Future of CCS Technology Adoption at Existing PC Plants

2013 NETL CO_2 Capture Technology Meeting

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Acknowledgements

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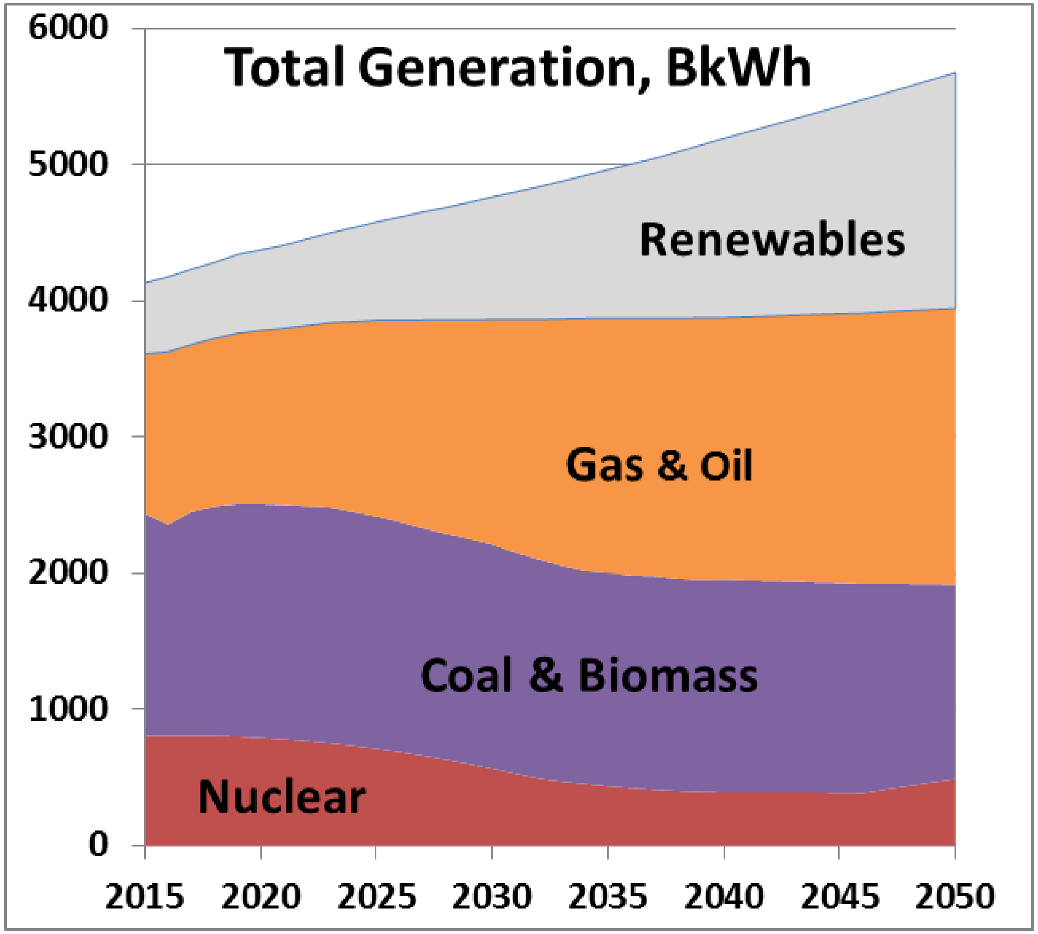
The work shown is preliminary and does not necessarily reflect the views of Argonne National Laboratory or the National Energy Technology Laboratory

- Period of Performance: 2013 Calendar Year
- Current project duration: 1 year
- Budget: $275K
- Tasks
  1. Evaluate Accelerated Deployment of CCS via CO_2-EOR
  2. Evaluate the Impact of the RD&D Funding Level and Schedule
  3. Examine the Interaction of Natural Gas Prices and Coal-Based CCS
  4. Examine the Integration of Renewable Generation and CCS adoption
  5. Evaluate the Opportunity for CBTL/Power Co-production Systems
  6. Evaluate Opportunities and Obstacles for R&D with NGCC with CCS *(yet to be done)*

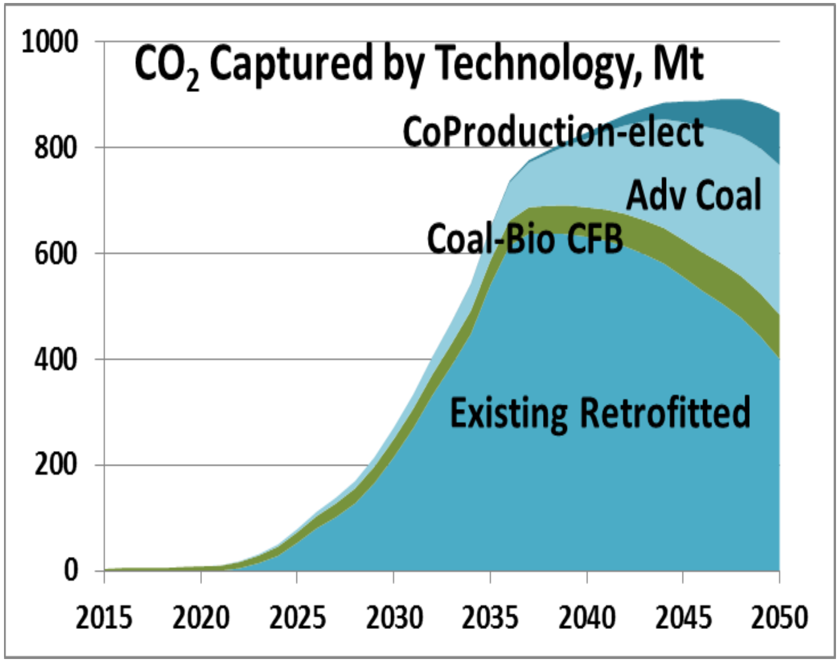
- Preliminary results/findings for Tasks 1-5

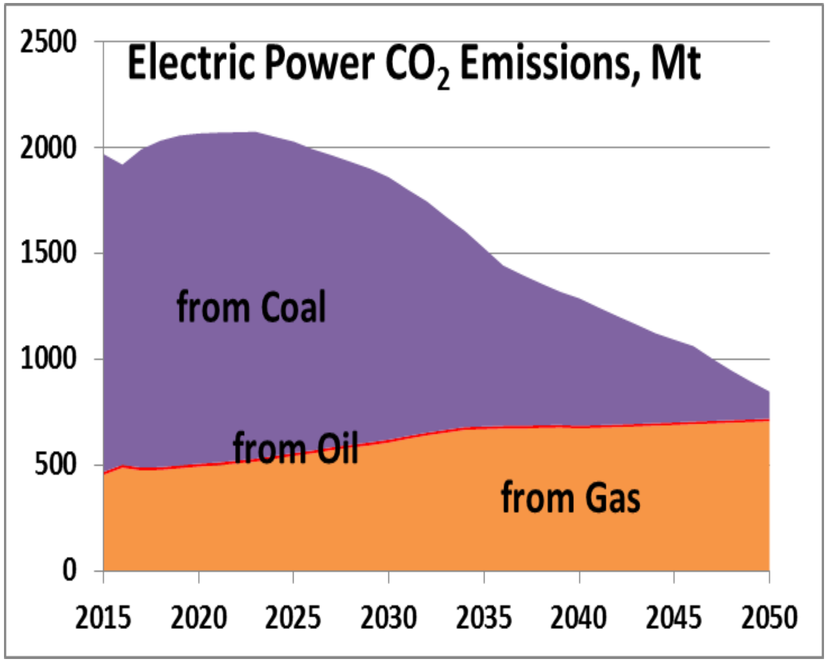
The purpose of this project is to examine the economic role of CCS technology in a power system context, using Argonne's Electricity Supply and Investment Model (ESIM)

Our Middle Case Scenario Generation Outlook

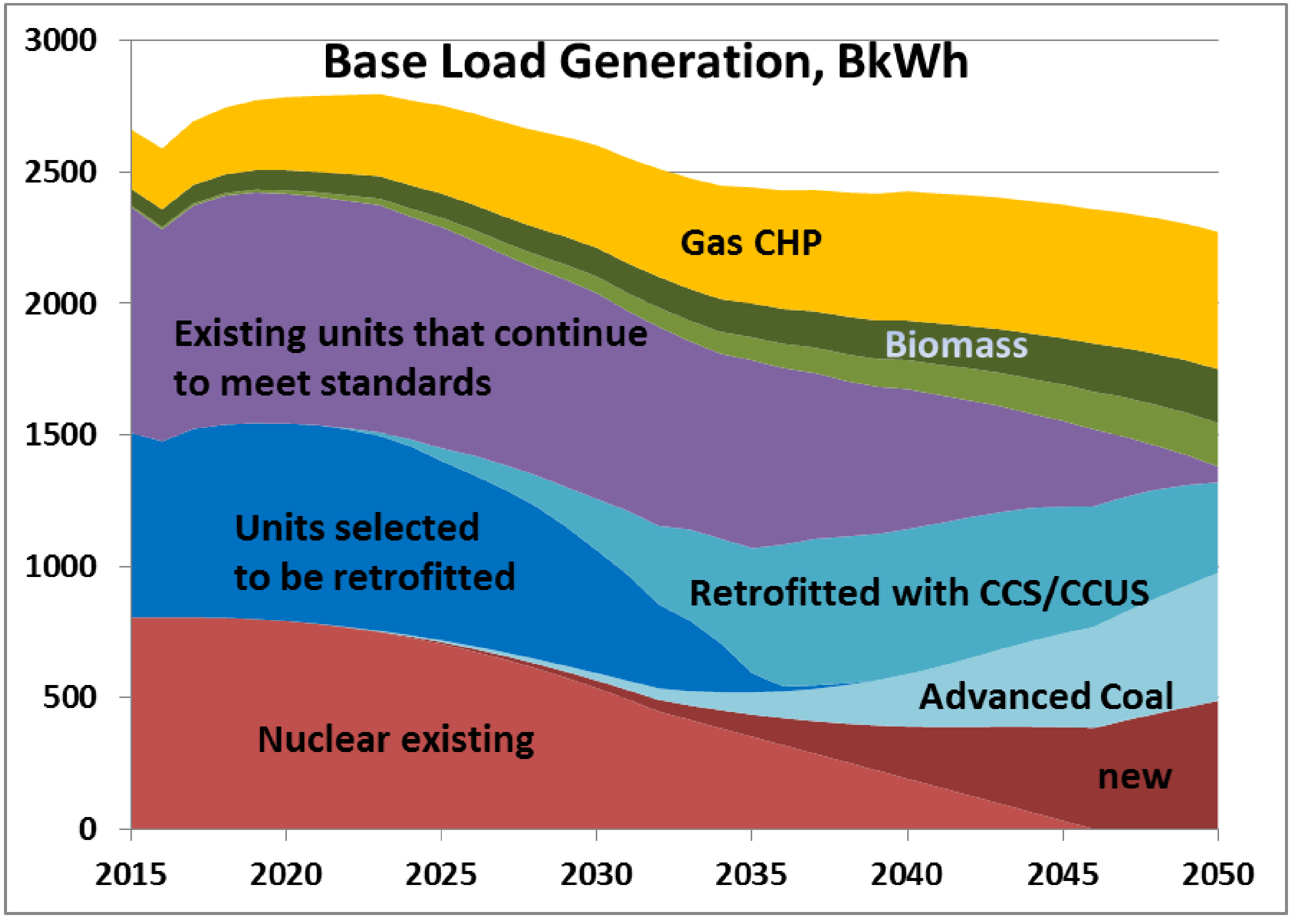


- In our simulations, most CO_2 is captured by retrofitting existing pulverized coal (PC) plants.
- Advanced technologies with CCS play an important role in the longer run.
- By 2050 almost all coal-based emissions are captured.



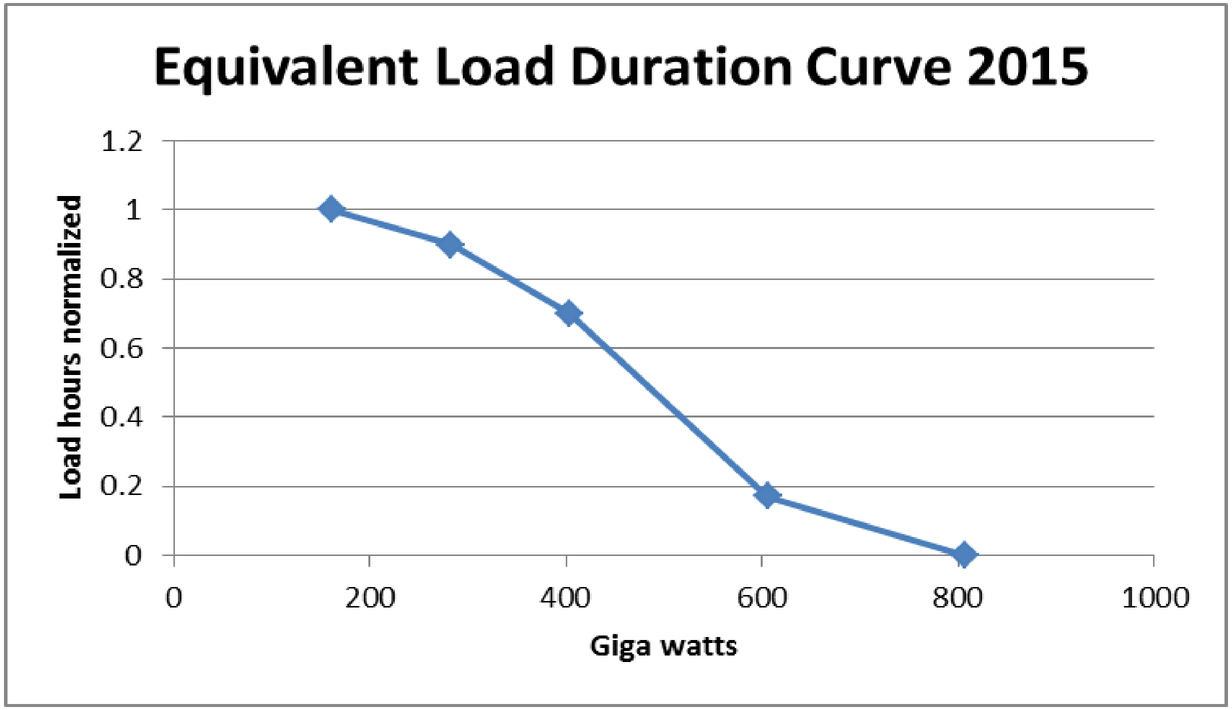


Substantial time goes into ramping up advanced coal and next generation nuclear technologies, providing an important window to retrofit existing PC units



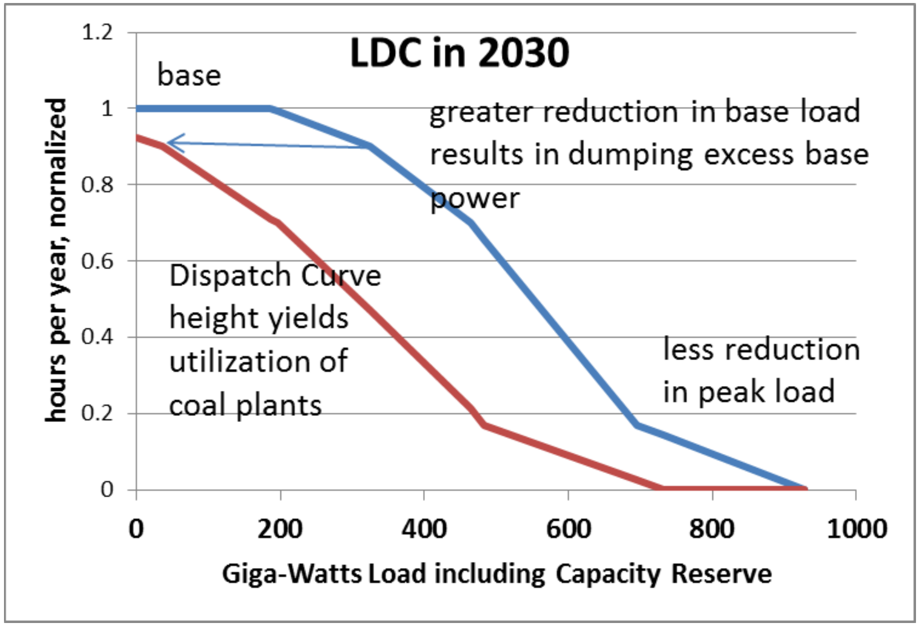
Our System Method: Equivalent Load Duration Curve

- “Equivalent” means making an adjustment to peak load to account for unit outages. This can be done using a convolution integral.
- The Eq.LDC gives the relationship for the system between hourly generation (Area under LDC) and required peak capacity (GW Length) fit to data
- Here we just call it the “LDC with Reserve Margin”



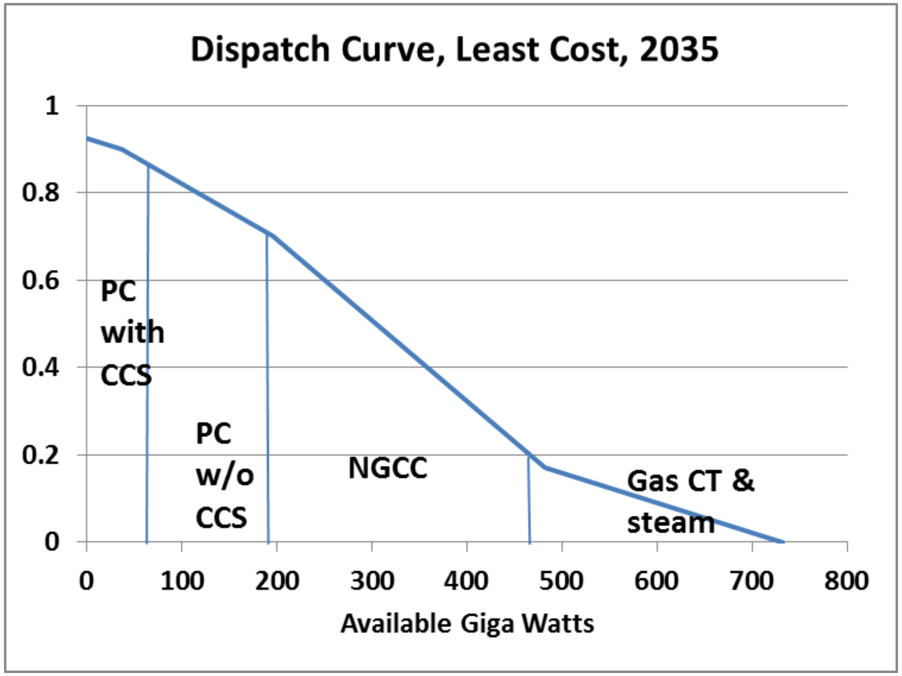
Constructing the Dispatch Curve from the Eq. LDC

- From the Eq.LDC we subtract Available Giga-Watts of "Must Run,"i.e.
  - Nuclear
  - CHP and other industrial sector base load generation
- And subtract hydro power and intermittent renewables
  - Intermittent renewables have little peak load capacity credit
  - Their generation favors base load, hence more renewable power is subtracted from base load than from peak load
  - Excess base load power may be dumped, as shown below in the "gap"



The Height of the Dispatch Curve Shows the Utilization Rate for Existing PC Units and NGCC

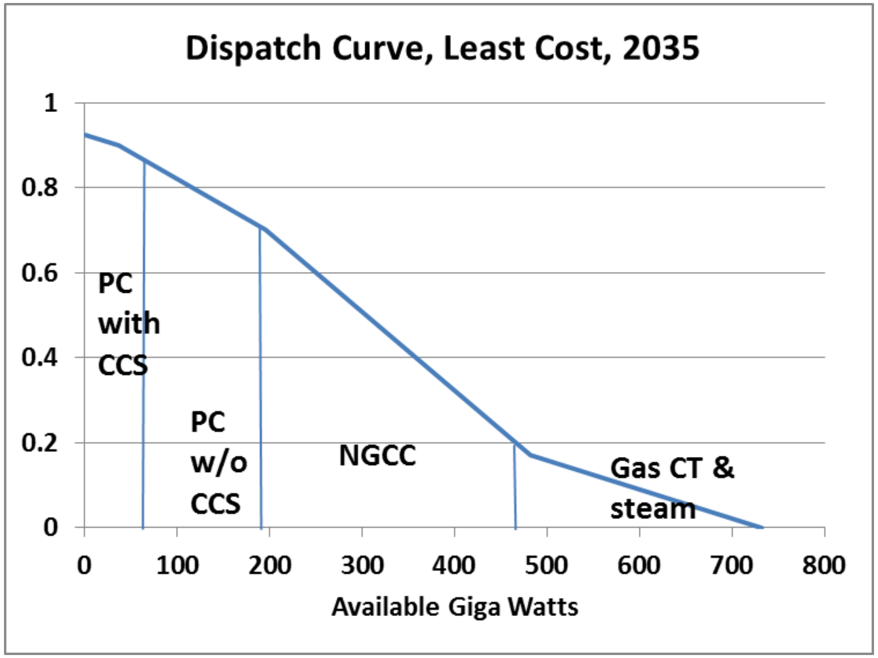
- PC units retrofitted with CCS should have the highest utilization assured by
  - a credit for producing CO_2 e.g., EOR market
  - A modest price on CO_2 emissions, e.g., \$30/ton CO_2 emissons
- About 1/3 of the generation lost to capacity derate is made up by higher utilization rates for PC units with CCS.
- Dispatch curve flattens over time due to more intermittent generators with little peak load credit.
- Units loaded by variable costs.
- Units stacked on load curve are derated “available GWs.”



The Economics of Older PC Unit Retirement vs. Adding NGCC Capacity is based on Dispatch Curve

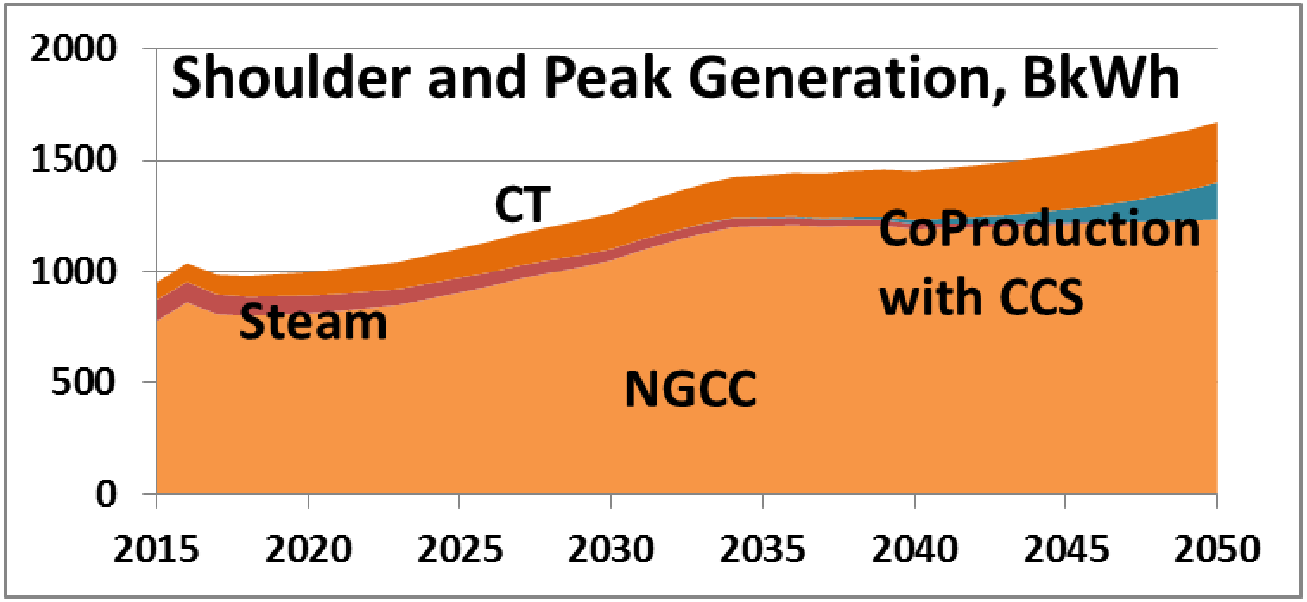
- The margin between continuing to run a PC unit (i.e., not Retire) or adding new NGCC capacity (and retiring coal) depends on:
  - Price of natural gas
  - Price of CO_2

- A price > $40/ton CO_2 can lead to gas & coal market volatility and instability as NGCC units could hop over existing PC units in the dispatch order, causing low, costly PC utilization or premature retirement

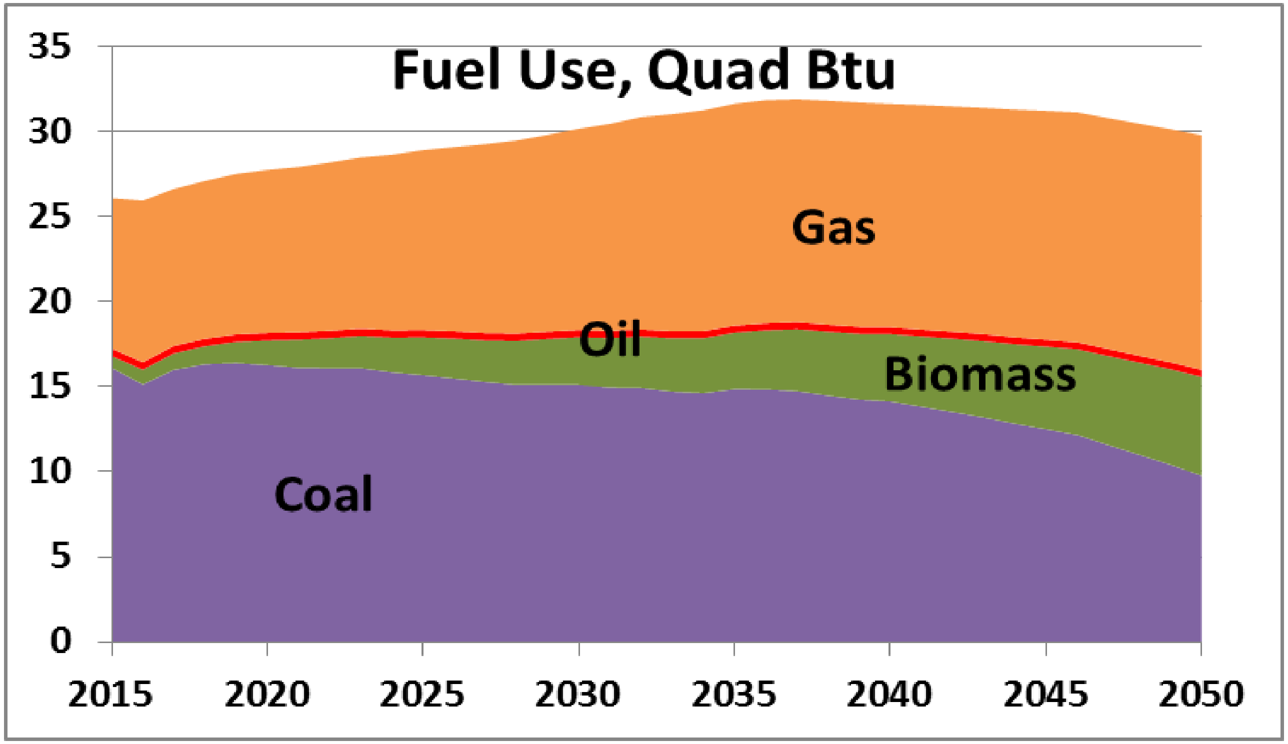


High or Low Gas Scenarios will Result in More or Less Existing PC Retirements that have not retrofitted CCS. Mid gas supply case shown below.

- Shoulder load is mostly NGCC.
- CTs provide almost as much required peak capacity as NGCC.
- Coal-based co-production plants can gain economic advantage by selling electricity during valuable shoulder and peak periods.



- Gas use is destined to grow.
- Growth in coal use will depend on whether new nuclear units are built and other advanced technologies.



We find that we need to do about the same number of PC plant retrofits in the High Shale Gas Scenario. The need for this technology is robust, given emission reductions.

Compare the two shale gas scenarios: High and Low. With more gas:

1. Some older, existing coal plants will be repowered with gas, reducing CO_2 emissions.

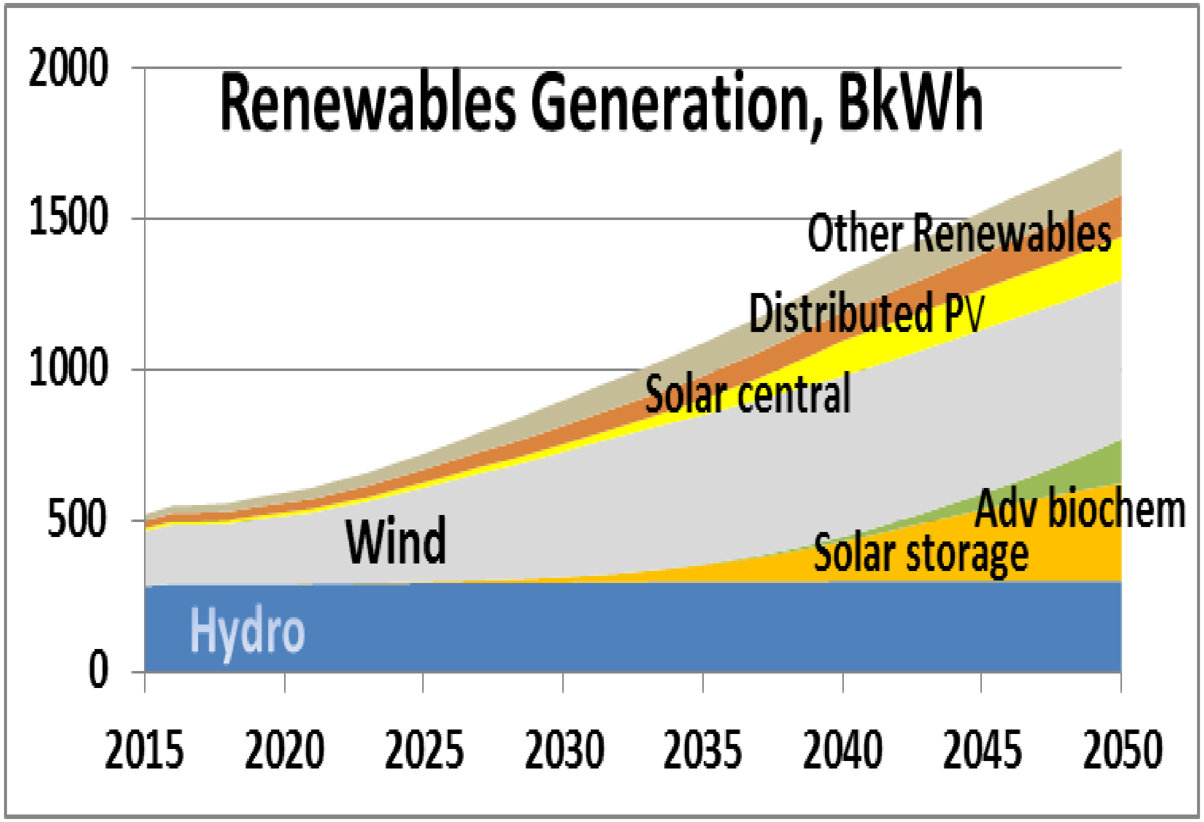
2. Some near-zero generation (i.e., renewables, IGCC with CCS, nuclear) will be displaced on the margin with gas, increasing CO_2 emissions.

Balancing 1 & 2, keeping the amount of CO_2 emissions reduction unchanged, we will need to get about the same amount of CO_2 reduction from retrofitting existing PC plants in both scenarios.

A power system representation is needed to estimate costs imposed by large penetration of intermittent renewables

Intermittency Costs:

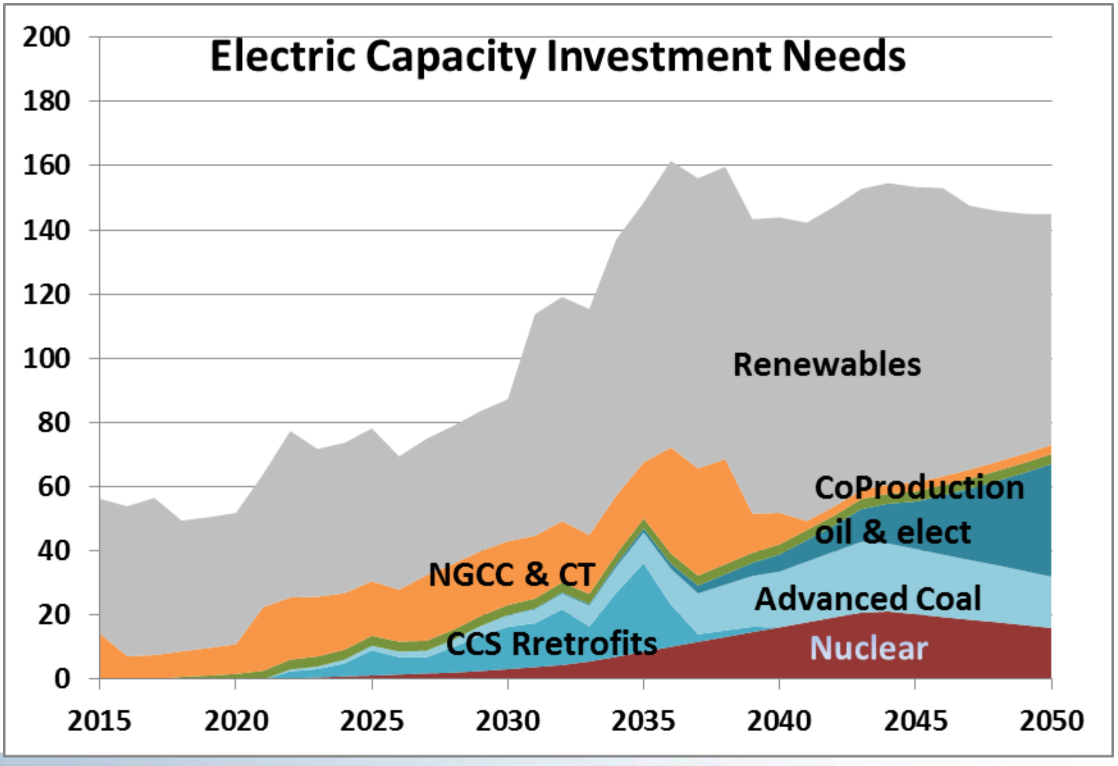
- Dumping extra power
- Lower PC utilization
- PC Heat Rates increase
- PC variable costs increase
- Reduces PC life
- More capacity investment needed to meet peak



Constructing a Balanced Portfolio of Generation Technologies using the Avoided Cost Method

- First incrementally reduce renewable generation
  - Calculate cost savings in renewable investment expenditures
- Run the ESIM model with the incrementally lower renewable generation, replacing the missing load with a mix of other generating capacity that yields the same CO_2 reduction
  - Increase CCS capacity at base load
  - Increase NGCC at shoulder load
  - Model calculates incremental increase in systems cost
- An important topic for EIA: Workshop on Levelized Cost of Electricity and Levelized Avoided Cost of Electricity, July 25, 2013
- Please see http://www.eia.gov/renewable/workshop/gencosts/ for more information and to register for webinar.

- CCS Retrofit Investment Requirements are relatively small compared with total capacity needs.
- Low renewable capacity factors implies large capital investment requirements
- Our preliminary results show a large payoff from CO_2 capture R&D on the order of 10 billion dollars per year savings in electricity costs for consumers and American businesses.



Incentives work better than Command and Control Approach

- Selling CO_2 for EOR adds incentive and reduces unit's variable cost
  - putting it higher on the loading order
  - increasing its generation and CO_2 production.
- Some credit for reducing CO_2, or small price on emitting CO_2, will provide an incentive to operated units with CCS with higher utilization that units without capture. This is a cost-effective way to further reduce CO_2.
- Electricity prices can be moderated for consumers and businesses if revenue from a modest price on CO_2 is recycled back to help fund investments advanced generation capacity.
- For more information on this work, we will be updating our web site by mid-September:

  http://amiga.dis.anl.gov/
- Or contact me at dhanson@anl.gov