES AND WILD FIRES

- More frequent and severe
- Lead to yield declines
- Dangerous working conditions

FLOODS AND DROUGHTS

- Irregular and extreme precipitation events more frequent and severe
- 2016 CA Drought: $603M in ag losses
- 2019 Midwest floods: 5-10M bushels corn and soy rotted

INDUSTRIAL AGRICULTURE CONTRIBUTES TO CLIMATE CHANGE



*Additional food system related emissions are produced **across all sectors** (e.g. processing, refrigeration, cooking, transport, indirect deforestation abroad)

SOIL CARBON

- Forest and grassland conversion, tillage
  - **~17** coal-fired power plants
- **7.8M+ acres** converted to cropland from 2008-2012

METHANE

- Cattle, animal manure
- **~87** coal-fried power plants
- Equal to emissions from entire **oil and gas sector**

NITROUS OXIDE

- Excess fertilizer, animal manure
- **~73** coal-fired power plants

CARBON DIOXIDE

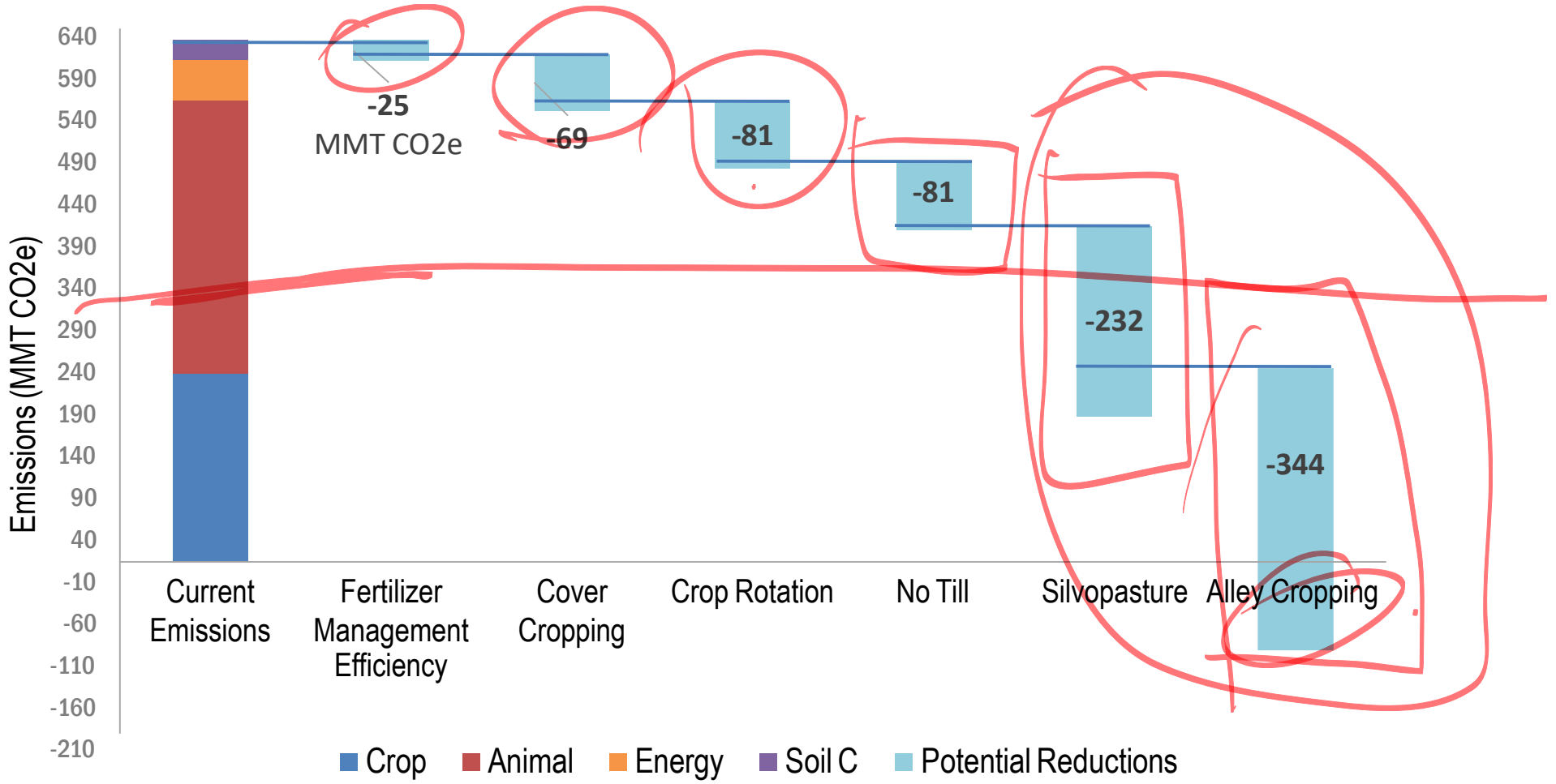
- Fertilizer manufacture, on-farm energy, food waste in landfills
- **~12** coal-fired power plants

AGROECOLOGICAL PRACTICES REDUCE CHEMICAL USE, POLLUTION, CLIMATE IMPACTS

Annual crop root mass (left) vs. perennial crop root mass (right). *Greater root mass improves drought/flood resilience and nutrient uptake.*

- Chemical-intensive, monoculture systems increase erosion and GHG emissions and are not necessary for high productivity and profitability
- **Organic and agroecological practices can provide ample nutritious food** while reducing fertilizer/pesticide needs and costs
- These proven practices include:
  - Perennial crops (*see image*)
  - Crop rotations (different yearly crops)
  - Cover crops (avoiding winter bare ground)
  - No-till, reduced till; prairie strips
  - Management intensive grazing
  - Agroforestry & silvopasture (trees)
  - Dry manure management
  - Organic fertilizer
  - Riparian buffers, wind breaks

CARBON-NEUTRAL FUTURE:
BETTER PRACTICES CAN REDUCE EMISSIONS



EARTHJUSTICE
BECAUSE THE EARTH NEEDS A GOOD LAWYER