Calpine
Flexible and High Capture CCS : An Operator's Perspective

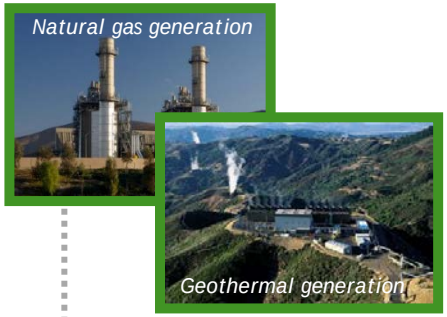
June 5th, 2024

Calpine at a Glance

National generation portfolio of approximately 26,000 MW with complementary services platform

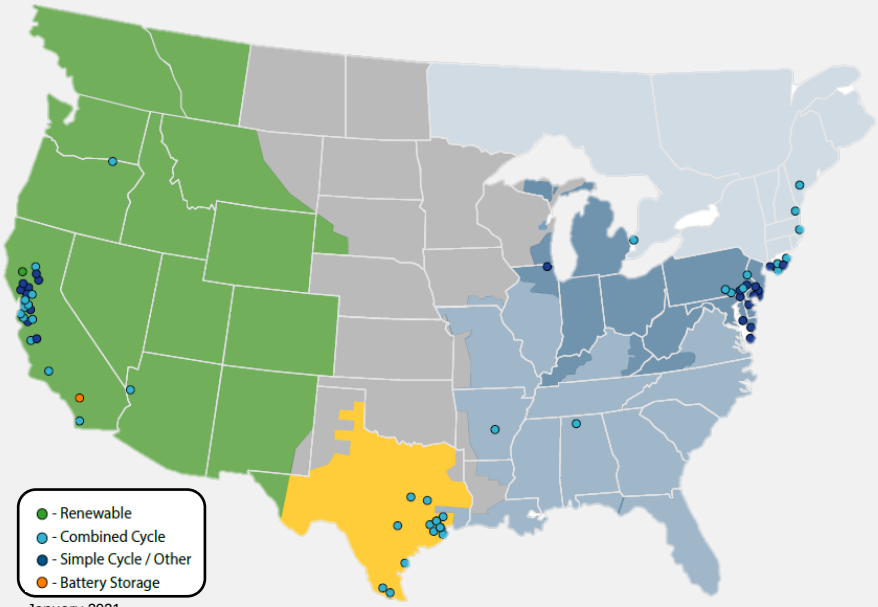
POWER GENERATION

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



INFRASTRUCTURE DEVELOPMENT

Energy storage pipeline; since 2000, constructed more MW in CA than any other entity



January 2021

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

Largest **geothermal** power producer in the world

More than **2,300** employees

CHAMPION ENERGY SERVICES®

CALPINE ENERGY SOLUTIONS

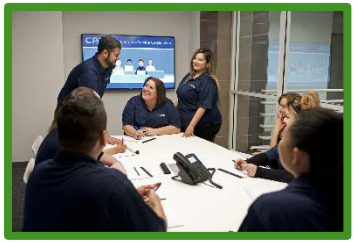
North American Power®

RISK MANAGEMENT & ENERGY SERVICES

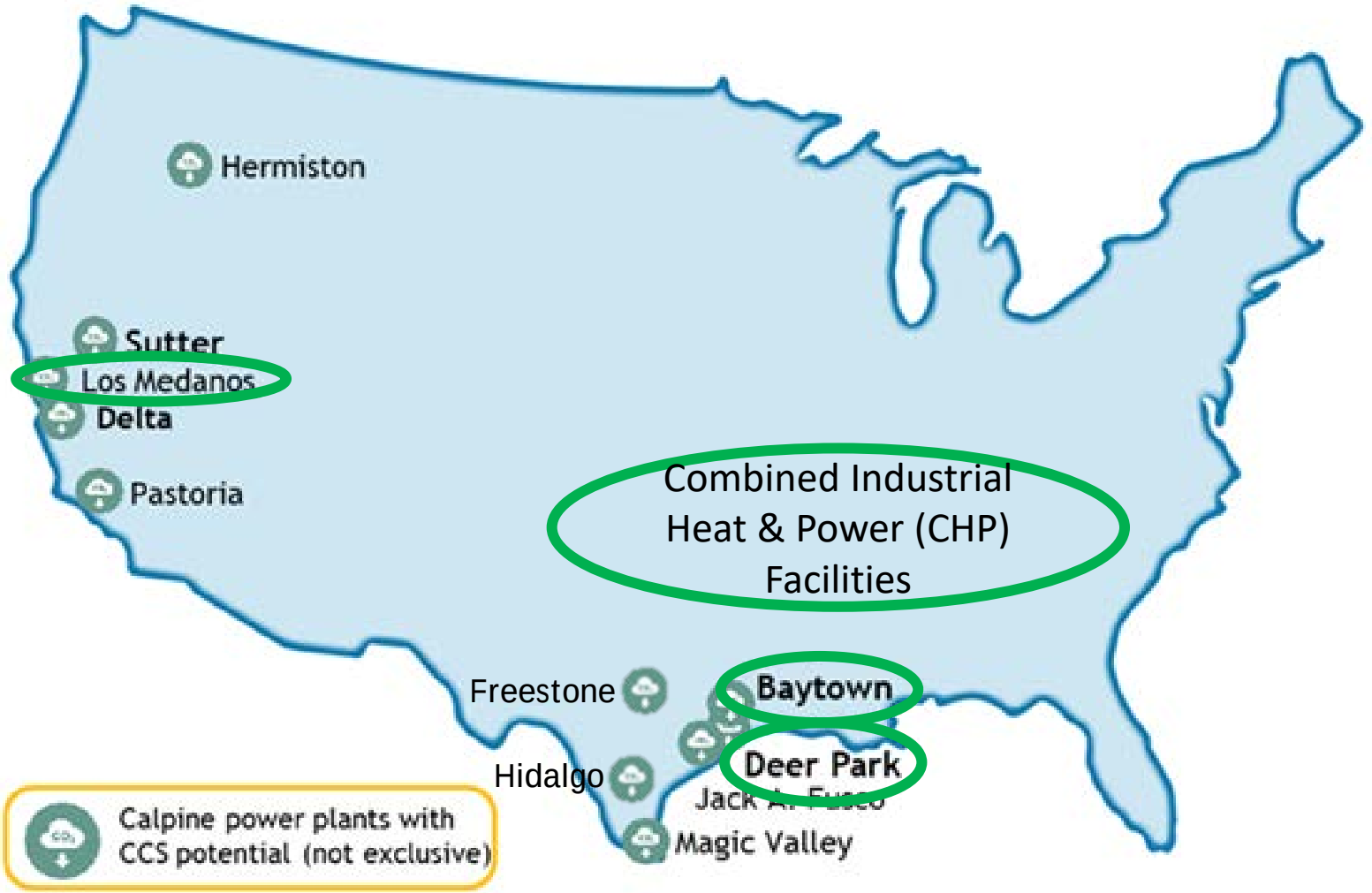
24 hour trade desk and expertise in load management

CCA DATA MANAGEMENT & CUSTOMER SERVICE

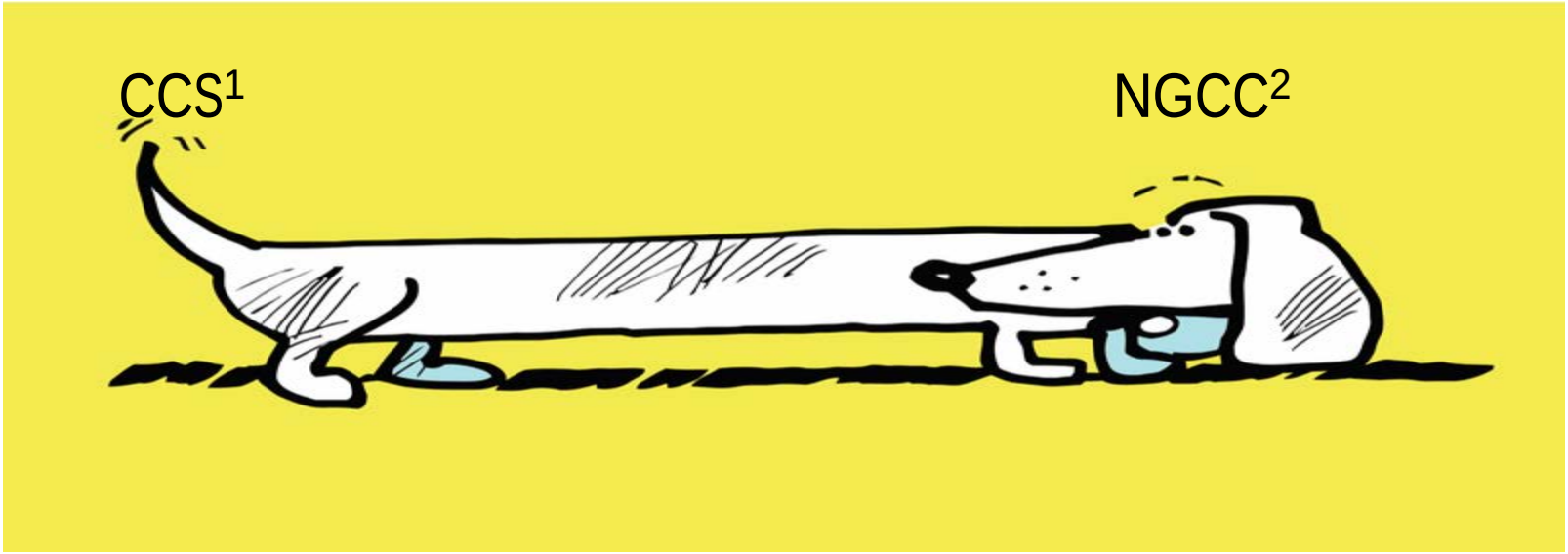
Data management and call center services



Calpine CCS Map



NGCC – CCS Design Considerations



Ensure that tail (minor operations optimizations) do not wag the dog (NGCC)

NGCC = Raw material supply source for CCS, high reliability is key.

NGCC with site hosts have increased reliability imperative.

1 – Carbon Capture & Storage; 2 – Natural Gas Combined Cycle

CCS CHP[1] Considerations – Baytown Energy Center (BEC)

1. Flue Gas Supply, *Steam* and Power Optionality
   - 3 Gas Turbines (GT)
   - 2 Gas Fired Auxiliary Boilers
   - 1 Steam Turbine

2. Consistent CO_2 Generation Profile
   - 2 GTs *"must run"* for host steam and power reliability
   - Site host steam demand fluctuations potential to induce CCS ramping

3. High CCS Capital Efficiency/Capacity Factor
   - BEC CCS capacity ~ 2 GT CO_2
   - 2 GT CCS capacity prevents downtime due to GT outages

1 – Combined Industrial Heat and Power

Flexible CCS an Operator's Perspective

Value Proposition for Flexible CCS Region and Site Specific

- Regions with explicit capacity markets
- Regions with explicit carbon markets
- Regions with higher renewable penetration
- Sites with long duration contracts eg CoGens

CCS retrofitted facilities must maintain ability to access current capacity during emergencies eg Texas Freeze

Option to implement flexibility more attractive relative to upfront CapEx

High Capture Rate CCS an Operator's Perspective

Value Proposition for High Capture Rate CCS

- Potential for marginal CapEx/OpEx to be offset by add'l CO_2 captured -> no increase marginal cost CO_2
- Potential for lower Carbon Intensity (CI) energy products to demand premium energy price
- Definition and quantification of low-CI and/or Net-Zero energy products varies significantly among stakeholders

High capture rates must be reliable and guaranteed to allow operators to market low-CI characteristics

Flexible CCS Solutions

1) Cool Solvent Storage
   - Excess rich solvent storage
   - Enables cold and hot processes to operate independently
   - Requires increased solvent storage and stripper capacity

2) Thermal Energy Storage
   - Maintain hot, lean temperatures in stripper etc
   - Add thermal energy storage systems to enable pre-heating prior to base facility Start-Up (SU)
     - Analogous to current chilled water peaking systems

Time delay between production of flue gas and hot process delays process SU.

Thoughtful equipment sizing can enable fast SU, at design capture rates.