Energy Generation Planning in 2015 and 2025

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To:
NCSL Task Force on Energy Supply
Tampa, FL

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The Electric Power Research Institute

Objective & Independent Research on

- Renewable, Nuclear & Fossil Generation
- Energy Efficiency & Utilization
- Transmission & Distribution
- Environmental Studies

- Over 500 Engineers & Scientists
- 460 Research Participants from over 40 Countries
- ~$350M annual funding
Three factors influence power generation decisions

- **Affordability**… current & projected all-in cost
- **Reliability**… grid impact
- **Environmentally Responsible**… land/water use & environmental impact
Basis for Presentation

“Program on Technology Innovation: Integrated Generation Technology Options”

• June 2011
Objectives of Report

• Provide **generic basis for comparison** of technologies for **base load generation**.

• Provide **strategic comparisons** of technologies over **plant lifetimes**.

• **Evaluate sensitivities** of **levelized cost of electricity (LCOE)** to potential **CO₂ costs & other parameters**.
Analytical Basis

• Used EPRI capital cost data & methodologies to calculate LCOEs.

• **Key assumptions:** capital cost, fuel cost, fixed & variable O&M, plant life, fuel type & energy content, cost of money.

• **No** production or investment tax credits assumed for any technologies.
Analytical Basis, con’t.

• Assumed current technology parameters & costs representative of 2011–2015.

• Mercury, SO$_x$/H$_2$S & NO$_x$ removal included in SCPC & IGCC Technologies.

• NO$_x$ removal included in NGCC Technology.
Capital Cost Estimating Approach

- Costs are to be reported in reference year $ (December 2010):
  - No cost escalation to startup date included
- Plant site clear & level
- Cost estimate assumes mature technology:
  - Plant assumed to operate as designed (no allowance for field modifications)
  - Extra costs for 1st-of-a-kind demonstration not included
Cost Basis

Total Capital Requirement (TCR) - “All-In” Costs

Sum of:

1. **Total Plant Cost (TPC):**
   - **Overnight Capital Costs:** Engineering, Procurement, & Construction (EPC)
   - All process & support facilities

2. **Owner’s Costs:**
   - Pre-production costs, working capital, land, license fees, interest during construction

3. **Project-specific Costs:**
   - Project development, utility interconnections, legal/financial consulting, owner’s project management
Technology Assumptions

• **Near Term** – 2010 to 2015
  – Modest extrapolation of today’s technology.
  – Based on foreseeable technology development.

• **Longer Term** – 2020 to 2025
  – Assume established R&D objectives are achieved, & technology development is successful.
  – Estimated reductions in costs are based on assessment of potential technology improvements.
Slide Explanations

• **Individual technology slides**
  – Shaded region: range of LCOEs
  – Solid line: median
  – Solid line & dashed line: upper & lower bounds of fuel price, respectively

• **Technology summary slides**
  – NGCC & biomass LCOE is presented as shaded region, reflecting wide range of fuel prices
  – Solar PV not included for 2015 and 2025 due to high LCOE
Near-Term: 2015
Supercritical Pulverized Coal (SCPC) – 2015

Levelized Cost of Electricity, $/MWh

All-in Capital Costs: $ 2,400 – 2,760 / kW
Fuel Costs: $ 1.8 – 2.0 / MMBtu

0.84 Metric Tons CO₂/MWh
X $50/Ton = +$42/MWh

All costs are in December 2010 $
Integrated Gasification Combined Cycle (IGCC) Coal – 2015

Levelized Cost of Electricity, $/MWh

All-in Capital Costs: $ 3,150 – 3,450 / kW
Fuel Costs: $ 1.8 – 2.0 / MMBtu

0.86 Metric Tons CO₂/MWh
X $50/Ton = +$43/MWh

All costs are in December 2010 $
SCPC & IGCC Comparison 2015

Levelized Cost of Electricity, $/MWh

All costs are in December 2010 $
Natural Gas Combined Cycle (NGCC) Fuel Cost Sensitivity Comparison – 2015

Levelized Cost of Electricity, $/MWh

Cost of CO₂, $/Metric Ton

All-in Capital Costs: $ 1,275 – 1,375 / kW
Fuel Costs: $ 4 – 8 / MMBtu

0.37 Metric Tons CO₂/MWh
X $50/Ton = $19/MWh

All costs are in December 2010 $
SCPC, IGCC, NGCC Comparison – 2015

Levelized Cost of Electricity, $/MWh

All costs are in December 2010 $

Cost of CO₂, $/Metric Ton

IGCC
SCPC
NGCC

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Nuclear – 2015

Levelized Cost of Electricity, $/MWh

0 10 20 30 40 50
Cost of CO₂, $/Metric Ton

All-in Capital Costs: $ 5,250 – 5,900 / kW
Fuel Costs: $ 0.4 – 0.8 / MMBtu

All costs are in December 2010 $
Biomass (dedicated) – 2015

Levelized Cost of Electricity, $/MWh

Cost of CO₂, $/Metric Ton

All-in Capital Costs: $ 4,000 – 5,000 / kW
Fuel Costs: $ 2 – 6 / MMBtu

No investment or production tax credits are assumed. CO₂ emissions are assumed to be neutral*.

*Biomass emissions can vary significantly based on fuel source & life-cycle emission assumptions. Conventionally, the release of carbon from biogenic sources is assumed to be balanced by the uptake of carbon when the feedstock is grown, resulting in zero net CO₂ emissions over some period of time.
Wind – 2015

Levelized Cost of Electricity, $/MWh

All-in Capital Costs

Off Shore Wind: $ 3,250 – 4,200 / kW
On Shore Wind: $ 2,120 – 2,825 / kW

No investment or production tax credits are assumed.

All costs are in December 2010 $
Concentrating Solar Thermal – 2015

Levelized Cost of Electricity, $/MWh

All-in Capital Costs: $ 4,050 – 6,500 / kW

No investment or production tax credits are assumed.

Note different Y axis scale

All costs are in December 2010 $
Solar Photovoltaic – 2015

Levelized Cost of Electricity, $/MWh

All-in Capital Costs: $3,725 – 5,050 / kW

Note different Y axis scale

No investment or production tax credits are assumed.

All costs are in December 2010 $
Comparative Levelized Costs of Electricity – 2015

Levelized Cost of Electricity, $/MWh

All costs are in December 2010 $

Offshore Wind
Onshore Wind
Biomass
IGCC
SCPC
Nuclear
NGCC

Average LCOE values based on estimated capital cost ranges.
No investment or production tax credits are assumed for any technology.
Longer-Term: 2025
Coal, 2025—Impact of CO$_2$ Capture, Transport & Storage (CCS) & Cost & Performance Improvements on Levelized Cost of Electricity

**Levelized Cost of Electricity, $/MWh**

<table>
<thead>
<tr>
<th>Technology</th>
<th>Capital Costs Range (K$/kW)</th>
<th>Fuel Costs ($/MMBtu)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC + CCS</td>
<td>$3,850 – 4,920</td>
<td>$1.80 – 2.0</td>
</tr>
<tr>
<td>IGCC + CCS</td>
<td>$3,750 – 4,600</td>
<td>$1.80 – 2.0</td>
</tr>
</tbody>
</table>

All-in Capital Costs

CCS = CO$_2$ Capture, Transport & Storage. Capture costs included in capital costs; transportation & sequestration assumed to be @ $10/metric ton

All costs are in December 2010 $
NGCC, 2025—Impact of CO₂ Capture, Transport & Storage (CCS) on Levelized Cost of Electricity

All-in Capital Costs

NGCC + CCS: $1900 – 2250 / kW
NGCC: $1275 – 1375 / kW
Fuel Costs: $4 - 8 / MMBtu

CCS = CO₂ Capture, Transport & Storage. Capture costs included in capital costs; transportation & sequestration assumed to be @ $10/metric ton

All costs are in December 2010 $
SCPC, IGCC, NGCC, 2025—Impact of CO$_2$ Removal, Transport & Storage (CCS) & Cost & Performance Improvements on Levelized Cost of Electricity

Levelized Cost of Electricity, $/MWh

All costs are in December 2010 $

CCS = CO$_2$ Capture, Transport & Storage. Capture costs included in capital costs; transportation & sequestration assumed to be @ $10/metric ton
Concentrating Solar Thermal—2025

Levelized Cost of Electricity, $/MWh

All costs are in December 2010 $

No investment or production tax credits are assumed.

Note different Y axis scale

All-in Capital Costs: $ 3,700 – 5,900 / kW

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Solar Photovoltaic – 2025

Levelized Cost of Electricity, $/MWh

Cost of CO$_2$, $/Metric Ton

All costs are in December 2010 $

No investment or production tax credits are assumed.

Note different Y axis scale

All-in Capital Costs: $ 3,175 – 4,325 / kW
Comparative Levelized Costs of Electricity – 2025

Levelized Cost of Electricity, $/MWh

Cost of CO₂, $/Metric Ton

All costs are in December 2010 $

Offshore Wind
Onshore Wind
Biomass
IGCC
SCPC
Nuclear
NGCC+CCS
NGCC

Average LCOE values based on estimated capital cost ranges.
No investment or production tax credits are assumed for any technology.
Closing Thoughts

• Uncertainties impacting near-term & long-term project decisions & research priorities:
  – Future electricity demands
  – New EPA regulations
  – Growth in state RPS
  – Potential efficiency standards
  – Future CO₂ emissions reduction programs
  – Future price of natural gas
  – CCS technology development & costs
  – Siting requirements
  – Renewable energy technology development
  – Technology-driven escalations & reductions in plant costs

• Demonstrates importance of developing & demonstrating a portfolio of low cost generation technologies.

Together…Shaping the Future of Electricity
Program on Technology Innovation: Integrated Generation Technology Options

EPRI Report 1022782
Together...Shaping the Future of Electricity