

# Low-Carbon Fuels

## Achieving the Last 10%-20% of Decarbonization

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Senior Program Manager

ESIG 2020 Fall Technical Workshop

Session 6: Fuels for the Future | October 15, 2020



**LCRI**  

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**LOW-CARBON  
RESOURCES INITIATIVE**

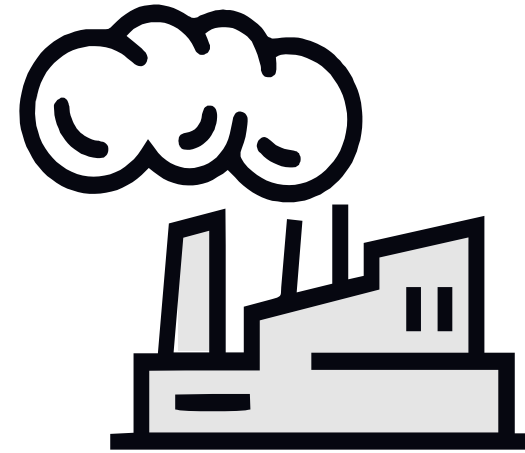
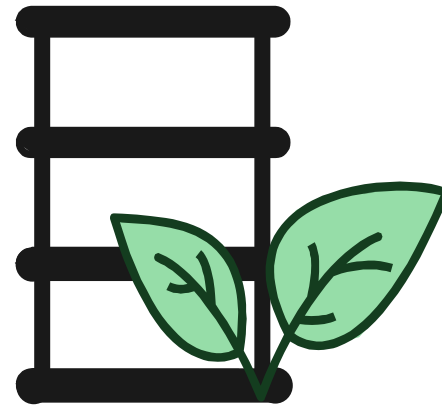
# Pathways to CO<sub>2</sub> Mitigation

## The Source

## The Fuel

## The Process

## The Destination



### Displacement

Nuclear

Renewable

Storage

### Low Carbon Fuel

Hydrogen

Ammonia

Biofuel

### CO<sub>2</sub> Capture

Pre-combustion

Post-combustion

Oxy-combustion

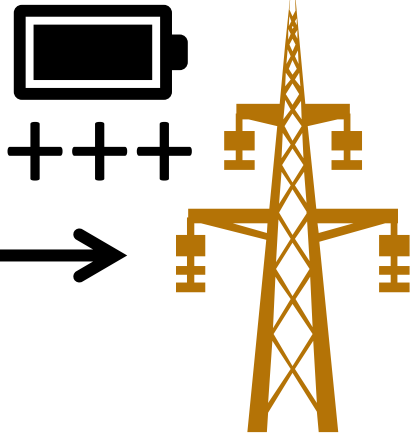
### Carbon Dioxide Removal

Direct Air Capture

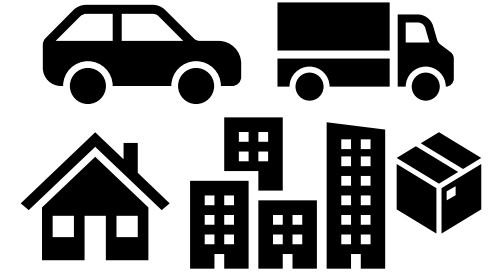
Bio-energy with CCS

Land Use and Mineralization

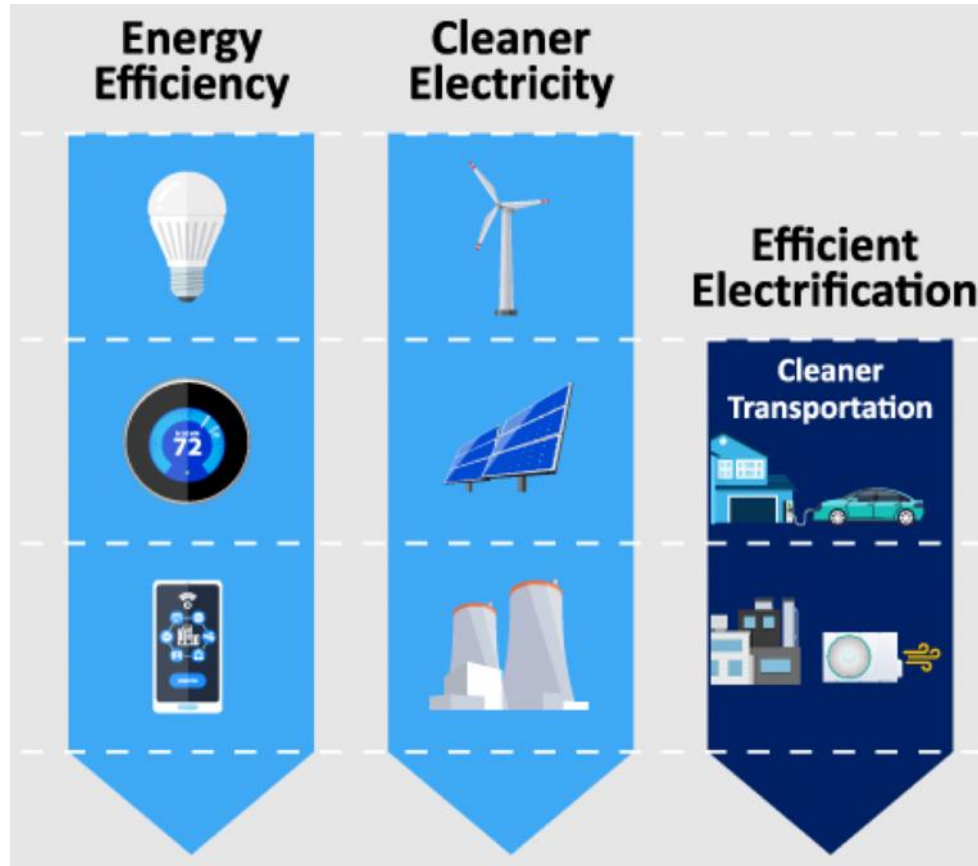
# Low-Carbon Generation



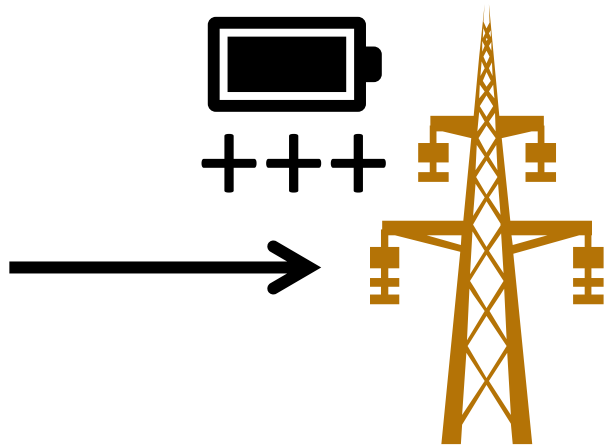
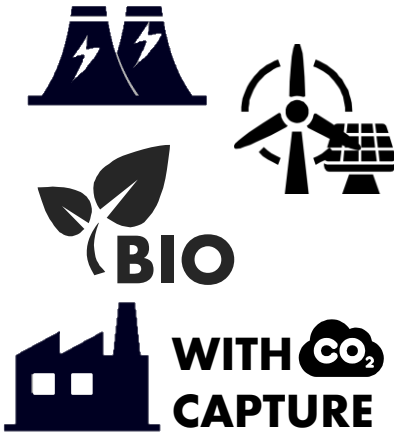
# ELECTRIFICATION



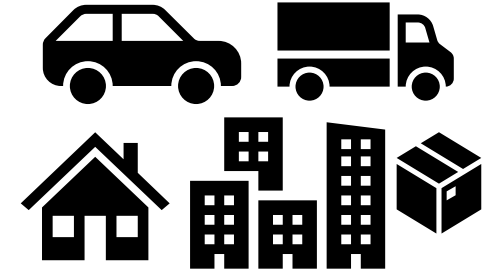
**Energy Efficiency,  
Cleaner Electricity and  
Efficient Electrification  
are key pathways to  
decarbonization today.**



## Low-Carbon Generation



## ELECTRIFICATION



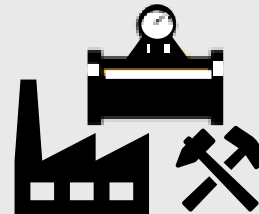
What does the next phase of decarbonization look like?

How will we continue to decarbonize our Generation Fleet?

## How will we decarbonize 'hard to electrify' places?



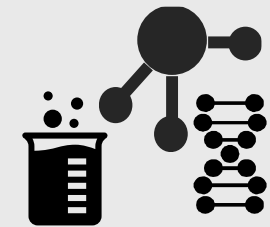
Shipping & Heavy-Duty Transportation



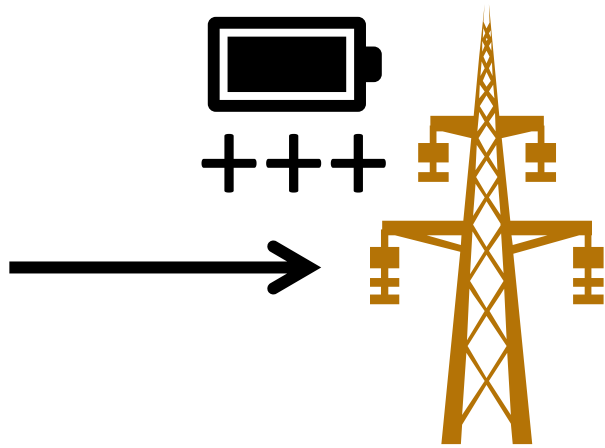
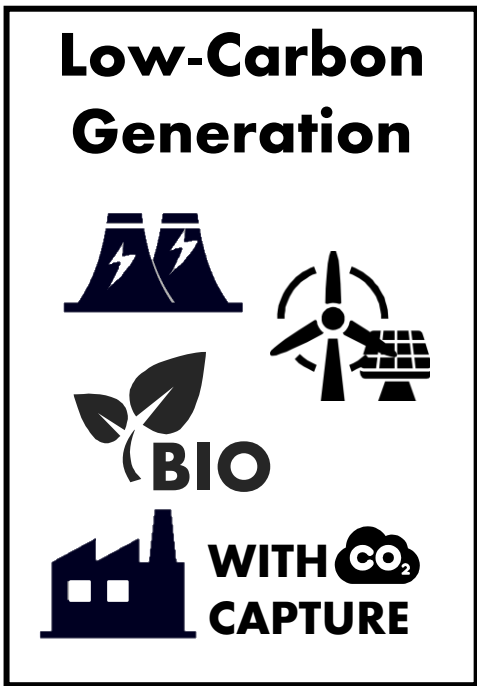
Oil & Gas Steel



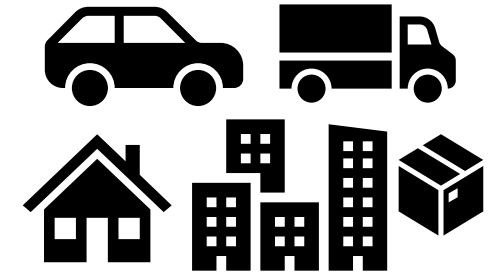
High Grade Heat



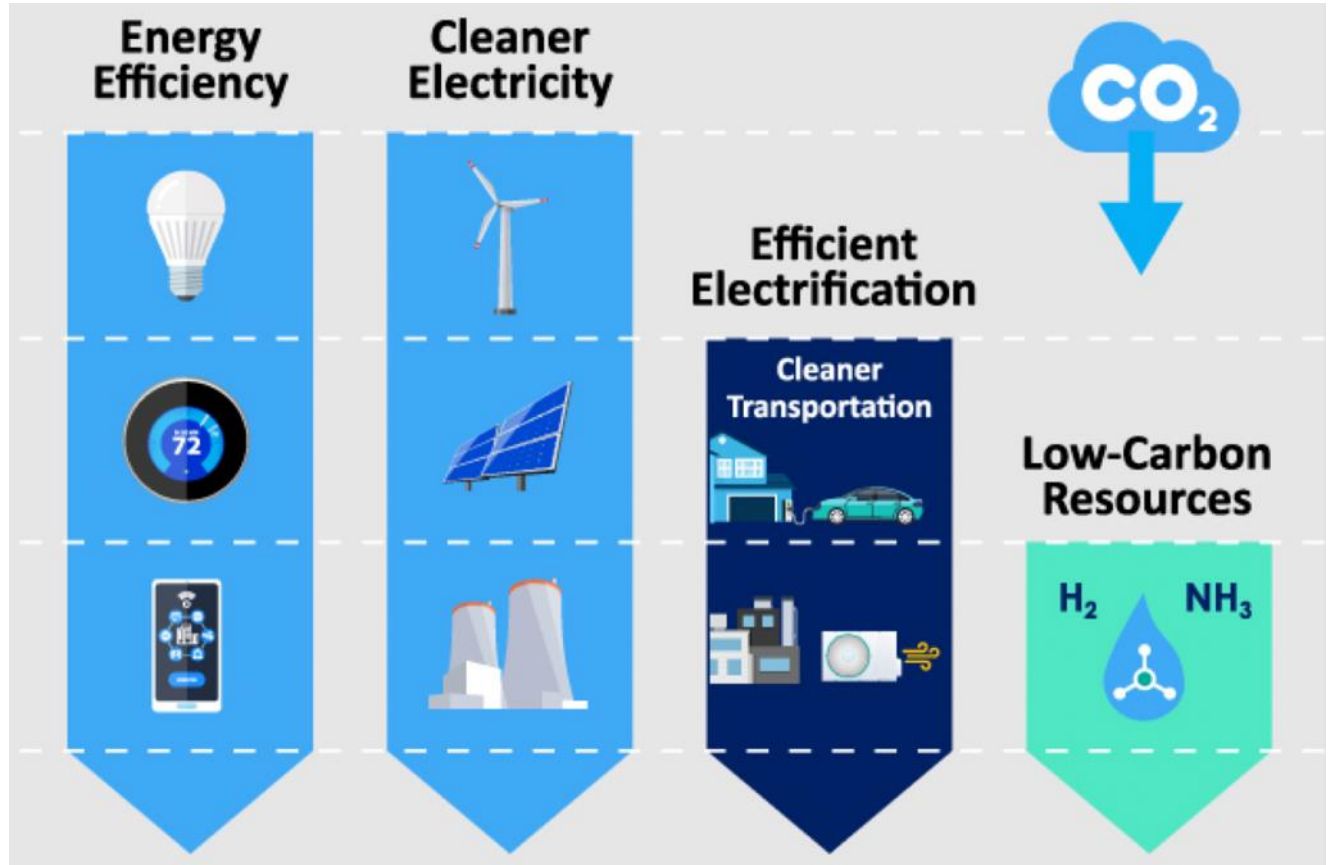
Chemical Production



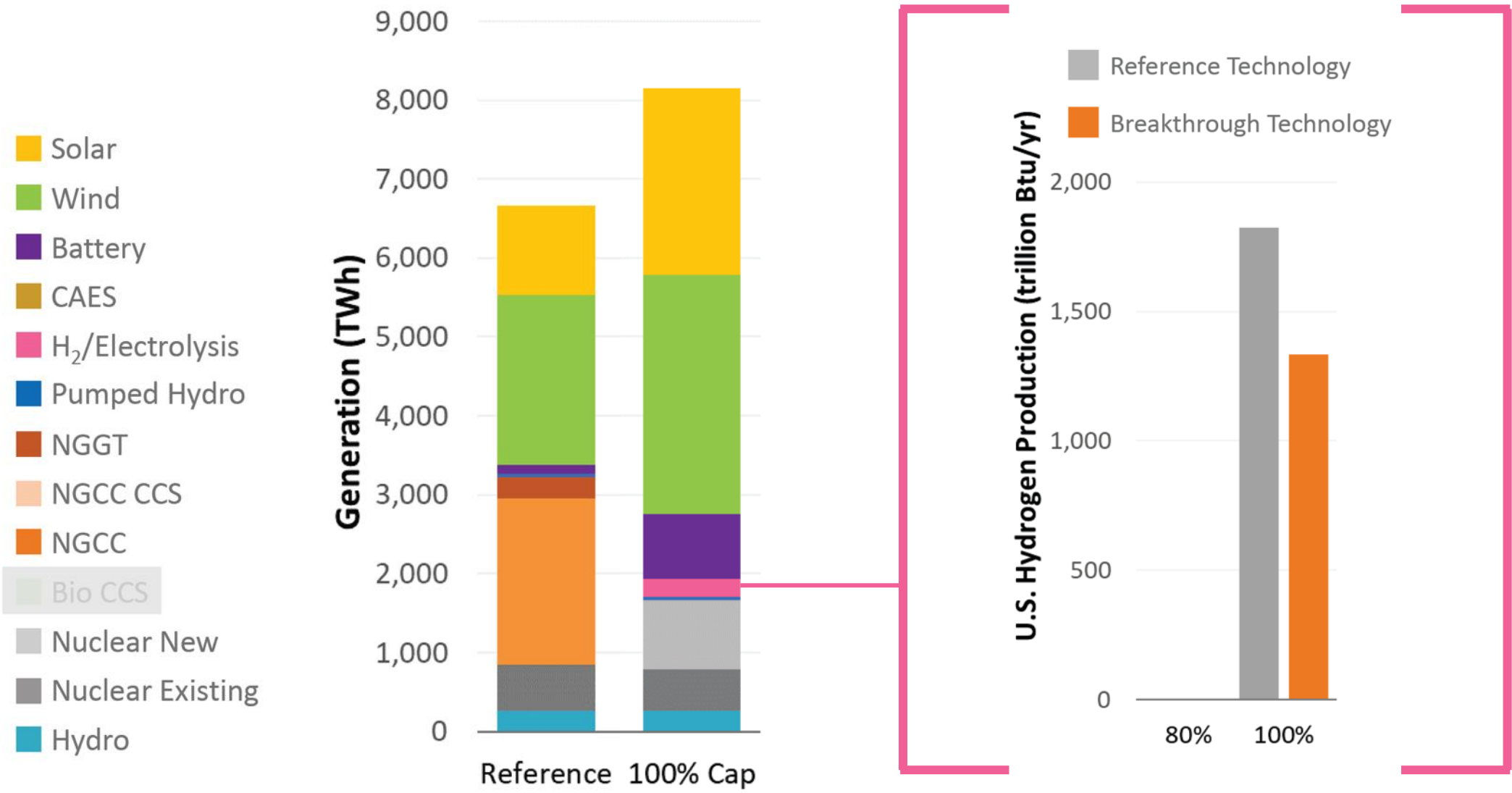
**ELECTRIFICATION**



The 4<sup>th</sup> piece of the carbon reduction timeline:  
**Low-Carbon Resources**



# Least-Cost Strategy to Achieve 100% CO<sub>2</sub> Cap without CDR

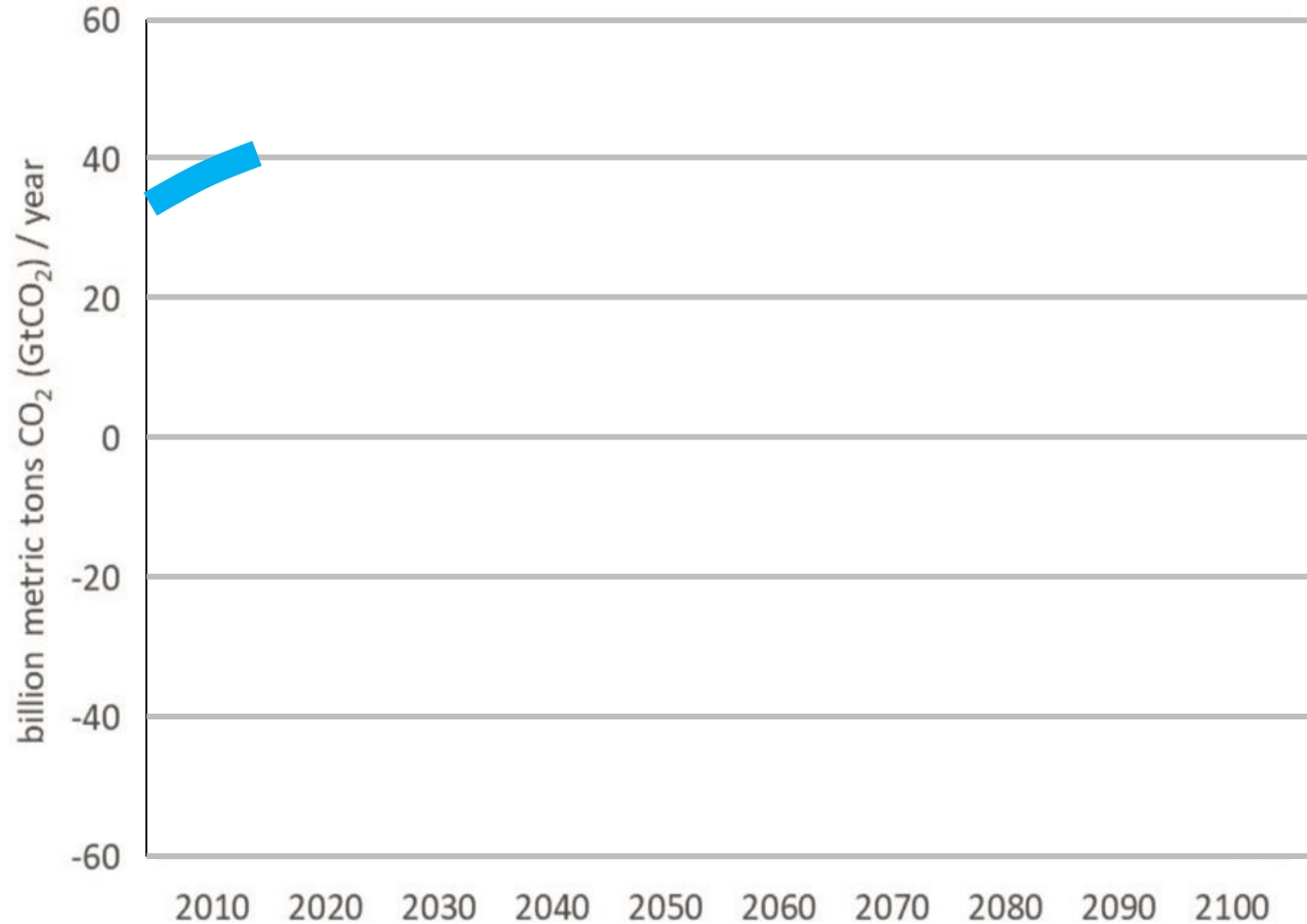


Results from EPRI Report 3002019612 (Technology-Neutral CO<sub>2</sub> Caps - Without Carbon Dioxide Removal Technologies [CDR])

# Pathways Consistent with Limiting Warming to 2°C

## Annual Global Net CO<sub>2</sub> Emissions

(408 results across models and assumptions)



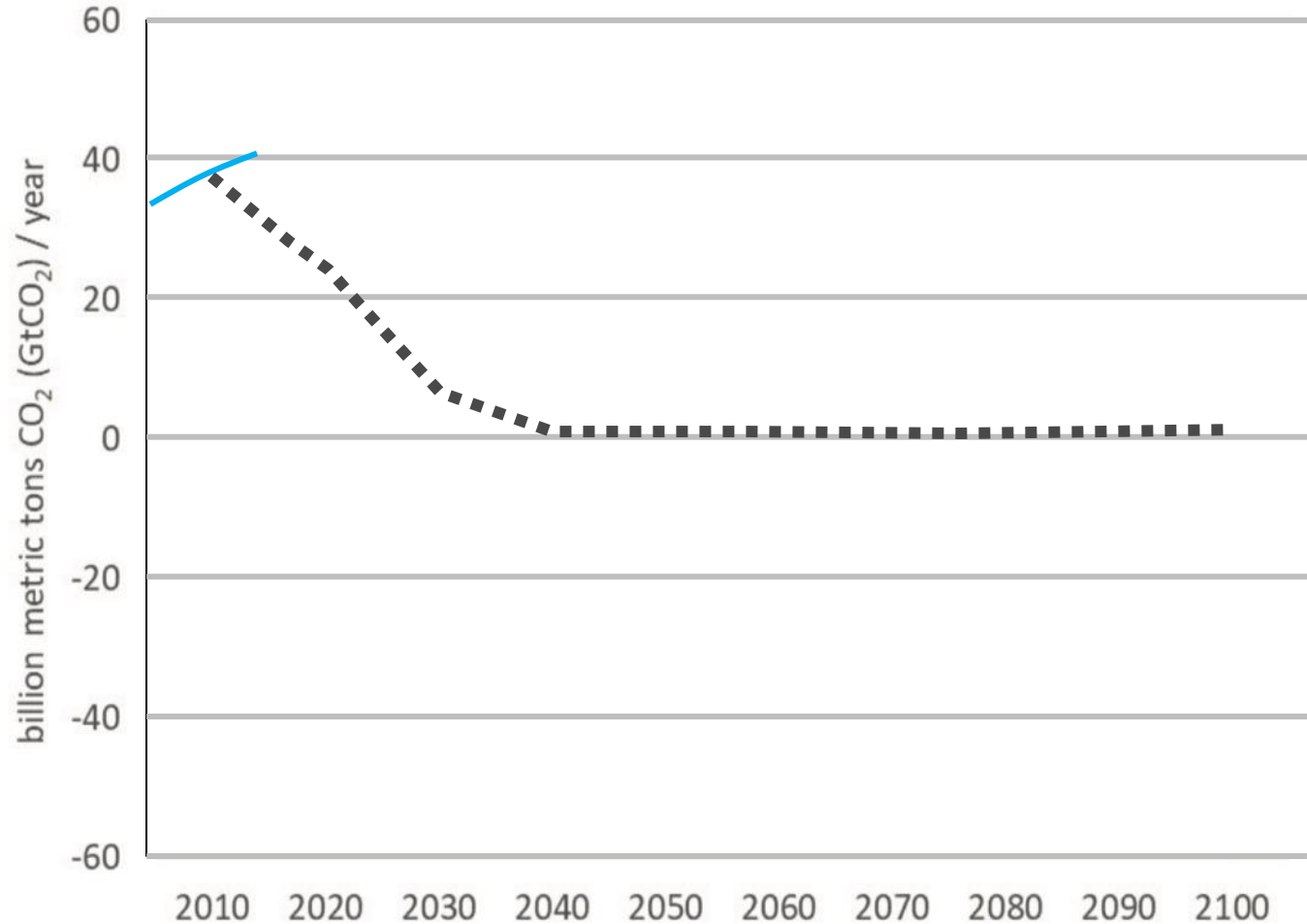
## Cumulative CO<sub>2</sub>



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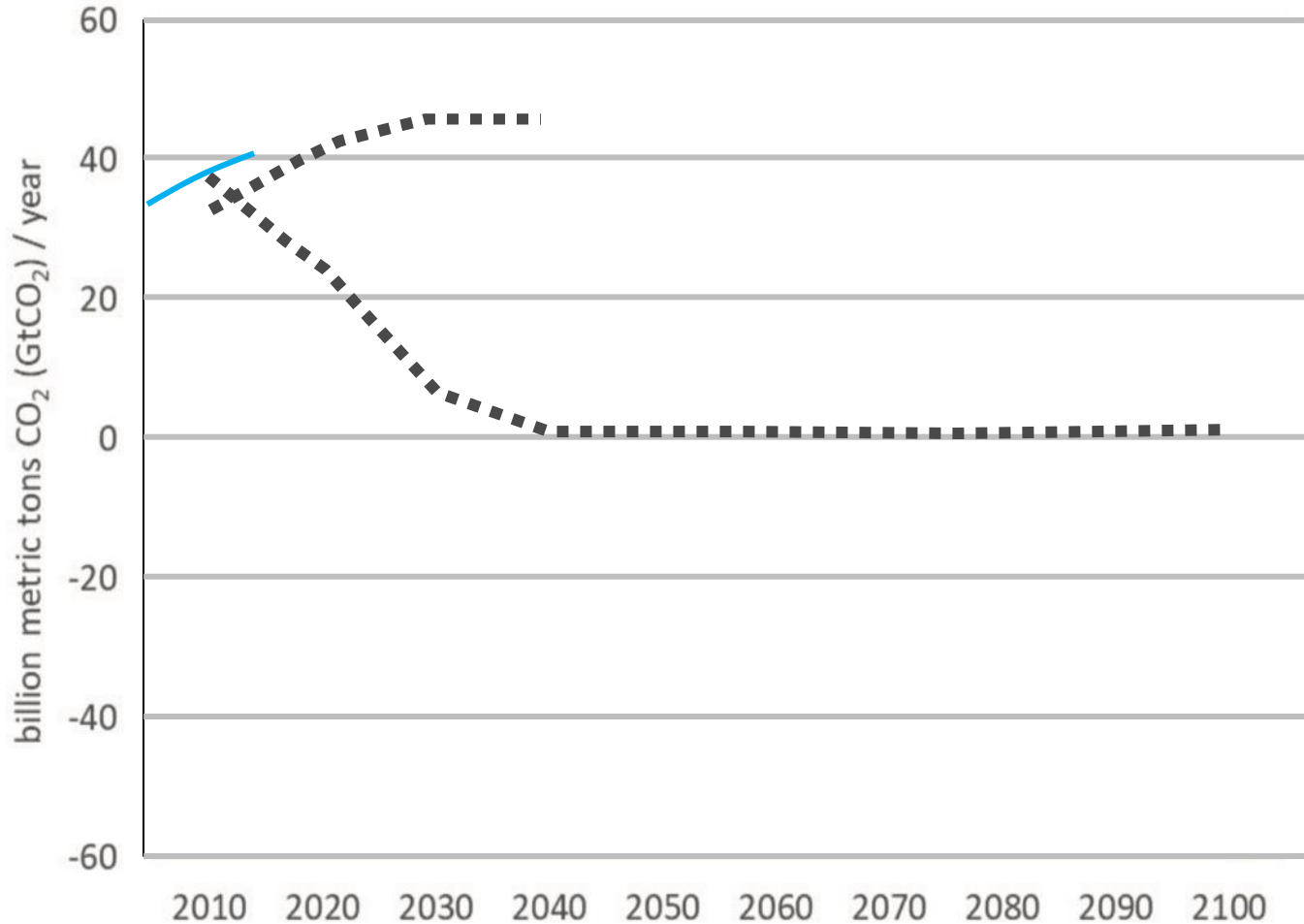


EPRi Report 3002016604

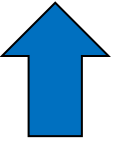
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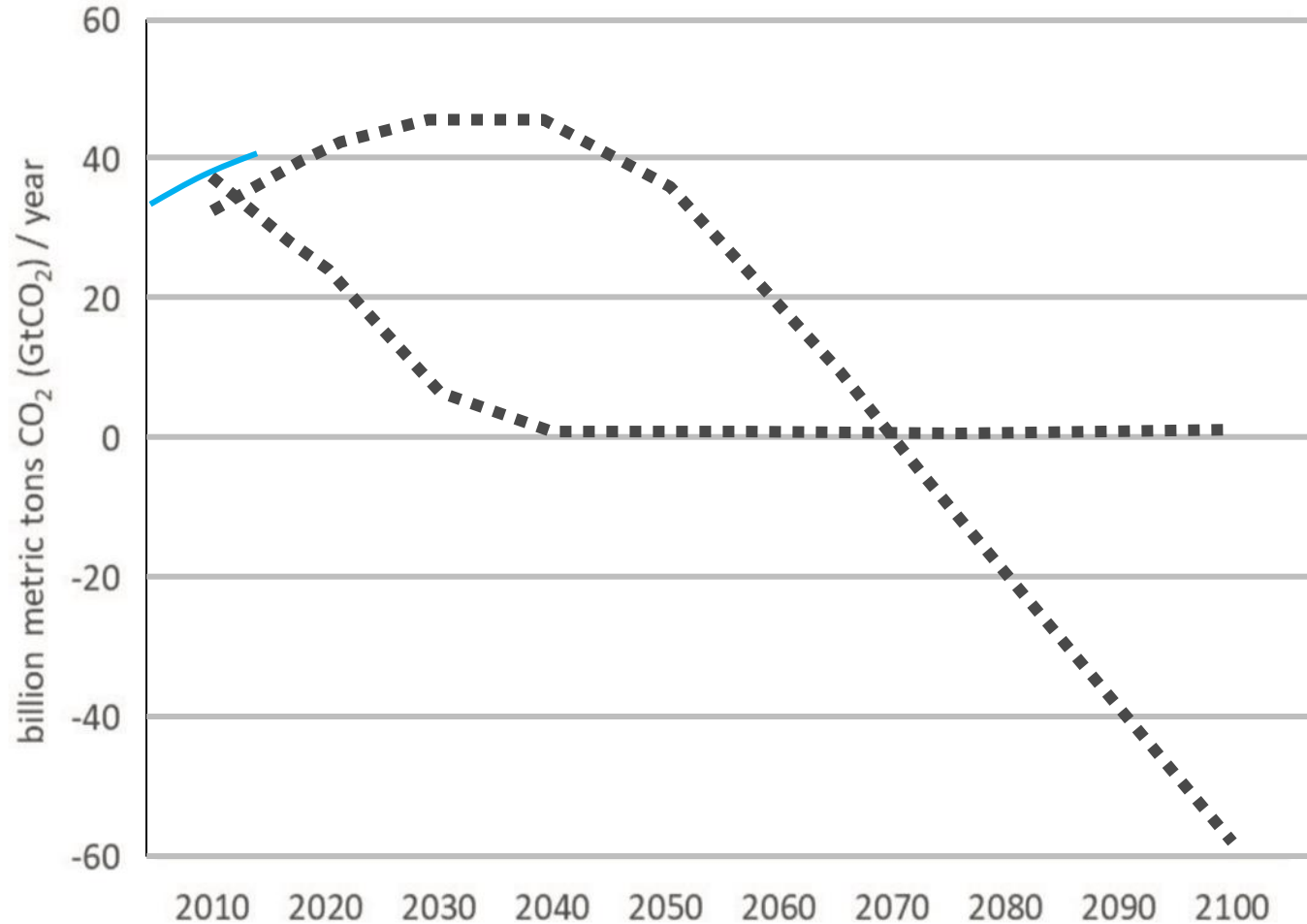


EPRi Report 3002016604

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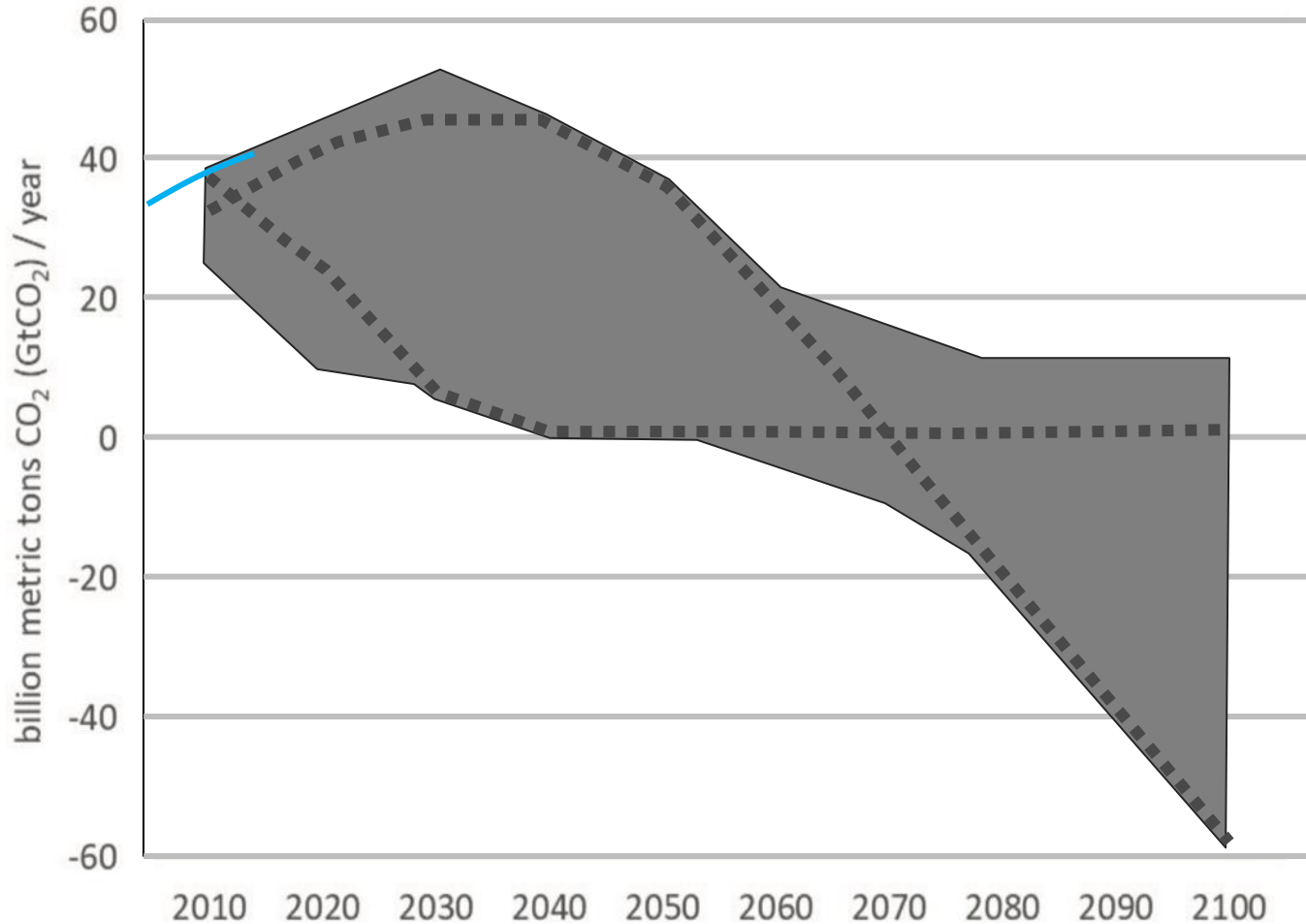


EPRI Report 3002016604

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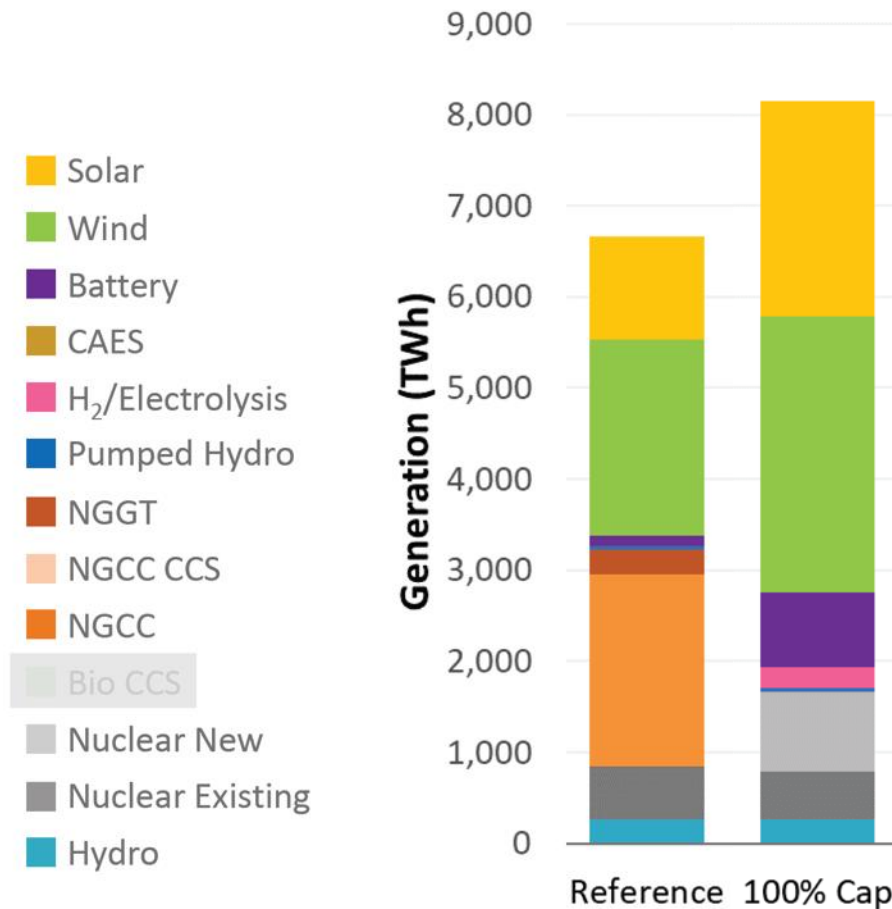
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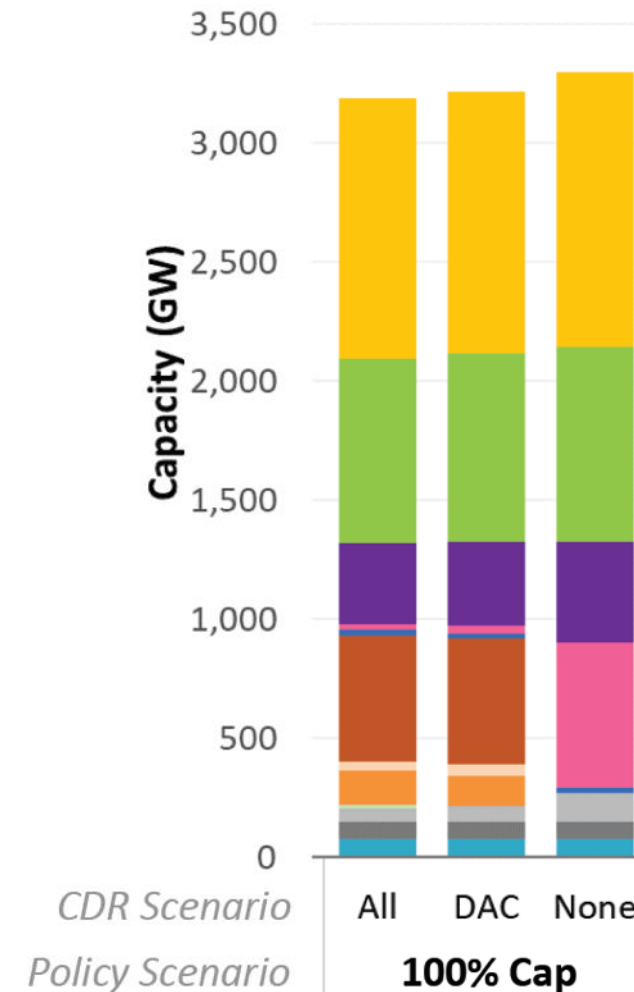
EPRi Report 3002016604

# Least-Cost Strategy to Achieve 100% CO<sub>2</sub> Cap with CDR

## Generation - No CDR



## Capacity - CDR Included



Results from EPRI Report 3002019612 (Impacts of Carbon Dioxide Removal Technologies[CDR])

\*DAC (Direct Air Capture)

# Two Major Decarbonization Trends are Emerging

Many companies in the electricity and natural gas sectors plan to significantly reduce CO<sub>2</sub> emissions by 2050

Energy consumers representing 40-60% of final energy demand\* are identifying pathways to adopt low-carbon resources



- Renewables and nuclear power generation, battery/grid storage, and energy efficiency to achieve significant reductions



- Pathways may include carbon capture, utilization, and storage (CCUS); hydrogen (and other alternate energy carriers); and negative carbon approaches



- Transitions are underway to incorporate bioenergy and renewable fuels, replace fossil fuels with alternate molecules, and deploy CCUS



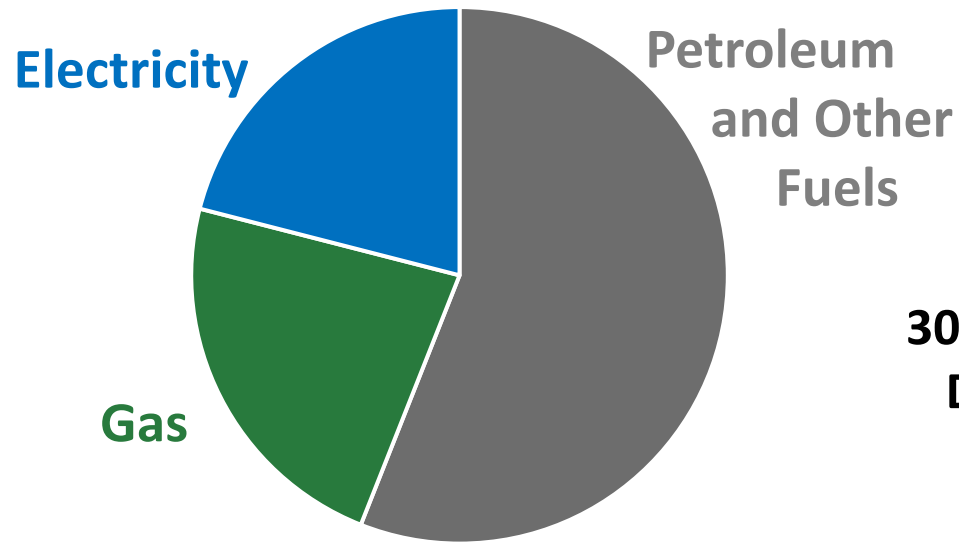
- Consumers require options -- integrated primary and final energy systems could support the transition to a future energy economy



*\*EPRI U.S. National Electrification Assessment*

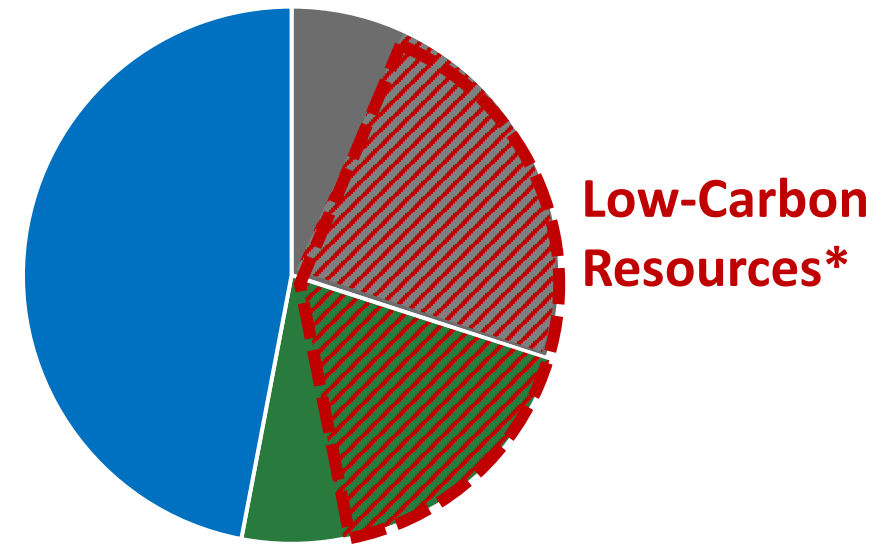
**Achieving economy-wide net zero emissions will require low-carbon energy resources**

# Low-Carbon Resources Enabling Decarbonization



Today

30-50%+ Growth Due to  
Direct Electrification  
*NEA\* Scenarios*

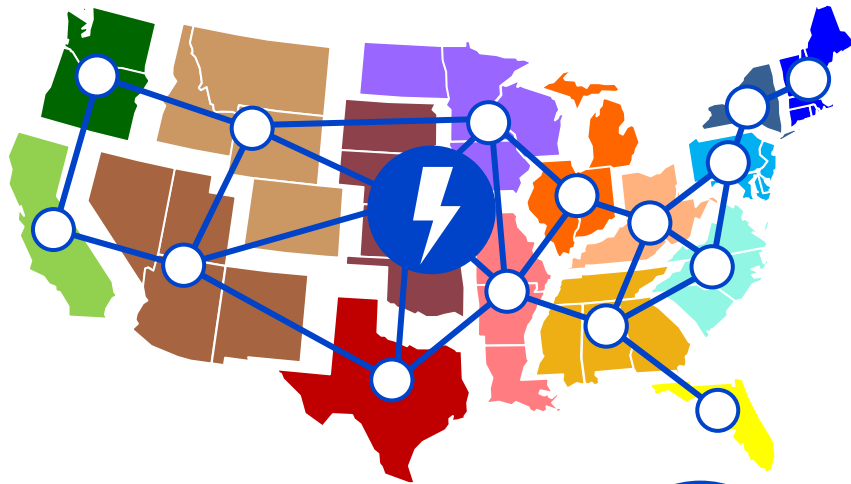


2050 Transformational Scenario

**In a decarbonized world, low-carbon resources could introduce significant potential complementary to direct electrification.**

# Modeling Potential Future Energy Systems

## Electric Generation



### Hydrogen



- Production and storage
- Conversion to end-use fuels
- Power-gas-power

### Bioenergy



- Feedstock supply and conversion
- Agriculture and forestry
- Renewable natural gas

Synchronized

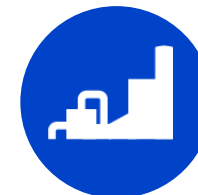
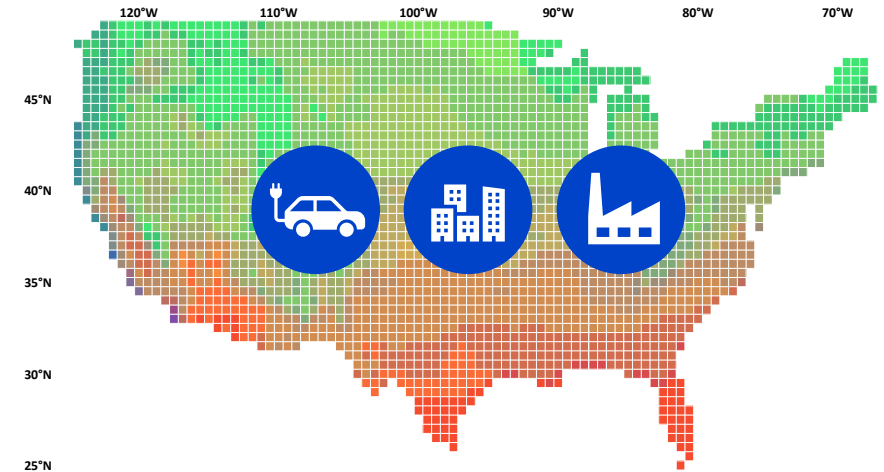


Hourly Load,  
Renewables,  
and Prices

New Model Features

Integrated Energy  
System Analysis

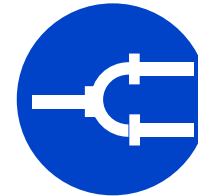
## Energy Use



### Other Low-Carbon Options

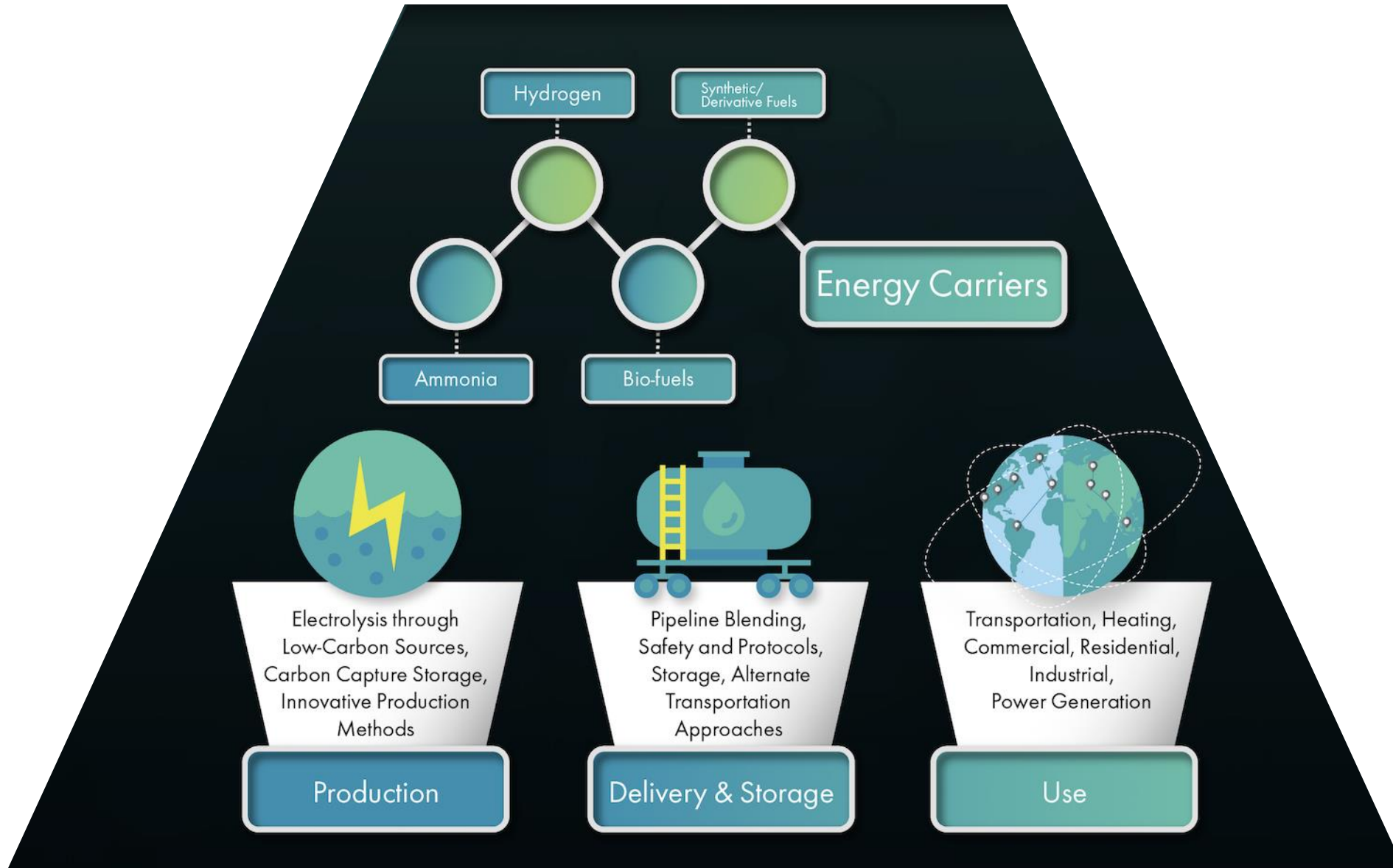
- Industrial CCS
- CO2 removal
- Advanced low-carbon energy

### Infrastructure



- Electricity T&D
- Natural gas pipelines
- Delivery of low-carbon fuels

# Low-Carbon Resources Value Chain





# LCRI

LOW-CARBON  
RESOURCES INITIATIVE

Enabling the Pathway  
to Economy-Wide Decarbonization