



**EPRI**

ELECTRIC POWER  
RESEARCH INSTITUTE

# **Generation Technologies in a Carbon-constrained World**

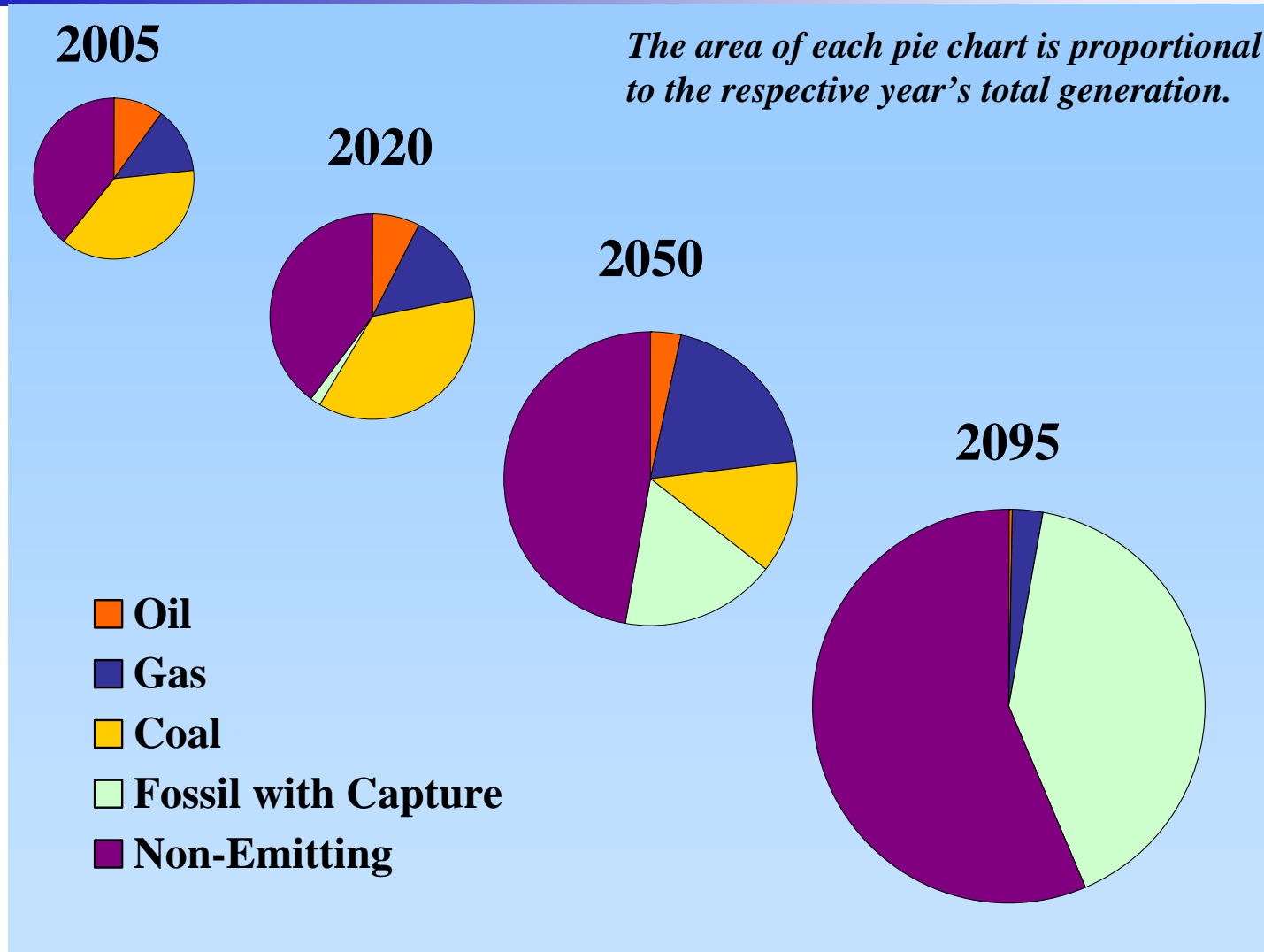
**Resources for the Future  
Policy Leadership Forum**

Washington, DC

March 30, 2006

**Steve Specker**  
President & CEO

# Global Generation Mix with 550 ppm CO<sub>2</sub> Limit



# Objective

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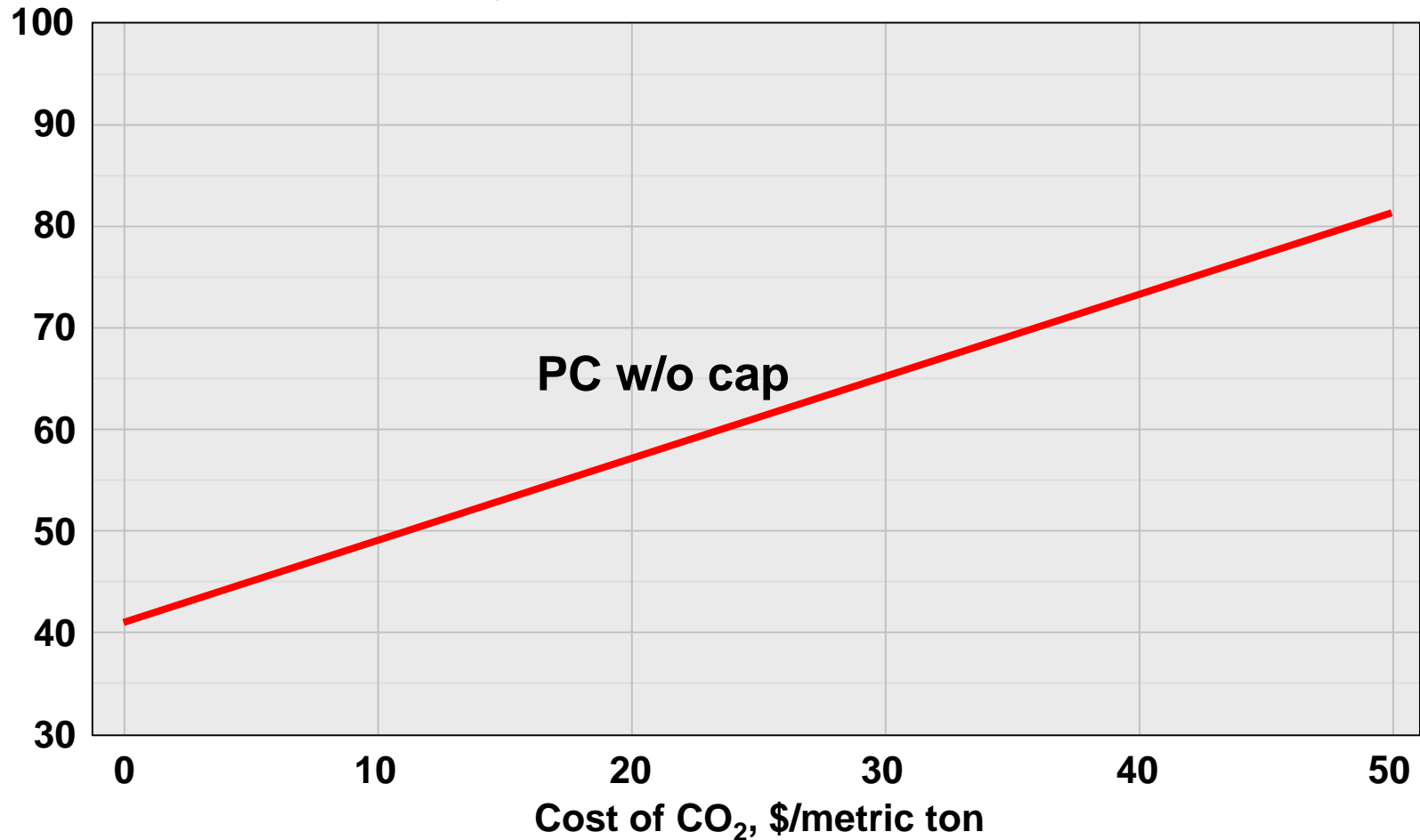
Provide an objective and factual framework for discussing generation technologies and investment decisions in a carbon-constrained world

# Framework Overview

- **Levelized cost of electricity**
  - Standard EPRI methodology
  - 2004 costs and \$'s
- **Two key uncertainties**
  - Future “cost” of CO<sub>2</sub>
  - Future price of natural gas
- **Two technology portfolios**
  - 2010 time-period
  - 2020 time-period

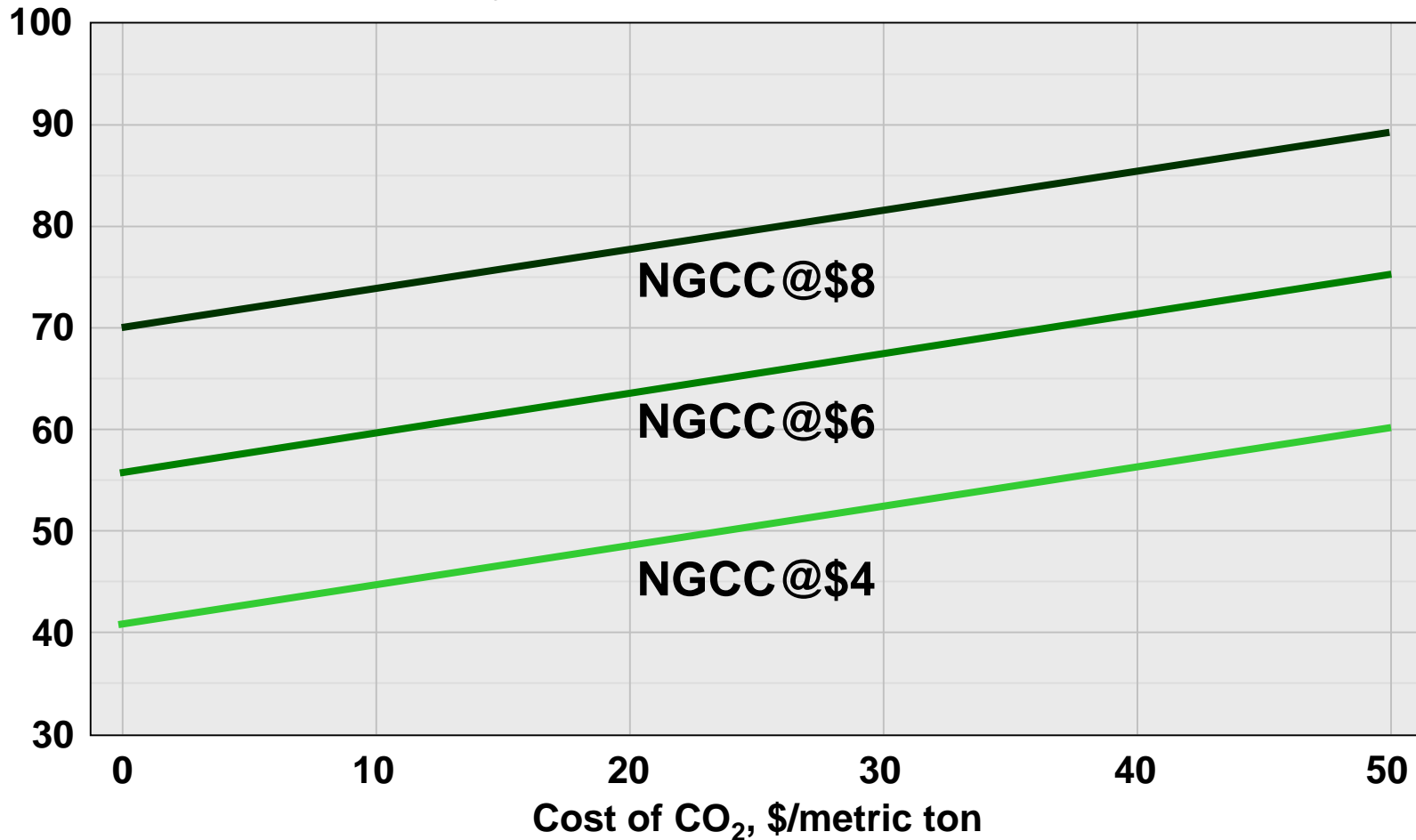
# Pulverized Coal in 2010 Time Period

Levelized Cost of Electricity, \$/MWh



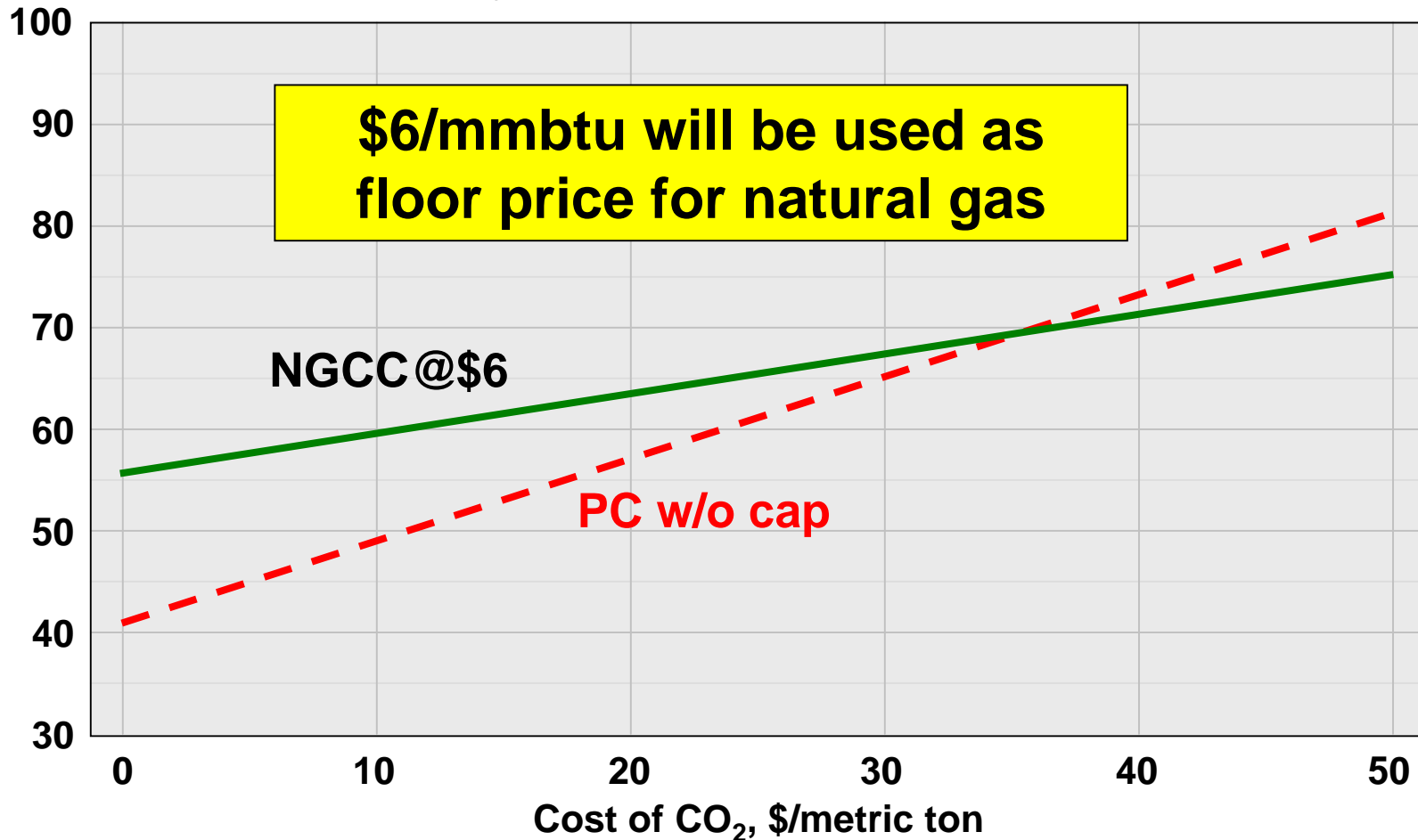
# Natural Gas Combined Cycle in 2010 Time Period

Levelized Cost of Electricity, \$/MWh



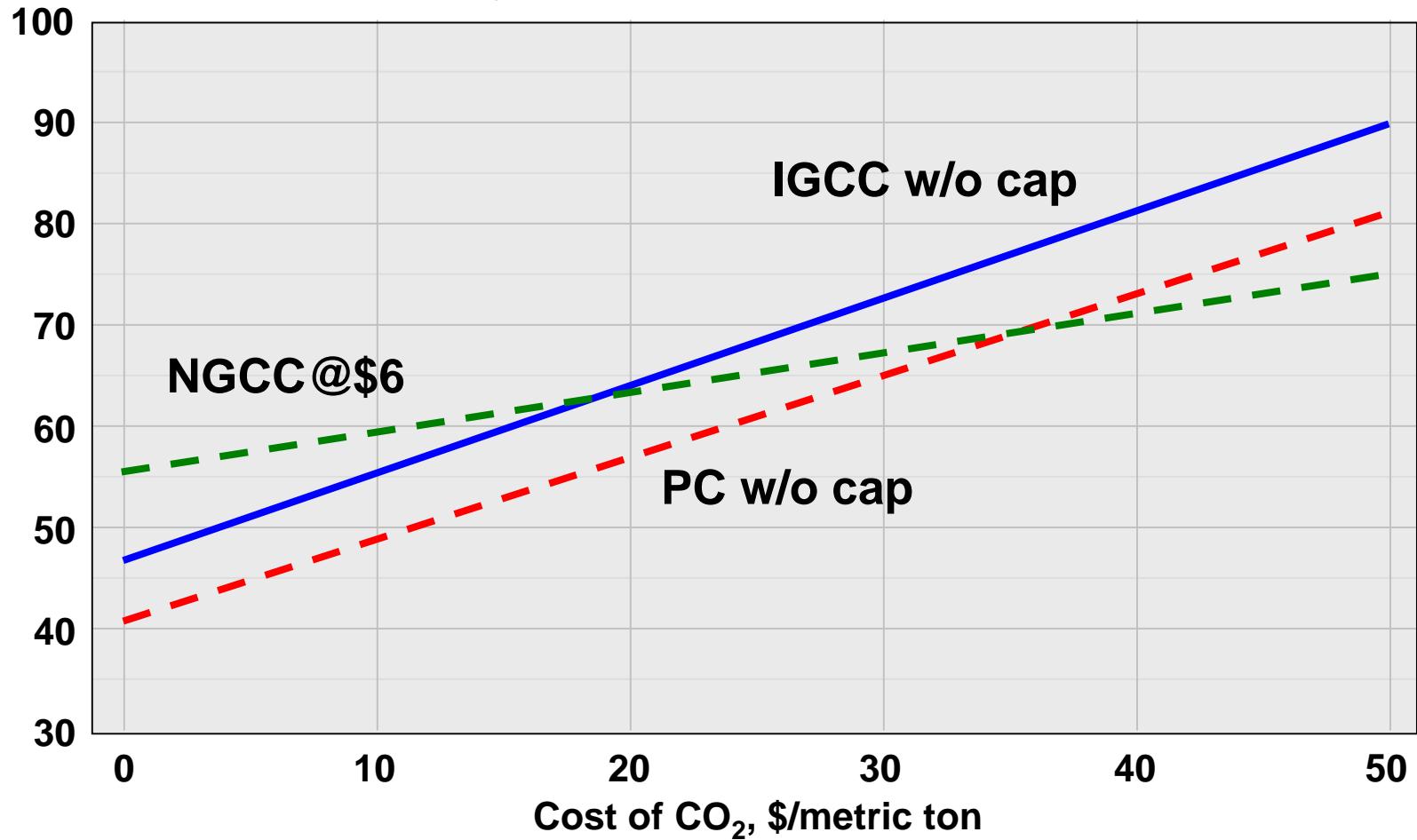
# Comparative Costs of 2010 Generating Options

Levelized Cost of Electricity, \$/MWh

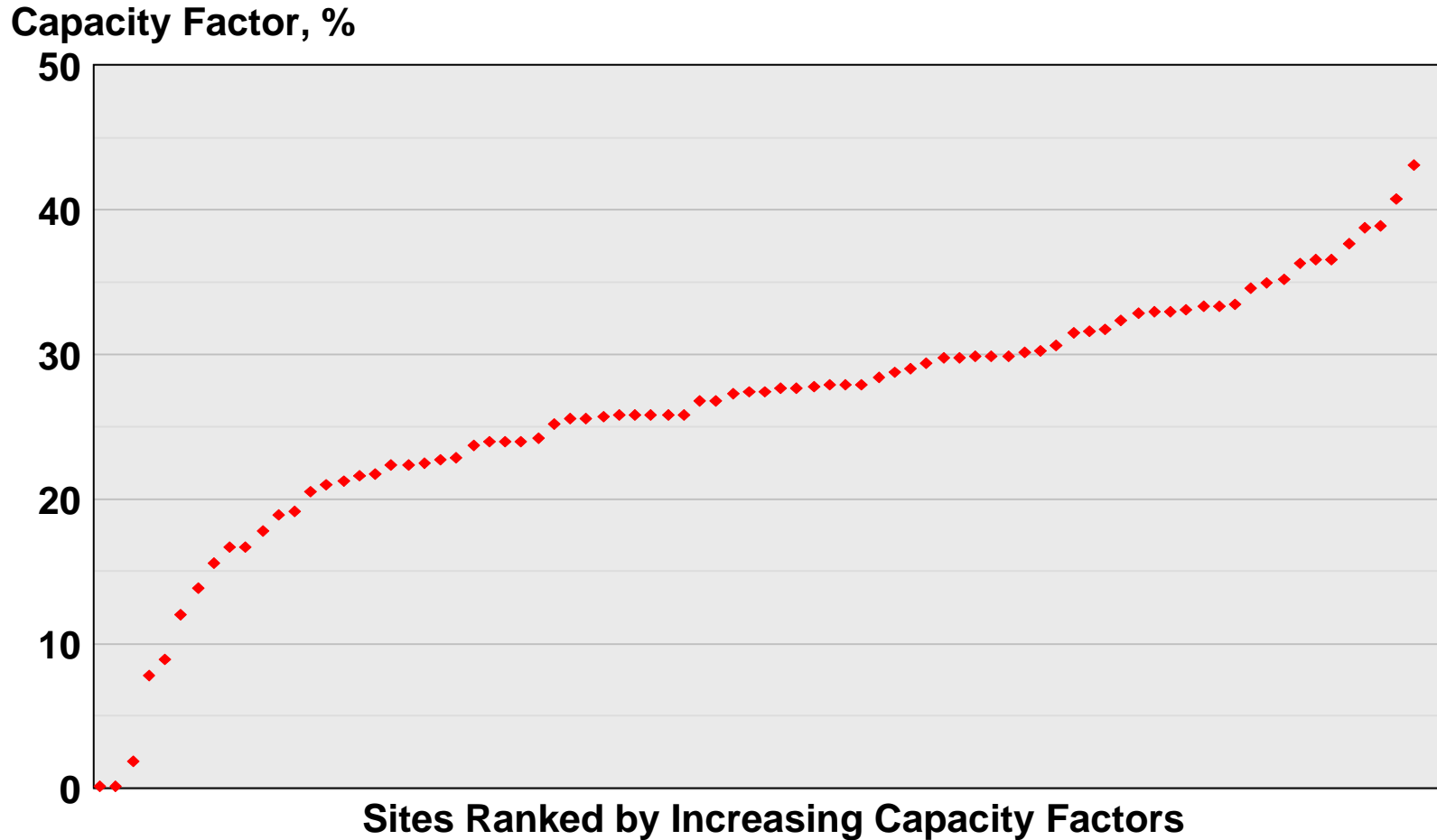


# Integrated Gasification Combined Cycle in 2010

Levelized Cost of Electricity, \$/MWh



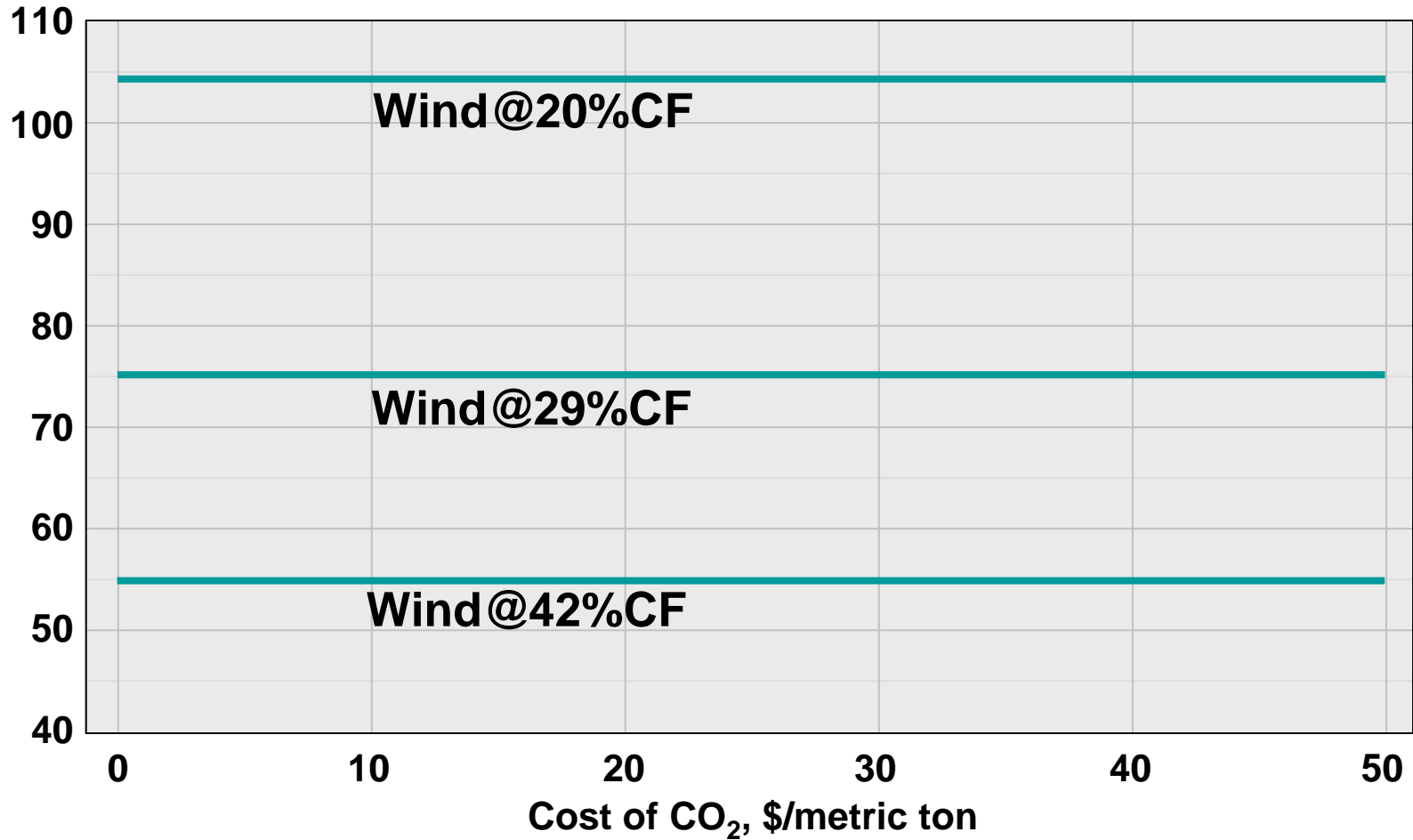
# U.S. Wind Plant Capacity Factors, 2004



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

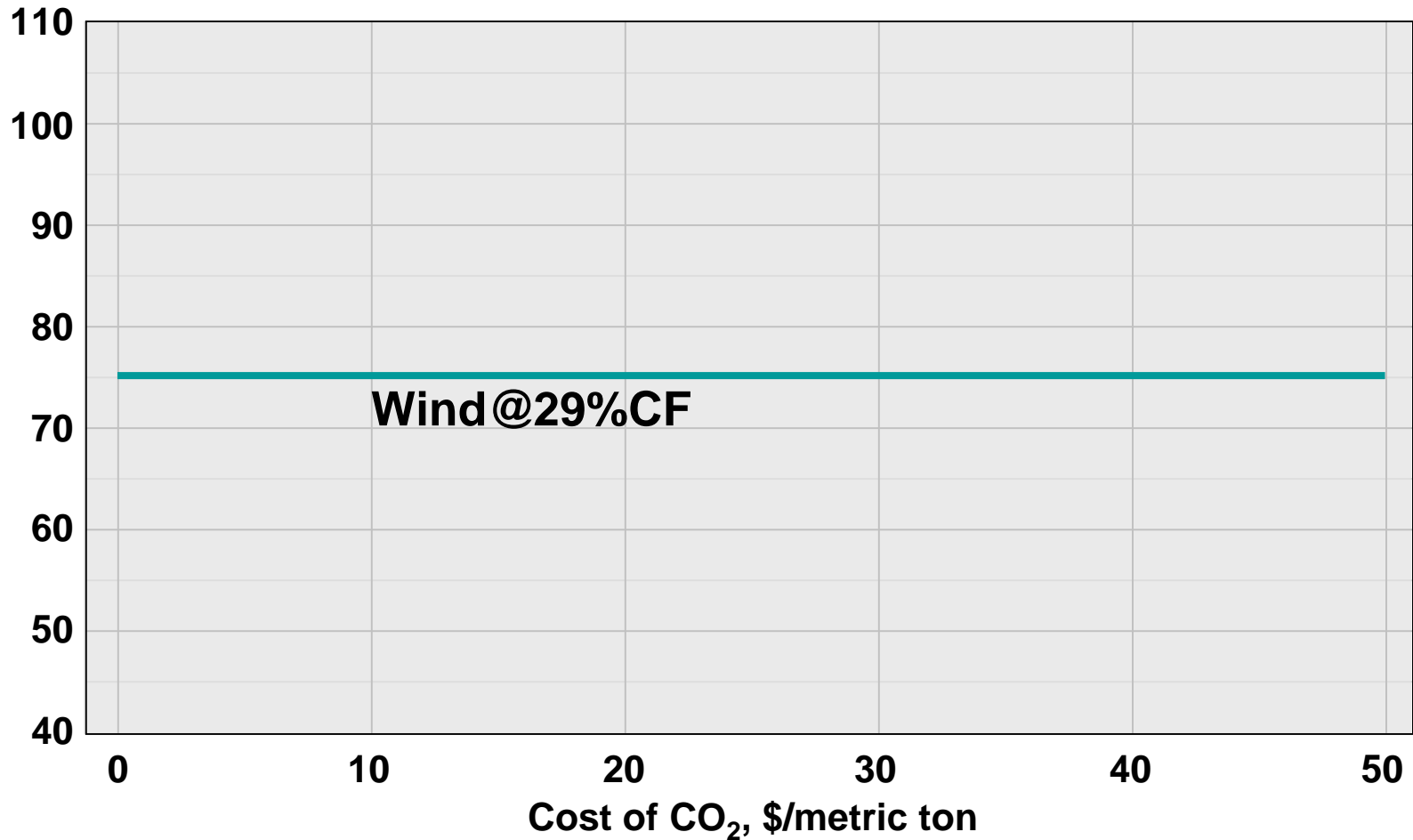
# Wind Generation in 2010 Time Period

Levelized Cost of Electricity, \$/MWh



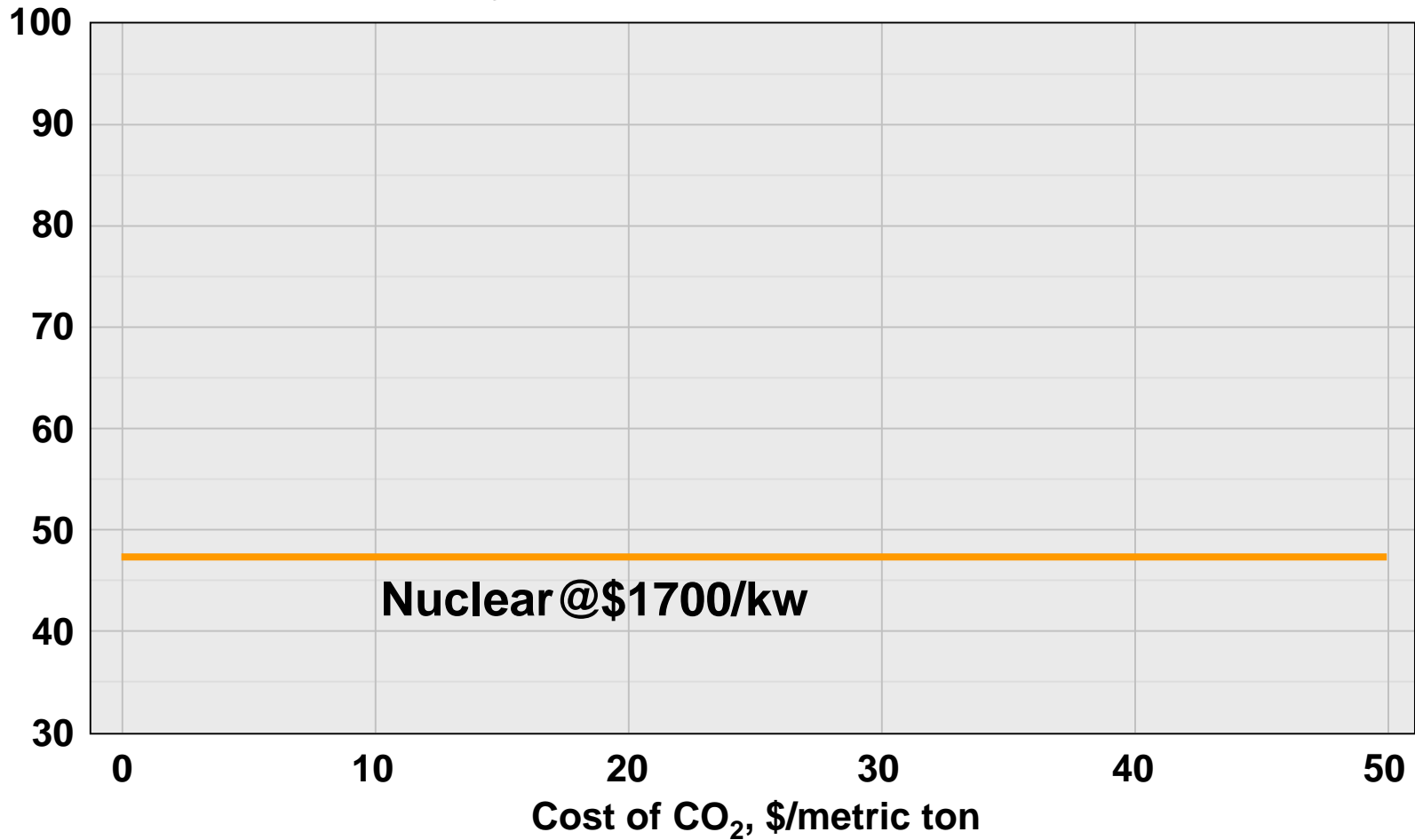
# Wind Generation in 2010 Time Period

Levelized Cost of Electricity, \$/MWh



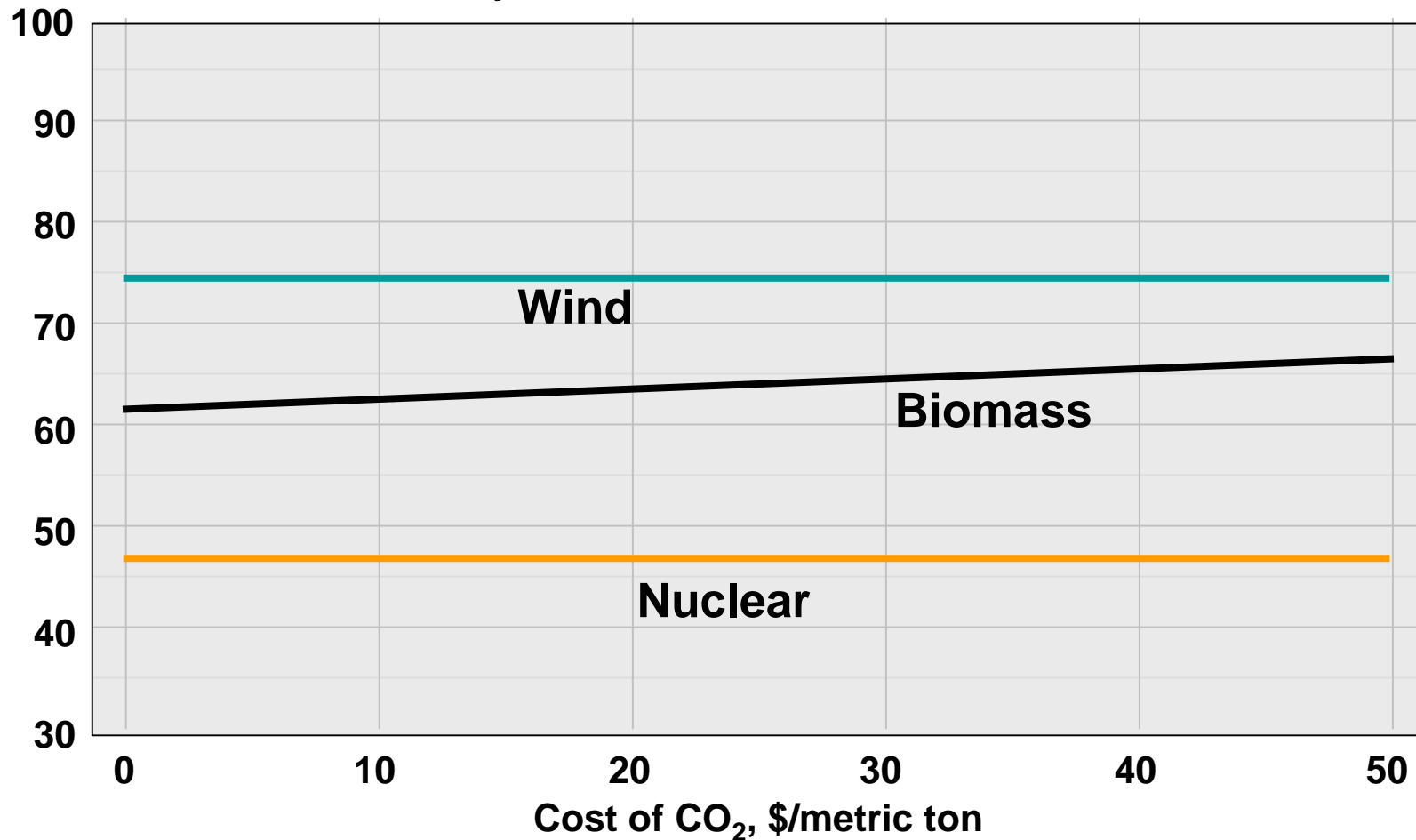
# Nuclear Generation

Levelized Cost of Electricity, \$/MWh



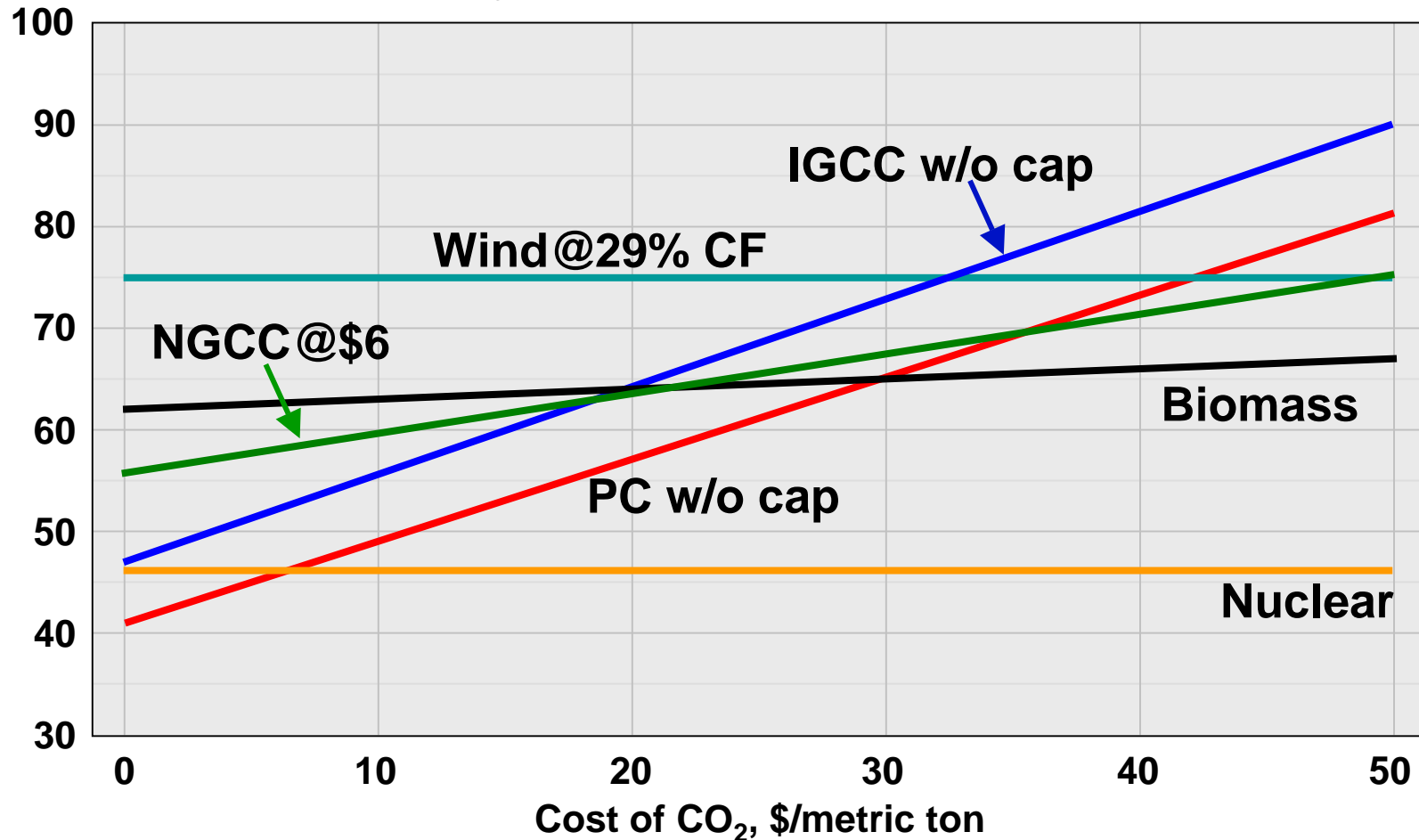
# Non-CO<sub>2</sub> Emitting Technologies in 2010 Time Period

Levelized Cost of Electricity, \$/MWh



# Comparative Costs of 2010 Generating Options

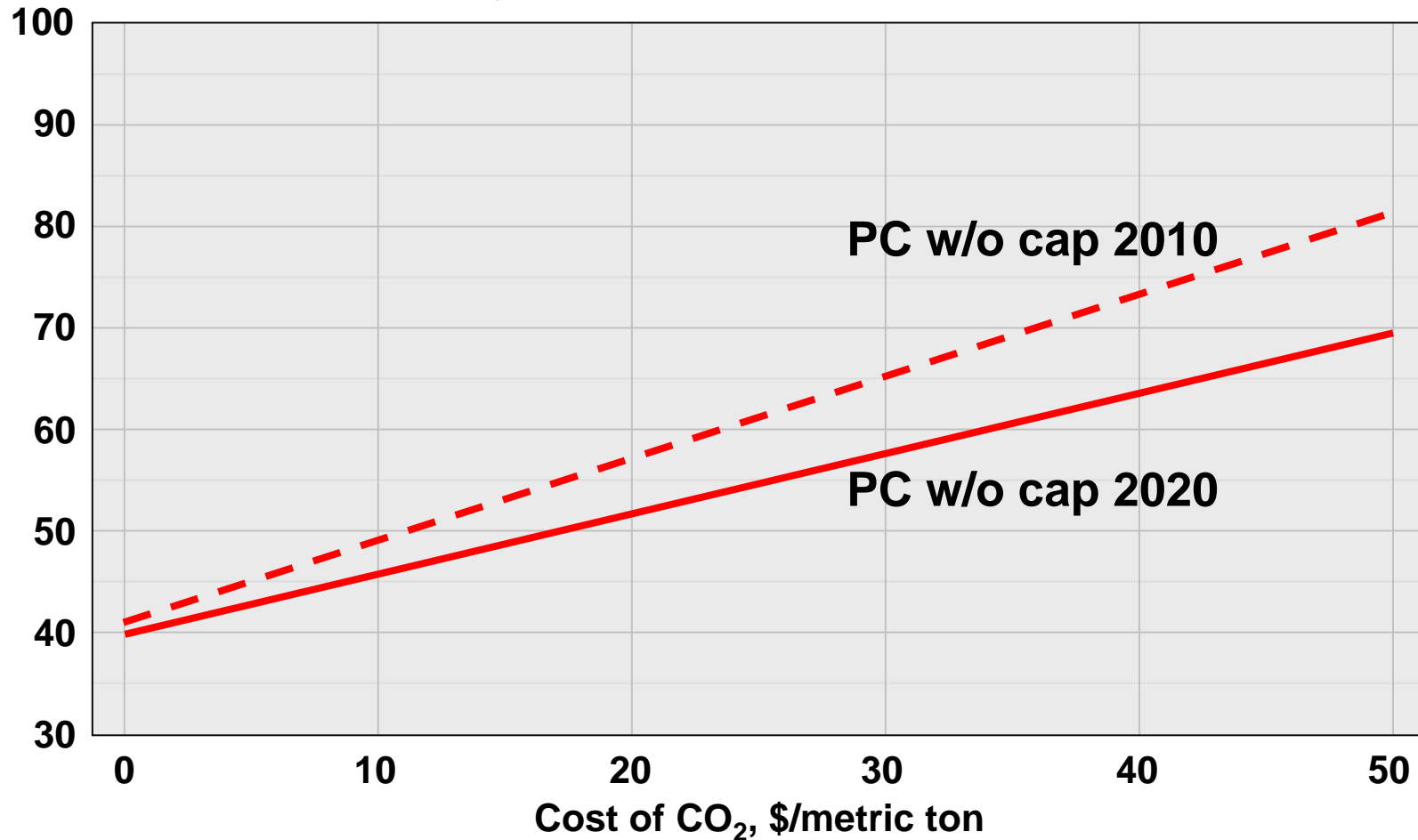
Levelized Cost of Electricity, \$/MWh



# What's Possible in 2020

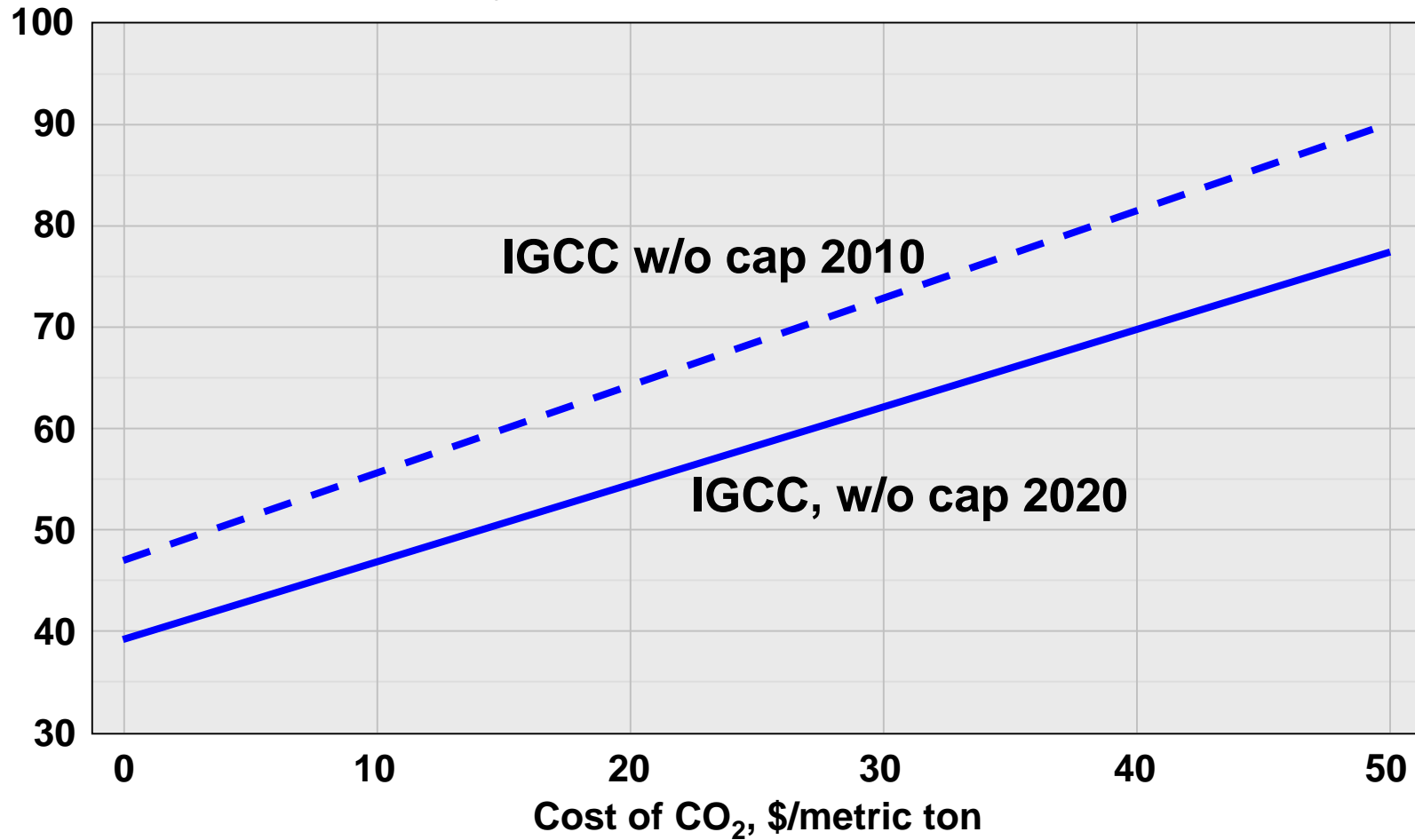
# Pulverized Coal w/o Capture

Levelized Cost of Electricity, \$/MWh



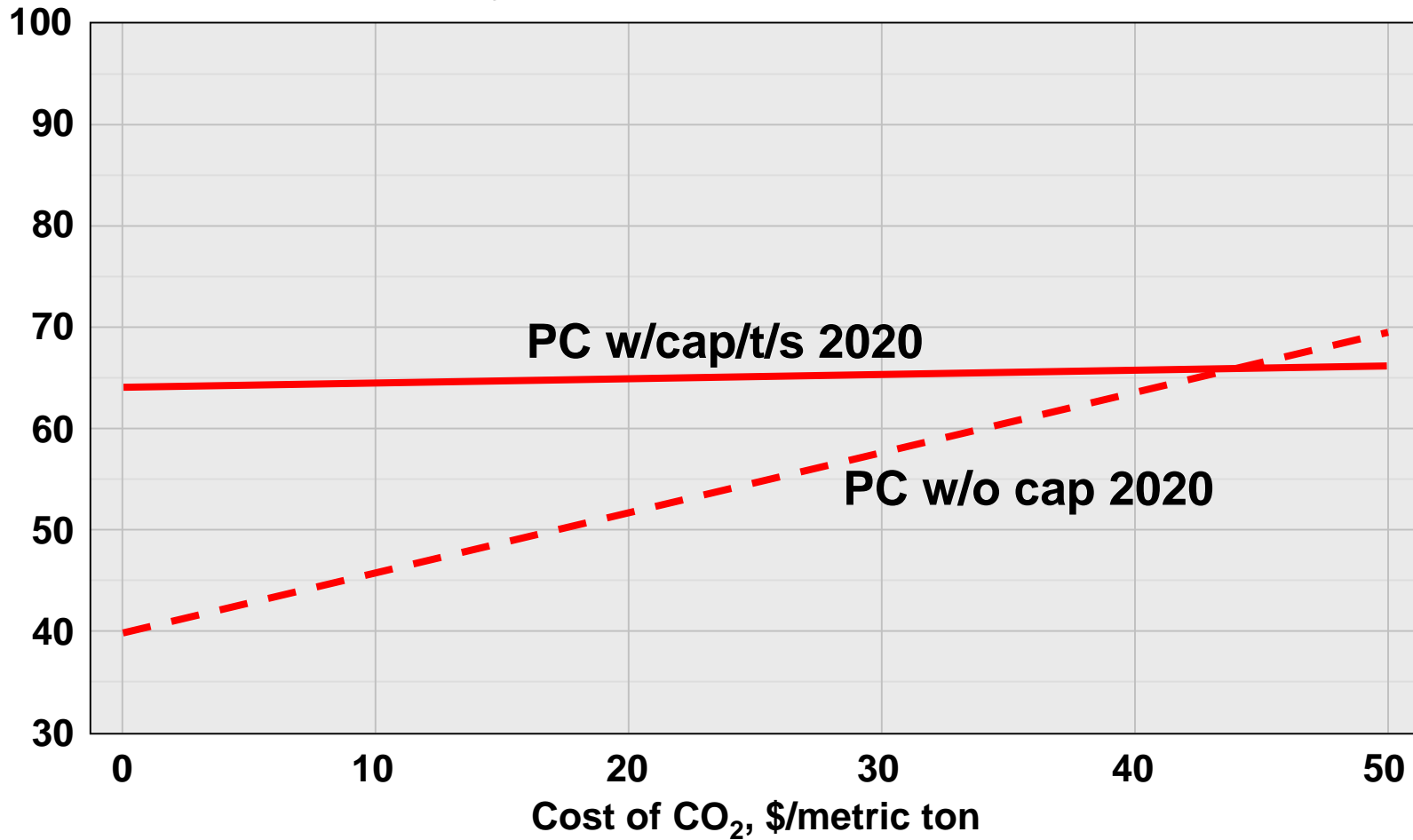
# IGCC w/o Capture

Levelized Cost of Electricity, \$/MWh



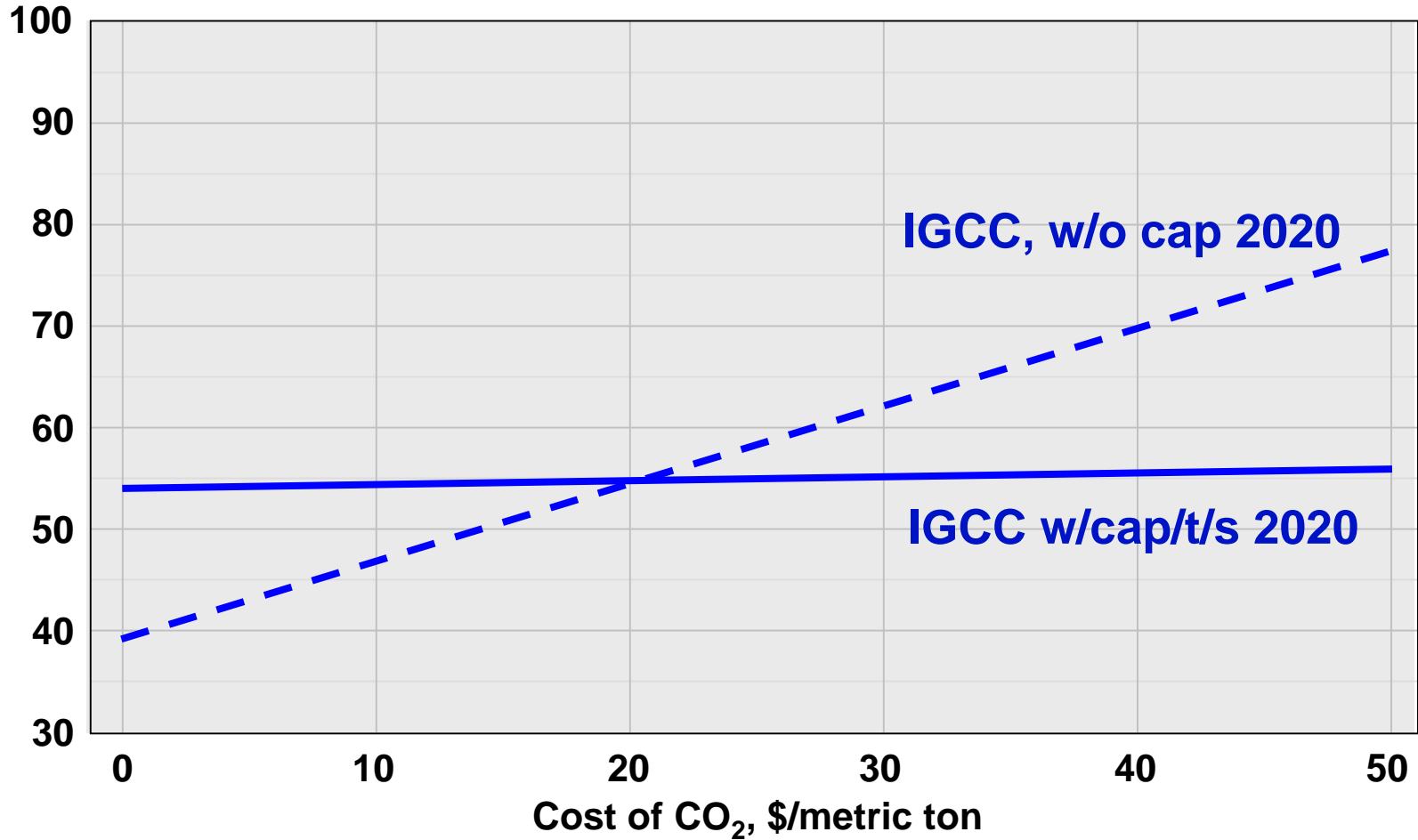
# PC with capture/transport/storage

Levelized Cost of Electricity, \$/MWh



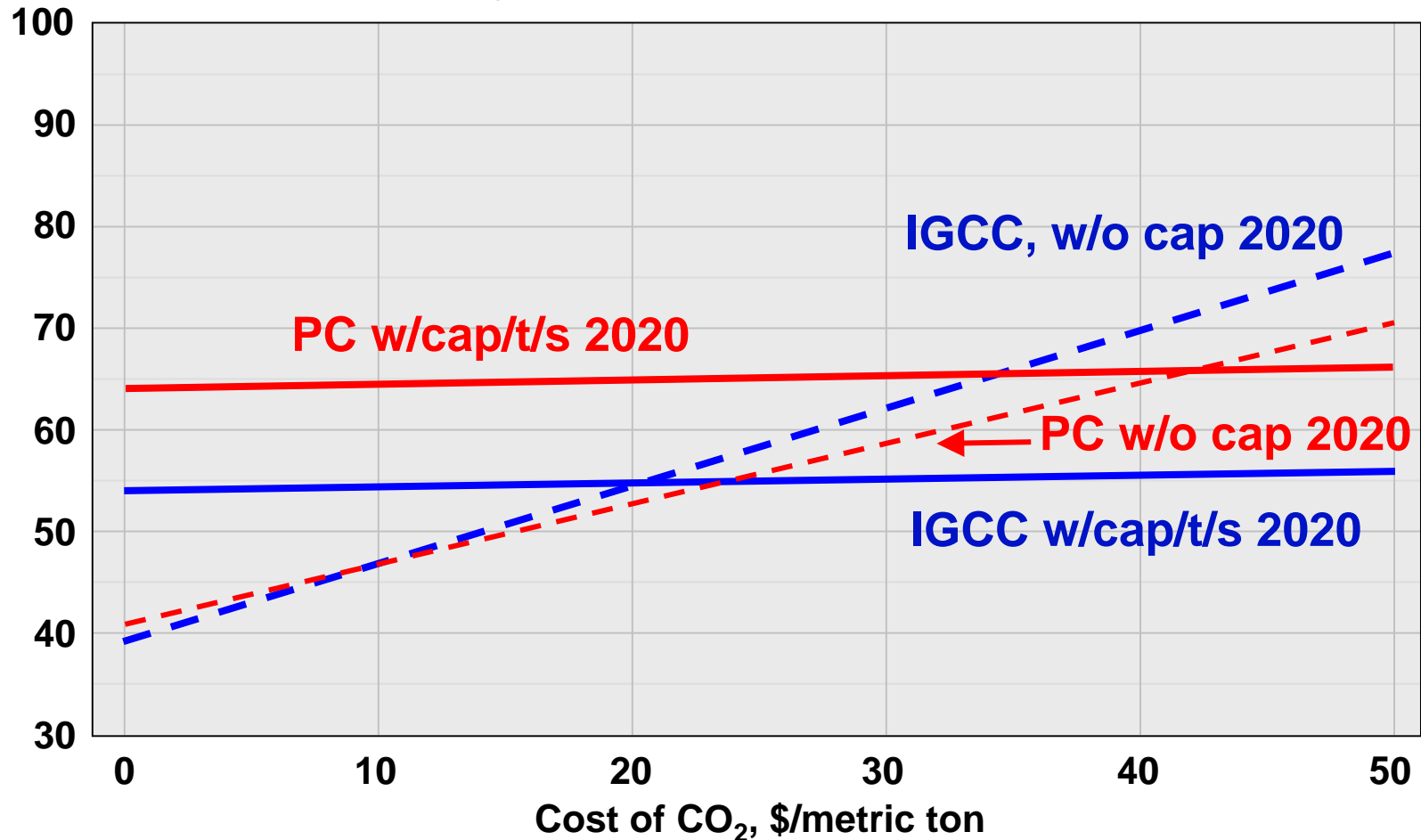
# IGCC with capture/transport/storage

Levelized Cost of Electricity, \$/MWh



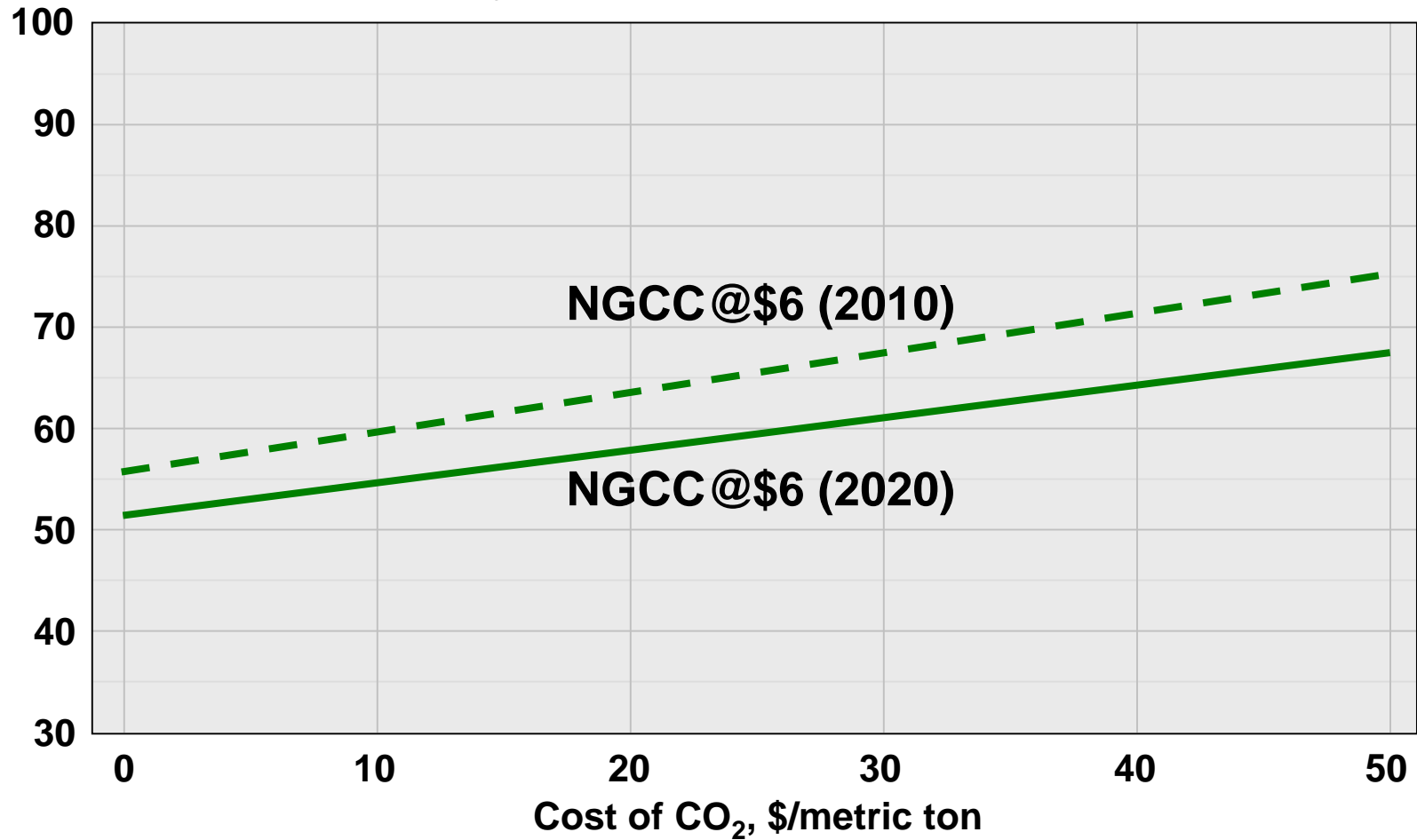
# Comparison of IGCC and PC

Levelized Cost of Electricity, \$/MWh



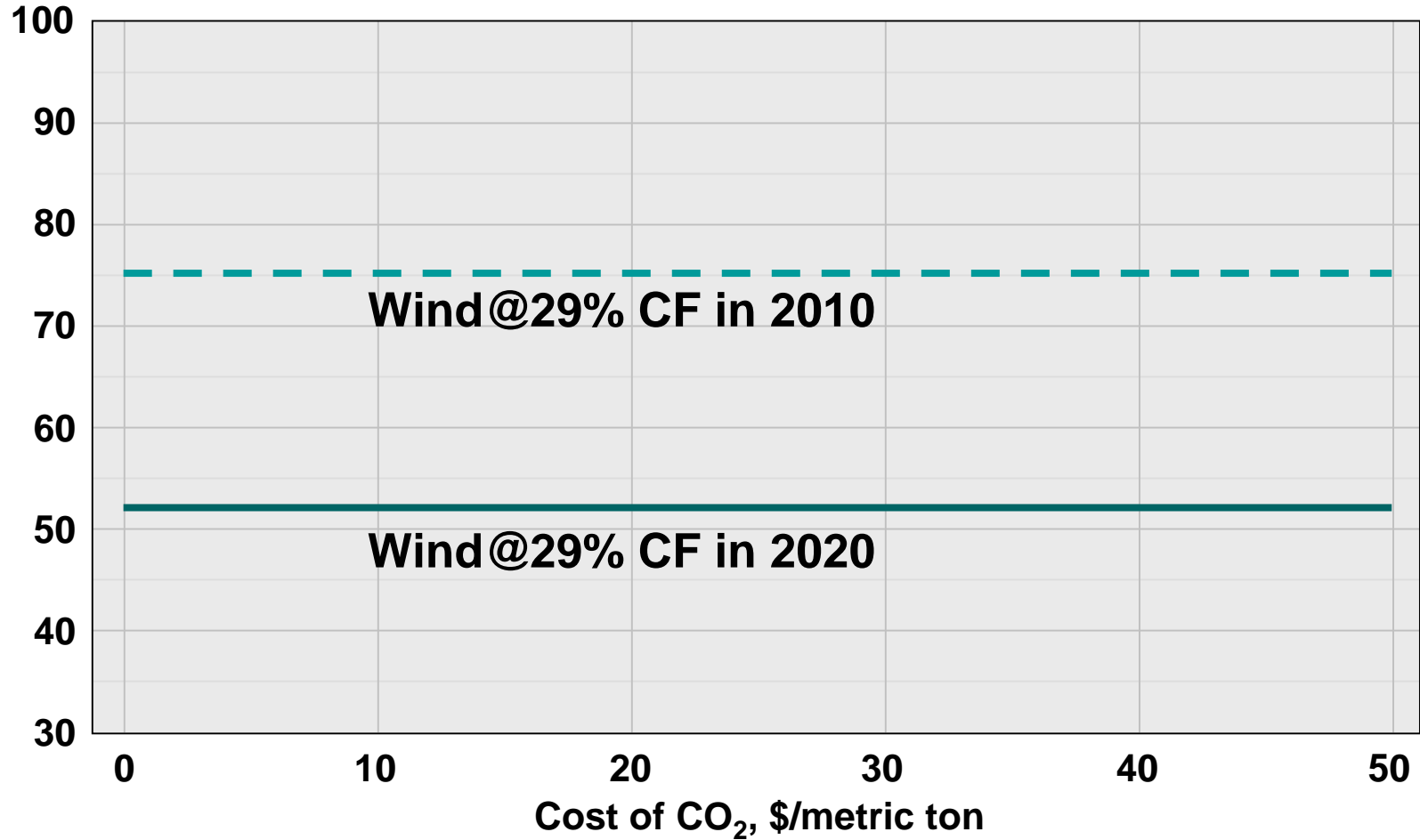
# Natural Gas Combined Cycle

Levelized Cost of Electricity, \$/MWh



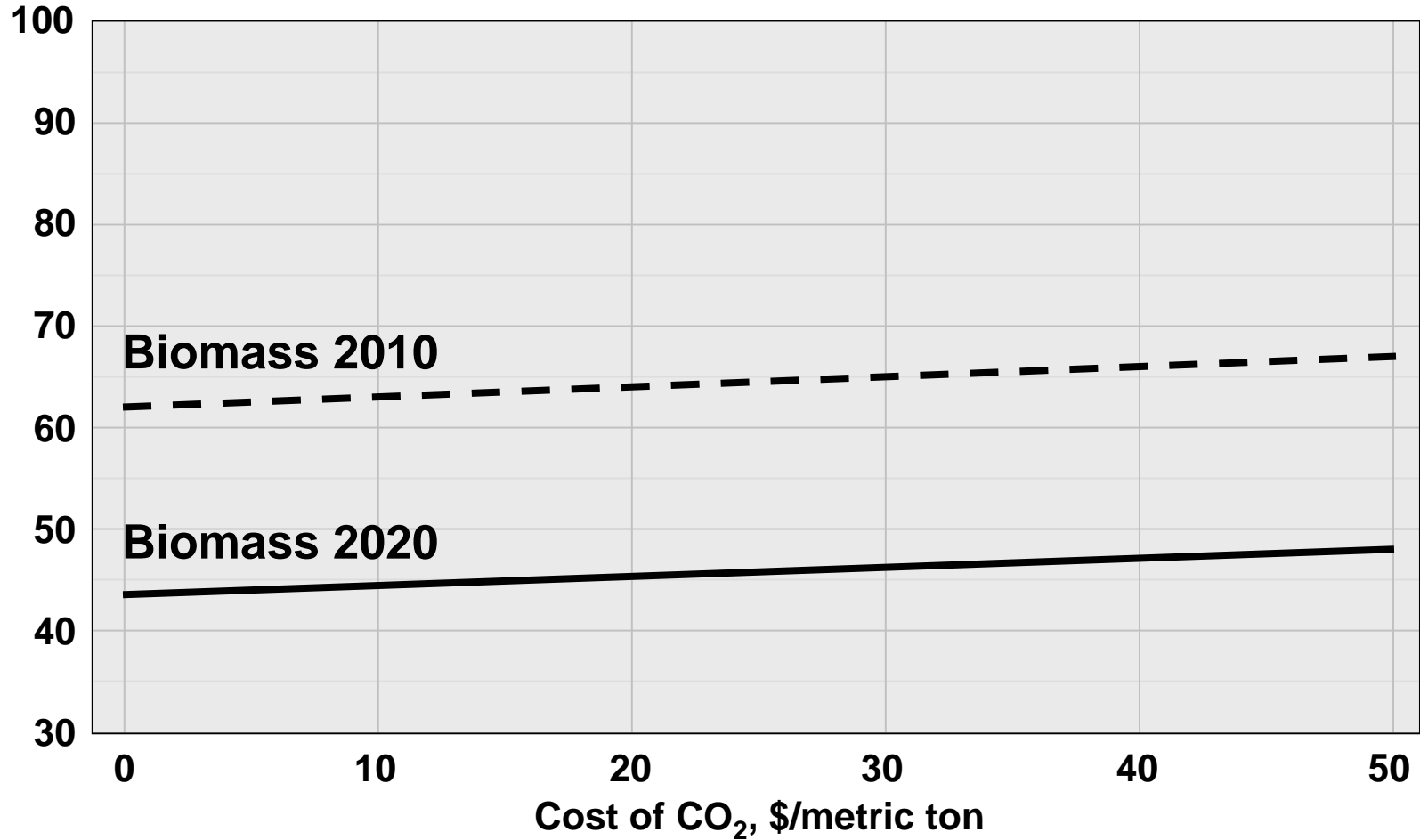
# Wind Generation

Levelized Cost of Electricity, \$/MWh



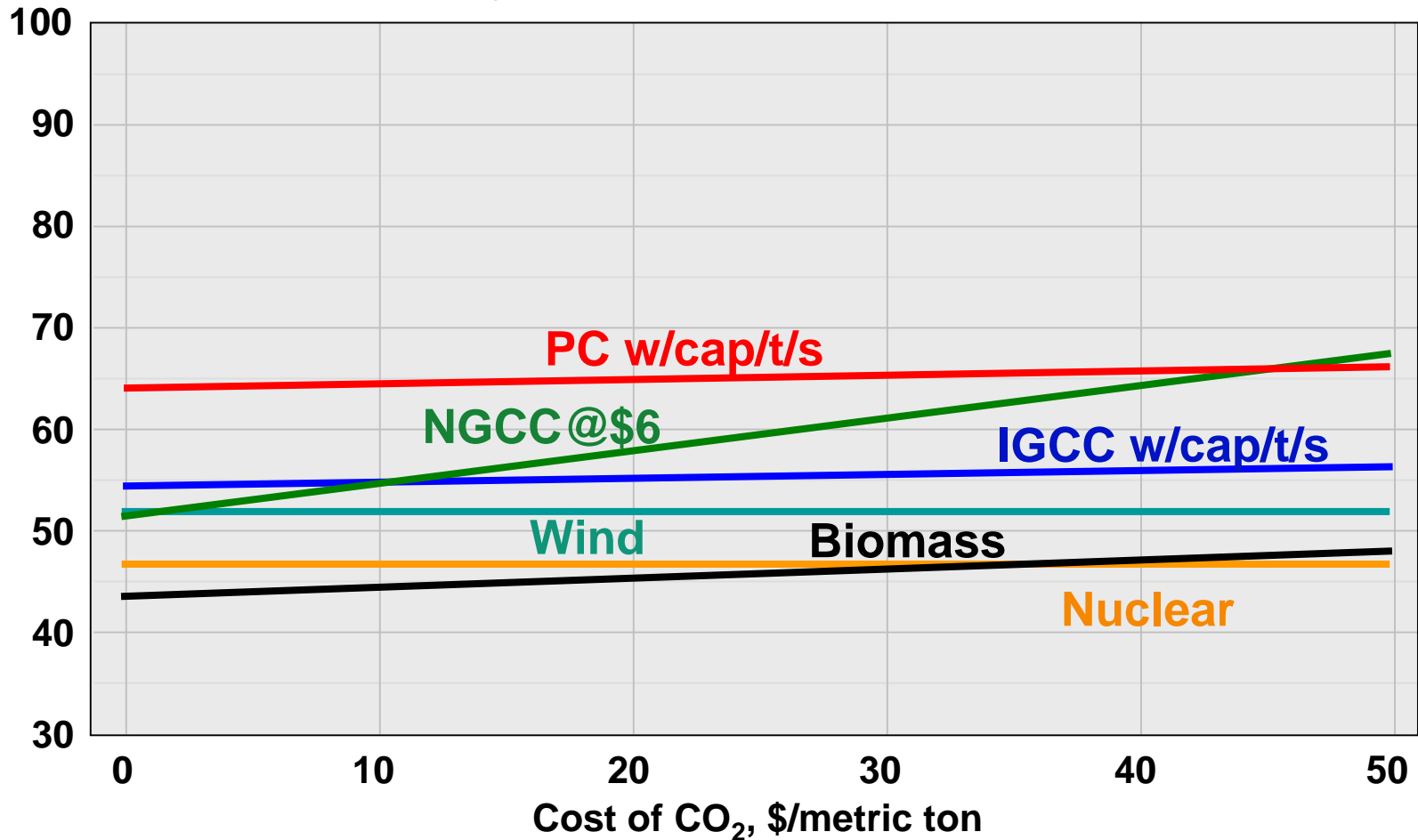
# Biomass

Levelized Cost of Electricity, \$/MWh



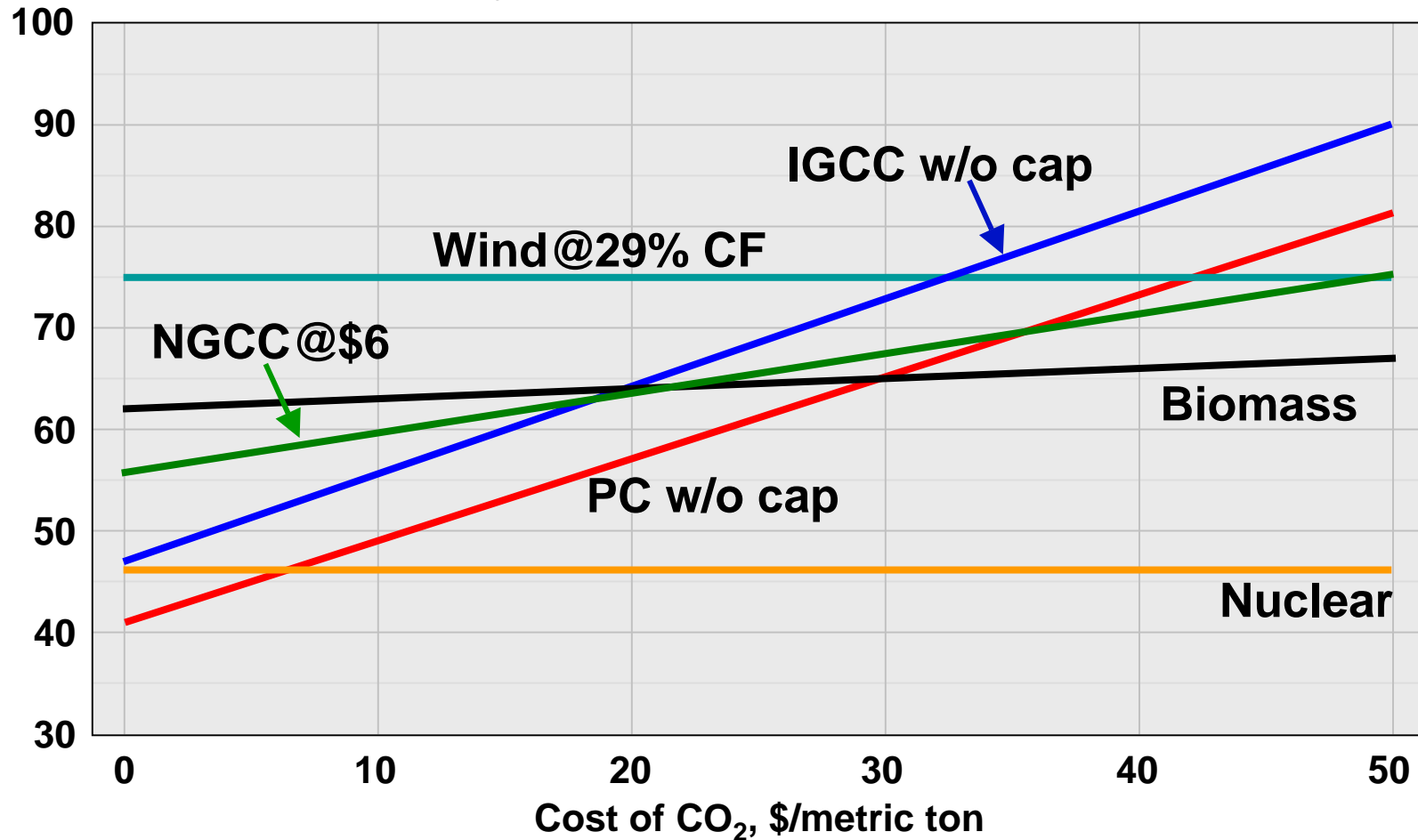
# Comparative Costs in 2020

Levelized Cost of Electricity, \$/MWh



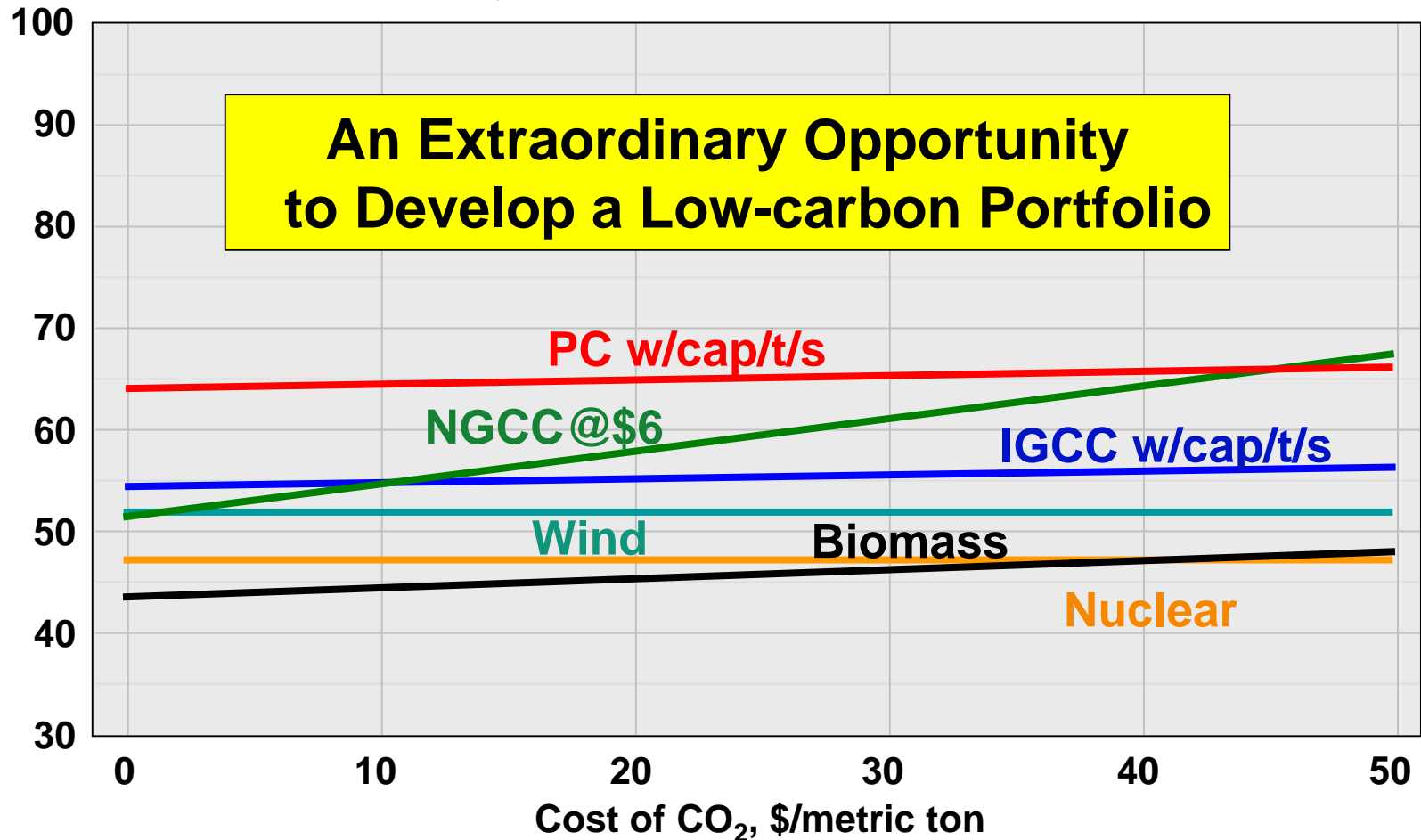
# Comparative Costs in 2010

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 CO<sub>2</sub> capture and deep geologic storage**
- **Advanced Pulverized Coal (PC) with post combustion CO<sub>2</sub> capture and deep geologic storage**
- **Advanced circulating fluidized bed with post combustion CO<sub>2</sub> capture and deep geologic storage**

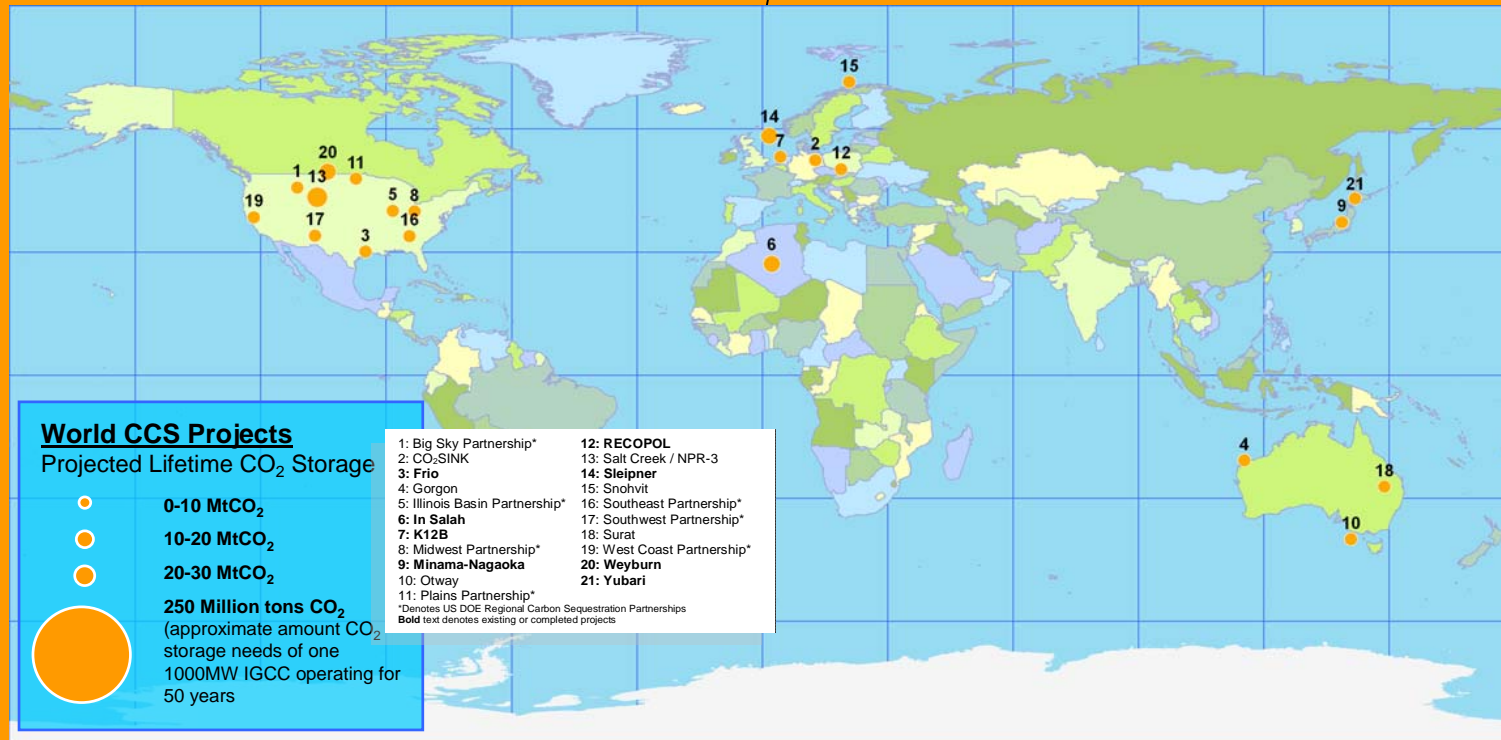
**All technologies required to meet future generation needs**

# CCS Deployment

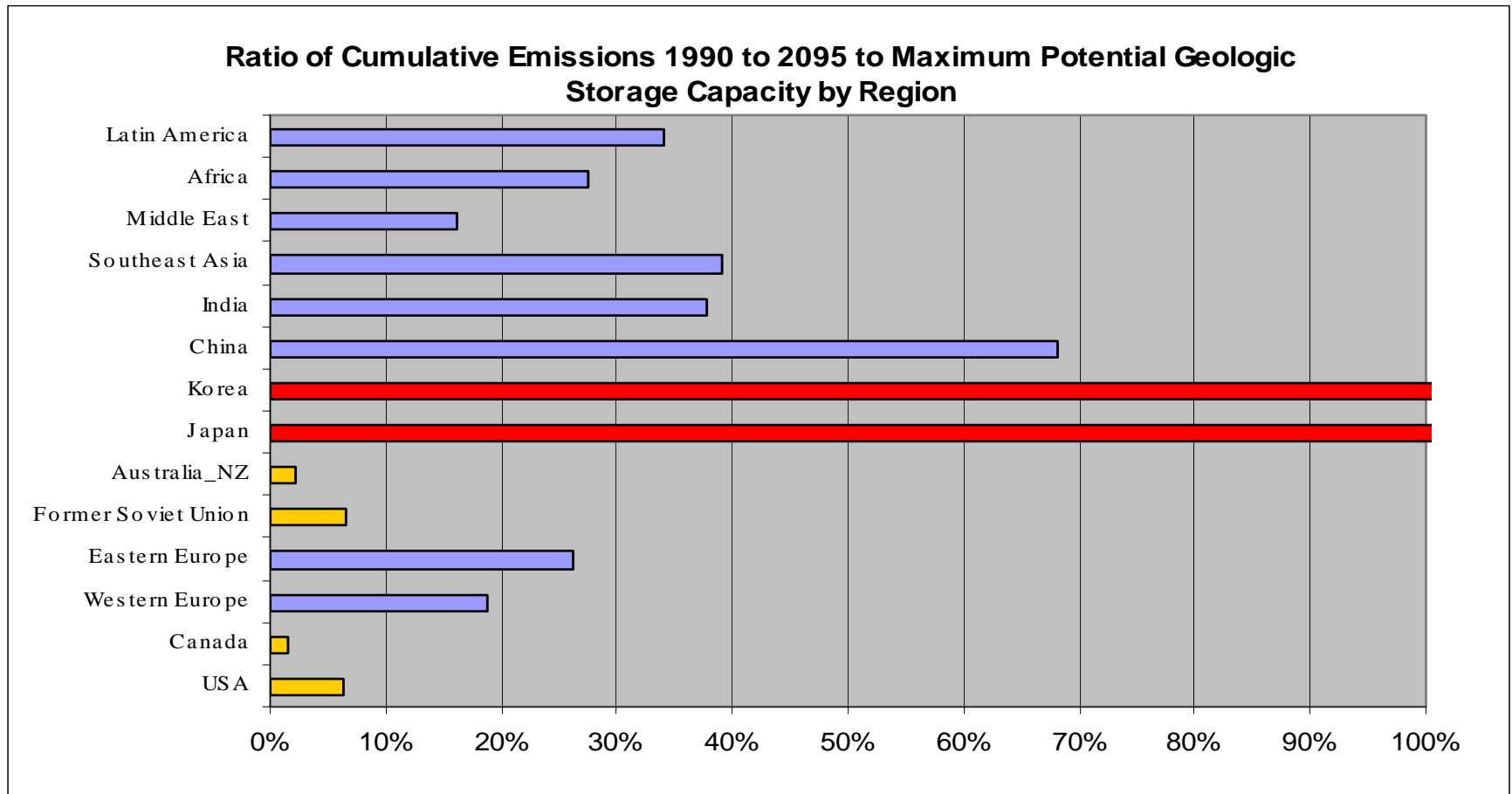
*Today and 2050 (on 550 ppmv path)*

Cumulative Global  
2005-2050  
CCS Deployment  
30,000 MtCO<sub>2</sub>

Cumulative USA  
(2005-2050)  
CCS Deployment  
8,000 MtCO<sub>2</sub>



# Potential Geologic CO<sub>2</sub> Storage Capacity



**U.S. has abundant coal resources and ample CO<sub>2</sub> 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 CO<sub>2</sub> capture capability/convertibility

- **FutureGen Alliance**

- A “living laboratory” for advancing IGCC technology and associated CO<sub>2</sub> capture technology and hydrogen co-production
- Demonstration of large-scale storage of “gasification power plant” CO<sub>2</sub>

- **EPRI CO<sub>2</sub> Capture Initiative**

- Focused on developing advanced post-combustion CO<sub>2</sub> capture technology for PC plants
- Understanding issues and demonstrating storage of CO<sub>2</sub> from combustion

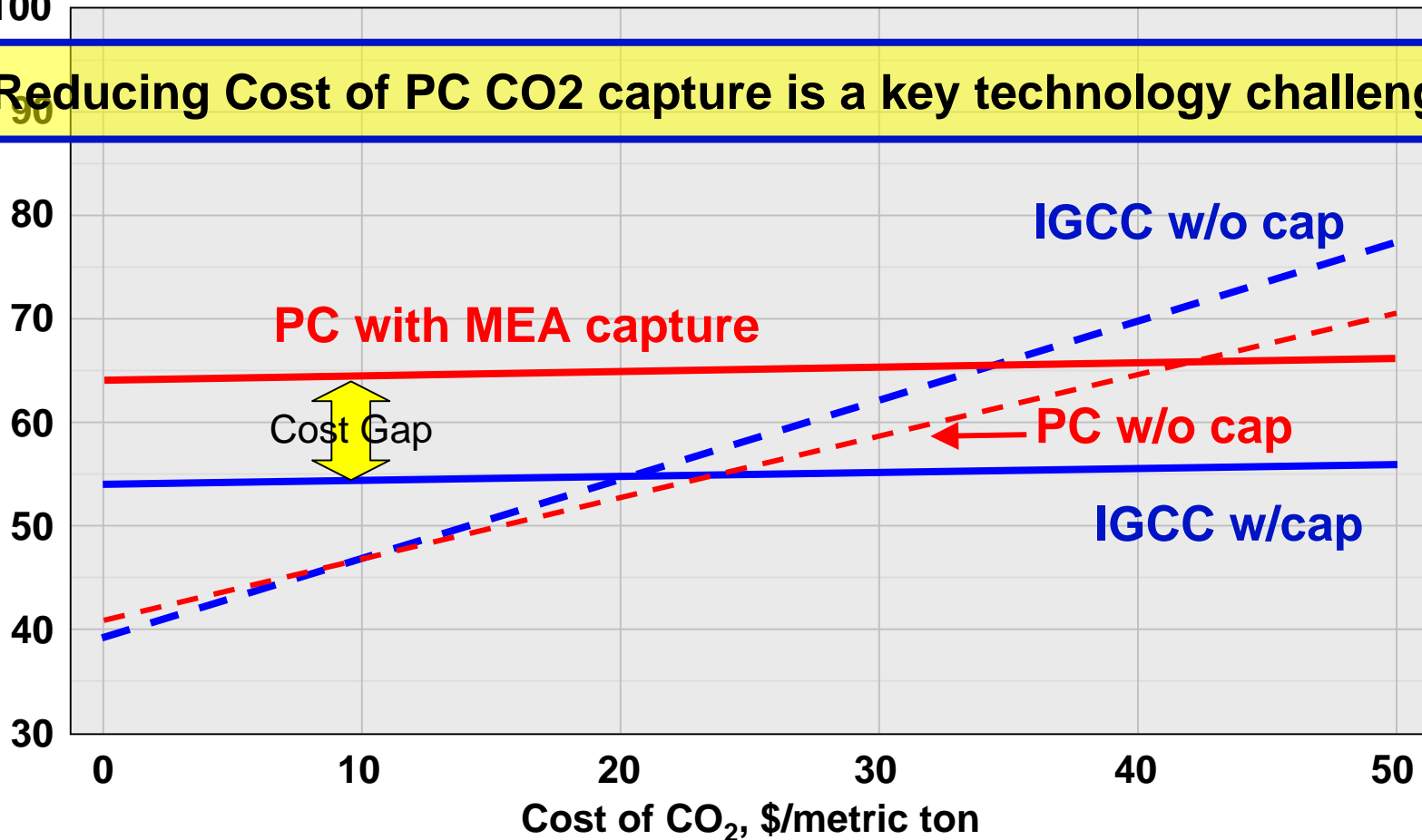
**Coordinated Plan Avoids Duplication and Gaps**

# Comparison of IGCC and PC (2020)

Levelized Cost of Electricity, \$/MWh

100

Reducing Cost of PC CO<sub>2</sub> capture is a key technology challenge



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

A multi-phase testing program to develop cost-effective and practical PC CO<sub>2</sub> 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 CO<sub>2</sub>

## Phase 2

- 10-MW CO<sub>2</sub> Test Center (150 Tonnes/day)
- Capture and store CO<sub>2</sub> at substantial scale and real operating environments
- Future phases – larger demos to scale-up to full plant

Focused on closing the PC CO<sub>2</sub> capture cost gap

# Closing Thoughts

- Four key uncertainties impacting near-term decisions on new generation:
  - Future cost of CO<sub>2</sub>
  - Future price of natural gas
  - Spent nuclear fuel storage
  - CO<sub>2</sub> 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**