Acknowledgments

- The following organizations helped prepare this presentation:
  - California Energy Commission
  - Bevilacqua-Knight, Inc. (BKi)
  - Pacific Gas and Electric Company (PG&E)
  - Lawrence Livermore National Laboratory (LLNL)
  - Lawrence Berkeley National Laboratory (LBNL)

- Funding by U.S. Department of Energy, National Energy Technology Laboratory
Why Evaluate CCS on California NGCC Units?

- ~50% of California’s electric power mix is generated with natural gas; coal provides 10–20%, mostly imported from other states
- California’s mandatory greenhouse gas reduction law (AB 32) requires GHG reductions of approximately 25% by 2020
  - Many NGCC plants are among the largest CO₂ emitters in the state
  - Electric utilities need information on costs, technical feasibility, and operational impacts of CCS on existing and future NGCC units
- Most power plant CCS studies focus on coal-fired units; NGCC flue gas composition is considerably different
  ~3–4% CO₂ for NGCC vs. ~13% for coal-fired boilers
  ~13% O₂ for NGCC vs. ~3–5% for coal-fired boilers

Adding CCS Appears Practicable for Many Large California NGCC Units

- Units have high capacity factors and significant remaining life
- Open plot space could possibly be used for CO₂ capture and compression equipment
- Many plants are within 50 km of potential geological storage sites
**Key Questions from Generation Planners**

- Which CCS technologies will be most cost-effective and least disruptive to system reliability?
- What are costs and output/efficiency reductions for CCS?
- What is effect on unit operating flexibility (part-load operation; unit ramp rates)?
- What is effect on electricity/gas supply markets?
  - What is effect on system reserve margins?
  - How will lost capacity be replaced?
- With limited water resources, how will cooling demand be satisfied?
- What permitting issues will CCS add?

**WESTCARB’s NGCC-CCS Study**

- Screen candidate CCS technologies for NGCC units
- Develop and apply procedures for screening existing and planned NGCC units/sites for CCS suitability, including geologic storage potential
- Build engineering-economic model(s) and evaluate selected CCS technology and NGCC unit combinations; conduct sensitivity studies
- Communicate results to stakeholders
- Develop/evaluate a conceptual design for a pilot-scale CCS test on a California NGCC unit or cogeneration unit
CCS Technology and NGCC Unit Screening

- Evaluate CO₂ capture technologies
  - Pre-, post-, and oxy-combustion
  - Emerging technologies and novel configurations
  - Timelines to commercial readiness
- Evaluate sites, configurations, layouts of existing/planned units for CCS retrofit suitability
  - Options for meeting cooling demand
  - Site-specific cost/performance impacts
  - Site-specific permitting obstacles
- Assess the viability of geologic storage near plant sites
  - Suitability of geology for saline formation storage or EOR/EGR
  - Land use compatibility with CO₂ pipeline construction/operation

Detailled Engineering-Economic Evaluation of Select Retrofit and New-Build Cases

- Develop cost and performance model(s) and risk analysis procedures
- Compare performance, cost, and risk for selected CO₂ capture technologies and California NGCC plant sites
  - Retrofits with nearer-term CCS technologies on existing units
  - New-build installations with nearer-term and emerging CCS technologies
  - Standard economic metrics
- Perform sensitivity studies for selected technology options
Geologic Evaluation of the CCS Potential of California NGCC Plant Sites

- LLNL has conducted an initial review of the local geology for 42 California NGCC power plant sites
- LLNL will construct detailed 3-D geologic models for the most promising sites

Geologic Parameters Considered in LLNL’s Initial Review of the 42 NGCC Sites

- Distance to potential CO₂ sinks; oil and gas fields with enhanced recovery potential
- Stratigraphy at or near the site
- Surface expression of nearby faults
- Depth to saline aquifers >10,000 ppm TDS

Northern California sedimentary basin with alternating layers of sandstone and shale. Adopted from California Division of Oil, Gas and Geothermal Resources, 1983.
### Study Results Will Help California Electricity Providers Plan for GHG Compliance

- California-specific information for feasibility, costs, and system impacts of implementing CCS on NGCC units
- Factors that affect the viability of capture technologies for different site and equipment configurations
  - Cost and performance
  - Commercial readiness
  - Environmental, health, and safety considerations
- Improvements in viability factors over time
  - Retrofits with near-term capture technologies
  - New-builds with emerging capture technologies
- Evaluation tools and lessons learned will be applicable to other gas-dominated power systems

### Technology Validation Will Help NGCC-CCS Move Forward

- Conduct a feasibility study for a proposed pilot-scale CCS technology validation test at a California NGCC unit or cogeneration plant
  - Consult with stakeholders to select a configuration that can best fill knowledge gaps
  - Develop preliminary project scope, design, cost estimate, permitting plan, and schedule
- Develop plans for proceeding with the proposed pilot test
Got Questions? Ask Us!

- Rich Myhre, WESTCARB Outreach Coordinator:
  rmyhre@bki.com (510-463-6109)
- Consuelo Sichon, WESTCARB Principal Investigator:
  Csichon@energy.state.ca.us (916-327-2222)
- Eric Worrell: eworrell@bki.com (510-463-6118)
- Katie Myers: myers31@llnl.gov (925-423-5037)
- Jeff Wagoner: wagoner1@llnl.gov (925-422-1374)
- Emma Wendt: exwx@pge.com (415-973-8820)
- J. Henderson: jmh6@pge.com (925-866-5491)
- Cheryl Closson, WESTCARB Project Manager, NGCC-CCS Study:
  Cclosson@energy.state.ca.us (916-327-2312)
- Elizabeth Burton, WESTCARB Technical Director:
  eburton@lbl.gov (925-899-6397)