

Calpine's Proposed Carbon Capture & Storage Project

May 2, 2023



Agenda

- **Introductions and Q & A format**
- **Overview, benefits and uses of Carbon Capture & Storage (CCS) technology**
- **CCS technology & safety**
- **SMUD's 2030 Zero Carbon Plan & how CCS can fit**
- **Pre-submitted Q & A**

Introductions

Moderator

Lucy Crocker

President of Lucy & Company

Presenters

George Peridas

*Lawrence Livermore
National Laboratory*

Barbara McBride

*Calpine, Ion Clean
Energy, 1PointFive*

Bryan Swann

SMUD

Overview, benefits and uses of Carbon Capture & Storage (CCS) technology

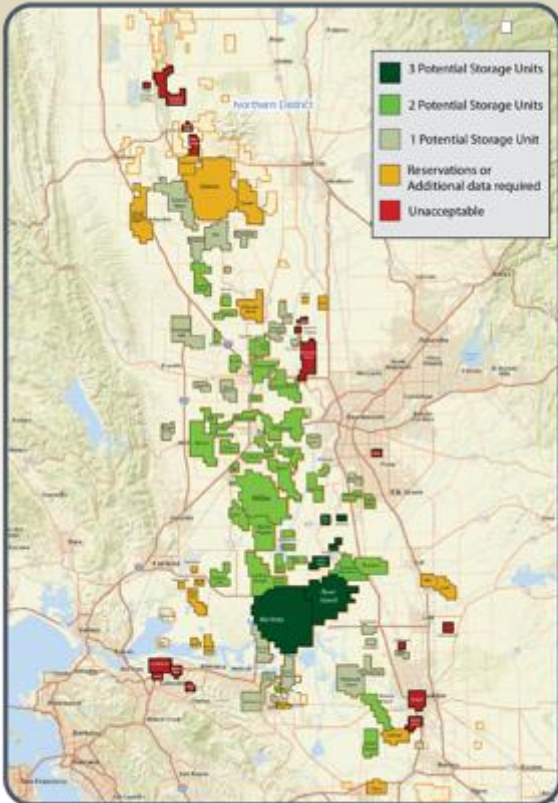
George Peridas

Lawrence Livermore National Laboratory

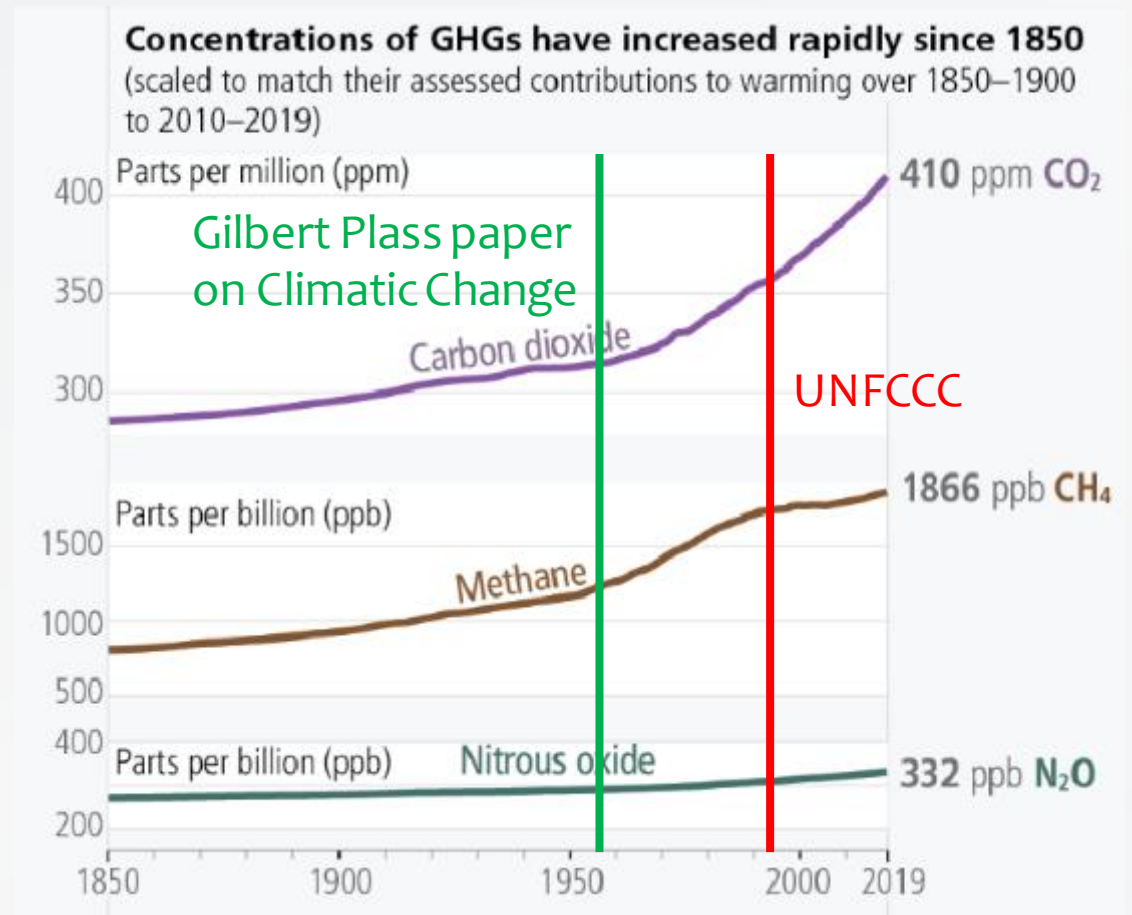
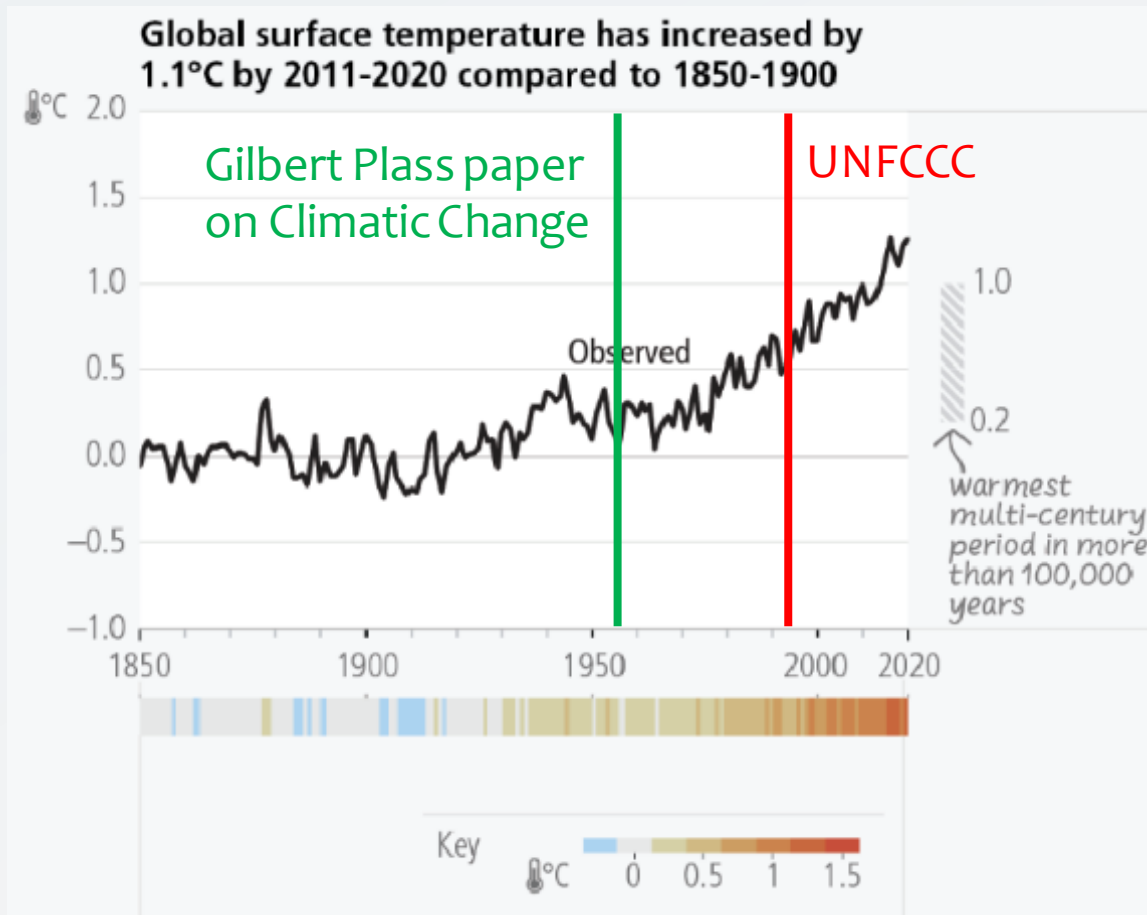
Carbon Capture, Removal & Storage

George Peridas

May 2nd, 2023



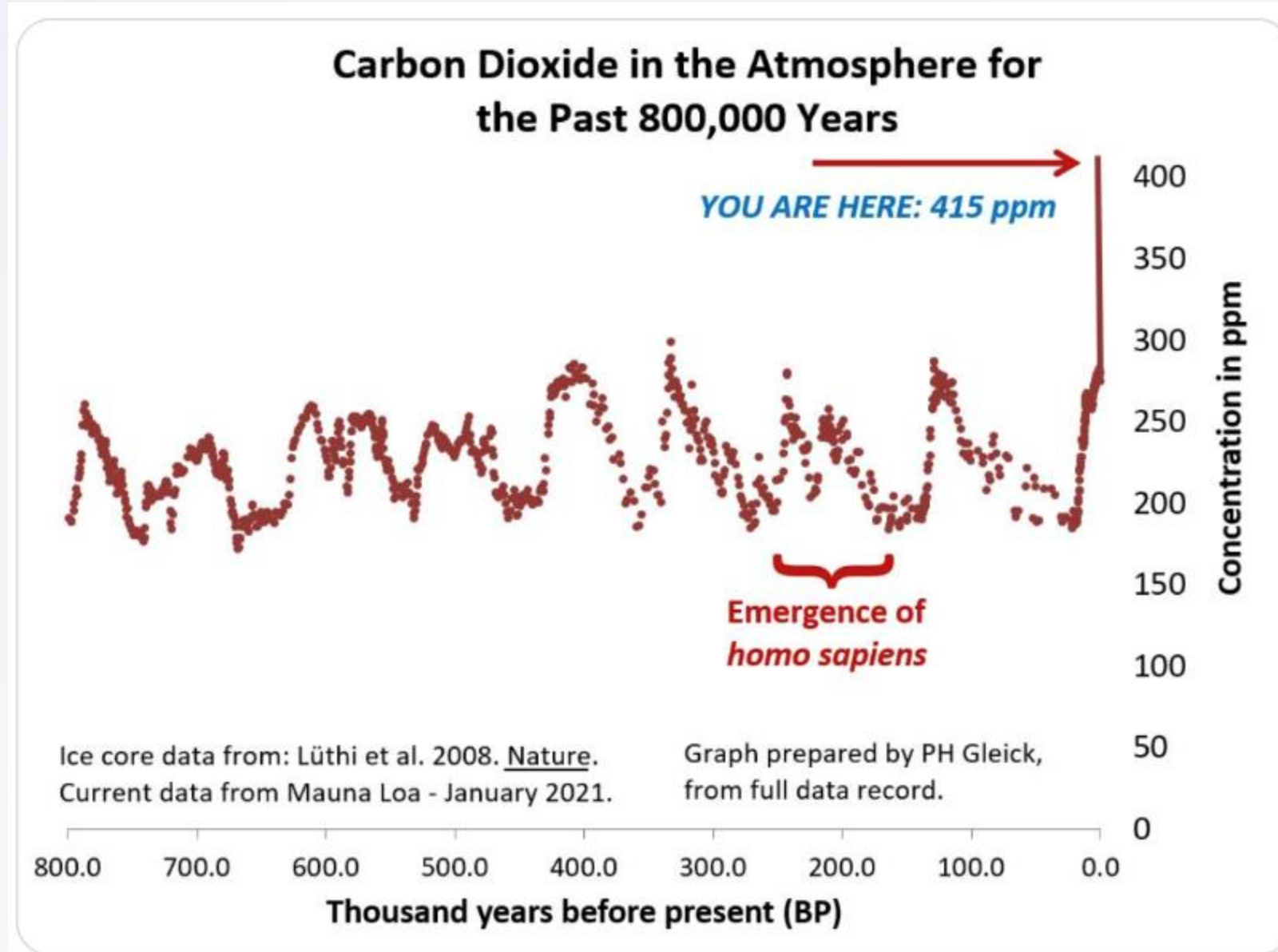
Temperature & GHGs since 1850



Source: IPCC AR6 SYR, <https://www.ipcc.ch/report/sixth-assessment-report-cycle/>
Also see: <https://onlinelibrary.wiley.com/doi/abs/10.1111/j.2153-3490.1956.tb01206.x>

CO₂ in the atmosphere...

- Needs to stop increasing
- Needs to be brought back down
- Needs to return where it came from: deep underground

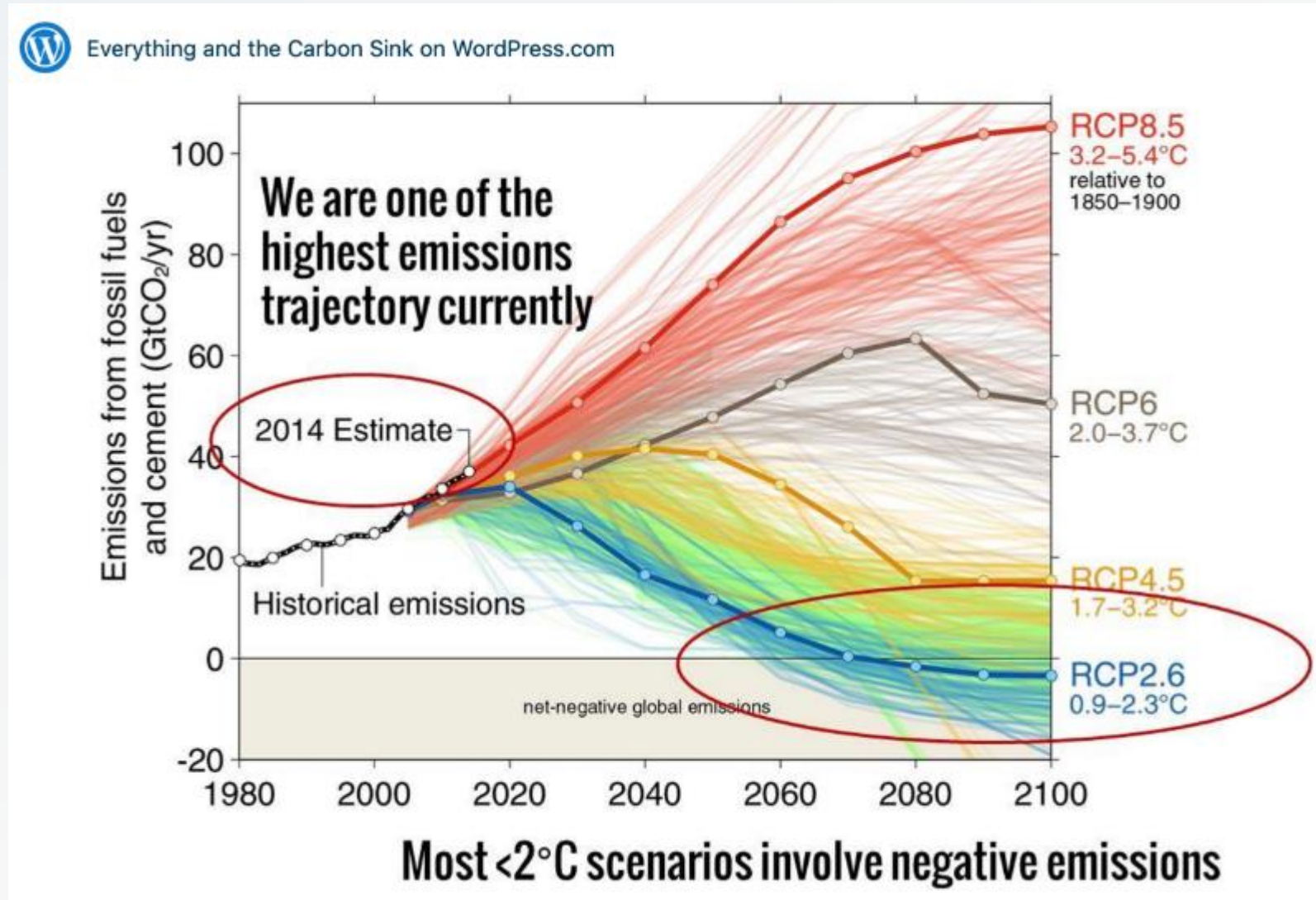


Source: Peter Gleick

<https://twitter.com/petergleick/status/1400849402164482051>

Overshoot then correct?

- Most scenarios for $<1.5^{\circ}\text{C}$ rely on CDR
- The speed at which we reduce emissions matters – not just the end state



Carbon capture

- Power plants
- Biofuel facilities
- Refineries
- Steel, cement and chemicals plants
- The air
- Chemicals/materials grab the CO₂
- Cost: \$25 - 200/tCO₂
- Typically the most expensive and engineering-intensive step

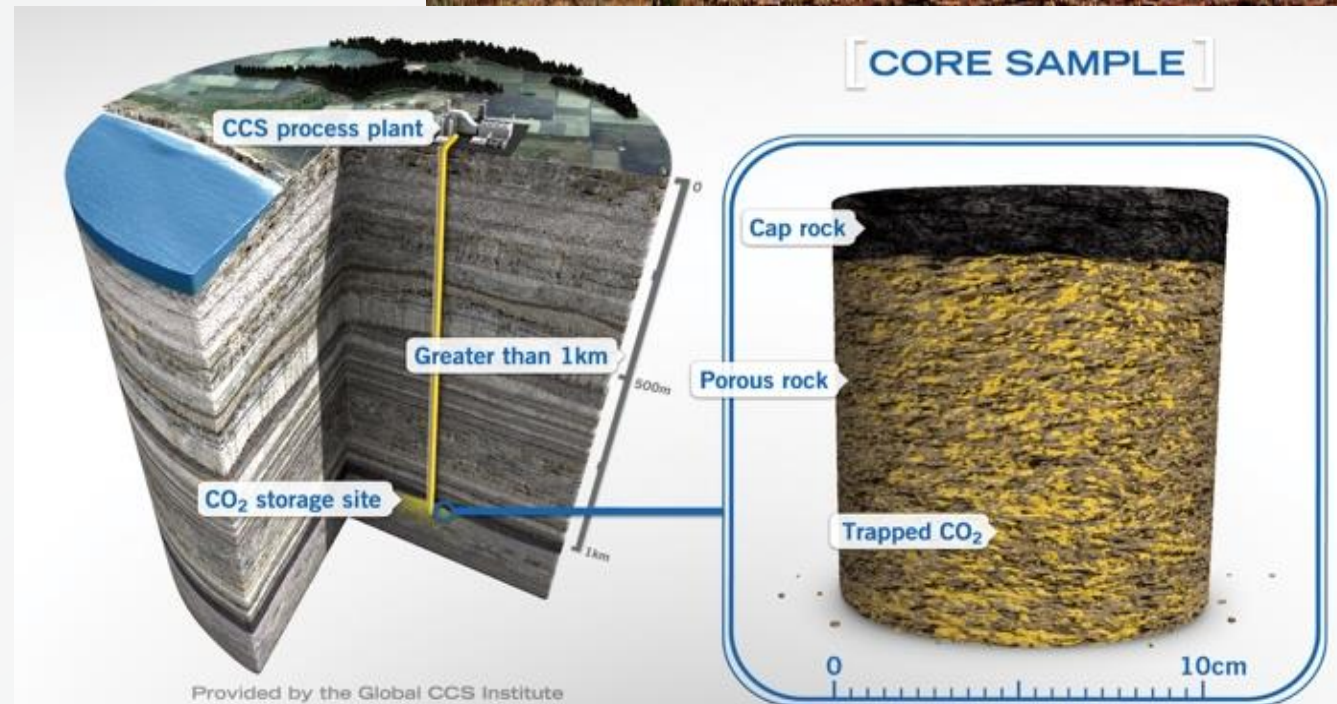
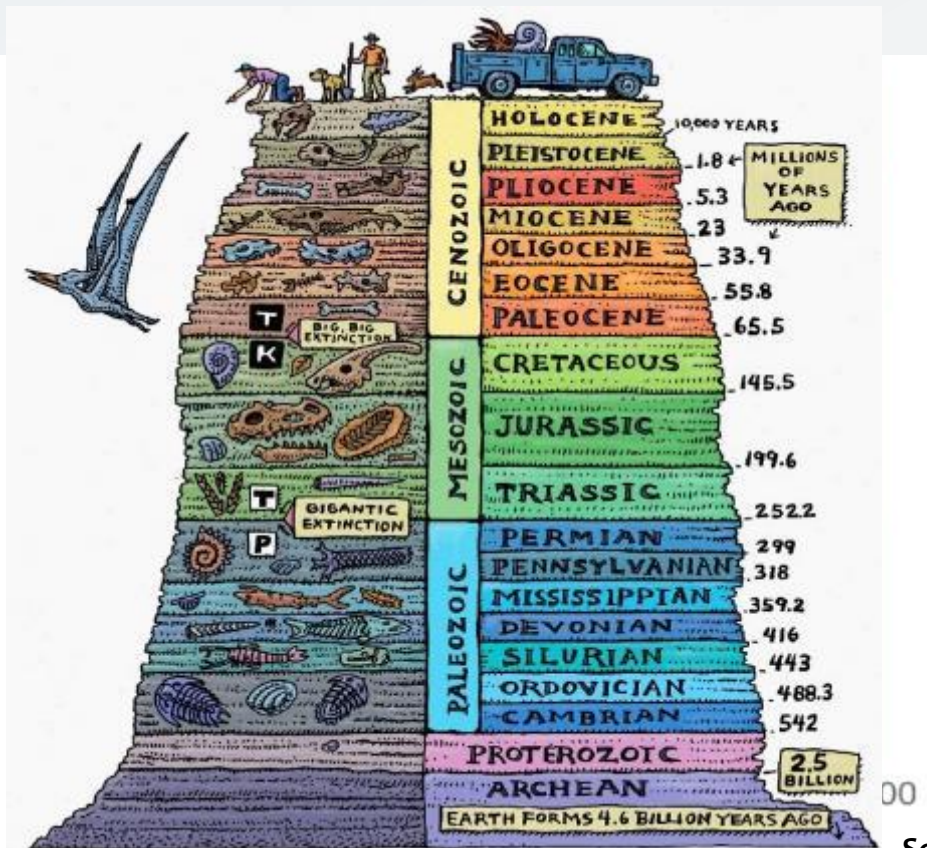


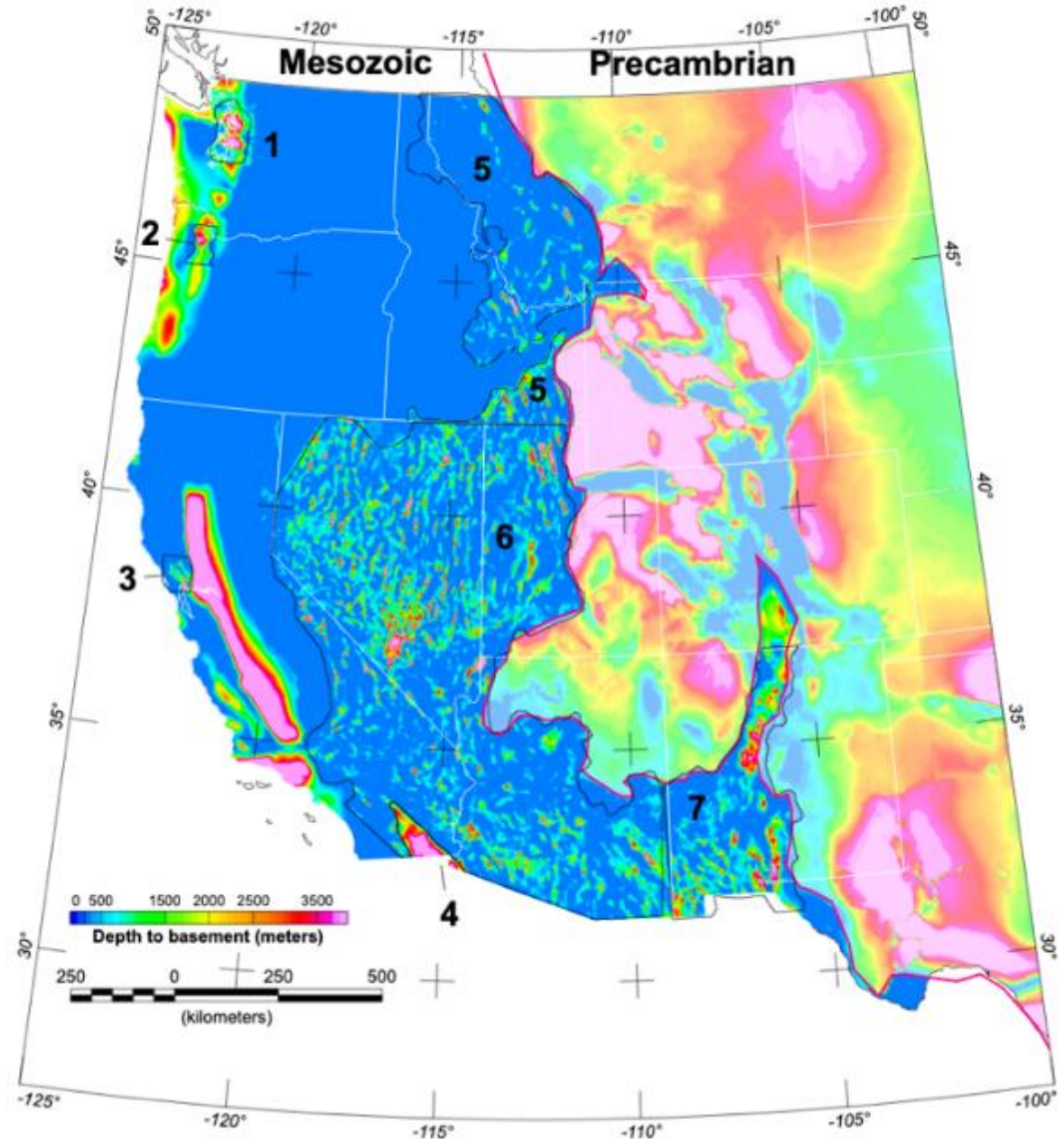
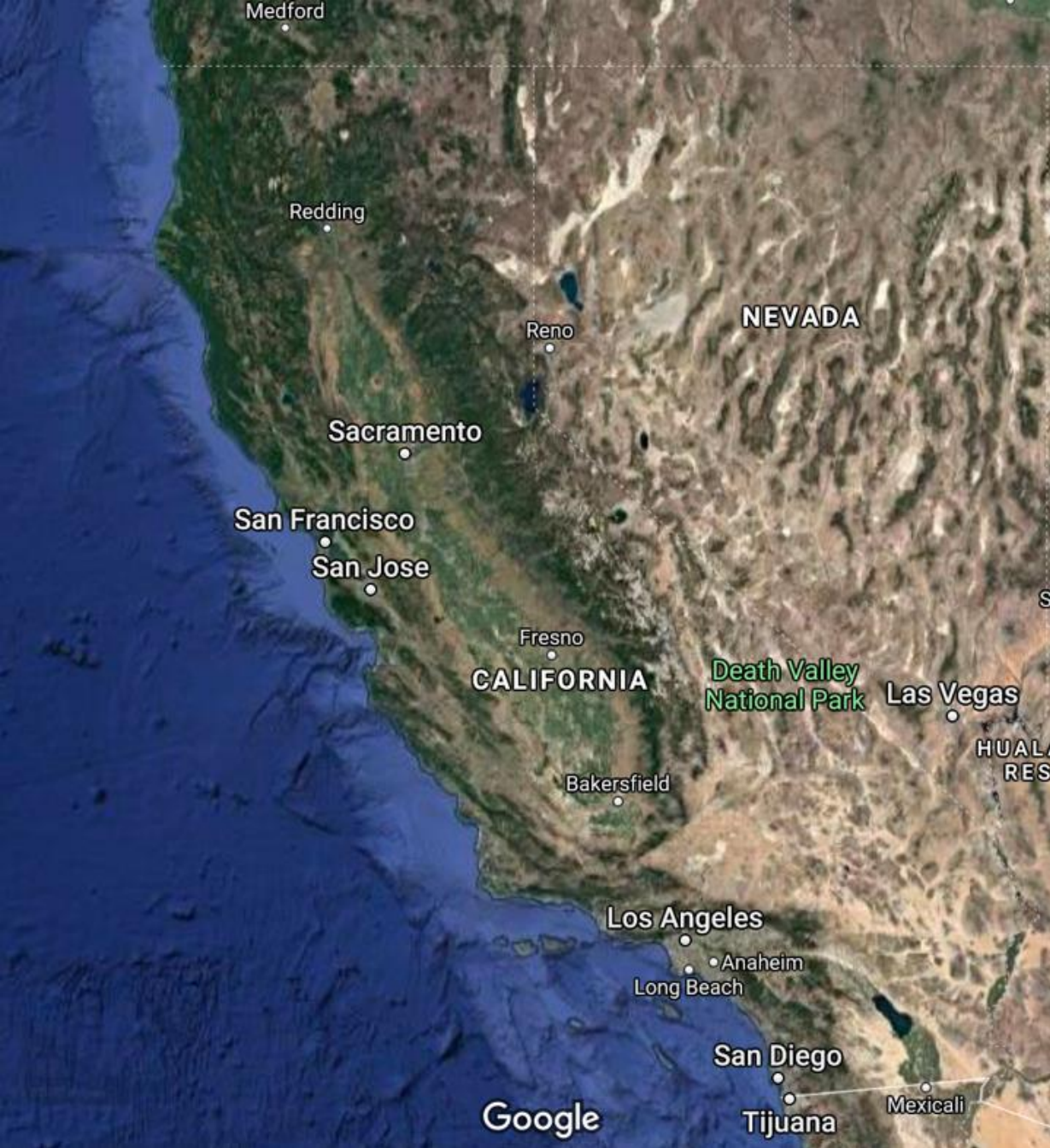
Climeworks DAC pilot, Zuerich, Switzerland



Geologic storage

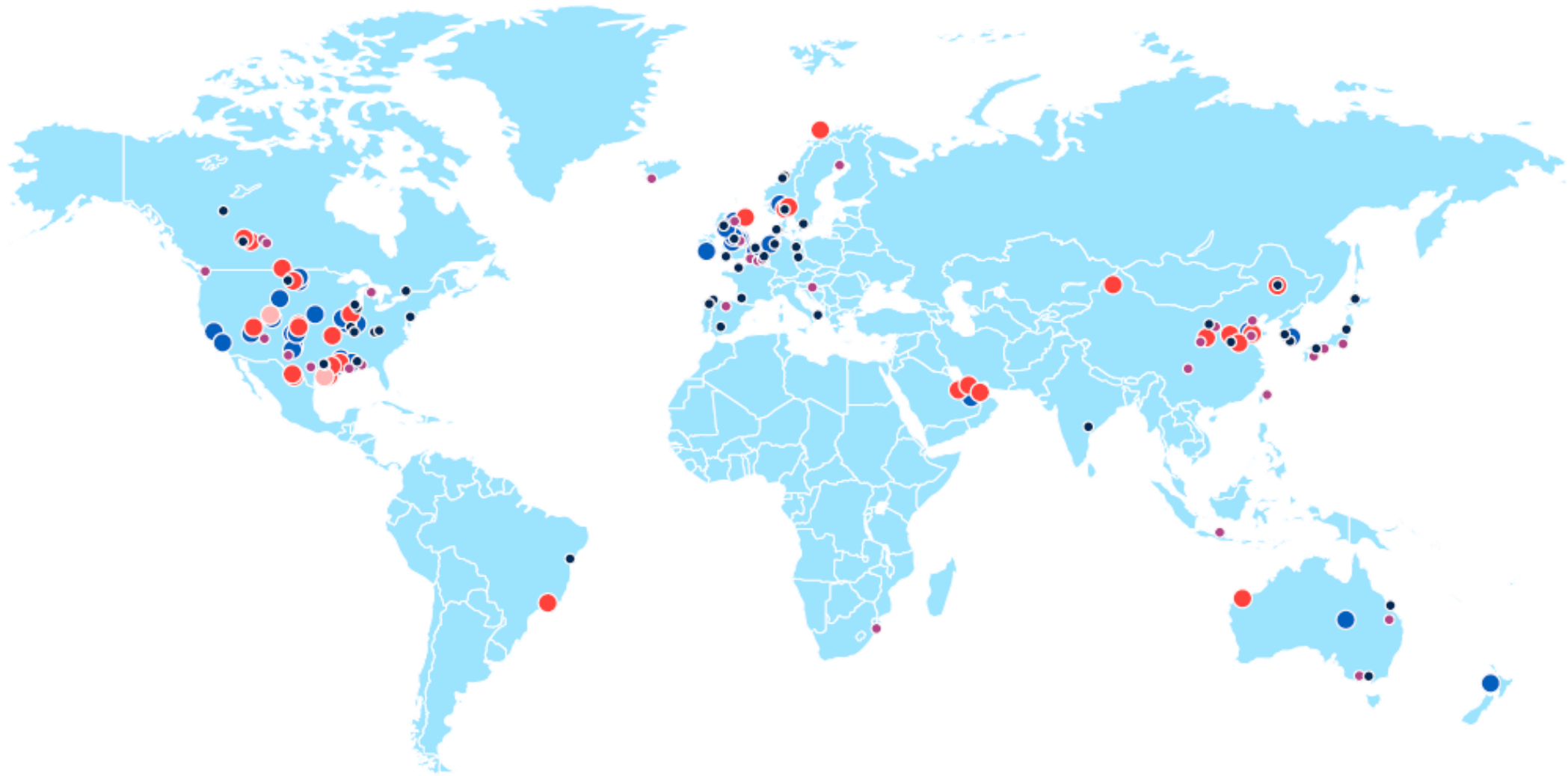
- CO₂ stored in solid but porous rock (e.g. sandstone)
- Far from groundwater, 1000s of feet deep (e.g. 1 mile)
- Multiple mechanisms trap the CO₂
- Mimics natural processes





USGS, 2018

CCS Projects Globally



- COMMERCIAL CCS FACILITIES IN OPERATION & CONSTRUCTION
- COMMERCIAL CCS FACILITIES IN DEVELOPMENT
- OPERATION SUSPENDED
- PILOT & DEMONSTRATION FACILITIES IN OPERATION & DEVELOPMENT
- PILOT & DEMONSTRATION FACILITIES COMPLETED

Source: Global CCS Institute

CDR Co-benefits

- Cleaner air
- Reduced wildfire risk
- Local revenues and benefits
- Local jobs
- Innovation and export opportunities

CCS technology & safety

Barbara McBride

Calpine, Ion Clean Energy, 1PointFive



America's Premier Competitive Power Company
... Creating Power for a Sustainable Future

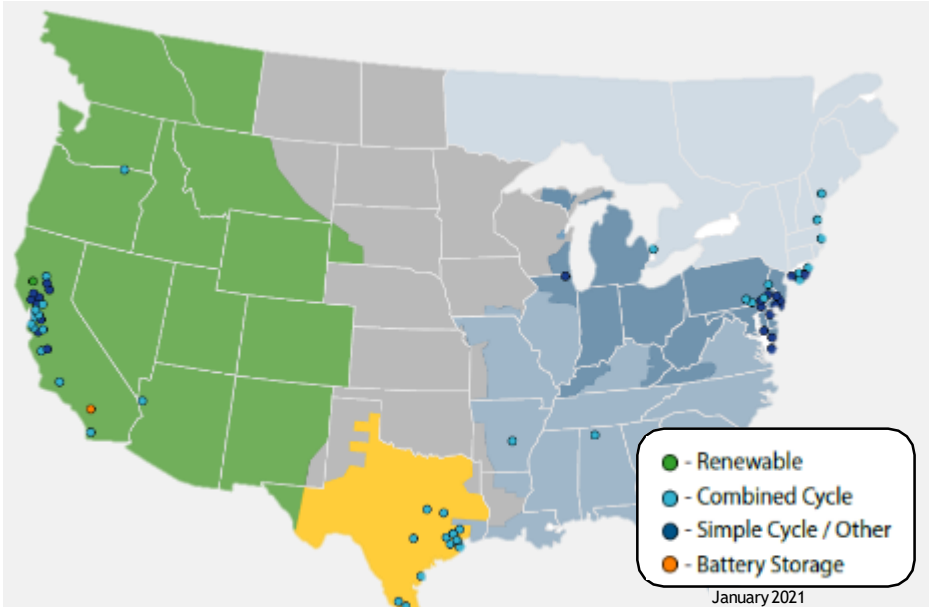


SMUD-Calpine Sutter CCS Retrofit Project Workshop

May 2, 2023

Calpine at a Glance

Calpine was founded in San Jose, California nearly 40 years ago on principles of sustainability



Serve customers in **23 states**, Canada and Mexico

Largest **geothermal** power producer in the world

Largest **Natural Gas Combined Cycle** and Cogen fleet in the United States

More than **2,300** employees



POWER GENERATION

Natural gas, geothermal, battery storage & alternative technologies; best-in-class maintenance program

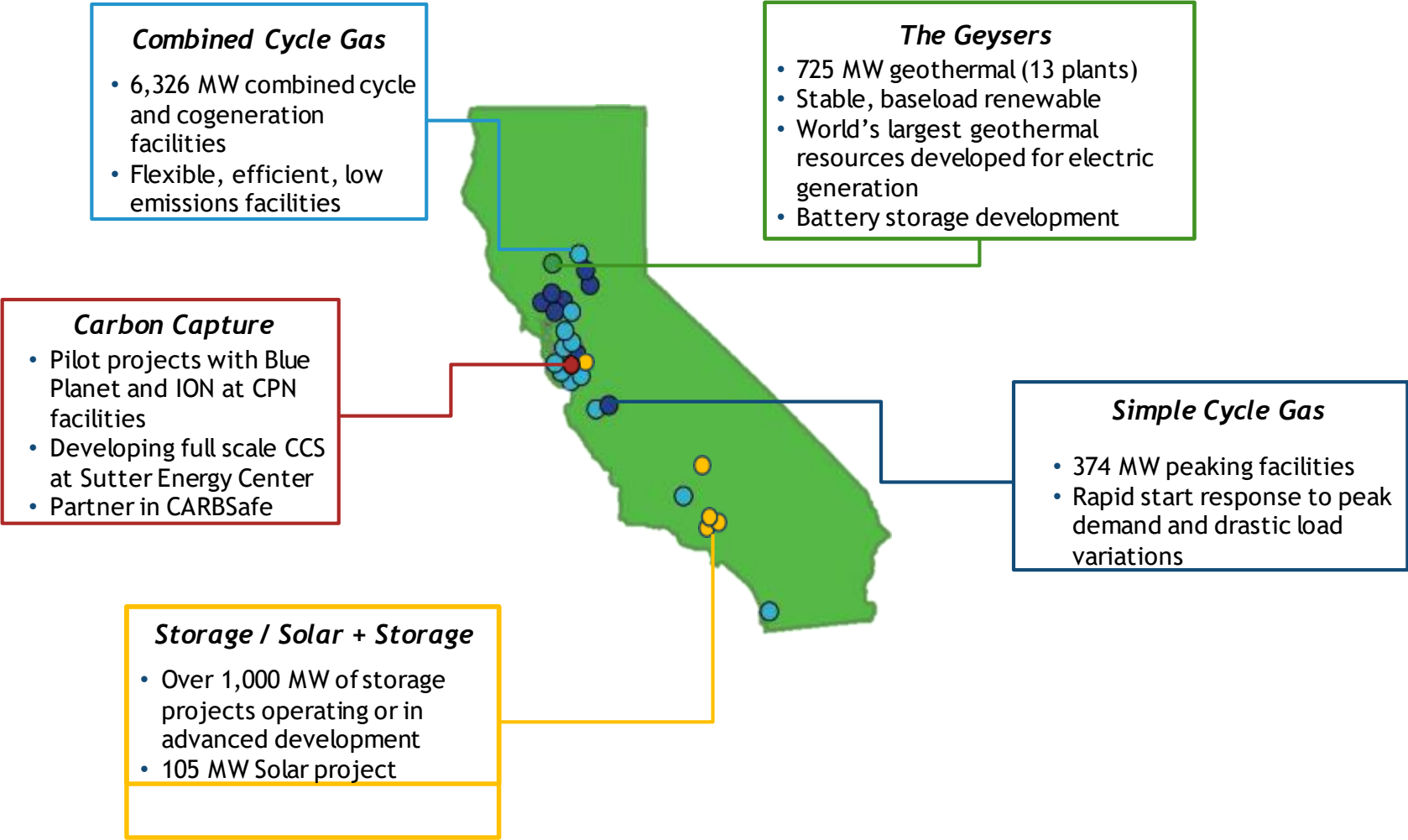


INFRASTRUCTURE DEVELOPMENT

Since 2000, constructed more MW in CA than any other entity. Significant battery storage and carbon capture projects in pipeline

Calpine in California

Calpine owns and operates 7,425 MW in the West



Excluded from image: CCGTs in Oregon and Arizona

Sutter Energy Center At-A-Glance

*Highly efficient ~550 MW natural gas
combined cycle power plant*

Located near Yuba City in Sutter County

Commercially operational July 2001



**Long-standing cooperation with the
local community**

First air-cooled, zero-liquid discharge
plant in California

Financial support to levee district



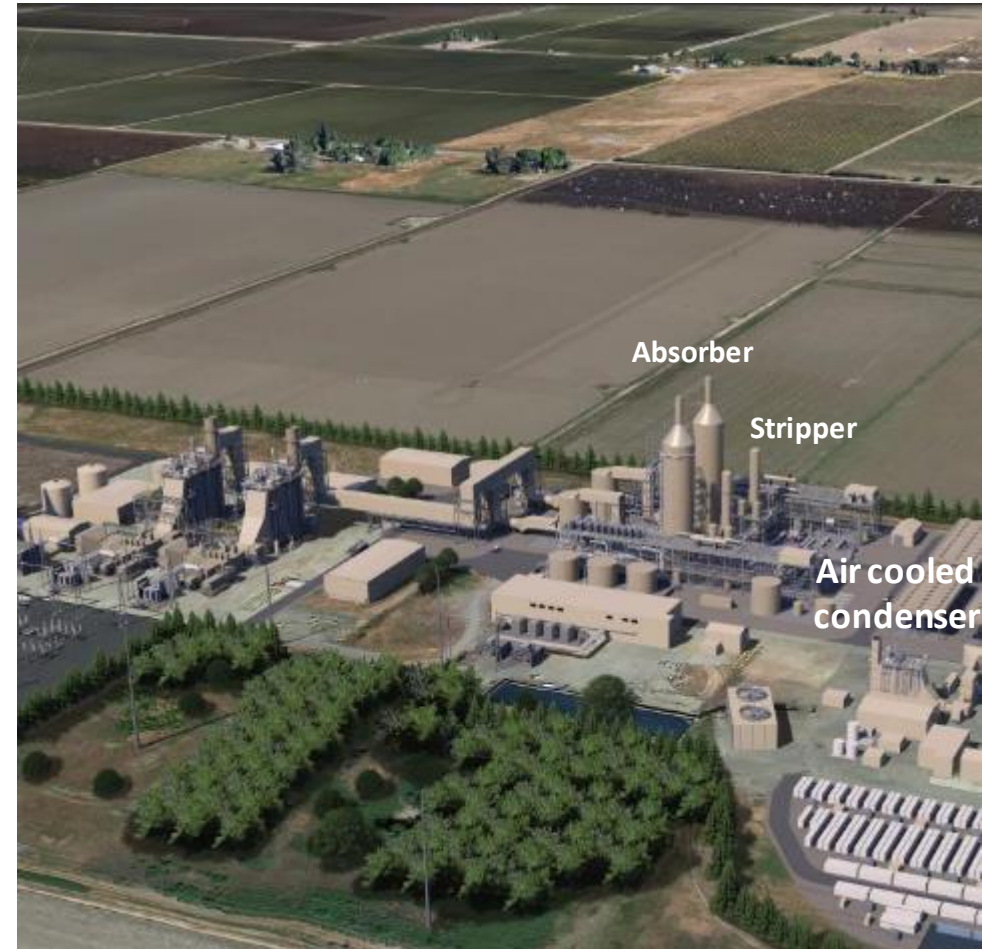
Critical for system and local reliability

State agency analyses show NGCCs critical to
meet electric reliability through 2045

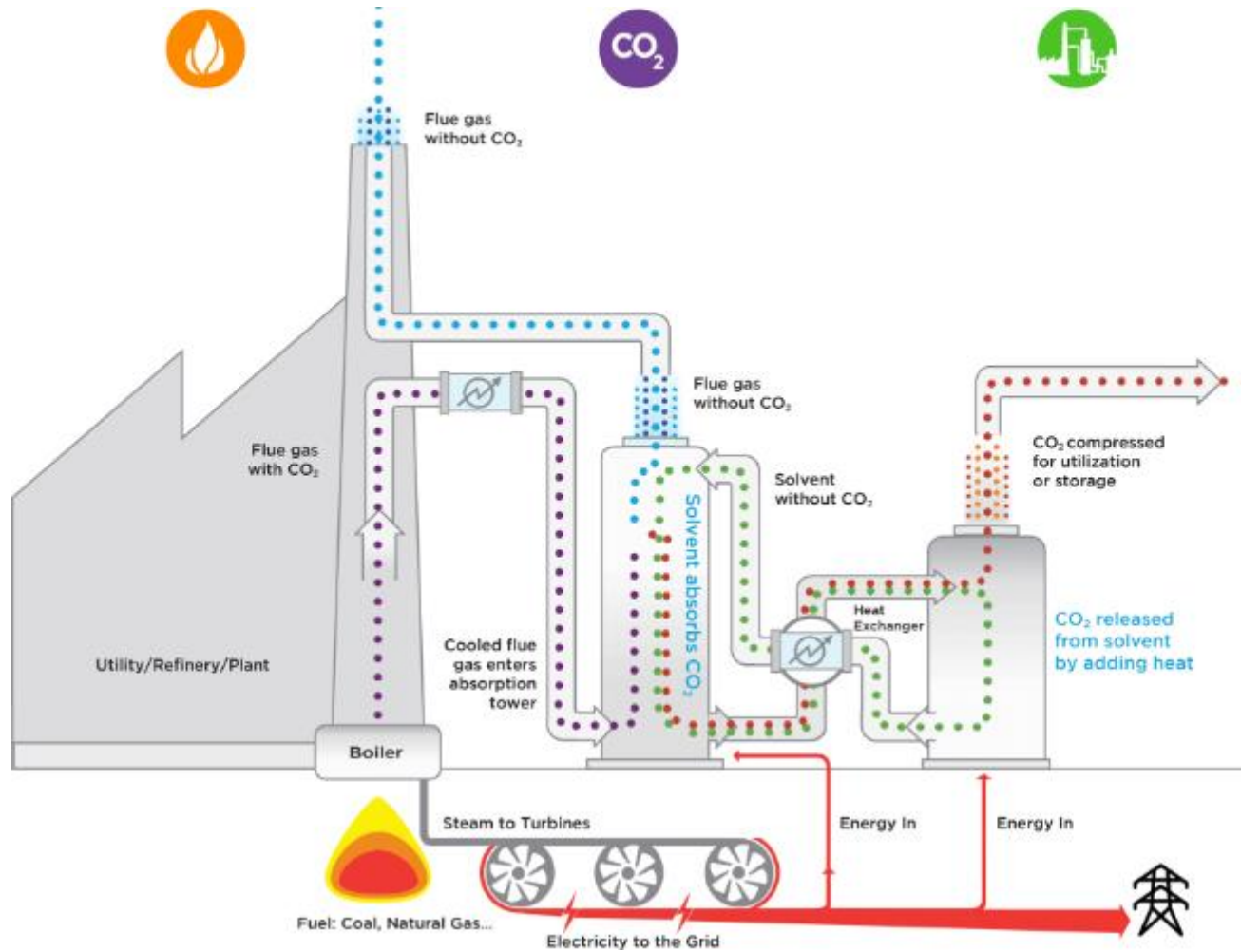
Supplies power to SMUD and CAISO (70%
capacity factor in 2022)

Sutter CCGT Carbon Capture and Sequestration Retrofit

- Post-combustion carbon capture retrofit for full 2X1 combined cycle power plant for 2027 commercial operation
- Captures ~1.75 mm tonnes per year at baseload operation
- >95% CO₂ capture efficiency
- **First-in-the-world** air-cooled capture facility
- Includes upgrades to existing facility to increase efficiency
- Provides opportunity for significant investment and fiscal support for region



ION Clean Energy Carbon Capture Technology



ION Clean Energy optimizes a technology that has been deployed for more than 100 years:

- Decreased power consumption
- Extended solvent life
- Lower emissions

Current DOE-funded pilot:

- Operational experience (including internships)
- Support permitting emission estimates
- Optimize design parameters

Sequestration: CO₂ Transport and Storage

*Sutter region has excellent geology for sequestration;
opportunity to use existing pipeline routes*

Transportation

- Contemplated CO₂ pipeline route follows existing rights-of-way
- Currently conducting Front End Engineering and Study
- Pipeline will be installed with state of the art Fiber Optic Cable Leak Detection System
- Remote automated shutoff valves will provide safety in the event of a leak
- Coordination with local emergency responders to ensure safe operation

Storage

- 1PointFive brings expertise as storage partner
- Optimal storage location and capacity verified by 3 independent engineering evaluations including LLNL
- DOE CarbSAFE II grant will validate characterization and safety
- US EPA well application under preparation

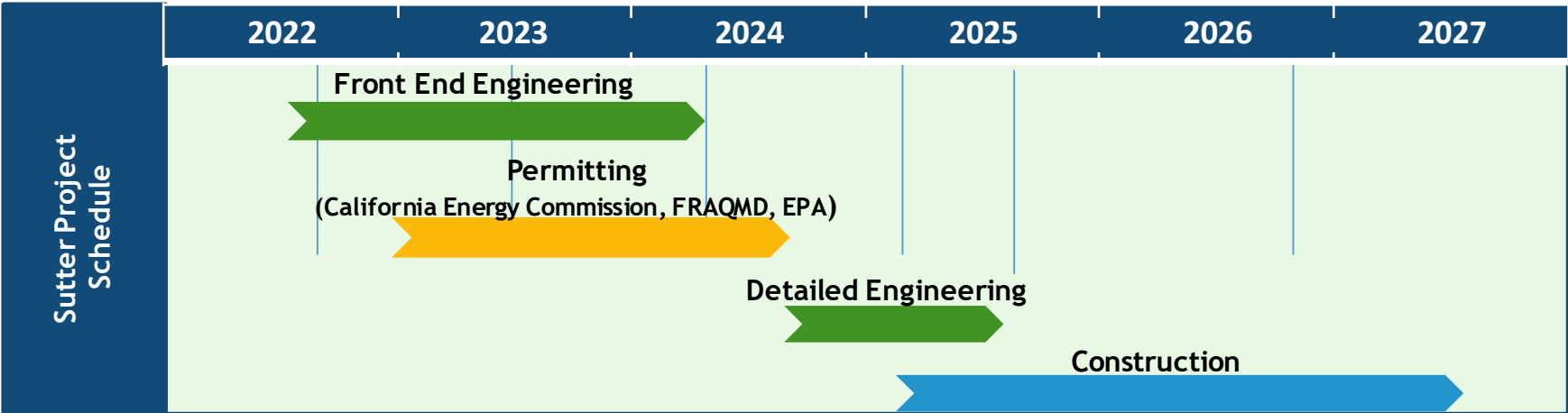


Development Plan for Sutter CCS Retrofit

- Calpine-funded Front End Engineering and Design study underway
- California Energy Commission (CEC) Amendment to be submitted in May for capture, transport & storage
- California Environmental Quality Act provides a robust, comprehensive, and inclusive environmental review process
- Environmental Justice and stakeholder engagement are an established and important part of the permitting process
- Early stakeholder engagement has identified and responded to the following:
 - Water use
 - Noise
 - Criteria Pollutants
- Calpine has an extensive and long-standing relationship with the California State Building Trades. Calpine plans to build this project under a Project Labor Agreement



Sutter Energy Center - Timeline



SMUD's 2030 Zero Carbon Plan & how CCS can fit

Bryan Swann
SMUD

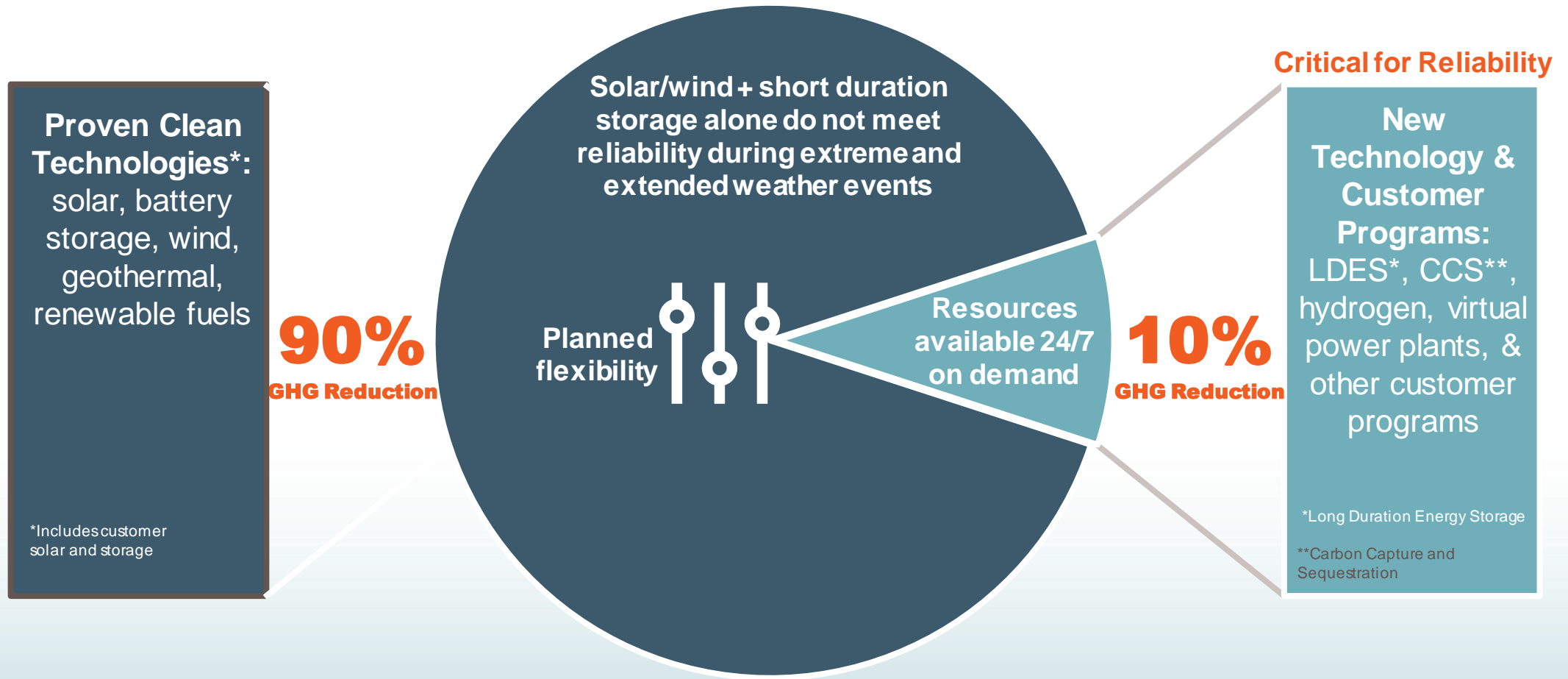
2030 Zero Carbon Plan overview

Affordable . Reliable . Equitable



2030 Zero Carbon Plan – the 10% gap

It takes a portfolio approach to achieve zero carbon.



Project portfolio benefits



Reduces GHG emissions in Sacramento sooner benefitting the communities surrounding our plants.



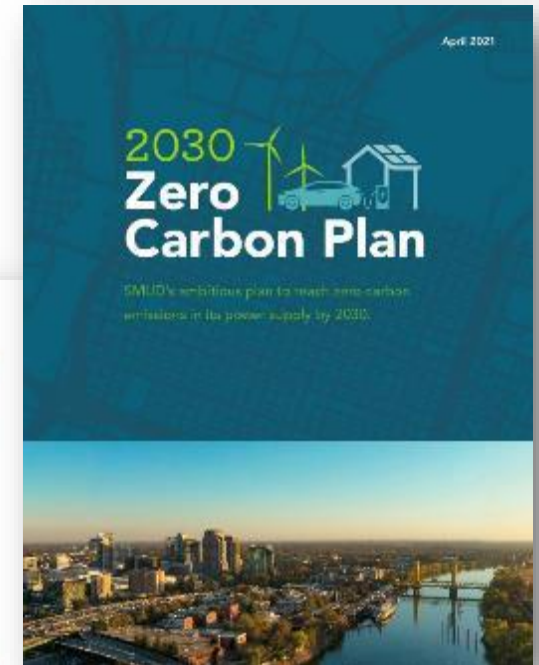
Provides a transitional clean resource to hydrogen and other clean fuels and technologies not yet mature.



Supports SMUD's local reliability needs with clean, reliable, efficient, 24x7 generation.



DOE funding opportunity significantly reduces the cost of this resource to SMUD.



Moderated Q&A from pre-submitted questions

Moderator

Lucy Crocker

President of Lucy & Company

Panelists

Barbara McBride

Senior Director,
Strategic Origination
and Development
Calpine

Erik Meuleman, Ph.D

Chief Technology
Officer
ION Clean Energy

Victor Parra Galvis

Lead Project
Coordinator
1PointFive

Bryan Swann

Director Resource
Strategy
SMUD



Affordability

100%



Zero
carbon
by 2030

Reliability