

Driving Innovation in Clean Energy

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Themes:

Electrification

Digitization

Integrated systems

Electrification

Vehicles

Building Heat & Hot Water

Industrial Processes

Hydrogen & synthetic fuels

On-site fossil fuel consumption as a percent of total energy consumption in 2015 (IEA)

	World	OECD
Residential and Commercial	8.1%	10.0%
transportation fuel	19.0%	24.6%
Industrial fuel	32.2%	23.9%
total	59.2%	58.6%

Industrial Energy Use in Europe (8.9 EJ total)

Temperature of process °C	Energy Used EJ
>500	42.9%
100-500	29.3%
<100	9.4%
space heat	14.3%
process cool	3.6%
space cool	0.5%
source:	

Digitization

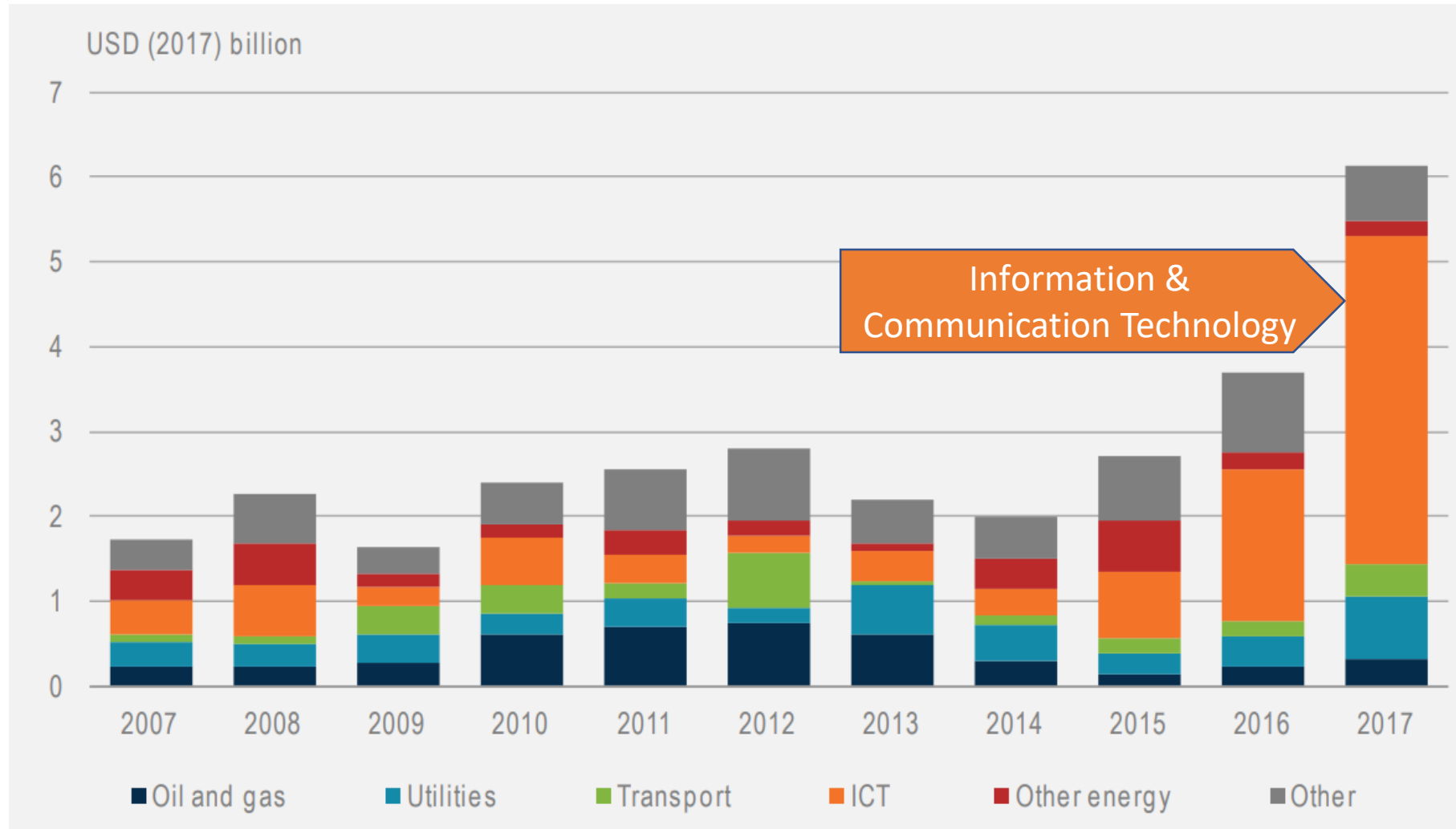
(low cost, sensors, communication, data management)

Design

Production

Operation

Global value of deals by corporate investors in energy-efficiency technology (IEA)



Integrated systems

Building Systems

Equipment

Building Design

Building Operation

Urban Design

Grid Integration

Transportation Systems

Shared Mobility Services

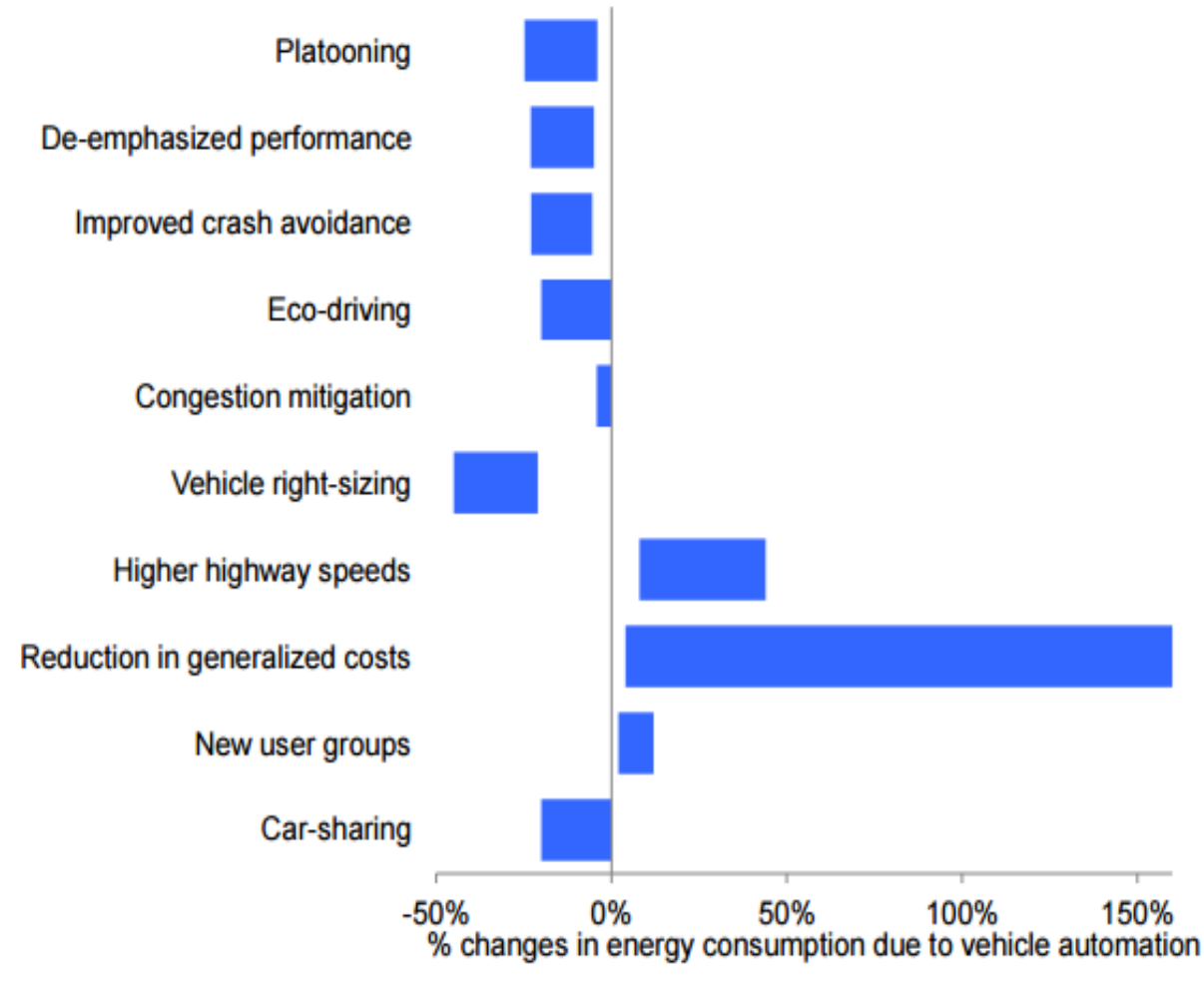
Electrification

Automated, Connected

What's New?

- Demand (demographics, life-style, telecommuting, online shopping/optimized delivery)
- Vehicle owner/operator -> buying mobility
- Urban design (transit oriented)
- Ubiquitous mobile devices
- New business models– mobility on demand (Uber, Lyft, Via, eBay Now, Amazon...)
- New Vehicle types (Connected, Automated, Right sized, Electric)
- Ubiquitous sensors and controls (including video)
- Vast amounts of data and powerful new data tools to describe, predict, and prescribe

Impact of Automated Vehicles on Energy Consumption



Industrial Energy Systems

Production processes (cement) can release of CO₂

Fossil fuels used as a raw material

light-weight materials improve efficiencies in
other sectors

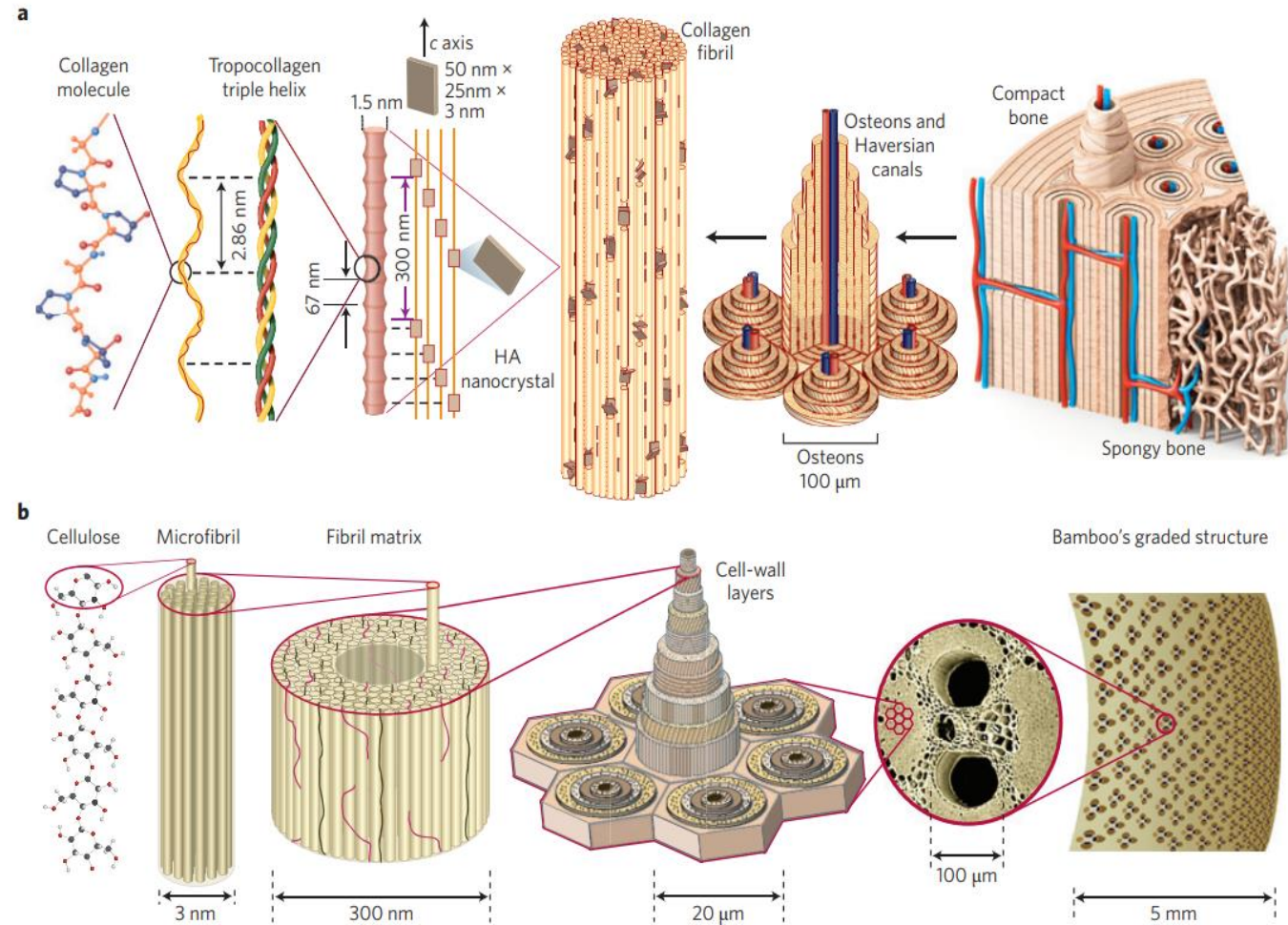
Potential for recycling -- a circular economy

Additive Manufacturing

- *They can reduce use of raw materials.* Parts can be designed to use material only where it is actually needed -savings of up to 90% are possible.
- *The production process itself can be more efficient*
- *The optimized, lightweight parts produced can increase the efficiency of vehicles, robots, and other devices using them*

Hierarchical structure of (a) bone, (b) bamboo

source: Wegst 2015

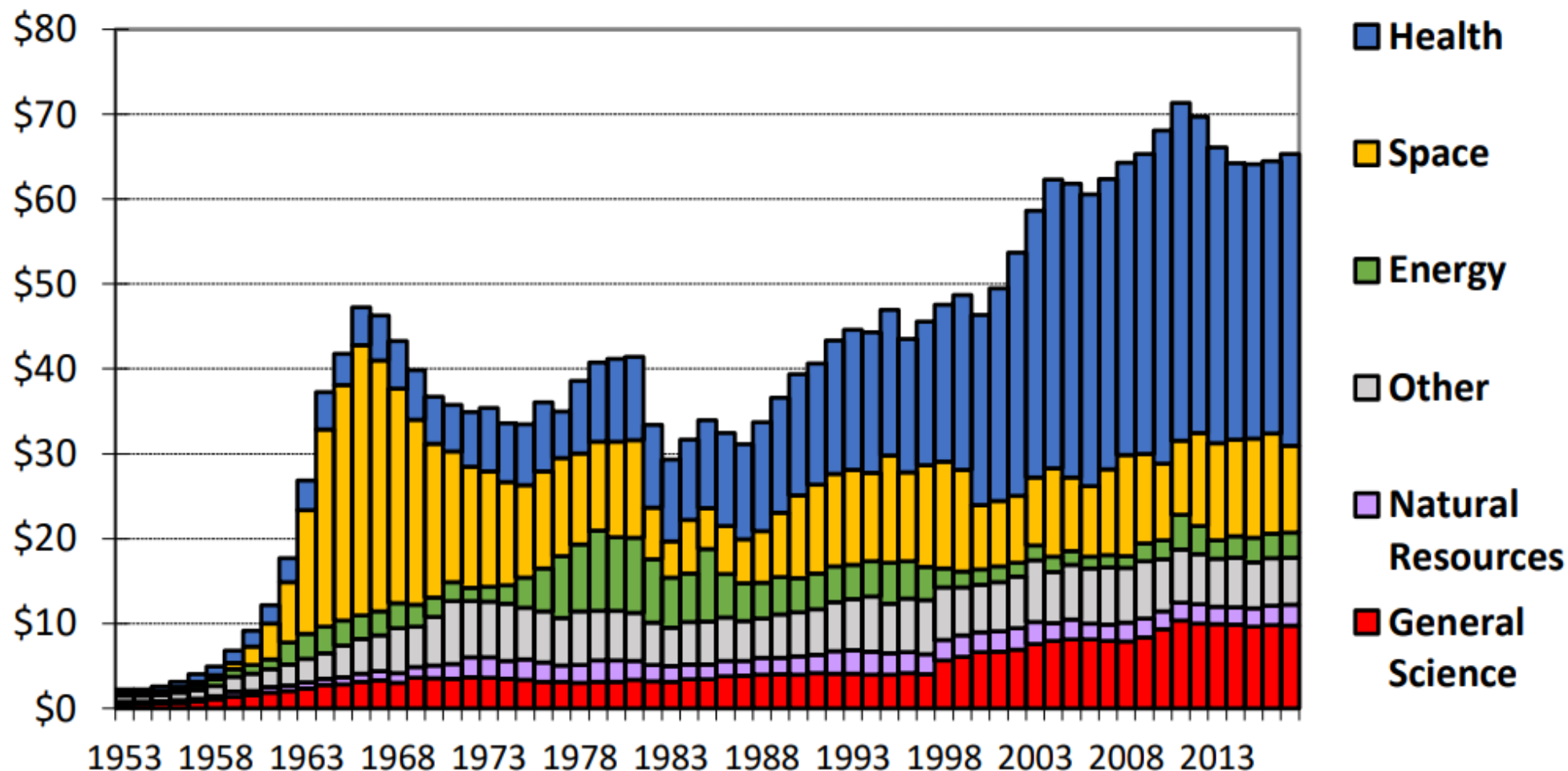


The Tools: Innovation: Push and Pull

- Push
 - **Research**
 - **Development**
 - **Demonstration**
- Pull
 - **Labeling** (e.g. energy labels, Energy Star)
 - **Regulation** (emission standards, fuel economy standards, appliance standards, ethanol fuel requirement)
 - **Tax credits** (e.g. Research and experimentation tax credit made permanent in 2017, credits for renewables, electric vehicles, fuel tax, Carbon Tax???)
 - **Subsidies** (recovery act loan guarantees, federal insurance for nuclear plants, weatherization, industrial assessment centers)
 - **Procurement** - learning curve

U.S. Trends in Nondefense R&D by Function

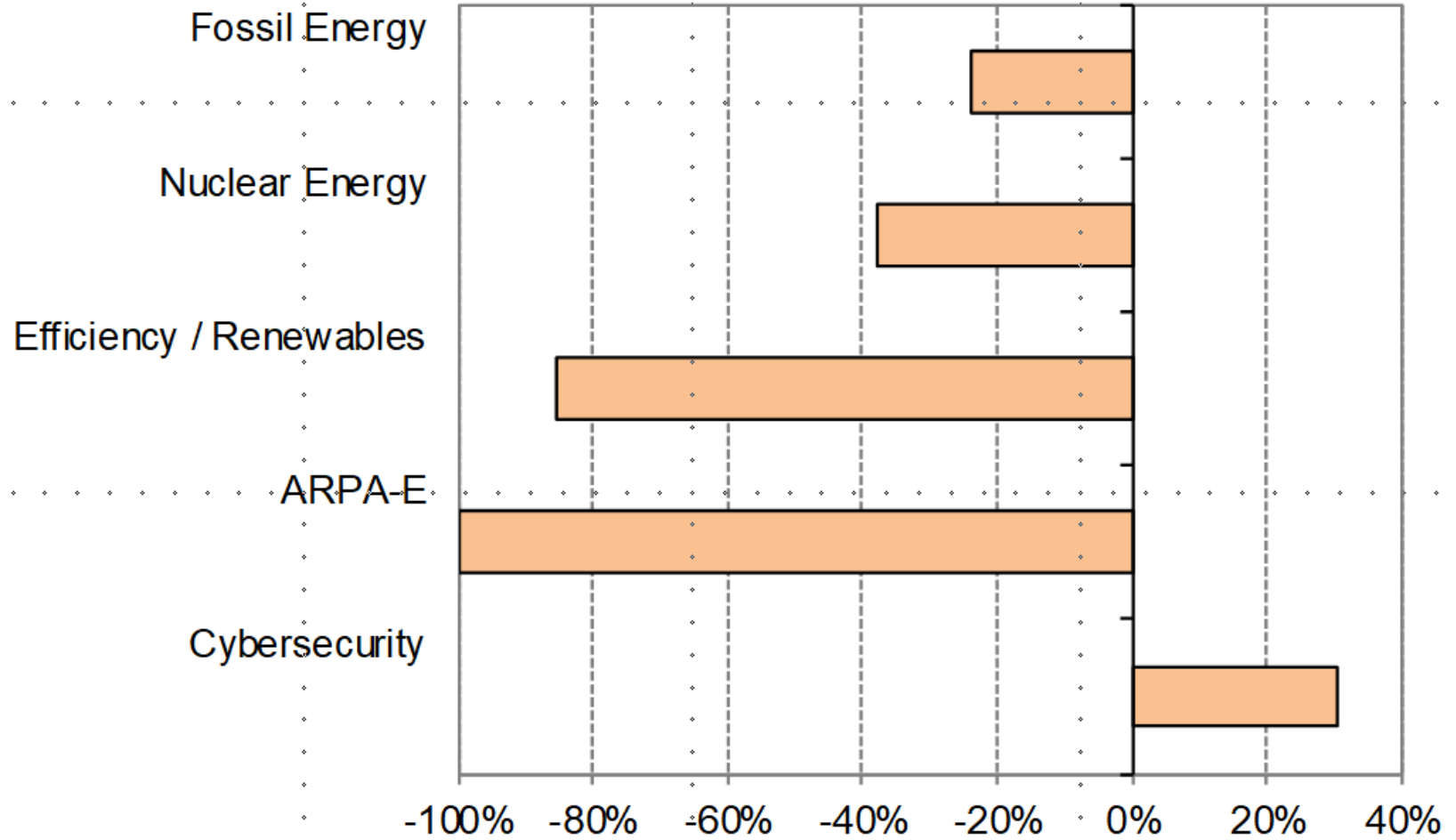
outlays for the conduct of R&D, billions of constant FY 2018 dollars



Source: AAAS, based on OMB Historical Tables in FY 2019 budget. Some Energy programs shifted to General Science beginning in FY 1998. © 2018 AAAS

FY 2020 Energy Program Budgets

percent change from FY 19, nominal dollars



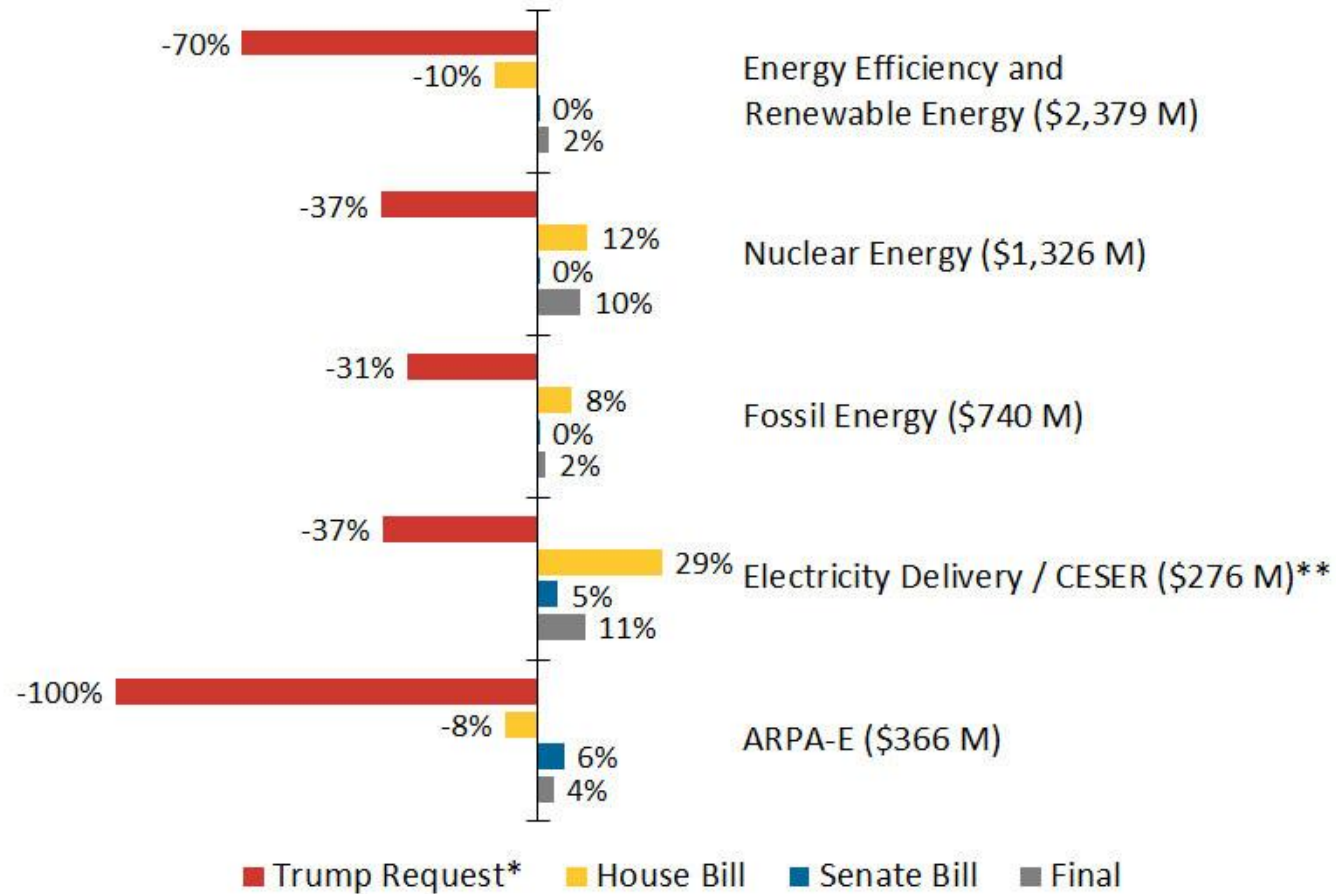
Based on agency and legislative data. © 2019 AAAS

Percent change from FY 2019

FY19 Appropriations: DOE Applied Energy R&D

% change from FY18 enacted

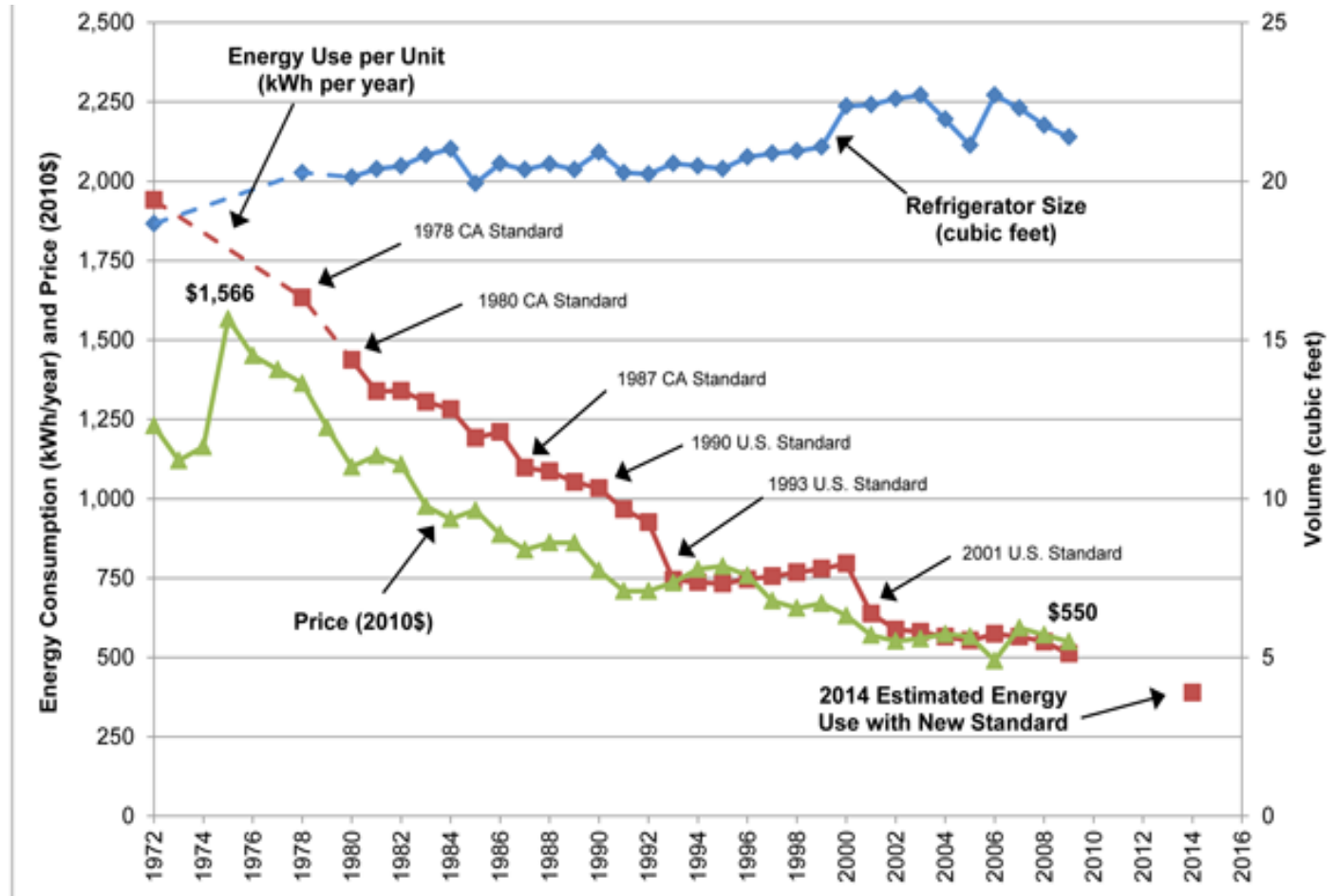
\$ in () are the FY19 amounts



* The administration submitted the budget request to Congress before the final amounts for fiscal year 2018 were set.

** The Electricity Delivery and Energy Reliability Office has been split into an Electricity Delivery Office and a Cybersecurity, Energy Security, and Emergency Response Office. The amounts for these offices are combined for comparability with the past structure.

The Impact of Refrigerator Standards



Sources: Association of Home Appliance Manufacturers (AHAM) for energy consumption and volume; U.S. Census Bureau for price

- Notes:**
- Data includes standard-size and compact refrigerators.
 - Energy consumption and volume reflect the DOE test procedure published in 2010.
 - Volume is adjusted volume, which is equal to the fresh food volume + 1.76 * freezer volume.
 - Prices represent the manufacturer selling price (e.g. excluding retailer markups) and reflect products manufactured in the U.S.

What is the public role in fostering system-wide transitions?