

# Carbon Capture and Storage (CCS) on the Road from Paris

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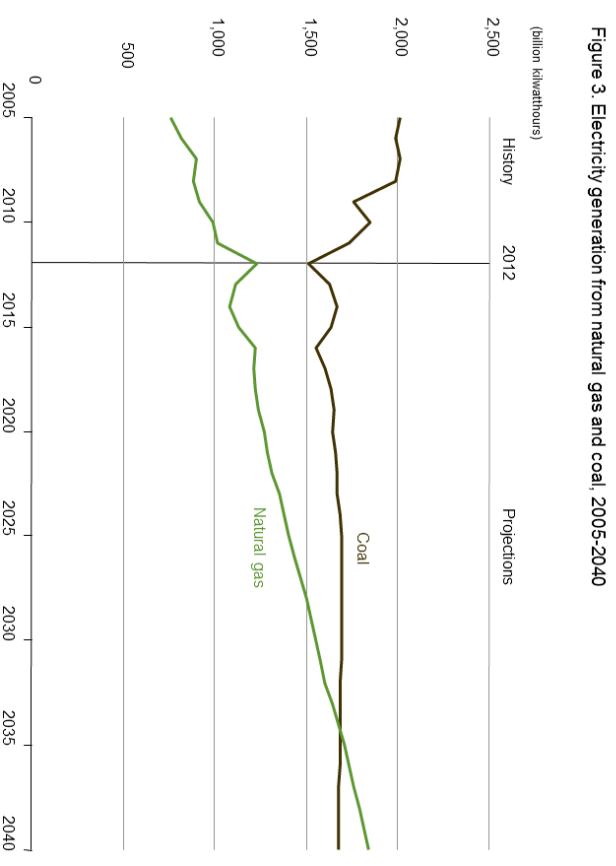
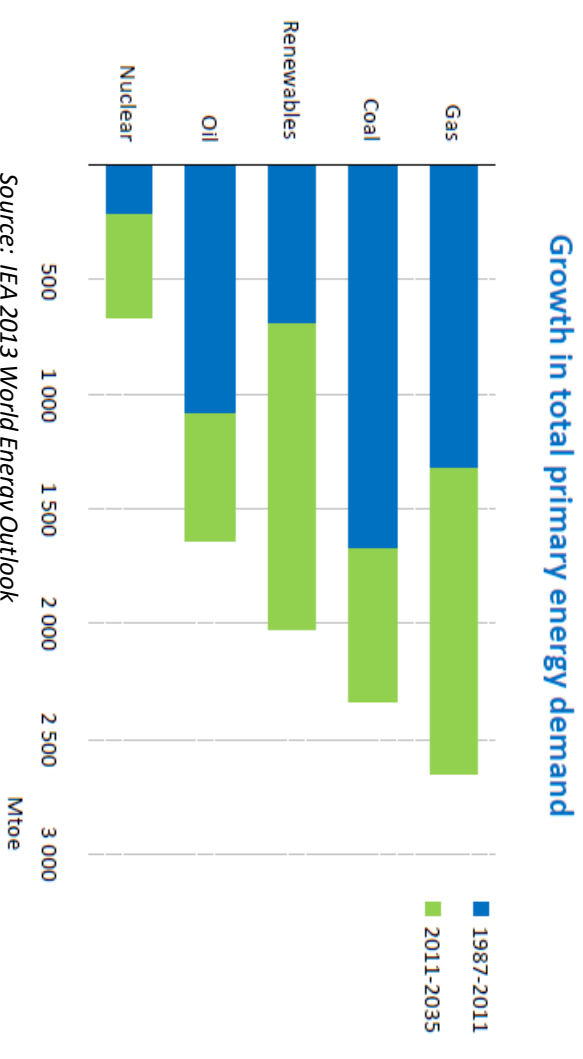
for Clean Coal and Carbon Management

U.S. Department of Energy

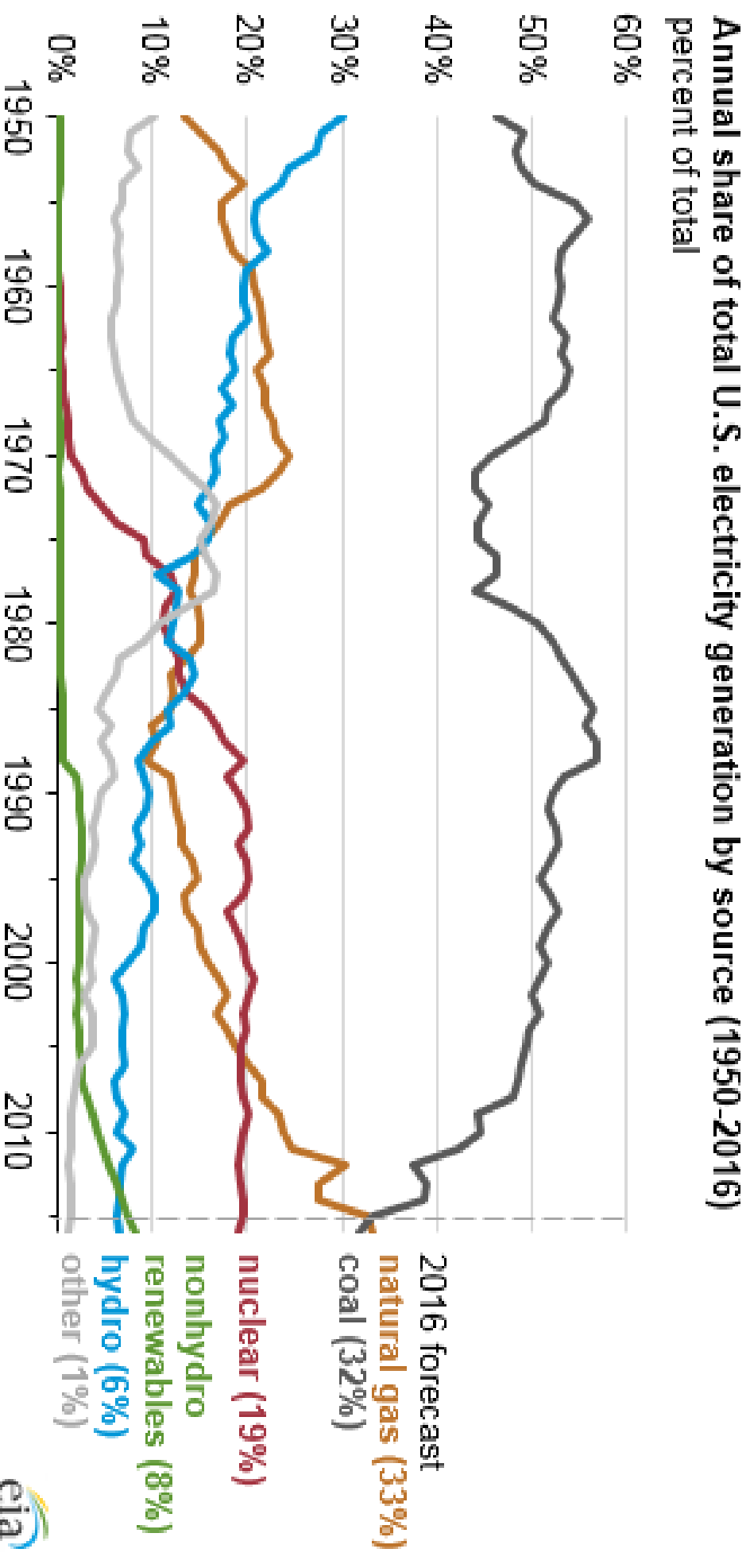
May 2016

# Future of fossil energy demand and generation

- Fossil energy reduces its world share of demand from 82% to 75% by 2035, offset by a surge in renewable energy (IEA 2013)
- Natural gas and renewables outpace growth and demand of all other sources world wide
- Natural gas is primary source of electricity generation in United States after 2035 (EIA2014)
- Fossil energy remains dominant share (68%) of United States electricity generation in 2040



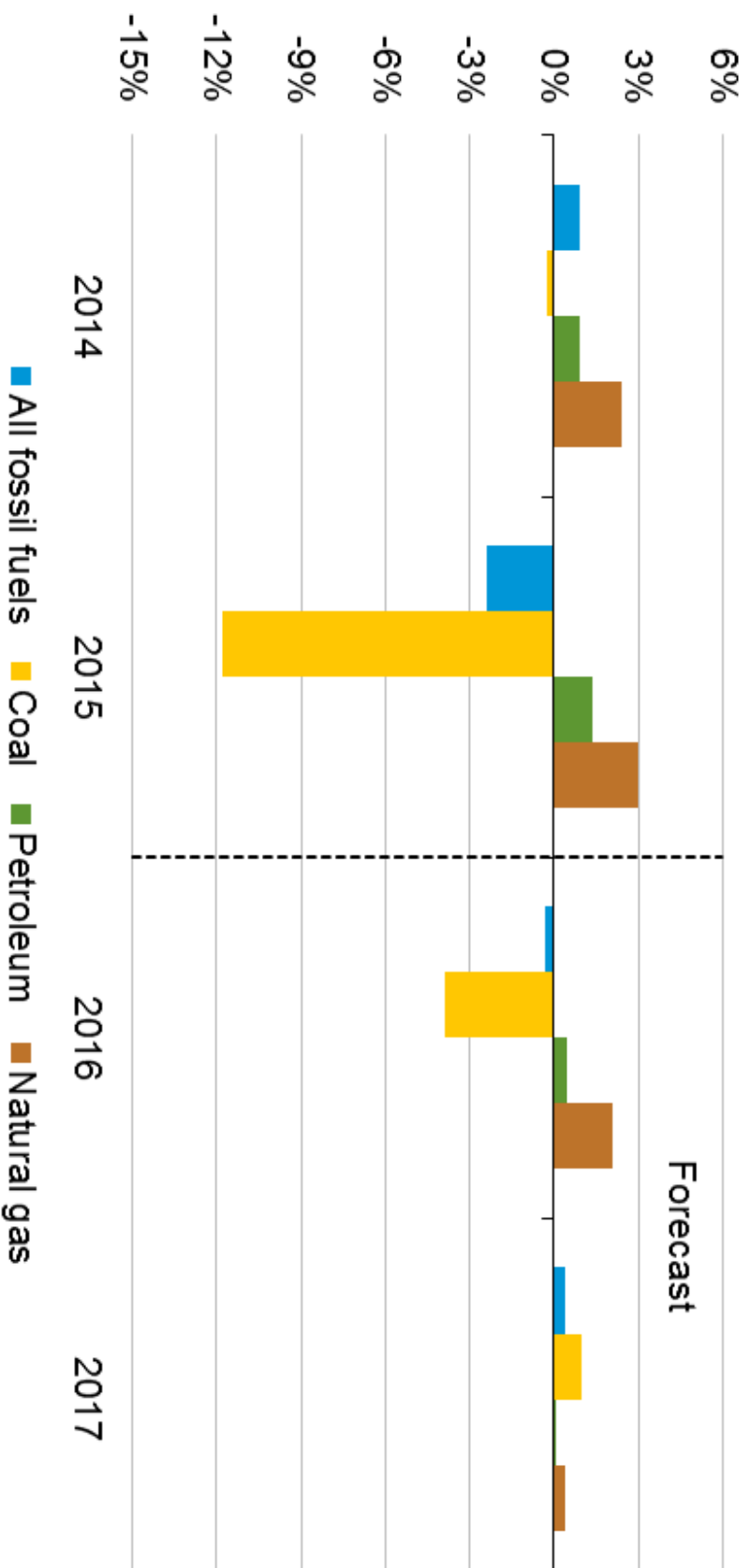
# Natural gas is expected to overtake coal in fuel used for power generation in 2016



# Projected growth in CO<sub>2</sub> emissions comes from gas, not coal



## U.S. Energy-Related Carbon Dioxide Emissions annual growth

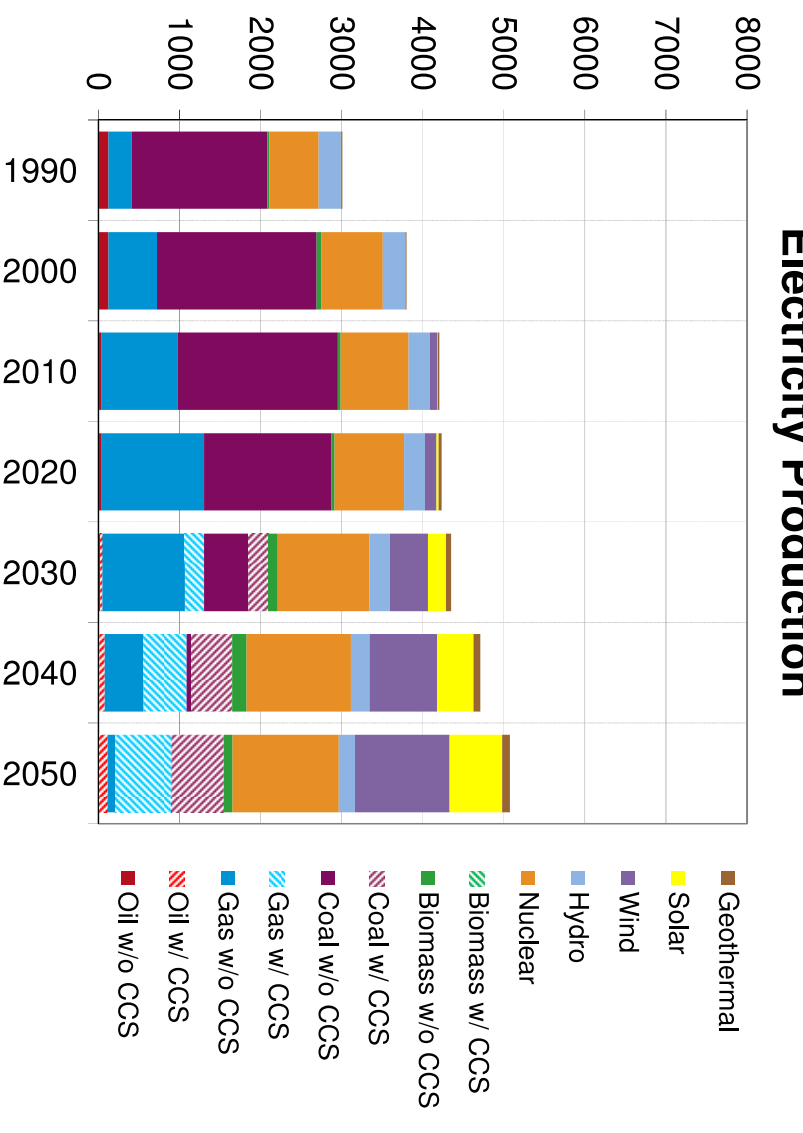
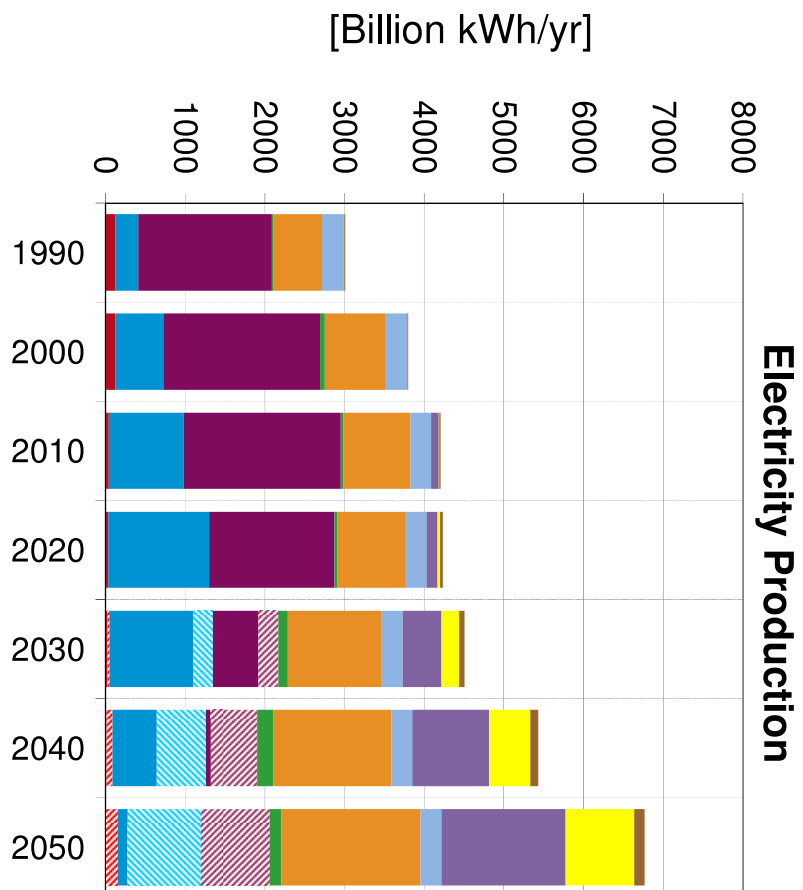


Source: Short-Term Energy Outlook, March 2016.

# CCS for coal and gas will be needed even with substantial efficiency

*US Power Gen: Mixed Scenario*

*US Power Gen: Low-Demand Scenario*



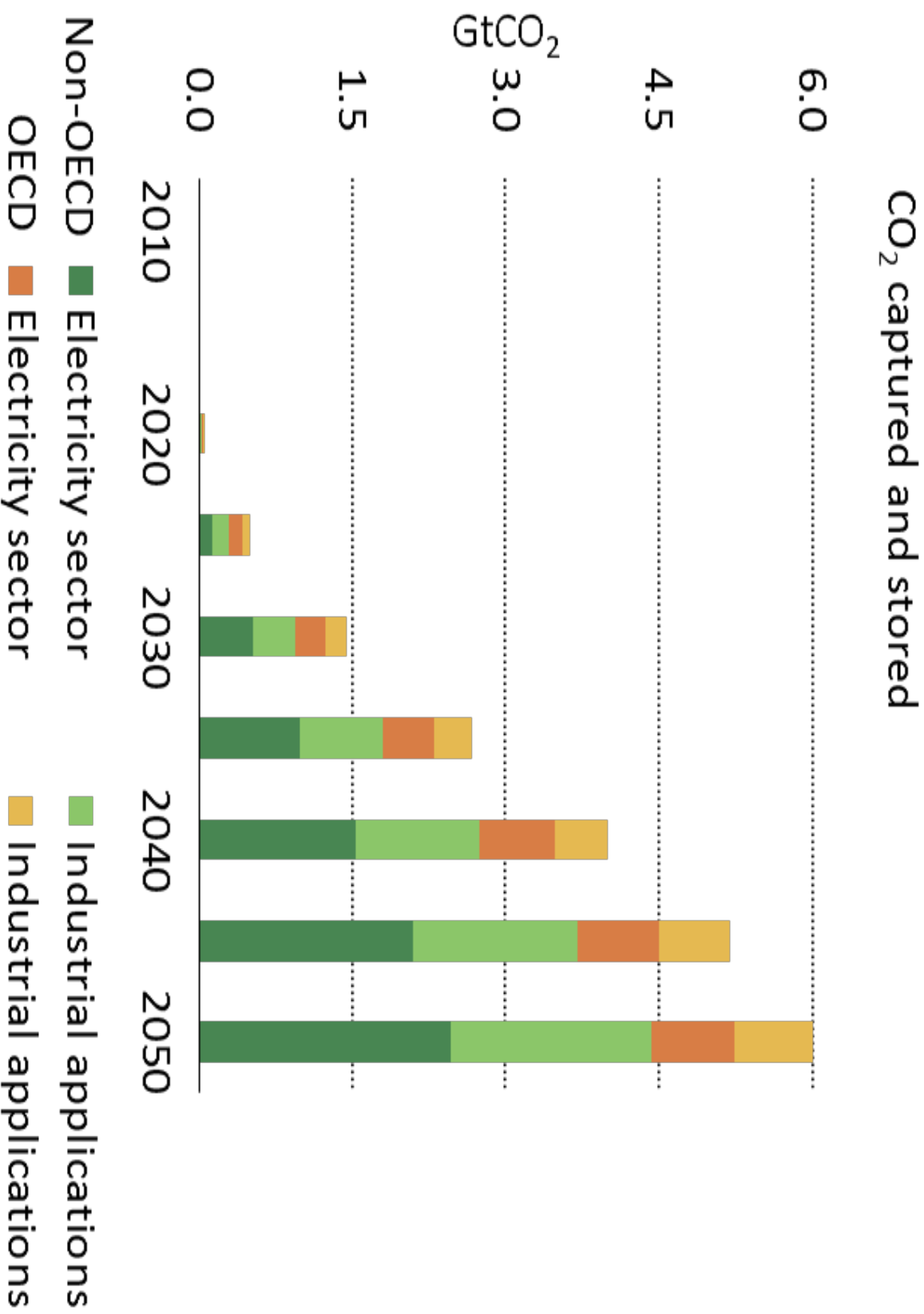
*Financing (cost recovery) is the main issue*

# Cost, policy, and parity

Figure 1.2 | Levelized Cost of Electricity (\$/MWh) for New Generation Sources and Levelized Power Purchase Agreement Prices for Recent Wind and Solar Projects

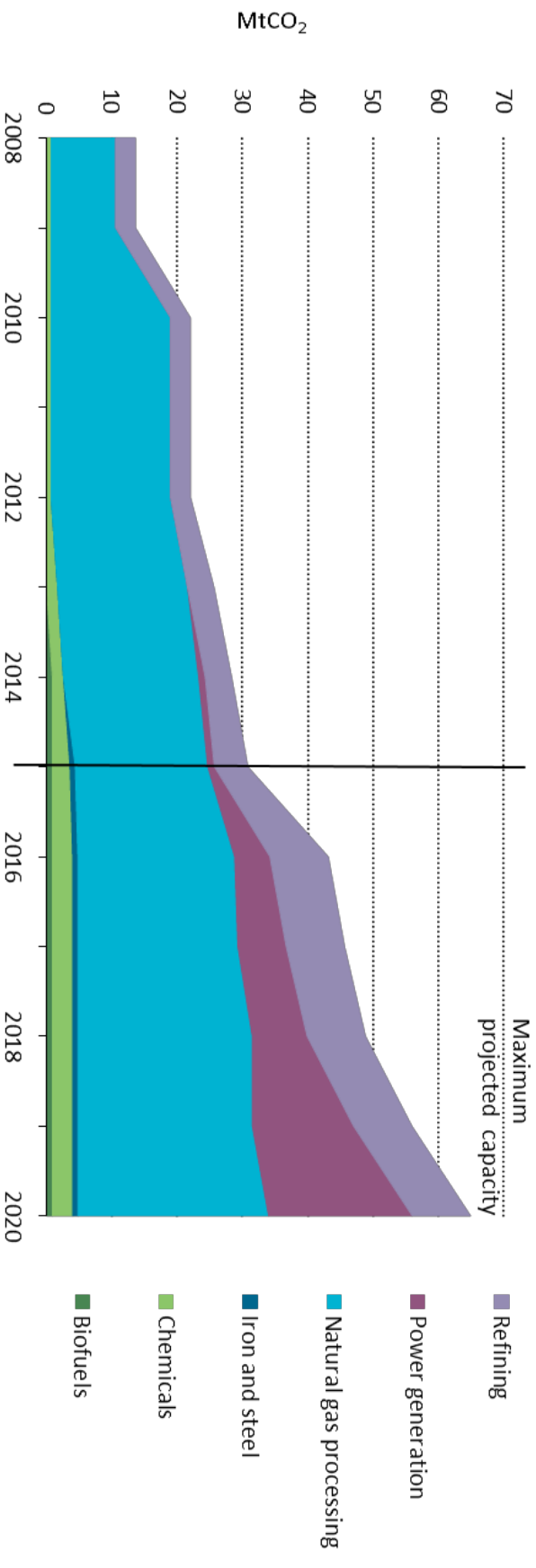


# In the 2DS case, CCS is important in both power and industrial applications



# CCS projects keep advancing, but slowly

**60**  
MILLION  
TONNES OF  
CO<sub>2</sub> STORED  
WITH  
MONITORING  
TO DATE

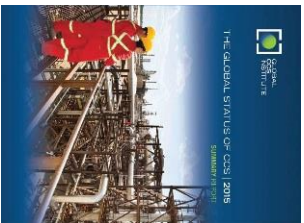


- *Maximum capture capacity from all projects in the pipeline is 65 MtCO<sub>2</sub> a year*
- *2DS calls for 500 MtCO<sub>2</sub> a year by 2025*





# Many more projects required

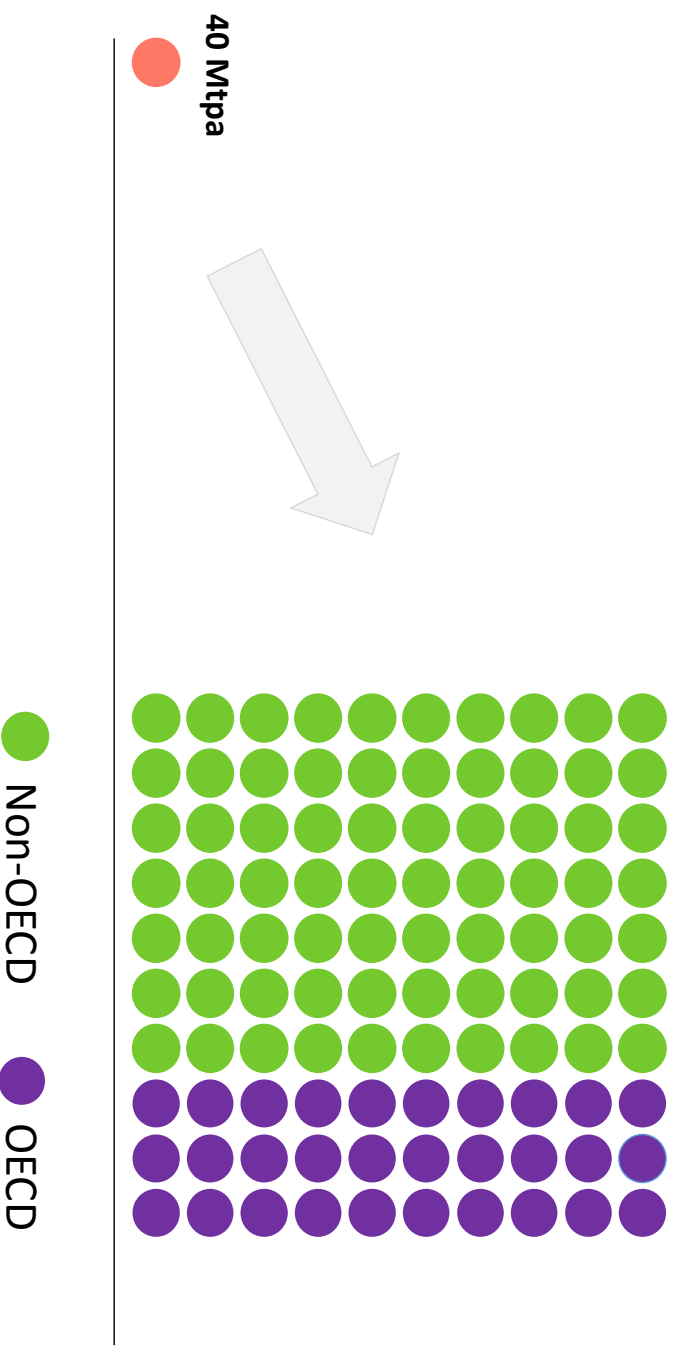


**Global Status  
of CCS: 2015**

- 43 large-scale CCS projects - combined capture capacity of 80 Mtpa\*:
- 22 projects in operation or construction (**40 Mtpa**)
- 9 projects in advanced planning, five nearing FID (15 Mtpa)
- 12 projects in earlier stages of planning (25 Mtpa)



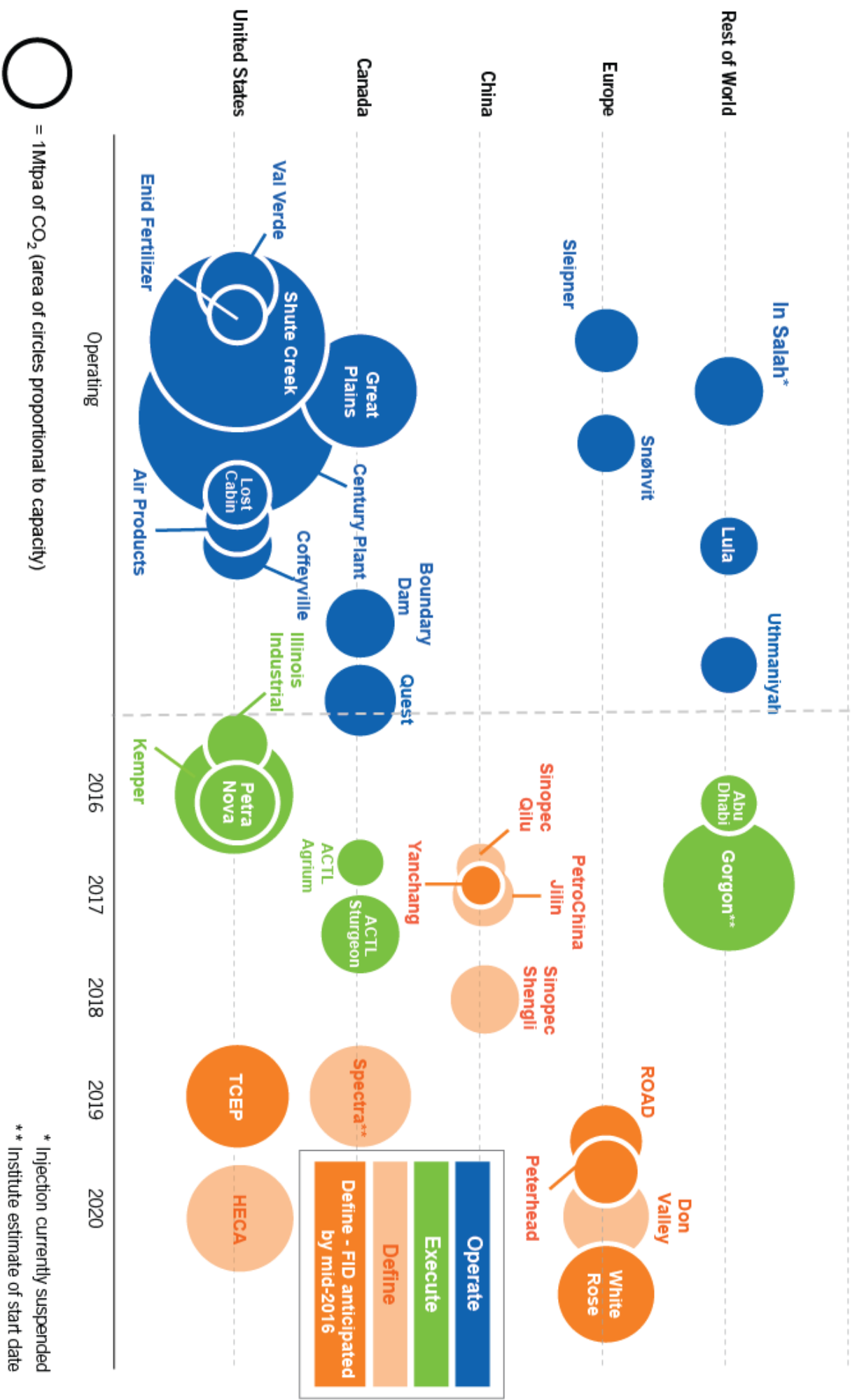
**4,000 Mtpa of CO<sub>2</sub>  
captured by CCS by 2040  
(IEA 450 Scenario)\*\***



**Requires money, organization, policy support**

\*\*Source: IEA, Energy Technology Perspectives (2015).

# International collaboration is key



\* Injection currently suspended  
 \*\* Institute estimate of start date

Source: Global Status of CCS: 2015, Global CCS Institute (2015)

# Mission Innovation



- 20 heads of state
- Countries represent 85-90 % of global R&D investment
- Each country supporting a doubling of its R&D investment over the next five years
- Complemented by a private sector initiative

# Mission Innovation and CCS

Country	CSLF Member	CCS in INDCs <sup>1</sup>	Large Scale CCS Projects (Source: Global CCS Institute)
Australia	✓		3 Large Scale Projects
Brazil	✓		1 Large Scale Project
Canada	✓	✓	6 Large Scale Projects
Chile			
China	✓	✓	9 Large Scale Projects
Denmark	Former Member		Pilot Scale Project
France	✓		Pilot Scale Projects
Germany	✓		Pilot Scale Projects
India	✓		Pilot Scale Project
Indonesia	Potential Member		Planned Pilot Scale Project
Italy	✓		Pilot Scale Projects
Japan	✓		Pilot Scale Projects
Mexico	✓		Planned Pilot Scale Project
Norway	✓	✓	2 Large Scale Projects
Republic of Korea	✓		2 Large Scale Projects
Saudi Arabia	✓	✓	1 Large Scale Project
Sweden			Pilot Scale Projects
United Arab Emirates	✓	✓	1 Large Scale Project
United Kingdom	✓		4 Large Scale Projects
United States <sup>2</sup>	✓		13 Large Scale Projects

<sup>1</sup> In addition to the countries listed in the chart above, Bahrain, Egypt, Iran, Malawi, and South Africa also included CCS within their INDCs.

<sup>2</sup> Although it did not list CCS specifically in its INDC, the U.S. is pursuing an all-of-the-above energy strategy to meet its climate targets that includes CCS.

# INNOVATION CCS

- **Consistent with Mission Innovation**, utilize a regional approach to accelerate the development and deployment of a full spectrum of CCS technologies

## **Broad deployment requires:**

- (1) Enabling CCS projects with infrastructure
- (2) Reducing costs through RD<sup>3</sup>
- (3) Driving deployment with incentives