



EPRI

ELECTRIC POWER
RESEARCH INSTITUTE

Generation Technologies in a Carbon-constrained World

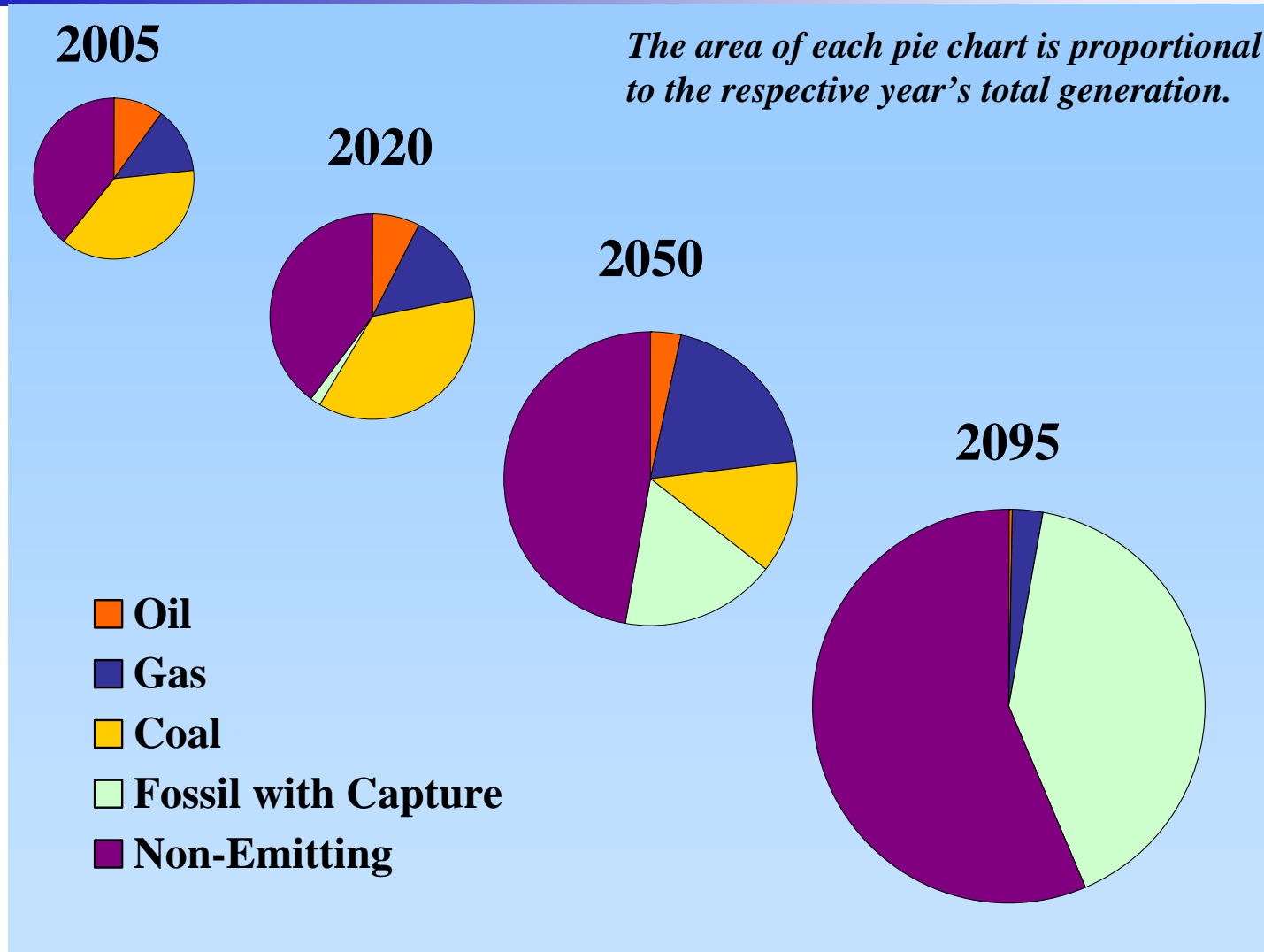
**Resources for the Future
Policy Leadership Forum**

Washington, DC

March 30, 2006

Steve Specker
President & CEO

Global Generation Mix with 550 ppm CO₂ Limit



Objective

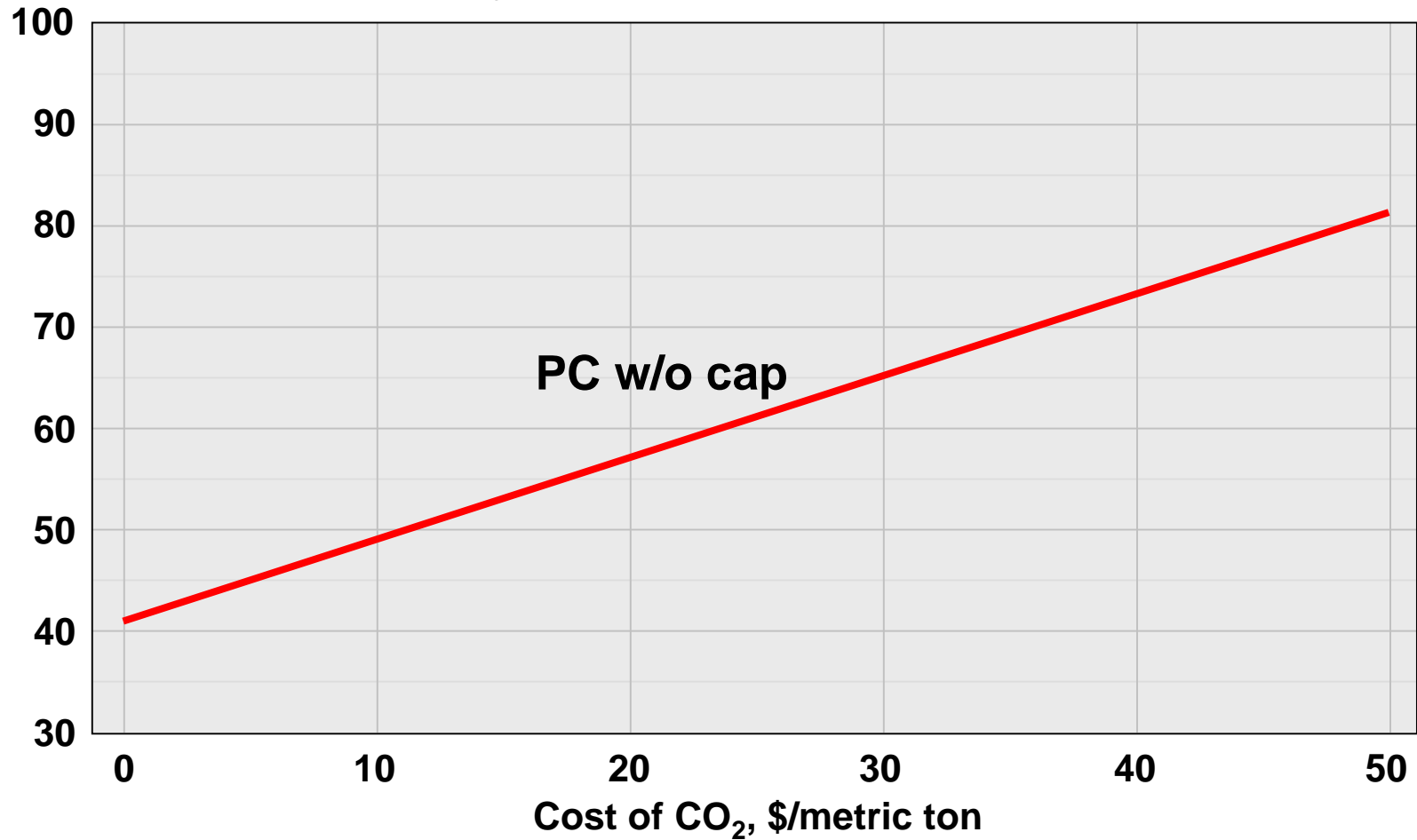
Provide an objective and factual framework for discussing generation technologies and investment decisions in a carbon-constrained world

Framework Overview

- **Levelized cost of electricity**
 - Standard EPRI methodology
 - 2004 costs and \$'s
- **Two key uncertainties**
 - Future “cost” of CO₂
 - Future price of natural gas
- **Two technology portfolios**
 - 2010 time-period
 - 2020 time-period

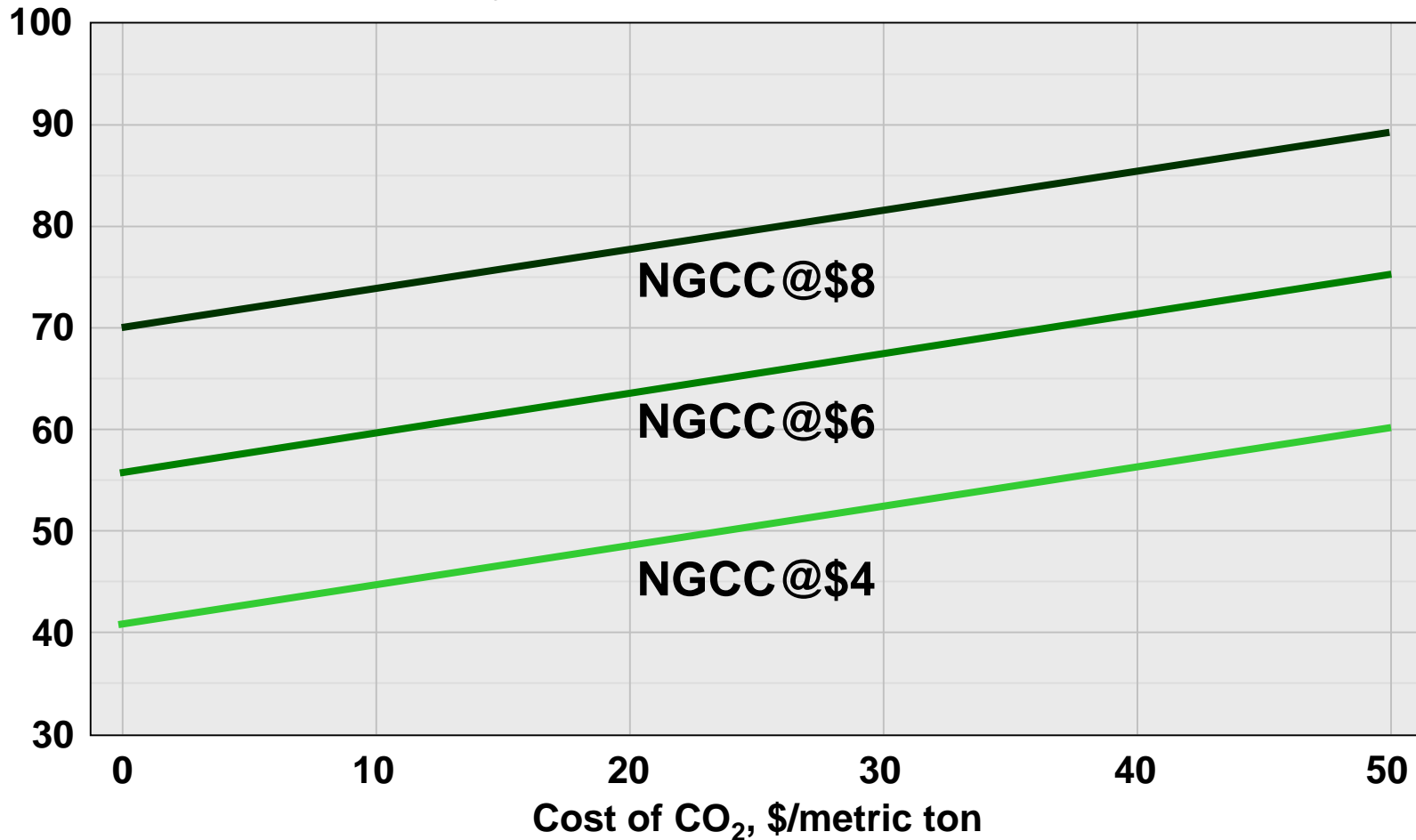
Pulverized Coal in 2010 Time Period

Levelized Cost of Electricity, \$/MWh



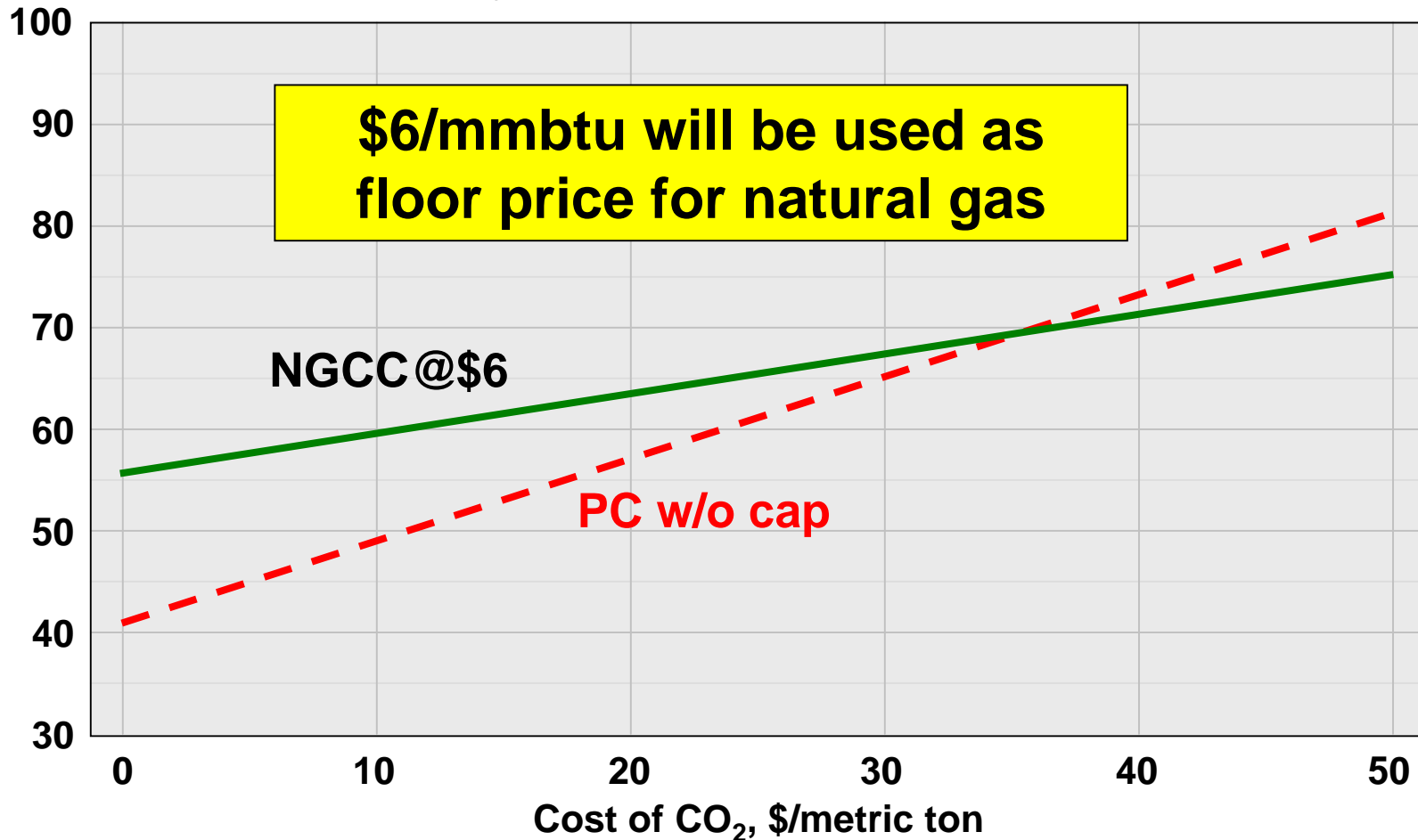
Natural Gas Combined Cycle in 2010 Time Period

Levelized Cost of Electricity, \$/MWh



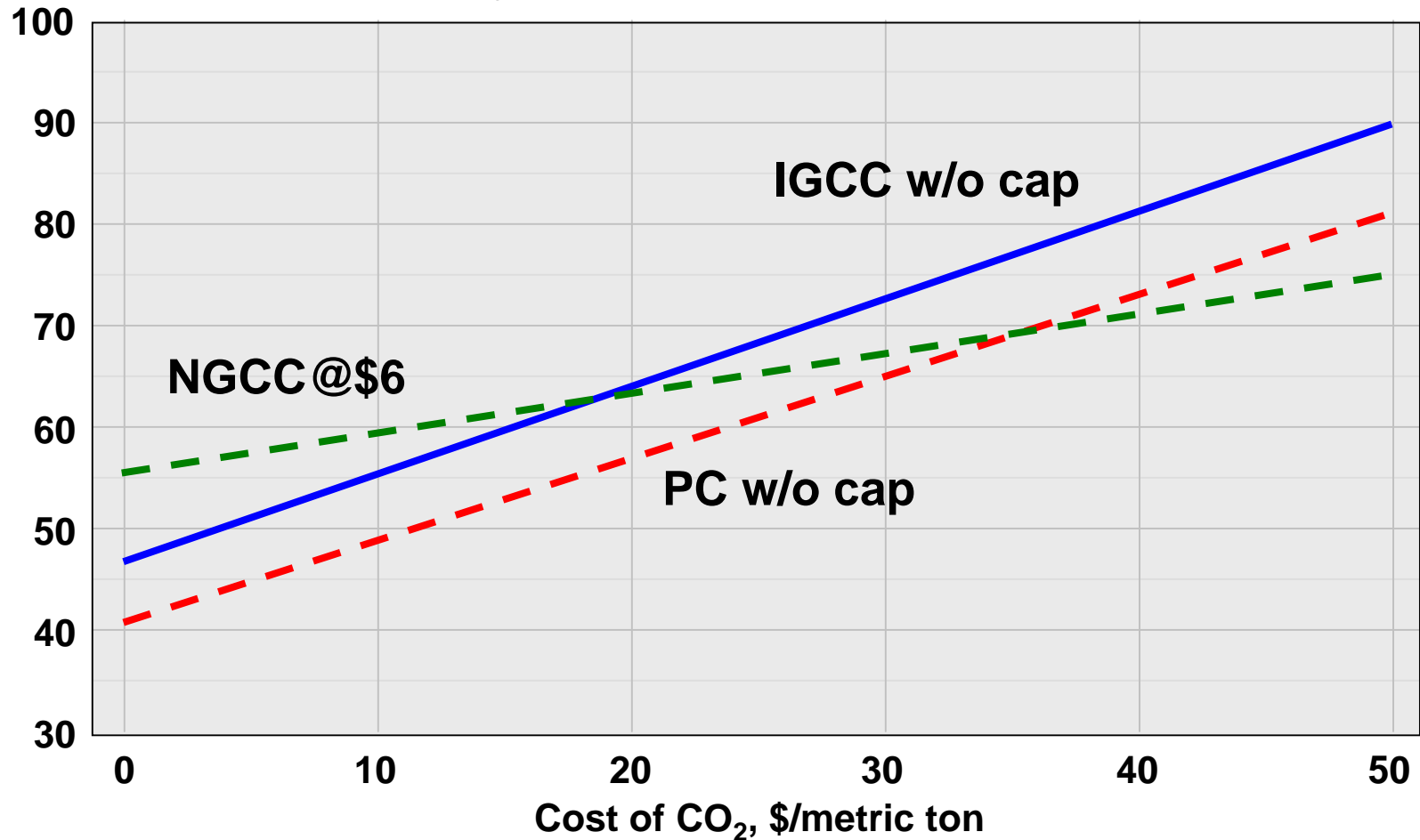
Comparative Costs of 2010 Generating Options

Levelized Cost of Electricity, \$/MWh

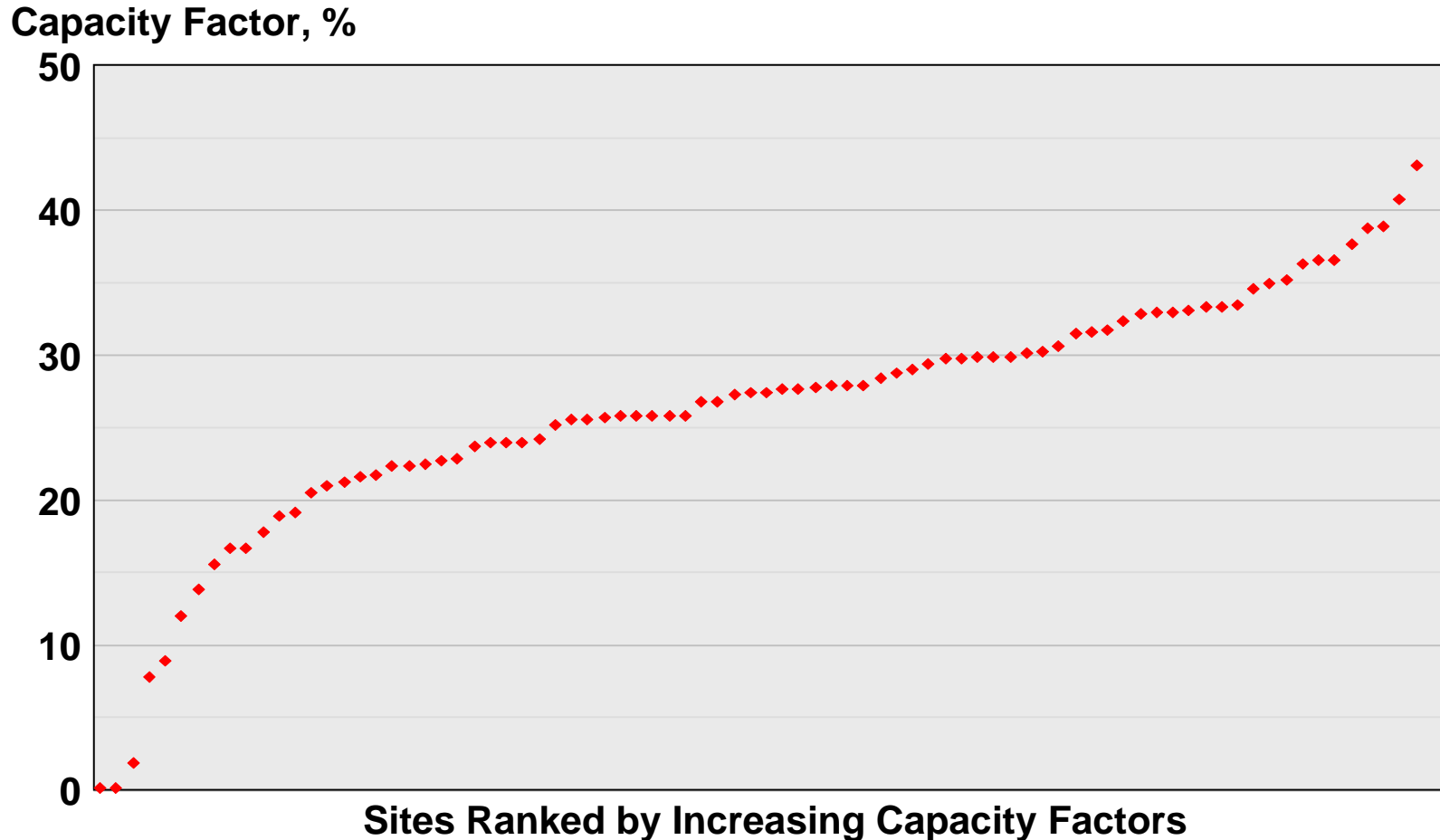


Integrated Gasification Combined Cycle in 2010

Levelized Cost of Electricity, \$/MWh



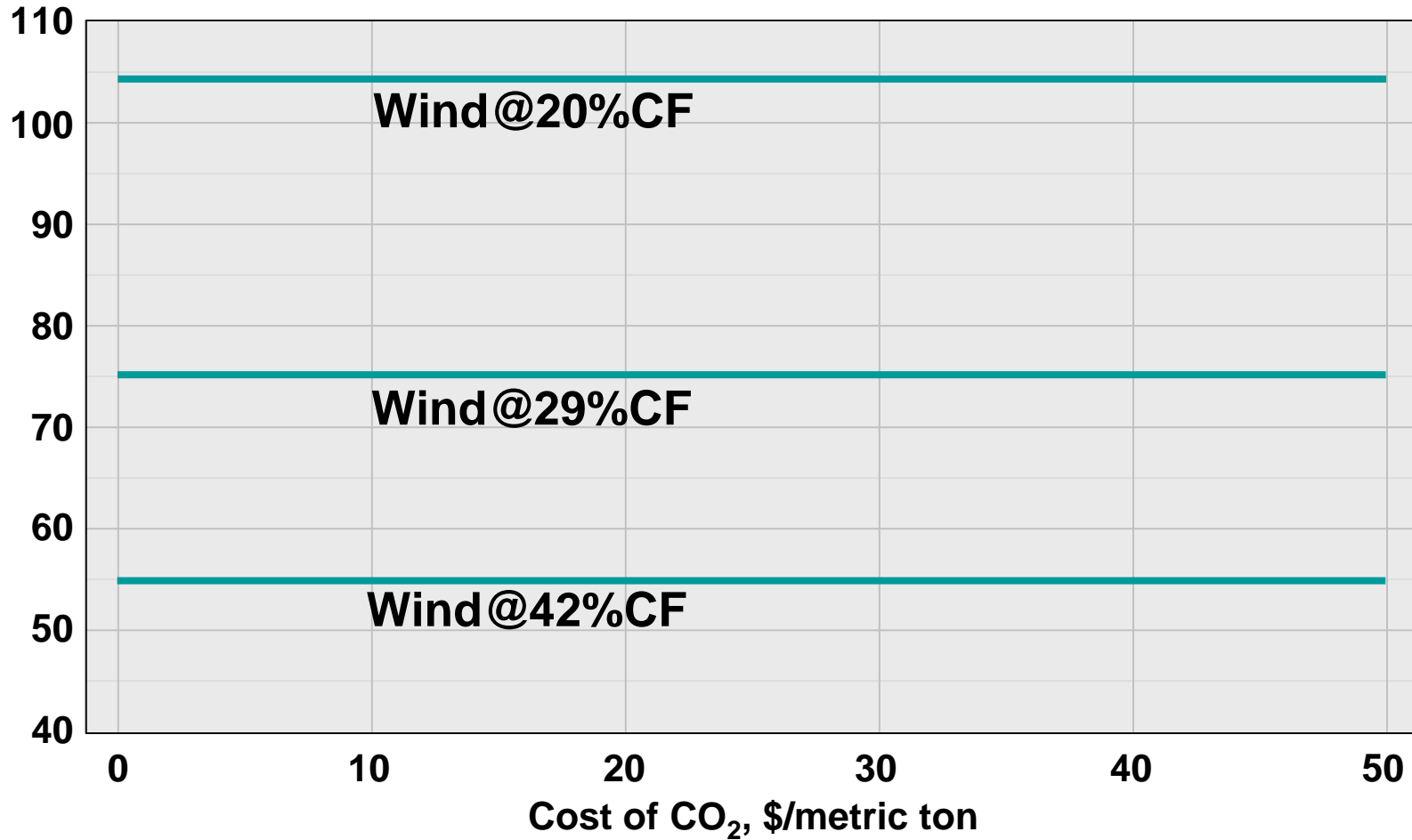
U.S. Wind Plant Capacity Factors, 2004



Source: EIA; EPRI Program 67 Newsletter, Energy Markets and Generation Response – Update on New Power Plants, September 2005

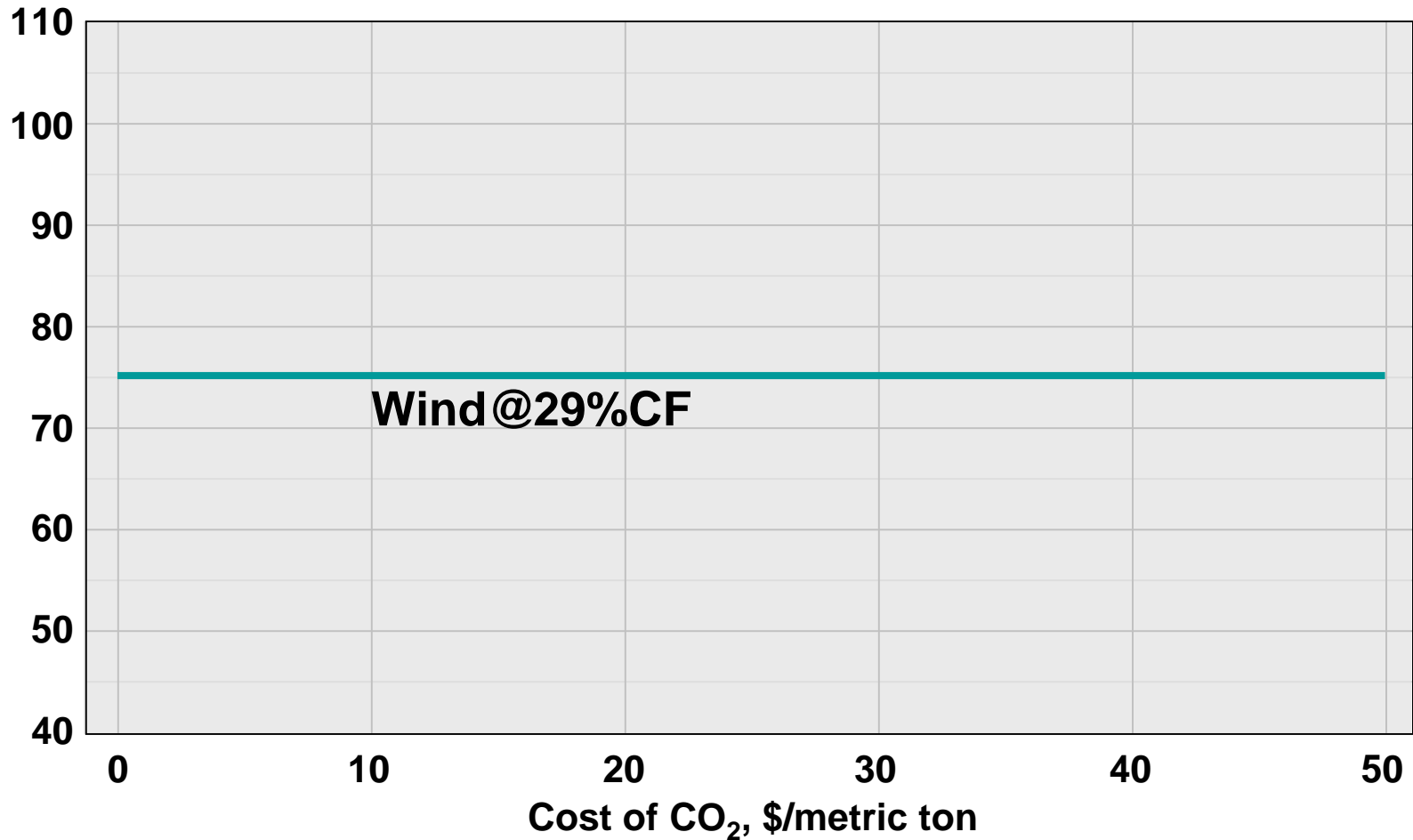
Wind Generation in 2010 Time Period

Levelized Cost of Electricity, \$/MWh



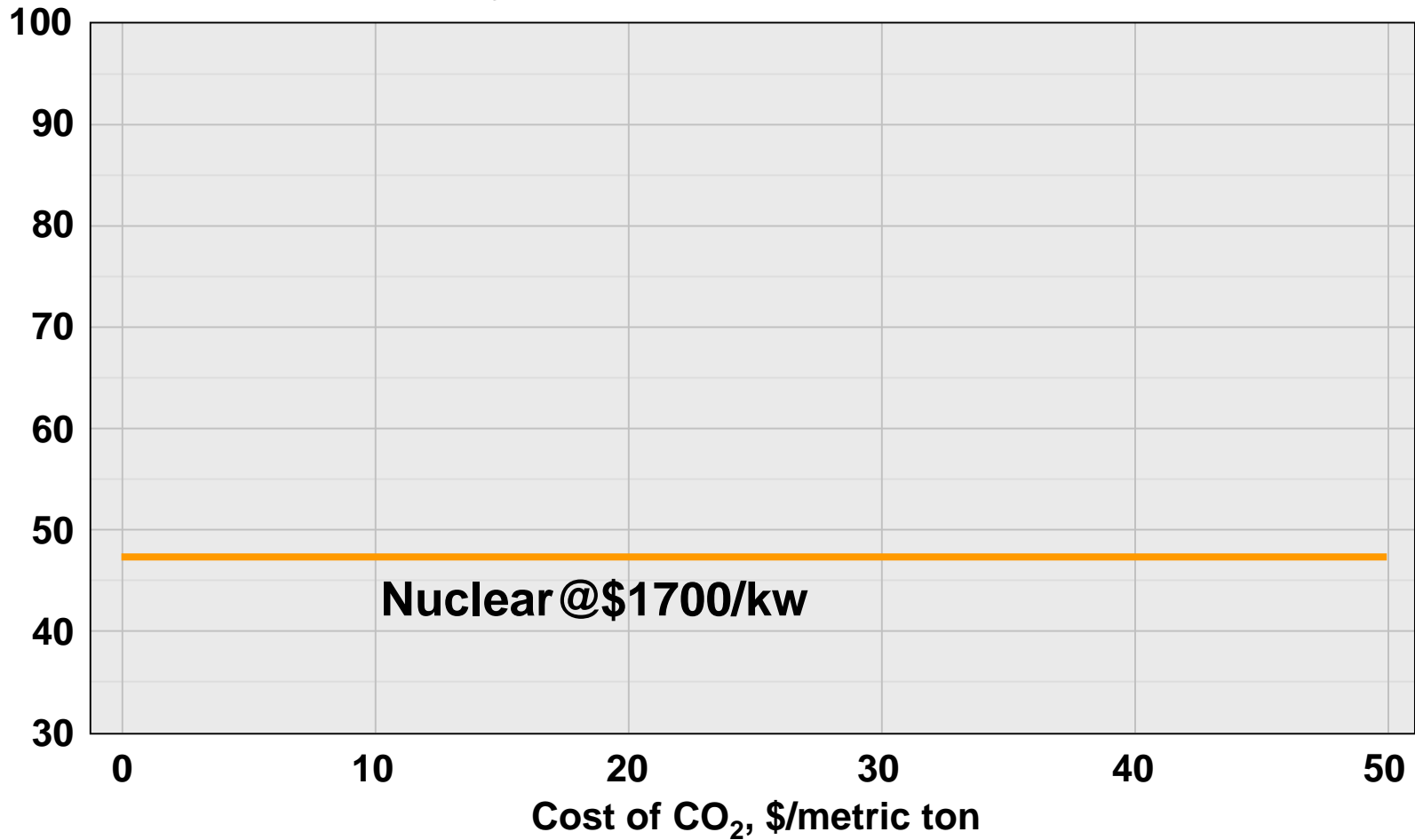
Wind Generation in 2010 Time Period

Levelized Cost of Electricity, \$/MWh



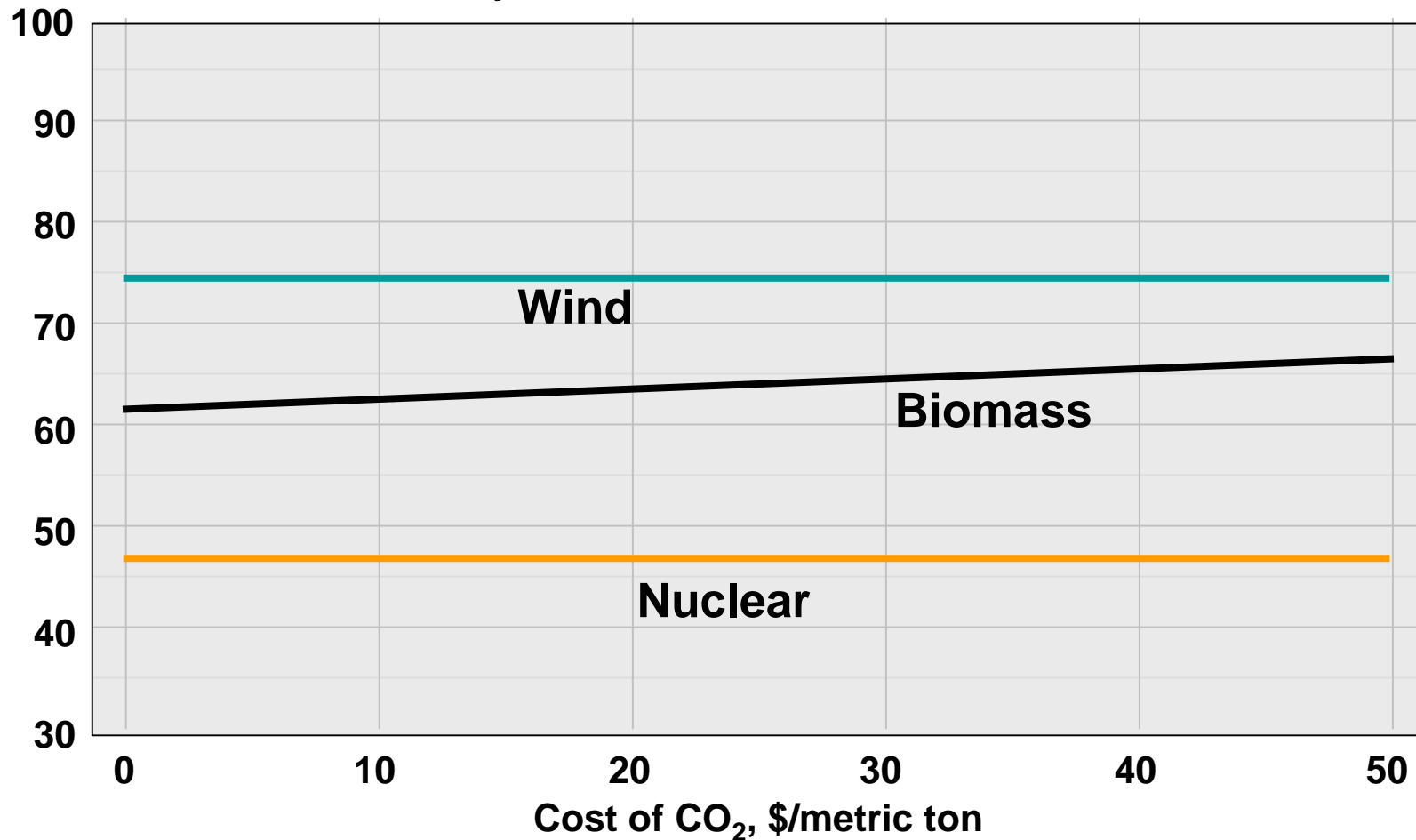
Nuclear Generation

Levelized Cost of Electricity, \$/MWh



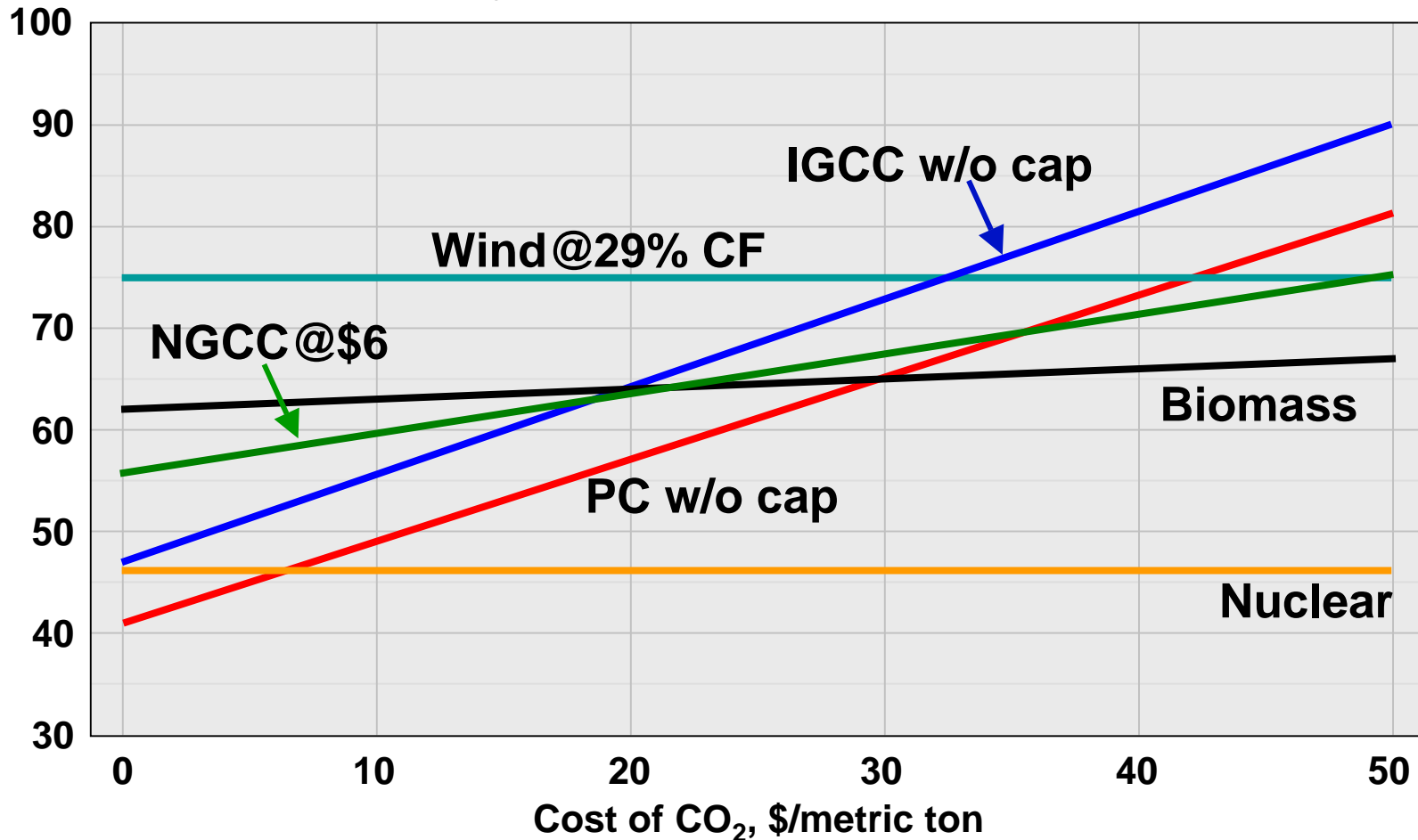
Non-CO₂ Emitting Technologies in 2010 Time Period

Levelized Cost of Electricity, \$/MWh



Comparative Costs of 2010 Generating Options

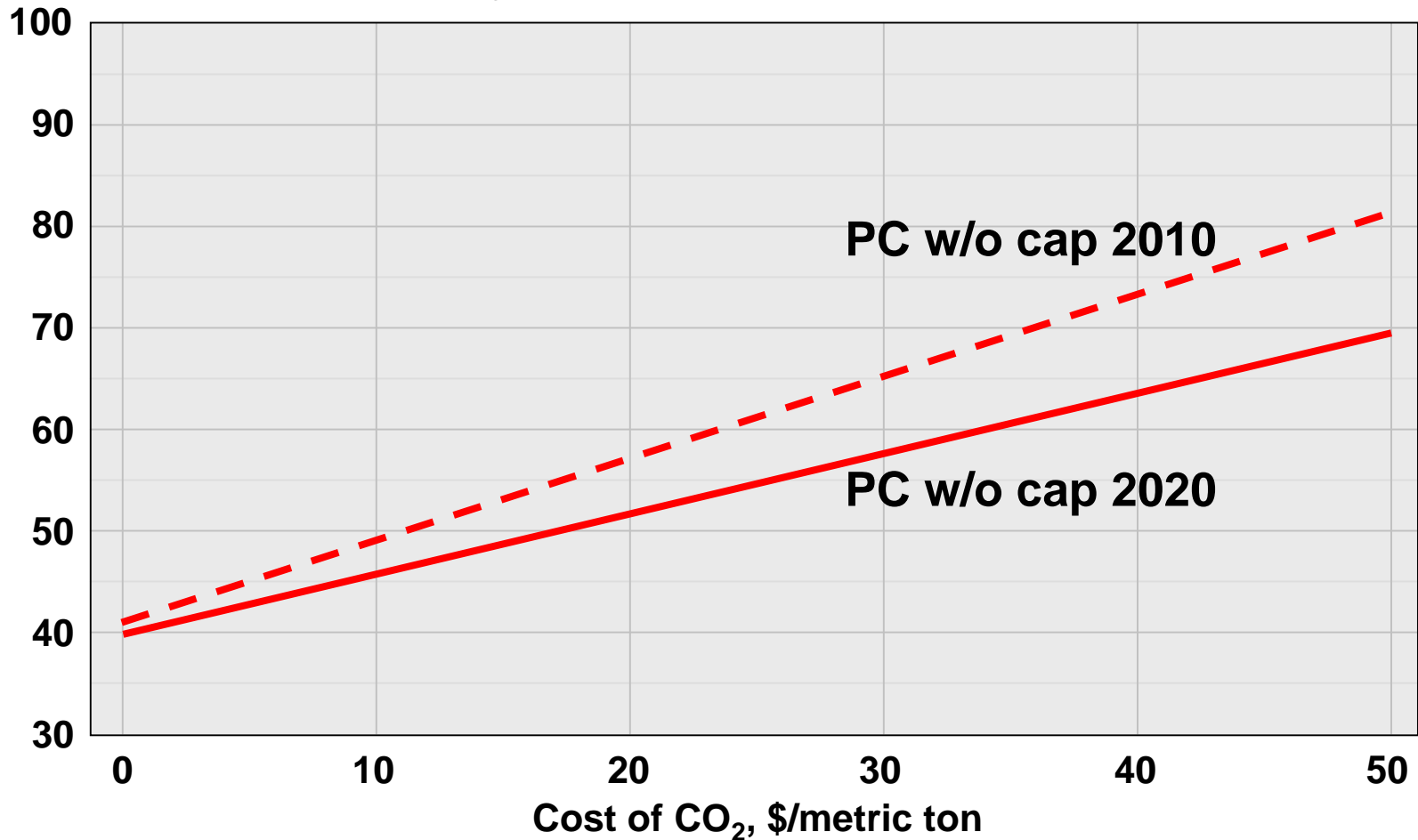
Levelized Cost of Electricity, \$/MWh



What's Possible in 2020

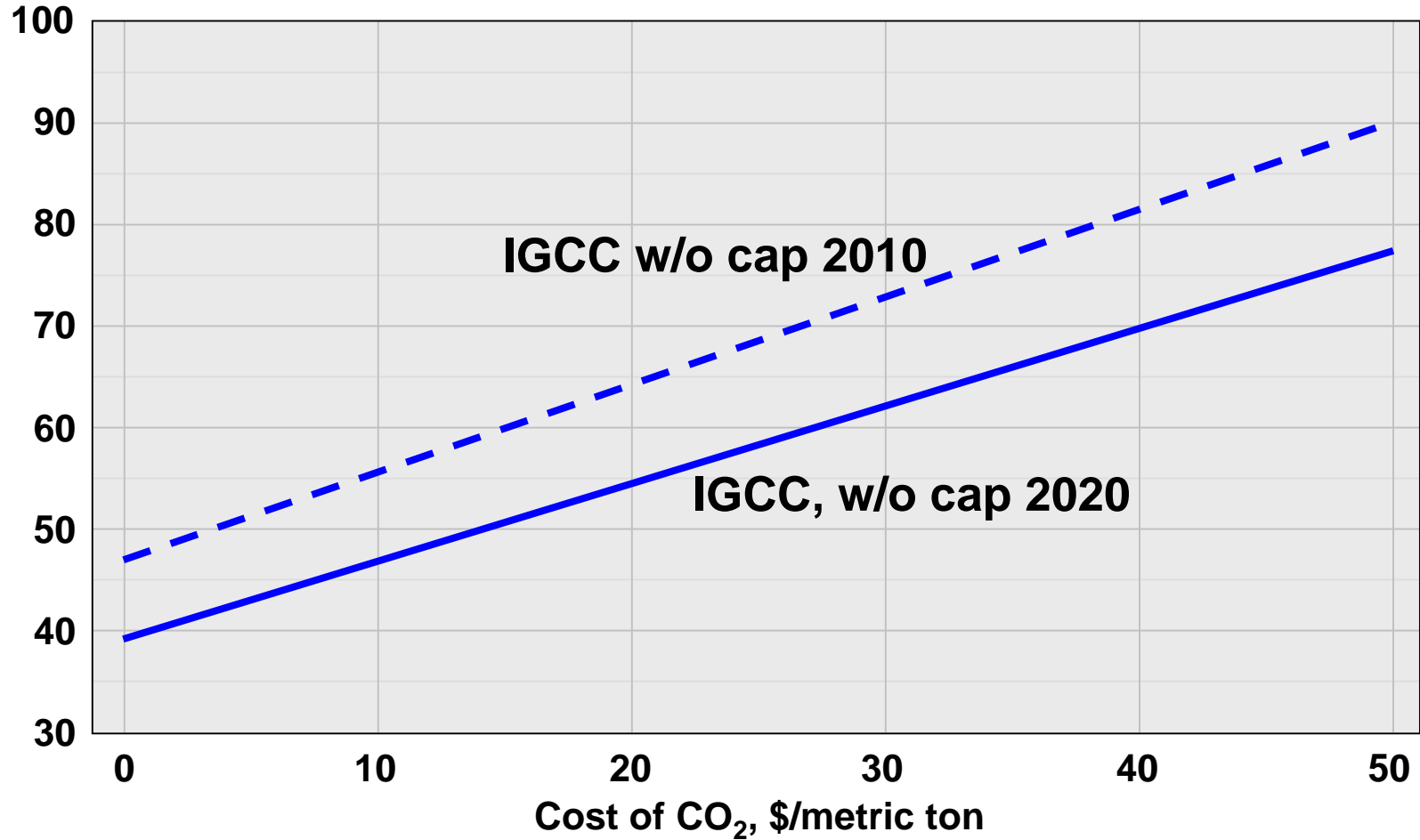
Pulverized Coal w/o Capture

Levelized Cost of Electricity, \$/MWh



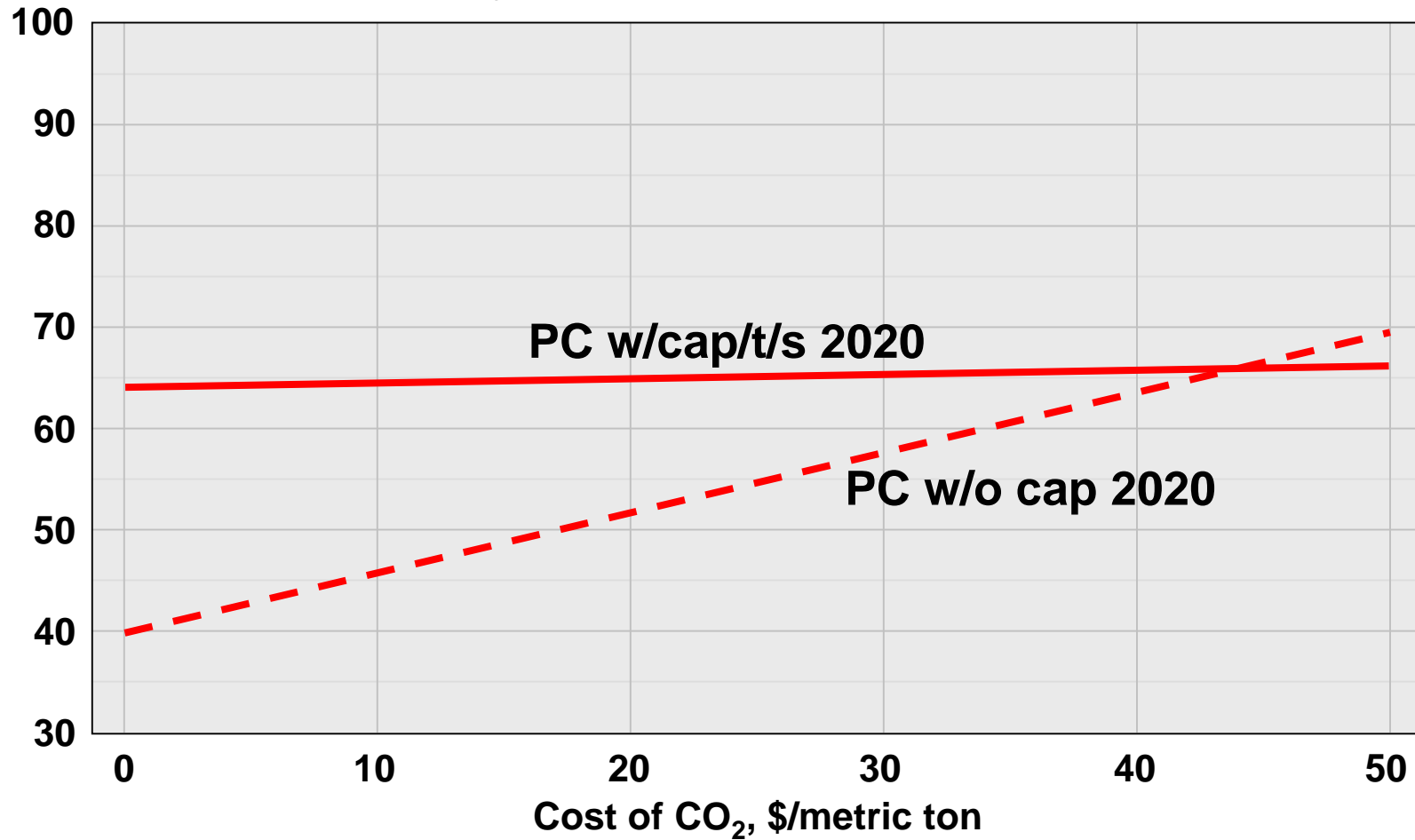
IGCC w/o Capture

Levelized Cost of Electricity, \$/MWh



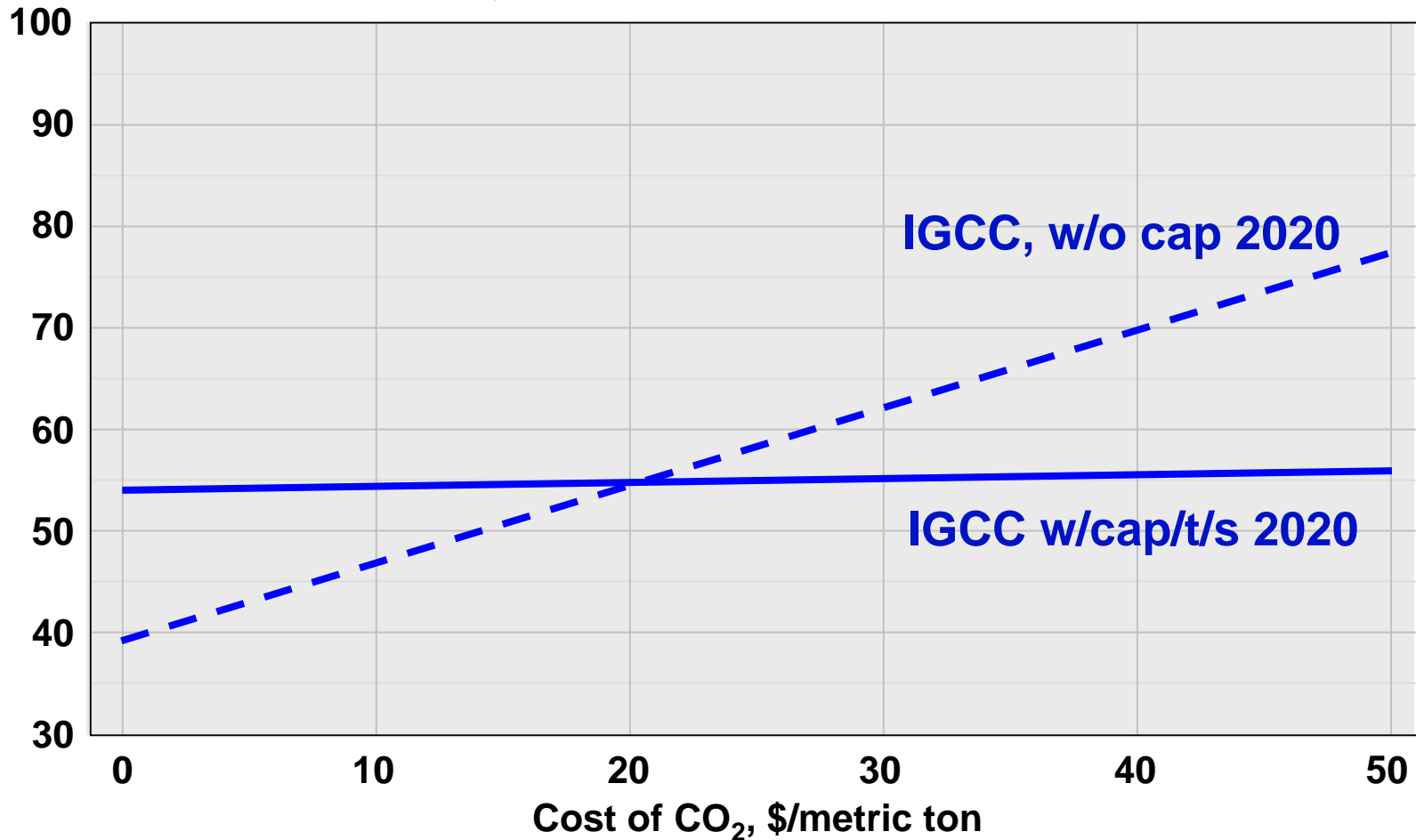
PC with capture/transport/storage

Levelized Cost of Electricity, \$/MWh



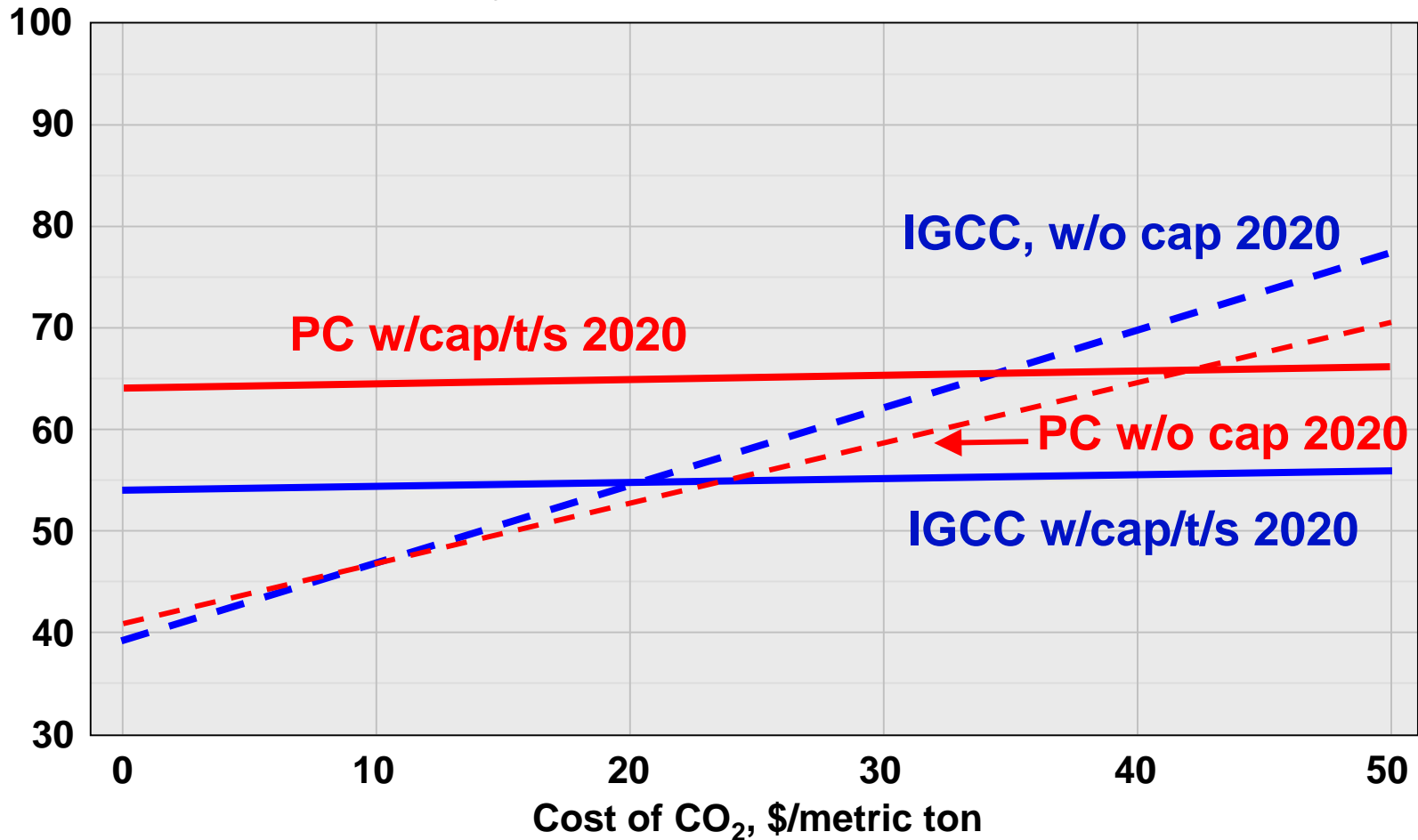
IGCC with capture/transport/storage

Levelized Cost of Electricity, \$/MWh



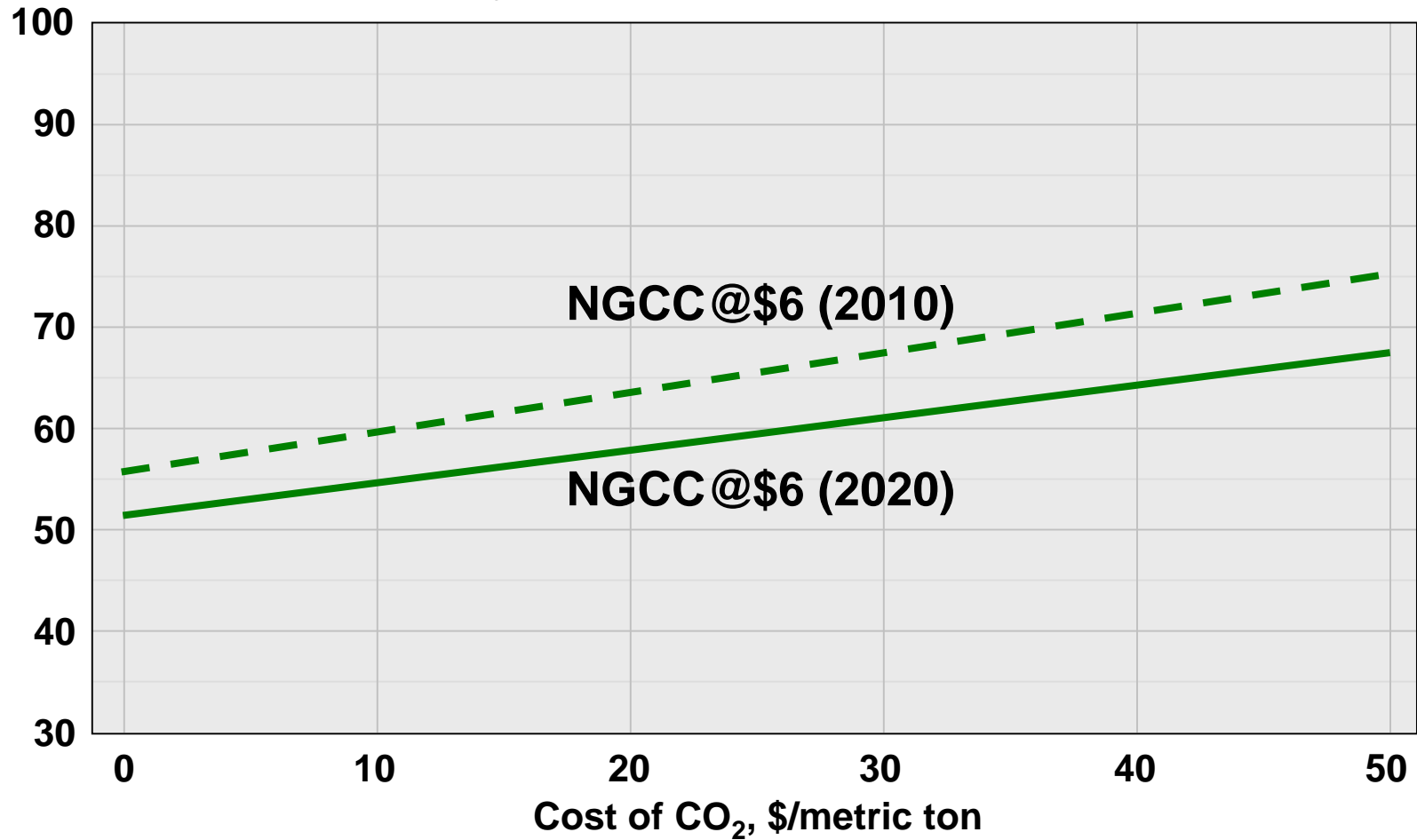
Comparison of IGCC and PC

Levelized Cost of Electricity, \$/MWh



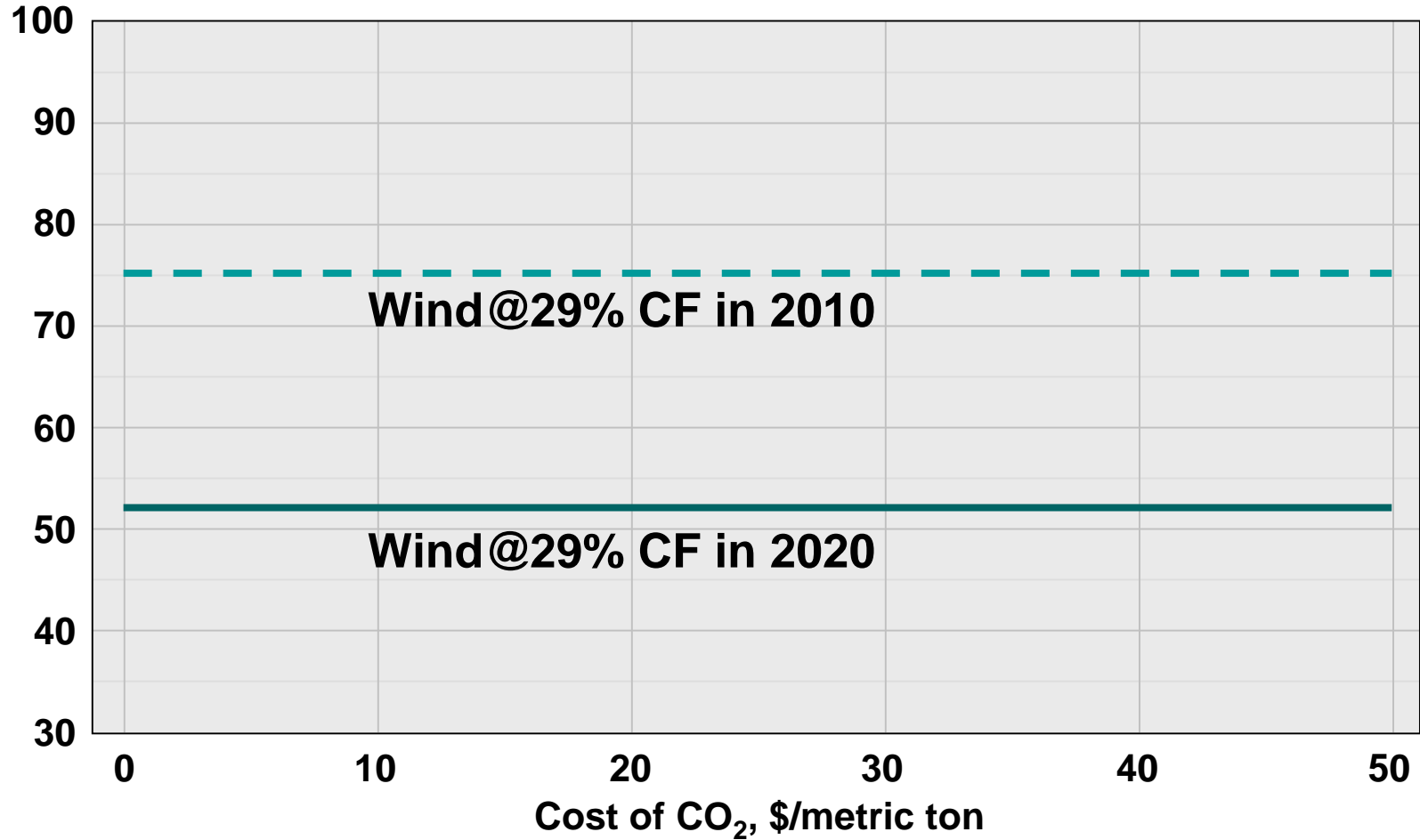
Natural Gas Combined Cycle

Levelized Cost of Electricity, \$/MWh



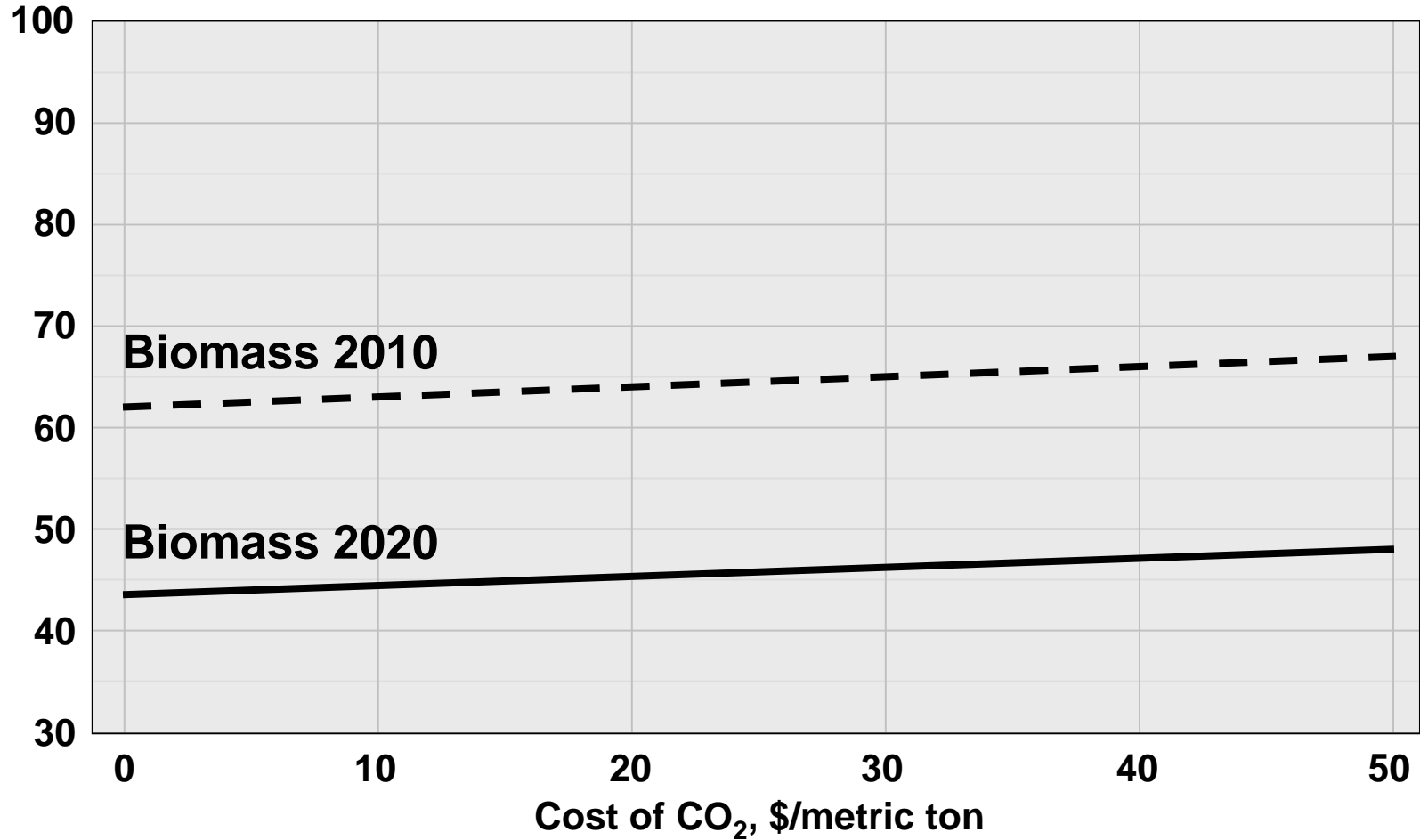
Wind Generation

Levelized Cost of Electricity, \$/MWh



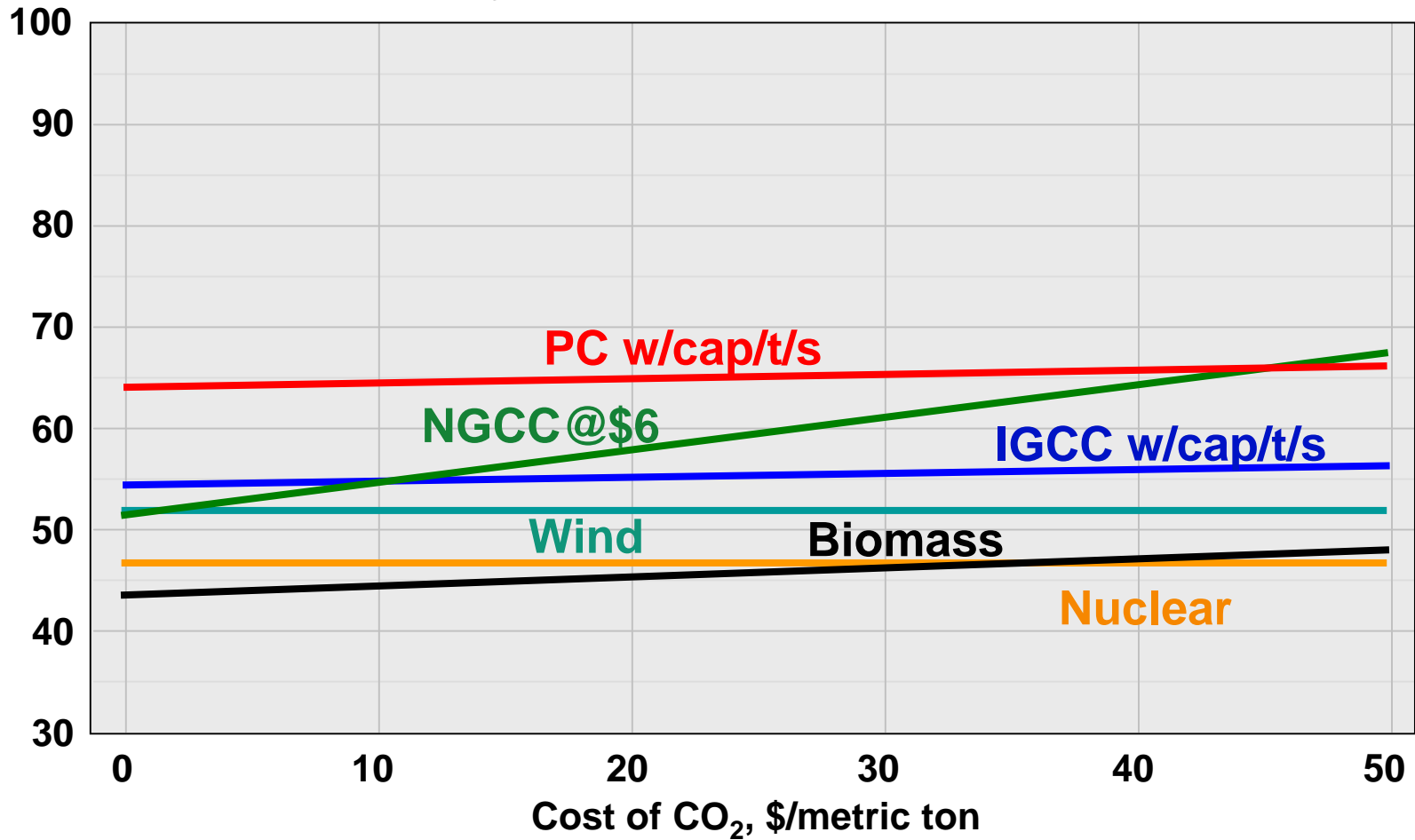
Biomass

Levelized Cost of Electricity, \$/MWh



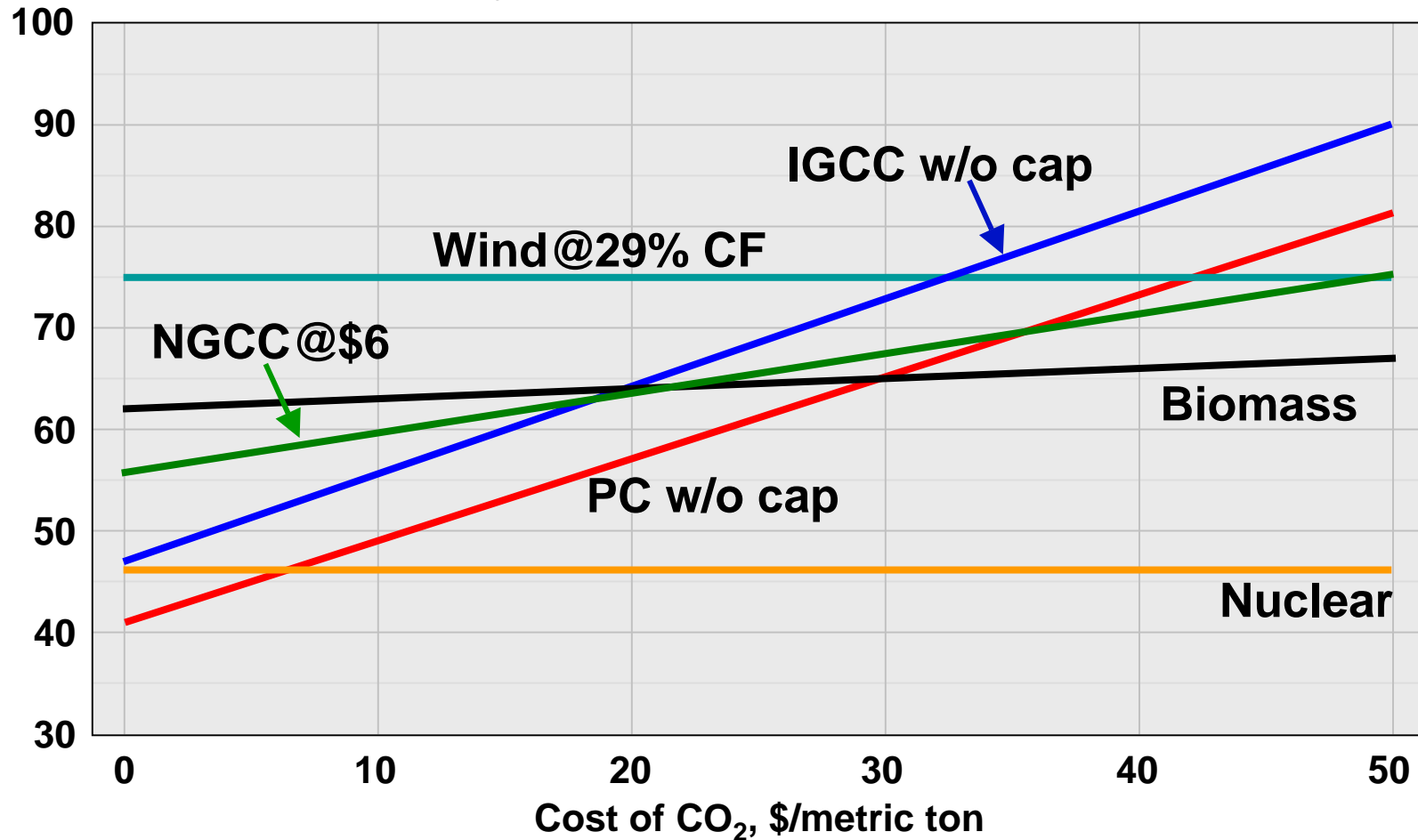
Comparative Costs in 2020

Levelized Cost of Electricity, \$/MWh



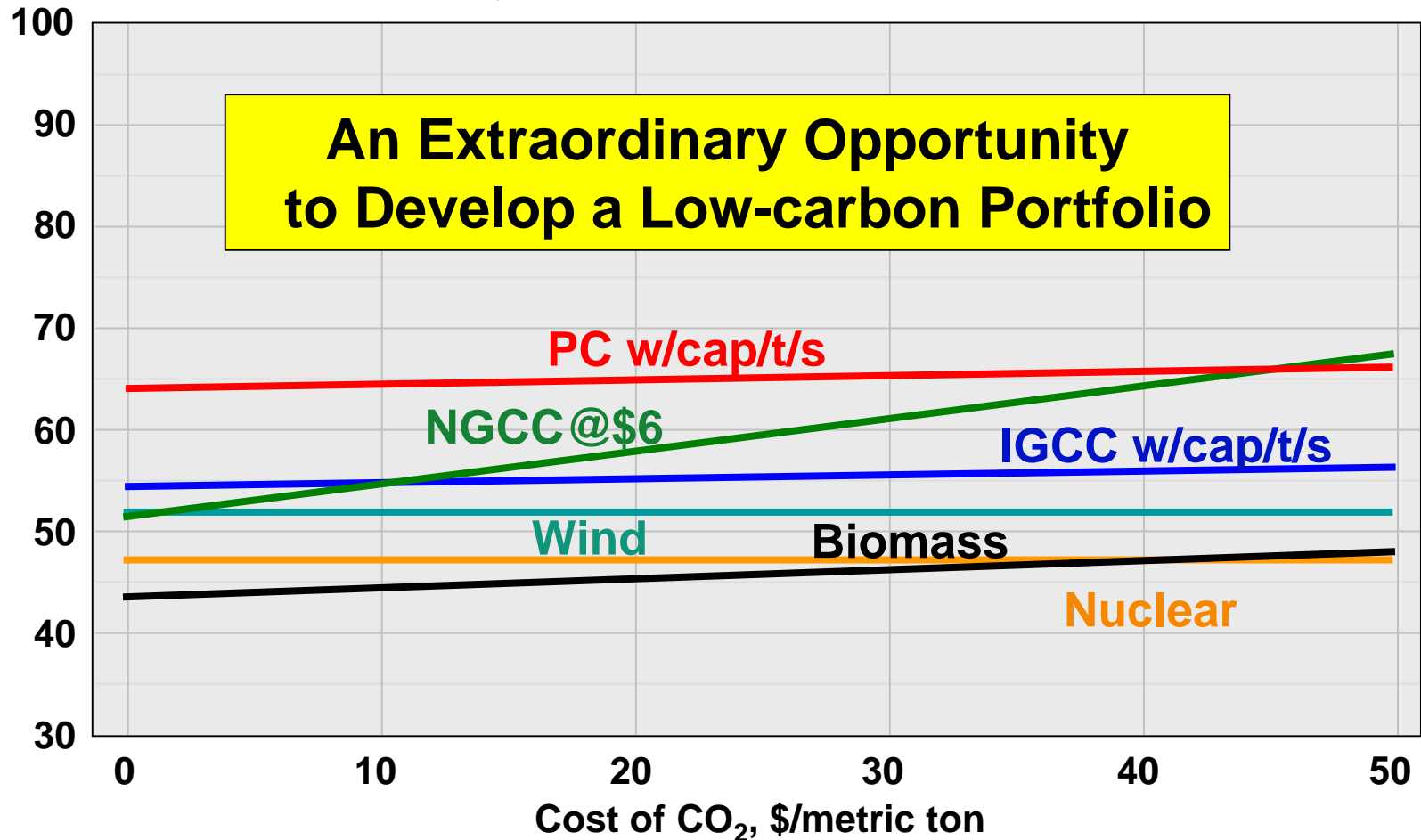
Comparative Costs in 2010

Levelized Cost of Electricity, \$/MWh



What's Possible: Comparative Costs in 2020

Levelized Cost of Electricity, \$/MWh



Fossil Generation with Capture

Advanced Coal Technology Platforms

- **Integrated Gasification Combined Cycle (IGCC) with CO₂ capture and deep geologic storage**
- **Advanced Pulverized Coal (PC) with post combustion CO₂ capture and deep geologic storage**
- **Advanced circulating fluidized bed with post combustion CO₂ capture and deep geologic storage**

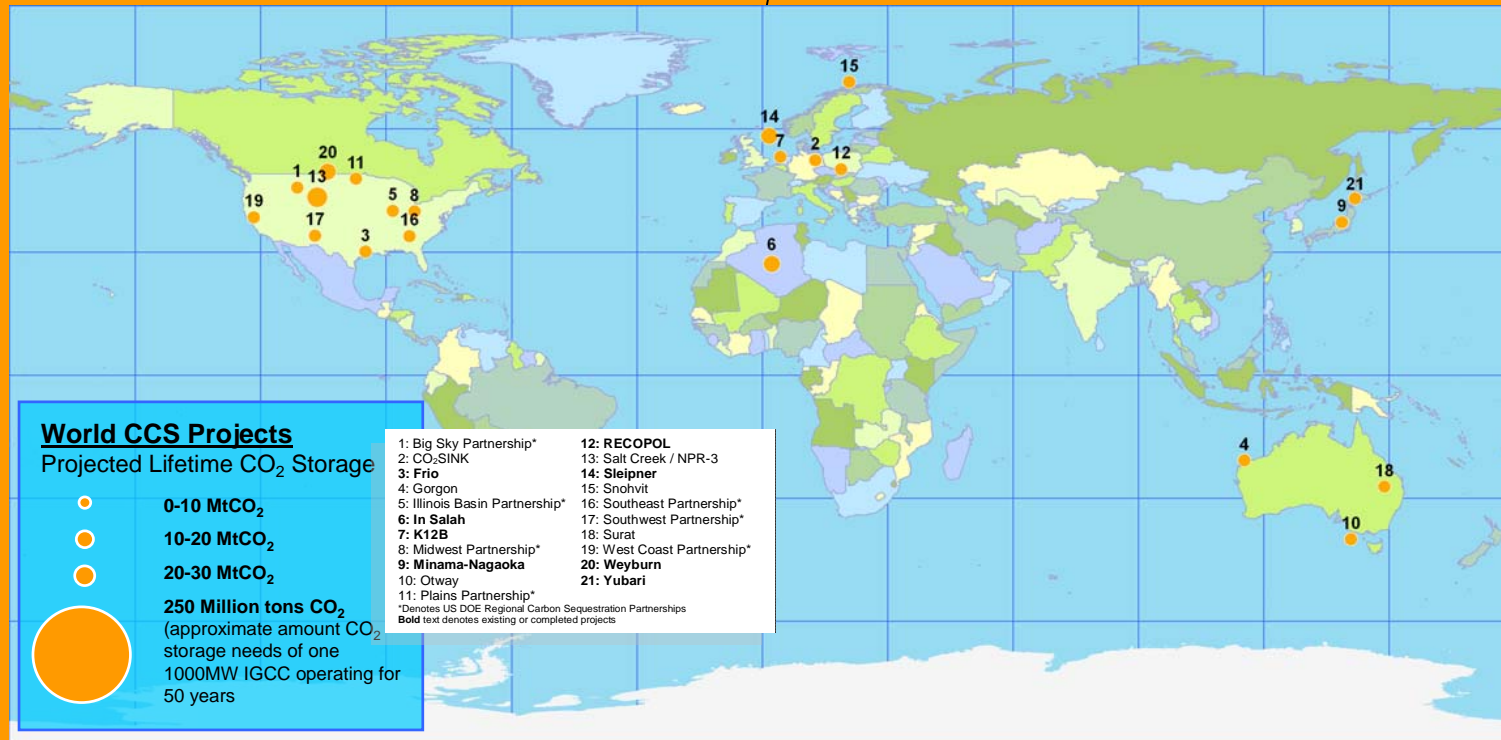
All technologies required to meet future generation needs

CCS Deployment

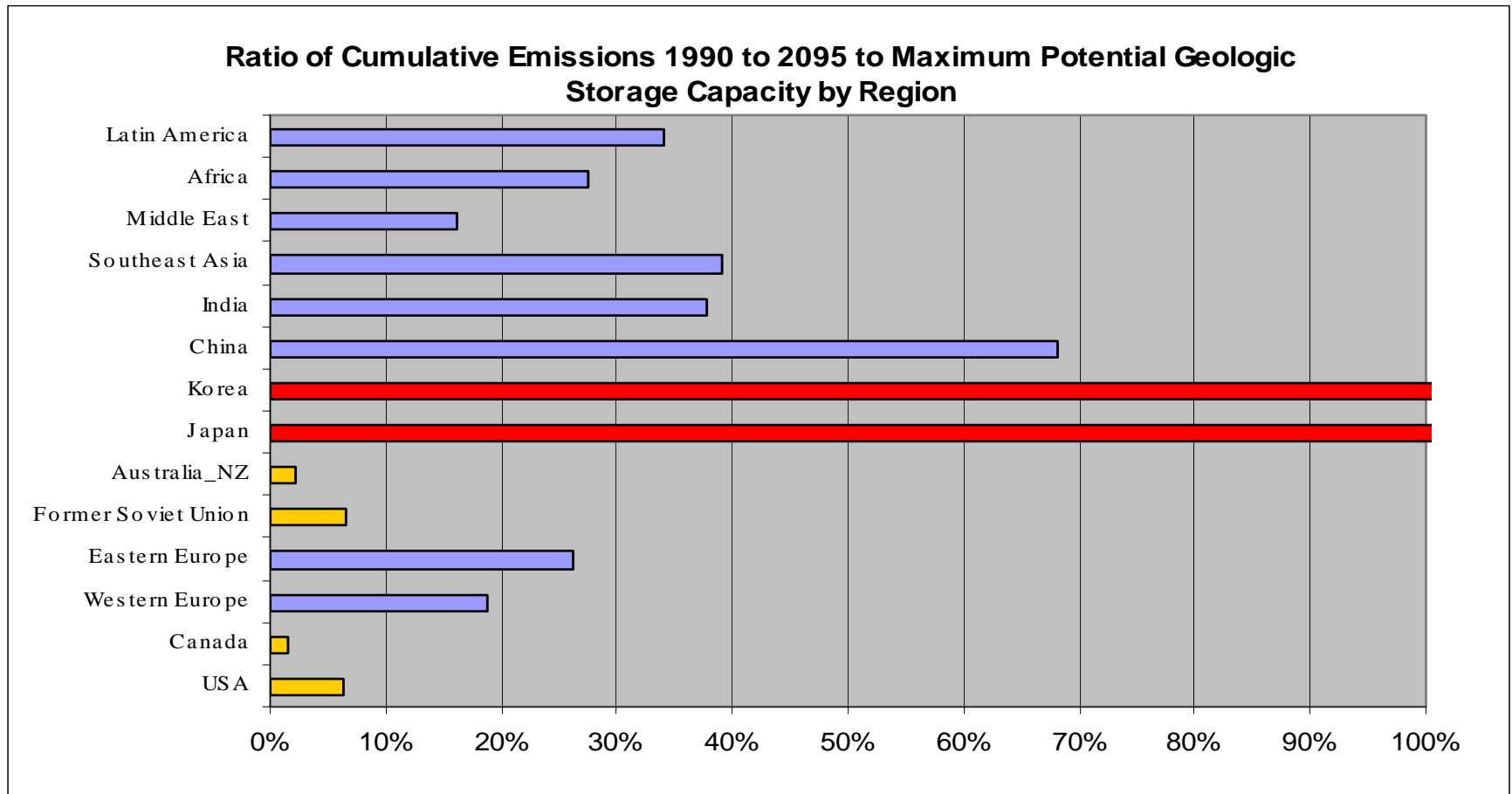
Today and 2050 (on 550 ppmv path)

Cumulative Global
2005-2050
CCS Deployment
30,000 MtCO₂

Cumulative USA
(2005-2050)
CCS Deployment
8,000 MtCO₂



Potential Geologic CO₂ Storage Capacity



U.S. has abundant coal resources and ample CO₂ storage capacity

Overview of Advanced Coal Programs

- **EPRI CoalFleet Program**

- Focused on accelerating the deployment of advanced coal technologies
 - IGCC
 - Ultra-supercritical PC
 - Supercritical Circulating Fluidized-Bed
- Development of IGCC CO₂ capture capability/convertibility

- **FutureGen Alliance**

- A “living laboratory” for advancing IGCC technology and associated CO₂ capture technology and hydrogen co-production
- Demonstration of large-scale storage of “gasification power plant” CO₂

- **EPRI CO₂ Capture Initiative**

- Focused on developing advanced post-combustion CO₂ capture technology for PC plants
- Understanding issues and demonstrating storage of CO₂ from combustion

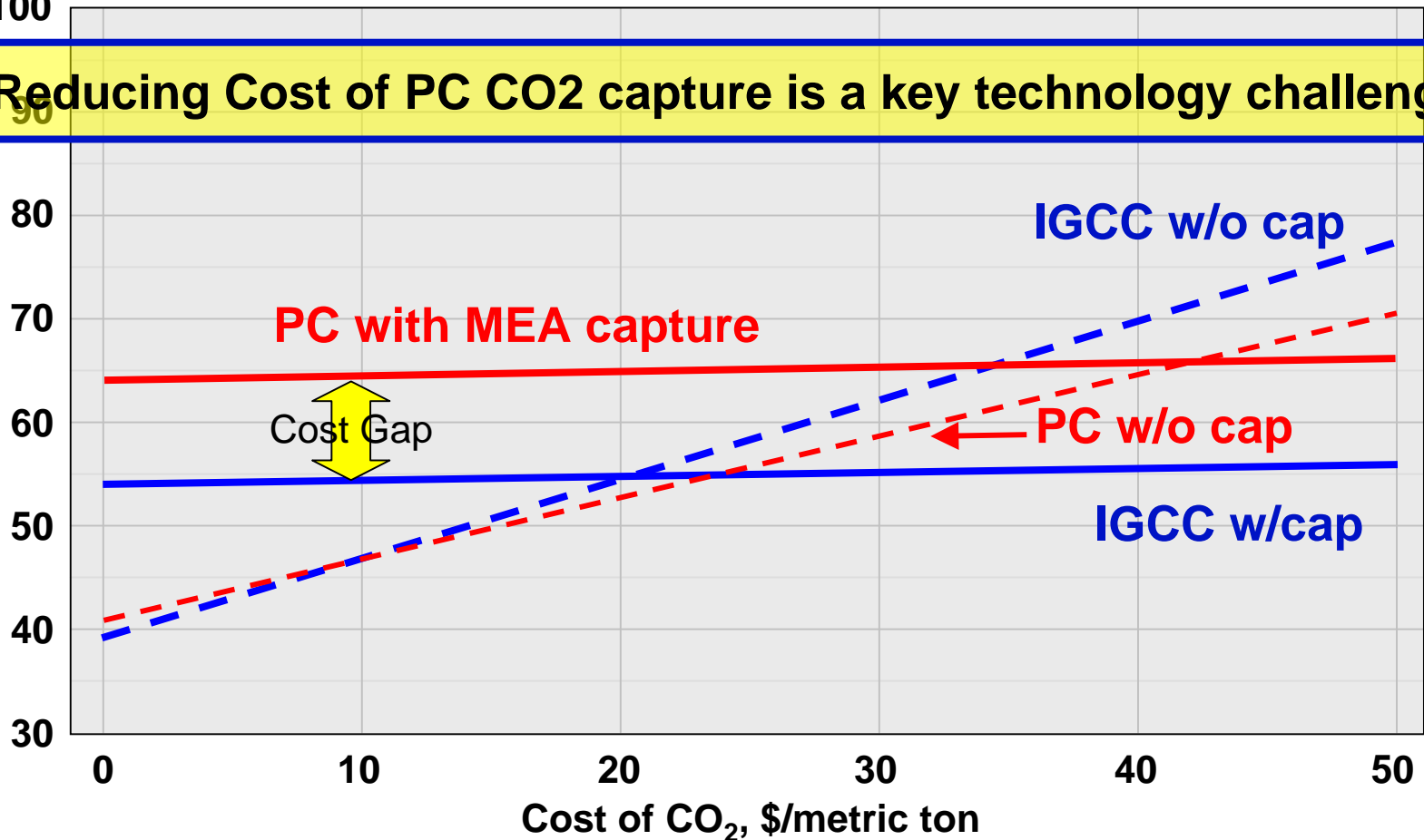
Coordinated Plan Avoids Duplication and Gaps

Comparison of IGCC and PC (2020)

Levelized Cost of Electricity, \$/MWh

100

Reducing Cost of PC CO₂ capture is a key technology challenge



EPRI CO₂ Capture Initiative

A multi-phase testing program to develop cost-effective and practical PC CO₂ capture technologies

Phase 1

- 5 MW Chilled Ammonia Pilot with Alstom
- Testing of other solvents or technologies
- Test materials to be used for compression, transport and injection of flue-gas CO₂

Phase 2

- 10-MW CO₂ Test Center (150 Tonnes/day)
- Capture and store CO₂ at substantial scale and real operating environments
- Future phases – larger demos to scale-up to full plant

Focused on closing the PC CO₂ capture cost gap

Closing Thoughts

- Four key uncertainties impacting near-term decisions on new generation:
 - Future cost of CO₂
 - Future price of natural gas
 - Spent nuclear fuel storage
 - CO₂ capture and storage
- Extraordinary opportunity to develop and demonstrate a very low emissions portfolio of generation technologies for operation by 2020.

Together...Shaping the Future of Electricity