From: William Johnston [wj3@comcast.net]
Sent: Saturday, September 12, 2009 9:28 AM
To: Biggins, James
Subject: Fw: Electricity Crisis-2 09-09-09 MOST NET CC3 Jobs OUTSIDE of MD- Sources: CEG Witness Anirban Basu, Penn State Univ, St. Louis Post-Dispatch
Attachments: Basu Testimony- Maryland Jobs and CC3.pdf; scwind.cfm.htm; Mason_Coupled Wind-CAES Power Plants_Comparative Base Load Power Plant Analysis__RERI_13 August 2009.pdf

James,

The email below had a minor error in your email address, now corrected. Attached is the important report by James Mason on the coupled wind-CAES alternative that should be one of the alternatives evaluated in the eis, in addition to others to follow.

Thank you for bearing with us on this. Any comment is appreciated. Bill Johnston

----- Original Message -----
From: William Johnston
To: Peter Vogt ; Bruce Gordon ; James Mason
Cc: Chris Bush ; Norman Meadow ; Paulette Hammond ; Millie Kriemelmeyer ; Allison Fisher ; Julia Clark ; Michael Marriott ; Paul Gunter ; James.Biggs@nrc.gov
Sent: Saturday, September 12, 2009 8:39 AM
Subject: Fw: Electricity Crisis-2 09-09-09 MOST NET CC3 Jobs OUTSIDE of MD- Sources: CEG Witness Anirban Basu, Penn State Univ, St. Louis Post-Dispatch

To all,

I just found this letter in my unfinished drafts, thinking I had already sent it out a day or two ago. Sorry for any old news. Please forgive, but I think it best to go ahead and let you see it.

See the latest EC, attached. Just wanted you to get a fair sample of Chris' stuff, and how it is growing. This will be the last time I pass his stuff on, unless particularly relevant to us. Just got off the phone with counsel for NRC and staff, who asks I communicate with him henceforth. I therefore just removed Laura Quinn's name from the copy list above, though it pains me. According to James Biggins, Esq., the scoping process has completed, which means our next opportunity for public input is comment on the draft eis after it comes out 2010 March. He says if we think some change in the nukers' application (maybe changes such as those which did cause the eis process to stop shortly after the 2008 March scoping meeting, resuming only recently, which Laura Quinn, manager of the eis process, had said a week ago Friday was the reason for the delay) has resulted in a potential environment impact that was not previously considered or known at the time of scoping, that a comment to that effect might still be considered within the preparation (by NRC staff with contractor assistance) of the draft eis.

What was the additional info that caused the delay? Probably the air issues, for which there was a later hearing some months ago. A couple neat issues come to mind, possibly new. Maybe other info caused delay, with other new eis issues. But are our rights to a meaningful eis, one not potentially significantly compromised by a scoping uninformed by going on two years in some of the most rapidly changing areas of technological and social capabilities, the need for which is rapidly gaining currency as we learn of unsettling changes we cause in our surrounding but fragile biosphere, the question being, ... Seems all such concerns should be defined and asserted ASAP. Would this become a federal eis case, if they don't rescope? Is the passage of time, and public education, scrutiny and participation, this delay in this case caused by applicants being required to submit additional info, to be ignored in respect of applicants' initial filing date and submittals, or is it the public interest or say the citizen right to opportunity to comment on scope on the basis of the entire submittal of information that has the greater weight? The regs need to be checked. Why proceed on the basis of such historical view of energy options, surely significant handicap is risked. To update and thereby complete the scoping process, we need to request Mason's wind-CAES coupling as one alternative for study (copy attached), and the Grand Solar Plan another (2008 Jan. Sciam), and a combination of conservation and sharkmeters (C. Bush) for limiting demand to existing capacity for the moment, in view of Vogt's SMECO data suggesting decreasing per capita demand. Local wind and solar could be encouraged for adding peak. Calvert County has $15 million for nuke, and nothing for wind or sun. Will smart sharkmeters become a part of us, the next context for cost dispute? How do you empower a smartmeter to shave peak, to sort your electrical needs? If we can avoid new capacity for awhile? Heck, clean energy could be online no later than nuke! Think an eis should ignore all this after such a delay?

ps: Bruce, just got your email re the killer windmill, with superconductors you can make the generator, way up on top of the pole, very light and therefore ten times more powerful. So I attached your attachment there here, for everyone else to see. This and many other items need to be brought to the attentions of the NRC and the PSC, immediately.

More later, W. Johnston

----- Original Message -----

From: Chris Bush

To: agalli@cleanwater.org ; savorsuccesslady3@yahoo.com ; wj3@comcast.net ; bowenga@co.cal.md.us ; demedis@co.cal.md.us ; parranwh@co.cal.md.us ; peters@opc.state.md.us ; asnyder@mde.state.md.us ; cmonk@saul.com ; bbolea@energy.state.md.us ; Leslie M. Romine ; george.liebmann2@verizon.net ; Nancy A. White ; Rshaffer@murphyshaffer.com ; Wmurphyshaffer@murphyshaffer.com ; Cindy Burda ; mdean@psc.state.md.us ; Chason, Todd R. ; Beverly.A.Sikora@bge.com ; Abraham Silverman ; Brian R. Greene ; Chris Bush ; Christopher R. Mellott ; Clifford M. Naeve ; Curtis B. Cooper, Esq. ; Daniel P. Gahagan ; Deborah E. Jennings ; Donald R. Hayes ; Douglas L. Anderson ; Gary Alexander ; Gary R. Alexander ; George Nilson ; H. Russell Frisby, Jr. ; Jeffrey Hooke ; Kimberly August, Esq. ; M.Brent Hare ; Marc D. Machlin ; Marc Hanks ; Matthew Nayden ; Michael C. Powell, Esq. ; Paula Carmody ; Randolph S. Sargent ; Richard M. Resnick, Esq. ; Ron Belbot ; Ron Herzfeld ; Steven R. Weiss ; Suzanne Sangree ; Telemac Chryssikos, Esq. ; Terri Czarski ; William Fields, Esq. ; Maria Allwine ; kojo@wamu.org ; hmstichel@ghsllp.com

Cc: mgp-disc@yahoogroups.com ; DII@yahoogroups.com ; DFHdiscussions@yahoogroups.com ; DEMOCRACY4Baltimore

Sent: Wednesday, September 09, 2009 4:30 PM

Subject: Fw: Electricity Crisis-2 09-09-09 MOST NET CC3 Jobs OUTSIDE of MD- Sources: CEG Witness Anirban Basu, Penn State Univ, St. Louis Post-Dispatch

----- Original Message -----

From: Chris Bush

To: Susan.Krebs@house.state.md.us ; michael.dresser@baltsun.com ; andrew.green@baltsun.com ; capletts@capitalgazette.com ; rmarkus@dhr.state.md.us ; Stephen Janis ; sjanis@gmail.com ; MDMorning ; amanda@sfbg.com ; dnazarian@psc.state.md.us ; info@midamerican.com ; jessica@40centerforemergingmedia.ccsend.com ; david.nitkin@baltsun.com ; ileech@vt.edu ; dborelli@nationalcenter.org ; laura.vozzella@baltsun.com ; gdubois@pol.net ; jfunk@plaind.com ; Governor Martin O'Malley ; annmarie.doory@house.state.md.us ; maggie.mcintosh@house.state.md.us ; Thomas.V.Mike.Miller@senate.state.md.us ; Michael.Busch@house.state.md.us ; tim.wheeler@baltsun.com ; George.Della@senate.state.md.us ; Shawn.Tarrant@house.state.md.us ; Barbara.Robinson@house.state.md.us ; Nathaniel.Oaks@house.state.md.us ; Frank.Conaway@house.state.md.us ; Emmett.Burns@house.state.md.us ; melvin.stukes@house.state.md.us ; gadi.dechter@baltsun.com ; daytondaily@coxohio.com ; andy.green@baltsun.com ; Andrew.Harris@senate.state.md.us ; Pipkin, E.J. Senator ; julie.scharper@baltsun.com ; Katherine.Klausmeier@senate.state.md.us ; Sue.Kullen@house.state.md.us ; andrea.siegel@baltsun.com ; michaels@cphabaltimore.org ; letters@washpost.com ; sean@progressivemaryland.org ; bunnysox2@aol.com ; letters@baltsun.com ; Jon Cardin ; info@sarbanesforbaltimore.com ; aldshropshire@annapolis.gov ; brian@illinoispirg.org ; john@sarbanesforcongress.com ; rsmith@wbal.com ; editor@gazette.net ; Info@opc.state.md.us ; elaine.garven@baltimorecity.gov ; campaign@martinomalley.com ; John.Astle@senate.state.md.us ;

jay.hancock@baltsun.com ; Joan.Carter.Conway@senate.state.md.us ; Jill.Carter@house.state.md.us ; CurtAnderson@aol.com ; Catherine.Pugh@house.state.md.us ; Johanna Neumann ; Nancy_Jacobs@senate.state.md.us ; MayorSD@baltimorecity.gov ; John.Fritze@baltsun.com ; Adams, Paul ; Pat McDonough ; dan.rodricks@baltsun.com ; Edwards, George Senator ; liz.kay@baltsun.com ; jean.marbella@baltsun.com ; Edward.Kasemeyer@senate.state.md.us ; Jim.Brochin@senate.state.md.us ; reinl@washpost.com ; Brian.McHale@house.state.md.us ; jim.rosapepe@senate.state.md.us ; :jes.phillips@gmail.com ; fsmith@wypr.org ; council1@baltimorecountymd.gov ; council2@baltimorecountymd.gov ; council3@baltimorecountymd.gov ; council4@baltimorecountymd.gov ; council6@baltimorecountymd.gov ; :council7@baltimorecountymd.gov ; cbball@howardcountymd.gov ; gfox@howardcountymd.gov ; jterrasa@howardcountymd.gov ; mksigaty@howardcountymd.gov ; Mike Tidwell, CCAN ; H. Russell Frisby, Jr. ; laura.smitherman@baltsun.com ; fahrenthold@washpost.com ; scott.calvert@baltsun.com ; Leslie M. Romine ; Steven R. Weiss ; dan.neil@latimes.com ; Bernard Young ; Stephanie Rawlings-Blake ; James Kraft ; Robert Curran ; Bill Henry ; Rochelle Spector ; Sharon Green Middleton ; Belinda Conaway ; governor@gov.state.md ; donaldf@gbc.org ; pwilkins@baltimoredevelopment.com ; gcichy@mtamaryland.com ; rob.gould@constellation.com ; kenneth.w.defontes@constellation.com ; bruce@wbal.com
Cc: mgp-disc@yahoogroups.com ; DII@yahoogroups.com ; DFHdiscussions@yahoogroups.com ; DEMOCRACY4Baltimore
Sent: Wednesday, September 09, 2009 1:26 PM
Subject: Electricity Crisis-2 09-09-09 MOST NET CC3 Jobs OUTSIDE of MD- Sources: CEG Witness Anirban Basu, Penn State Univ, St. Louis Post-Dispatch

Electricity Crisis-2 09-09-09

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+ MOST NET CC3 Jobs OUTSIDE of MD- Sources: CEG Witness Anirban Basu, Penn State Univ, St. Louis Post-Dispatch

~ Just 25,278 Net Jobs Created INSIDE Maryland (and Thos Jobs are TEMPORARY), Vs 66,888 Jobs Created OUTSIDE of Maryland!?!?!
~ Economist Anirban Basu Provides Testimony in Case No. 9173, the CEG/EDF Case that Indicates 72,078 Jobs Would be Created, In-State, from the CC3 Expansion
~ Basu's Estimate Indicates that the 72,078 Jobs Would be Composed of 60,930 Jobs in Construction and Related Muliplier Spin Off Jobs, as Well as an Additional 11,148 Jobs from Non-Labor Costs, Like Materials and Such
~ Basu DID Indicate that the 11,148 NON-Labor Cost Jobs were Based on Just $1 BILLION DOLLARS Spent for Such Costs INTRA-STATE Maryland: HOWEVER, an Additional $6 BILLION DOLLARS is Spent OUT-OF-STATE Maryland
~ Applying Basu's Formula to the OUT-OF-STATE Spending Would Result in 66,888 Jobs Created OUT-OF-STATE (Calculated as Follows: 11,148 x 6 [$7 BILLION DOLLARS in TOTAL, Less $1 BILLION DOLLARS INSIDE Maryland, = $6 BILLION DOLLARS OUTSIDE Maryland- there are 11,148 Jobs Created for Each $1 BILLION DOLLARS in Spending)
~ Basu's Estimates for INSIDE Maryland, However, did NOT Take Into Account the LOSS of 46,800 Jobs from Higher Electricity Rates
~ Electricity Rates Would Jump 40% During the Construction Period of CC3, Based on Similar Estimates from Missouri, in the St. Louis Post-Dispatch's Citation of a Missouri Office of Public Counsel Study Stating that Electricity Rates Would SKYROCKET 40% During the Construction Period of a Proposed New Nuclear Plant in Missouri Pushed by Ameren (along w/ Constellation Energy)
~ Missouri BLOCKED Such a Proposal, But Look for Such MASSIVE RATE HIKES in Maryland if CC3 Goes Thru
~ Penn State University Researchers Say that 11,700 Jobs are LOST for Each 10% Rate Hike in Electricity Rates
~ Hence, CC3 Will LOSE 46,800 JOBS for Maryland (Calculated as Follows: 11,700 x 4)
~ Netting the Job Loss W/ Basu's Claims of Jobs Added Only Results in 25,278 Net Jobs Added from CC3 in Maryland, Which is Swamped by Jobs Created OUTSIDE Maryland of 66,888
~ Maryland is Getting a RAW DEAL Here
~ Basu Testifies that CEG Pays Estimated $256 MILLION DOLLARS in State Local Taxes in Maryland for 2008
~ However, CEG's Financials Show a $1.3 BILLION DOLLAR Loss in 2008
~ Now, CEG May Have Paid Estimated INCOME Taxes of $256 MILLION DOLLARS, BUT if there's a LOSS for State Tax Purposes, then Those Tax Payments Have to be REFUNDED!?!?!?
~ Basu does NOT Point This Out, However

~ This Writer Contacted Basu's Office at the Sage Policy Group at 10:40 am on Wed., Sept 9, 2009 at (410) 522-7243, and Talked w/ Basu's Executive Assistant Sheena
~ Chris Bush had Asked to Leave a Voicemail for Basu, but Sheena Said that She Would Take a Message Instead
~ Bush Then Left a Lengthy Message- Which Began to Exasperate Sheena Cuz of Its Length- but Bush Said to Sheena that it Was Important to Attempt to Get Basu's Side fo the Story, Hence the Message, and That Also Should Basu Not Call Bush Back, Bush Would Have Made Every Effort to Reach out to Get Basu's Views
~ No Call Back from Basu at the Time of this Writing
~ (NOTE: This Writer is Sending a Copy of this Email to Anirban Basu of the Sage Policy Group for His Comments, if Any, Which Will be Posted Here)-cb
~ (NOTE 2: There Can be Significant Differences Between a Financial Statement and Tax Return Due to Book/Tax Adjustments)-cb

+ *Former Prez Clinton Supports Return of Fairness Doctrine*

~ Former Prez Clinton Indicates that It's Time for a Return to the Fairness Doctrine
~ Clinton Said that "Big Money" is Going to Right Wing Talk Shows
~ Clinton was Complaining about Talk Radio's Efforts to Block the Stimulus Plans
~ Yours Truly OPPOSED Wall Street Bailouts as Well, But Talk Radio UNfairly Treats Most Issues Cuz it does NOT Provide Balanced Coverage
~ That's Especially Apparent Comparing the Opposition to the Public Option w/ Censorship of Pro-Consumer Views re Electricity Rates, on WBAL 1090 AM's Ron Smith Show

+ *Obama Will Jump 15 Points in the Polls- from Reenergized Dems- if the Prez Strongly Supports the Public Option in His Speech to Congress Tonight- Ed Schultz of the Ed Schultz Show on Air America Network/Jones Radio Network...Chris Bush Wants a Derivatives Tax to Pay for Health Care- and for the Great Plains Wind Project and the American Hybrid Project (AHP), Too!!!*

~ Progressive Commentator Ed Schultz Said on His Show Today, at 12:47pm on Wed., Sept 9, 2009, that President Obama will Jump 15 Points in the Polls If the Prez Takes a Strong Position on the Public Option in Tonight's Speech to Congress
~ Schultz Said that the Prez Would Get the Boost from Reenergized Dems Who've Been Disappointed w/ BOB's Position on this Topic So Far
~ Chris Bush Wants Universal Coverage, but Wants a Derivatives Property Tax of 1% ("Micro-Prop") to Pay for Such Care- of Which 5/10ths of 1% Would Cover all Costs
~ The Remainder of the Tax Would be Used for Other Purposes- Including the Great Plains Wind Project and the American Hybrid Project (AHP)
~ Bush OPPOSED a Senate Plan to FINE Americans $3,800 to Require Them to Buy Expensive Health Insurance

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> MOST NET CC3 Jobs OUTSIDE of MD-Sources: CEG Witness Anirban Basu, Penn State Univ, St. Louis Post-Dispatch...

...Just 25,278 Net Jobs Created IN Maryland (and Those Jobs are TEMPORARY), Vs 66,888 Jobs Created OUTSIDE of Maryland?!?!?!?...

...Economist Anirban Basu Provided Testimony in Case No. 9173, the CEG/EDF Case that Indicated 72,078 Jobs Would be Created, In-State, from the CC3 Expansion...

...Basu's Estimate Indicates that the 72,078 Jobs Would be Composed of 60,930 Jobs Created In Construction and Related Multiplier Spin Off Jobs, as Well as an Additional 11,148 Jobs from Non-Labor Costs, Like Materials and Such...

...Basu DID Indicate that the 11,148 NON-Labor Cost Jobs Were Based on Just $1 BILLION DOLLARS Spent for Such Costs INTRA-STATE Maryland: HOWEVER, An Additional $6 BILLION DOLLARS Spent OUT-OF-STATE Maryland...

...Applying Basu's Formula to the OUT-OF-STATE Spending Would Result in 66,888 Jobs Created OUT-OF-STATE (Calculated as Follows: 11,148 x 6 [$7 BILLION DOLLARS in TOTAL, Less $1 BILLION DOLLARS INSIDE Maryland, = $6 BILLION DOLLARS OUTSIDE Maryland- there are 11,148 Jobs Created for Each $1 BILLION DOLLARS In Spending])...

...BUT, Basu did NOT Reduce Jobs in Maryland Caused by HIGHER ELECTRICITY RATES...

...Penn State Researchers Have Noted that 11,700 Jobs are LOST for Each 10% INCREASE in Electricity Rates...

...AND, the St. Louis Post-Dispatch has Reported that a Similar Nuclear Power Plant Effort in Missouri Would Have Resulted in a 40% RATE INCREASE During the Construction Work in Progress (CWIP) Phase, The Paper Quoting a Study by the Missouri Office of Public Counsel (the Missouri Nuclear Plant Expansion was STOPPED; btw, Ameren was the Chief Power Company, Working in Partnership with Constellation Energy!?!?!)...

...Multiplying 11,700 x 4 = 46,800 Jobs LOST in Maryland Cuz of the CC3 Expansion...

...that Means that Net Jobs in Maryland Will only Be 25,278 FROM the CC3 Expansion, YET...

...66,888 Jobs are Being Created OUT-OF-STATE...

...Maryland is Getting the SHORT END OF THE STICK FROM CC3!?!?!?/

Basu Also May be Tricking the Public w/ His Testimony On Behalf of Constellation Energy...

...That's Cuz the Noted Economist Sez that CEG Paid $256 MILLION DOLLARS in Estimated State and Local Taxes to Maryland in 2008...

....BUT, CEG had a $1.3 BILLION DOLLAR NET OPERATING LOSS in 2008, Which Means that the Estimated Taxes Paid for INCOME TAX (Which Would be the Largest Component of the State and Local Taxes Paid) Represent OVERPAYMENTS WHICH WILL BE REFUNDED TO CEG?!?!?!...

...Yet, Basu did NOT Mention Any Refunds In His Testimony...

...Chris Bush Called Basu's Office at Sage Policy Group at 10:40 am Wednesday, Sept. 9, 2009, to Get Basu's Side fo this Story...

...Basu was NOT In, but His Executive Assistant Sheena Took a Message- Although She Appeared to be Getting Exasperated Taking a Lengthy Message on the Particulars of Chris Bush's Question (Bush Asked BOTH About the Jobs Lost Due to Higher Electricity Rates AND Queried on the Topic of the 2008 Net Operating Loss for CEG)(Bush Asked Sheena for Basu's Voicemail, but Sheena Indicated that She Would Take a Message Instead)

(NOTE: this Email is being Sent to Anirban Basu of the Sage Policy Group for His Comments, if Any, Which Will be Posted Here)-cb

(NOTE 2: there Can be Significant Differences Between the Financial Statements and the Tax Return Due to Book/Tax Adjustments)-cb

- see the slideshare.net link; the stltoday.com link; the "Basu Testimony- Maryland Jobs and CC3" pdf attachment
- newsflash: MOST NET CC3 Jobs will be OUTSIDE of MD- Sources: CEG Witness Anirban Basu, Penn State Univ., St. Louis Post-Dispatch
- let's start w/ Basu
- the Economist presented testimony in Case No. 9173, the CEG/EDF Case, that 72,078 jobs would be created, in-state, from the CC3 expansion
- that total has two components: 1) 60,930 jobs from construction and related muliplier spin off jobs; 2) 11,148 jobs from non-labor costs like materials and such ("Basu", windows page # 22, Exhibit 8 chart; windows page # 23, exhibit 10):

Exhibit 8: Construction jobs and income and related multiplier effects: Impact in Maryland

Total jobs 60,930

Exhibit 10: Estimated impacts of $1 billion dollars of purchases of construction materials, goods, and services in Maryland

Employment (full-and-part-time jobs)

Total Impacts 11,148

- Basu refers to the 11,148 jobs as "non-labor cost" jobs ("Basu", windows page # 23, paragraph 3):

If $1 billion of the roughly $7 billion for non-labor costs were spent in Maryland on a variety of construction materials, equipment, and services, over 5,000 direct jobs and almost 6,000 multiplier effect jobs would be created in the state.

- an important point for BOTH the 60,930 construction/related jobs AND the 11,148 "non-labor cost" jobs is that they are TEMPORARY ("Basu", windows page # 22, paragraph 3; windows page # 23, paragraph 3):

It should be stressed that theses on-time impacts occur over the estimated 68 month period of construction.

As with the direct project jobs, these impacts would include indirect and induced impacts and would be one-time effects occurring only during the construction period.

- 72,078 jobs sounds like a good thing, right?
- not so fast
- it's quite likely that electricity rates will SKYROCKET during the construction work-in-progress period (CWIP) to pay for these expenses ahead of time: that's what Constellation Energy, and its partner Ameren, tried to do in Missouri, only to be defeated by citizen outrage in that state who cited a study by the Missouri Office of Public Counsel that rates would zoom during the construction period ("stltoday", paragraphs 1-3):

The various opponents and proponents of the Ameren/nuclear plant/CWIP repeal bill in the Missouri Legislature are, well, going nuclear. Sorry, couldn't help myself.

One of the Legislature's biggest and most contentious issues this year, the bill under consideration would repeal Missouri's ban against construction work in progress, which would allow Ameren to recover financing costs (and some other costs) related to its proposed nuclear plant in Callaway County, before the plant is up and running.

*Opponents, citing a statement by Public Service Commission chairman **Robert Clayton**, and a study by the Office of Public Counsel **Lewis Mills**, say the bill will lead to increased costs of up to 40 percent.*

- how many jobs are lost with such a high electricity rate increase?
- well, Penn State researchers say that 11,700 jobs are lost with each 10% increase in electricity rates ("slideshare", slide 7)
- let's do the math: 11,700 x 4 = 46,800
- so, we have to subtract 46,800 from Basu's 72,078 to arrive at NET JOBS from CC3: 72,078 - 46,800 = 25,278
- one might ask: well, it's a lot less, but still 25,278 jobs are being added; what's the problem?
- well, the problem is that MOST JOBS from CC3 are being added OUT-OF-STATE: 66,888 jobs OUTSIDE of Maryland, vs 25,278 Net jobs INSIDE Maryland
- the 66,888 figure is based on Basu's number above of 11,148, and the fact that Basu says only $1 BILLION DOLLARS of $7 BILLION DOLLARS of non-labor costs will be in Maryland, as referenced above
- multiply 6 x the other 11,148 ($7 BILLION DOLLARS - $1 BILLION DOLLARS in MD = $6 BILLION DOLLARS OUT-OF-STATE; Basu Sez that 11,148 jobs are created for each $1 BILLION DOLLARS in non-labor costs) = 66,888
- so, bottom line, 25,278 jobs created INSIDE Maryland, whereas 66,888 jobs created OUTSIDE Maryland
- sounds like Maryland is getting a raw deal to me
- on another aspect of Basu's testimony, the Economist said that CEG had paid Estimated $256 MILLION DOLLARS in state and local taxes in Maryland in 2008 ("Basu", windows page # 18, Exhibit 4):

Exhibit 4: Fiscal impacts of CEG current operations in Maryland (thousands)

Maryland State and Local Taxes Paid   Total 2008 Estimated State and Local Tax

$256,031

- while Basu did NOT say WHICH state and local taxes he was referring to, the high amount indicates that most of this is State INCOME TAX
- during 2008, CEG would likely have paid quarterly estimated state INCOME TAX payments to the Comptroller
- here's the problem: CEG had a NET OPERATING LOSS of $1.3 BILLION DOLLARS in 2008
- this would mean that ALL the Estimated payments would be REFUNDED to CEG, yet Basu does NOT mention this
- Chris Bush called Basu's office w/ the Sage Policy Group at 10:40am on Wed., Sept. 9, 2009, at (410) 522-7243, to inquire about these two issues (i.e., the loss of jobs from higher electricity rates being factored in, AND the refund of estimated payments by CEG cuz of the NOL)
- Bush talked w/ Basu's Executive Assistant Sheena
- yours truly asked for Basu's voicemail to leave a detailed message, but Sheena told Bush to give her the message instead
- Sheena was getting exasperated at the length of the message, but this writer told her that the length was necessary so as to fully convey to Basu the context of the question so as to afford hiim the option of fully responding- and that, in the event Basu did not return my call, then Bush would have made the effort to obtain his viewpoint accordingly
- Basu has not returned my call at the time of this writing
- *(NOTE: while CEG posted a $1.3 BILLION DOLLAR loss in its financial statements for 2008, there are book/tax adjustments which can result in significant differences between the financials and the tax return)-cb*
- *(NOTE 2: this email is being sent to Anirban Basu of the Sage Policy Group for his comments, if any, which will be posted here)-cb*

http://www.slideshare.net/davidpassmore/elimination-of-electricity-rate-caps-in-pennsylvania-20112015-presentation-710471

http://www.stltoday.com/blogzone/political-fix/political-fix/2009/04/war-of-words-ads-heats-up-in-ameren-bill-dispute/

> Former President Bill Clinton Supports a Return to the Fairness Doctrine

- see the wikipedia.org link
- former President Bill Clinton supports a return to the Fairness Doctrine ("wiki", paragraphs 43-45):

Former President [Bill Clinton](#) has also shown support for the Fairness Doctrine. During a February 13, 2009, appearance on the [Mario Solis Marich](#) radio show, Clinton said:

"Well, you either ought to have the Fairness Doctrine or we ought to have more balance on the other side, because essentially there's alaways been a lot of big money to support the right wing talk shows."

Clinton cited the "blatant drumbeat" against the stimulus program from conservative talk radio, suggesting that it doesn't reflect economic reality.[28]

- while yours truly opposed the Wall Street Bailouts as well, Talk Radio is UNfair cuz it does NOT provide balanced coverage of issues
- that's especially apparent when comparing the opposition to the public option w/ the censorship of pro-consumer positions as regards electricity rates, on WBAL 1090 AM's Ron Smith Show
- stay tuned

http://en.wikipedia.org/wiki/Fairness_Doctrine

> Obama Will Jump 15 Points in the Polls, From Re-Energized Democrats, If Bob Solidly Supports the Public Option on Health Care In Tonight's Address to Congress- Ed Schultz of the Ed Schultz Show on Air America/Jones Radio Network, at 12:47pm Wednesday, Sept. 9, 2009...

...Chris Bush Wants Universal Coverage as Well, But Backs a Derivatives Property Tax of 1% ("Micro-Prop") to pay for the Care, of Which 5/10ths of 1% Would be Used for Health Care (Bush OPPOSES Fines of as Much as $3,800 to Coerce Citizens to Pay for Expensive Health Insurance), with the Remainder Used for Other Purposes, Including the Great Plains Wind Project and the American Hybrid Project (AHP)

- Ed Schultz, of the Ed Schultz Show on Air America Radio/Jones Radio Network, just announced that Obama will jump 15 points in the polls- because of re-energized Dems- should BOB take a strong stand on the public option in tonight's address to Congress
- Schultz made these comments at 12:47pm on Wed., Sept 9, 2009
- Chris Bush wants universal coverage as well, but backs a Derivatives Property Tax of 1% ("Micro-Prop") to pay for the care, of which 5/10ths of 1% would be used for health care (Bush OPPOSES fines of as much as $3,800 to coerce citizens to pay for expensive health insurance)
- the remainder of the 1% of the Derivatives Tax would be used for other purposes, including financing the Great Plains Wind Project and the American Hybrid Project (AHP)

Chris Bush
20 Ridge Rd.
Catonsville, MD 21228
chris.bush@verizon.net
(410) 375-9010

Hearing Identifier: CalvertCliffs_Unit3Cola_Public_EX
Email Number: 892

Mail Envelope Properties (247428D7073C447B9CDDA94FE7954ED7)

Subject: Fw: Electricity Crisis-2 09-09-09 MOST NET CC3 Jobs OUTSIDE of MD-Sources: CEG Witness Anirban Basu, Penn State Univ, St. Louis Post-Dispatch
Sent Date: 9/12/2009 9:28:24 AM
Received Date: 9/12/2009 9:28:39 AM
From: William Johnston

Created By: wj3@comcast.net

Recipients:
"Biggins, James" <James.Biggins@nrc.gov>
Tracking Status: None

Post Office: billsdi4600

Files	**Size**	**Date & Time**
MESSAGE	36227	9/12/2009 9:28:39 AM
Basu Testimony- Maryland Jobs and CC3.pdf	541007	
scwind.cfm.htm	53915	
Mason_Coupled Wind-CAES Power Plants_Comparative Base Load Power Plant Analysis__RERI_13 August 2009.pdf	899647	

Options
Priority: Standard
Return Notification: No
Reply Requested: No
Sensitivity: Normal
Expiration Date:
Recipients Received:

Before The
Public Service Commission of Maryland

Case No. 9173, Phase II

IN THE MATTER OF THE

CURRENT AND FUTUE FINANCIAL CONDITION OF

BALTIMORE GAS AND ELECTRIC COMPANY

Rebuttal Testimony

Of

Anirban Basu
Sage Policy Group

On Behalf of

Constellation Energy Group

September 8, 2009

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I. INTRODUCTION AND WITNESS QUALIFICATIONS

Q. PLEASE STATE YOUR NAME AND BUSINESS ADDRESS.

A. My name is Anirban Basu. My business address is Sage Policy Group, Inc., 6 North Broadway, Suite 2, Baltimore, MD 21231.

Q. BY WHOM ARE YOU EMPLOYED?

A. Sage Policy Group, Inc.

Q. PLEASE DESCRIBE SAGE.

A. Sage Policy Group, Inc. is an economic and policy consulting firm specializing in economic, fiscal and legislative analysis, program evaluation, and organizational and strategic development. The firm's clients include public agencies at every level of government, multinationals, law firms, developers, money managers and an array of nonprofit organizations operating in a variety of segments.

Q. WHAT ARE YOUR RESPONSIBILITIES IN YOUR CURRENT POSITION?

A. I am Chairman and Chief Executive Officer.

Q. PLEASE DESCRIBE YOUR EDUCATION.

A. I earned my B.S. in Foreign Service at Georgetown University in 1990. I earned my Master's in Public Policy from Harvard University's John F. Kennedy School of Government, and my Master's in Economics from the University of Maryland, College Park. My Juris Doctor was earned at the University of Maryland School of Law in 2003.

Q. PLEASE DESCRIBE YOUR QUALIFICATIONS.

A. I am a widely recognized economist in the Mid-Atlantic region, in part because of my consulting work on behalf of developers, bankers, brokerage houses, energy suppliers and law firms. On behalf of government agencies and non-profit organizations, I have written several economic development strategies, including co-authoring Baltimore City's economic growth strategy. In recent years, I have written extensively regarding issues related to the deregulation of energy, the possibility of organizing purchasing cooperatives, the impact of energy-related investment on demand for construction services and optimal industry structure.

II. <u>PURPOSE AND SCOPE</u>

Q. ON WHOSE BEHALF ARE YOU PRESENTING THIS REBUTTAL TESTIMONY?

A. I am sponsoring this rebuttal testimony on behalf of the Constellation Energy Group, Inc. ("CEG").

Q. WHAT IS THE PURPOSE OF YOUR REBUTTAL TESTIMONY?

A. The purpose of this rebuttal testimony is to respond to the intervenor reply testimonies that were filed with the Maryland Public Service Commission.

In particular, I will provide my reaction to Staff Witness Frayer's analysis of the macroeconomic impact of the transaction, including the impact associated with the development of a third nuclear facility at Calvert Cliffs. I will also provide my own key findings as they relate to the current economic and fiscal impacts of CEG operations in Maryland, the potential economic and fiscal impacts of closing the partial sale of the CENG

JV to EDF, and the potential economic and fiscal impacts of construction of a nuclear power plant at Calvert Cliffs.

Q. DO YOU HAVE ANY EXHIBITS?

A. Yes. Attached as AB-1 is my Curriculum Vitae and attached as AB-2 is Sage Policy Group's analysis titled, "Impacts of Constellation Energy Group."

III. ANALYSIS

Q. MTEF WITNESS HOOKE IMPLIES THAT CEG IS NOT A MAJOR PART OF THE MARYLAND ECONOMY.[1] WHAT IS YOUR CONCLUSION?

A. I conclude that CEG produces a positive impact on Maryland's economy and tax revenue collections. With respect to Constellation's current operations in Maryland, the company supports directly and indirectly nearly 24,000 jobs with associated income of approximately $1.8 billion. This translates into nearly $75,000 per job. Constellation's operations also generate $2.2 billion in activity for other businesses located in Maryland. These ongoing operations are associated with $390 million in annual tax collections in Maryland, including State and local taxes. Please see Exhibit AB-2 for further details on this analysis.

Q. WHAT, IF ANY, LEVEL OF ECONOMIC IMPACTS WOULD RESULT FROM THE PARTIAL SALE OF CENG TO EDF?

A. The sale of almost one half of Constellation's nuclear power business to EDF would generate a major one-time tax event, with the State receiving an estimated $129 million of income taxes were the transaction to move forward. Constellation has also stated that EDF

[1] *See* Hooke Reply Testimony at 5-7.

would establish its U.S. headquarters in Maryland were the sale to move forward. That $20 million would be contributed toward a visitors and environmental education center at Calvert Cliffs, and a contribution of $36 million would be made to the Constellation Energy Group Foundation.

Q. HOW WOULD THE STATE INCOME TAXES AFFECT THE STATE OF MARYLAND'S OPERATING GENERAL FUND BUDGET?

A. To put the estimated $129 million fiscal impact into perspective, the Governor was recently required to cut the State's budget by $454 million. Based on the composition of these cuts, one can state with a healthy degree of precision what level of service could be restored were the Constellation-EDF transaction to move forward.

The estimated $129 million infusion, which would require very little countervailing State government delivery of service, could be used to restore approximately $7 million in Medicaid payments to hospitals, managed care organizations, community and other healthcare providers, restore $11 million in higher education expenditures, increase State worker compensation by $23 million to offset the impact of furloughs and salary reductions, increase assistance to local governments by roughly $65 million, including $6 million in police aid, more than $3 million to community colleges, $6 million to local health departments and approximately $50 million in additional assistance to local governments from monies collected from highway users. An additional $23 million could be used for a variety of purposes, including economic development, juvenile justice, K-12 education and support for Maryland's environment.

Q. HAS STAFF WITNESS FRAYER RAISED CERTAIN ISSUES TO WHICH YOU WOULD LIKE TO RESPOND? IF SO, WHICH ISSUES?

A. Yes, she has. I will respond to Ms. Frayer's analysis of the macroeconomic impacts of a third nuclear plant at Calvert Cliffs.[2]

Q. FIRST OF ALL, HOW DO YOU THINK THE TRANSACTION IMPACTS THE POTENTIAL OF CONSTRUCTING A NEW NUCLEAR PLANT IN THE STATE?

A. Constellation is an important corporate citizen that contributes massively to the state's economy and to Maryland's ability to support high incomes and relatively low unemployment rates. Were the EDF Transaction to occur, development of a third nuclear reactor at Calvert Cliffs would become more likely and would position Constellation and EDF to generate even greater economic and fiscal impacts into the future while contributing to a reduction in the state's carbon footprint and promoting energy reliability among other public policy objectives.

Specifically, the deal opens up to Maryland a world of opportunity with respect to the development of clean energy and clean technologies. EDF and France are leaders in nuclear technology, and that expertise would be delivered to Maryland in meaningful ways, including the location of EDF's U.S. headquarters in Maryland. The EDF transaction with CEG also appears to be a necessary precursor to the third nuclear reactor at Calvert Cliffs, which would create greater energy reliability, jobs and tax base.

[2] See Frayer Reply Testimony at 24-51.

Q. IN RESPONSE TO STAFF WITNESS FRAYER'S TESTIMONY, PLEASE SUMMARIZE YOUR OWN CONCLUSIONS REGARDING THE POTENTIAL BENEFITS TO MARYLAND OF CONSTRUCTING A NEW NUCLEAR PLANT IN THE STATE.[3]

A. I have prepared my own analysis as detailed in AB-2. For the total project period, a total of over 42,000 years of direct construction work will be created by the project. The total compensation associated with these direct jobs is estimated at $3 billion. The total multiplier effect of this direct impact will be an additional 29,000 years of work with associated income of $1.6 billion. Given the estimate that 85 percent of the spending of the direct workers will occur in Maryland, these impacts can be seen as the equivalent of over 36,000 years of direct project work for Maryland residents with associated income of over $2.5 billion and a multiplier effect in Maryland of almost 25,000 years of work for Marylanders with associated income of over $1.3 billion. In total, the design, development, construction, and operation of a third nuclear plant at Calvert Cliffs will support directly or through the multiplier effect almost 61,000 years of labor generating associated income of almost $3.9 billion. It should be stressed that these are one-time impacts that occur over an estimated 68 month period of construction.

These impacts will also result in income and sales tax revenue for state and local governments in Maryland. During the project period, the $3.9 billion income impact in Maryland will generate almost $300 million in tax revenue over the project period.

Q. MS. FRAYER APPEARS TO ONLY HAVE CALCULATED THE BENEFITS ASSOCIATED WITH THE JOB CREATION ASSOCIATED WITH A

[3] *See* Frayer Reply Testimony at 51-59.

POTENTIAL THIRD REACTOR AT CALVERT CLIFFS.[4] WITH RESPECT TO CONSTRUCTION, ARE THERE POTENTIAL BENEFITS BEYOND PAYROLL-RELATED CONSTRUCTION COSTS?

A. Yes, for every $1 billion of non-labor costs spent in Maryland on a variety of construction materials, equipment, and services, over 5,000 direct jobs and almost 6,000 multiplier effect jobs would be created in the state. This would result in an estimated impact of approximately $610 million of income related to job creation and approximately $1.75 billion in additional business sales. As with the direct construction jobs, these impacts would include indirect and induced impacts and would be one-time effects occurring only during the construction period. The fiscal impacts associated with $1 billion of purchases of goods and services from Maryland suppliers would total approximately $47 million during the construction period.

Q. PLEASE SUMMARIZE YOUR CONCLUSIONS REGARDING THE POTENTIAL PERMANENT AND ONGOING BENEFITS TO MARYLAND OF A NEW NUCLEAR PLANT IN THE STATE?

A. Once the third nuclear plant at Calvert Cliffs became operational, annual spending in Maryland would be boosted by $166 million in 2009 dollars, with $38 million dedicated to payroll and an estimated 360 permanent workers and $127 million toward non-payroll expenses that would support local business sales. Once one considers Maryland-specific multiplier effects, more than 2,300 jobs would be supported in the local economy with associated annual income exceeding $150 million. Business sales would be augmented by nearly $275 million per annum, and this total does not include the value of sales originating

[4] Frayer Reply Testimony at 54.

from the new plant itself. The plant would contribute an estimated $56 million in taxes to State and local government.

Q. WHAT ARE YOUR CONCLUSIONS RELATED TO STAFF WITNESS FRAYER'S METHODOLOGY AND DATA SOURCES?

A. The Sage analysis was based on assumptions similar to those noted in Ms. Frayer's testimony as to the scale of employment generated by construction and operation. Sage, however, used a more detailed assessment of the construction labor requirements over the estimated 68-month construction period which resulted in a slightly smaller estimate of total labor requirements (15,612 years of labor estimated by Sage versus 15,800 years of labor estimated by Ms. Frayer). Sage also used the assumption of a 68-month construction period versus a 4-year construction period used by Ms. Frayer. Both Sage and Ms. Frayer used $34 as an average hourly wage for construction labor. Sage used IMPLAN to estimate the multiplier effect of this income, rather than RIMS II used by Ms. Frayer. Both are widely accepted sources for estimating economic impacts.

Q. CAN YOU DISCUSS THE FACTORS YOU USED TO CALCULATE ECONOMIC IMPACTS THAT ARE DIFFERENT FROM OR IN ADDITION TO THE FACTORS MS. FRAYER USED TO CALCULATE ECONOMIC IMPACTS?

A. In addition to looking at the employment and income impacts associated with construction, Sage also considered income and sales tax revenues that this construction-related income would generate for state and local government in Maryland. Over the total construction period, construction workers and the related multiplier impact would generate almost $297 million in income and sales tax revenue in Maryland.

Sage also calculated impacts associated with non-payroll related construction impacts, or the purchase of construction-related materials in Maryland. For example, if $1 billion of total non-labor construction costs were spent in Maryland, this spending would support an estimated 11,100 jobs with associated income of $610 million, generate an additional $1.75 billion in business sales and generate an additional $56 million in tax revenue for state and local governments in Maryland.

Q. HOW DOES YOUR ANALYSIS OF THESE BENEFITS COMPARE TO MS. FRAYER'S ANALYSIS?

A. Though our absolute amount of benefits calculated for these items are different, in the end I think Ms. Frayer's conclusion that significant benefits exist is reasonable.

Q. DOES THIS CONCLUDE YOUR REBUTTAL TESTIMONY?

A. Yes, it does.

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Sage Policy Group, Inc.
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Baltimore, MD 21231
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Career Brief

Anirban Basu is Chairman & CEO of Sage Policy Group, Inc., an economic and policy consulting firm in Baltimore, Maryland. Mr. Basu is one of the Mid-Atlantic region's most recognizable economists, in part because of his consulting work on behalf of numerous clients, including prominent developers, bankers, brokerage houses, energy suppliers and law firms. On behalf of government agencies and non-profit organizations, Mr. Basu has written several high-profile economic development strategies.

In recent years, he has focused upon health economics, the economics of education and economic development. He currently lectures at Johns Hopkins University in micro-, macro- and international economics.

Mr. Basu is involved with numerous organizations in a voluntary capacity, including serving as a Baltimore City Public School System board member. Mr. Basu is also on the boards of Union Memorial Hospital, the MedStar strategic planning committee, Chesapeake Habitat for Humanity and the Maryland Business Council. He is also chairman of the Baltimore County Economic Advisory Committee and economic advisor to the Baltimore-Washington Corridor Chamber of Commerce.

Mr. Basu earned his B.S. in Foreign Service at Georgetown University in 1990. He earned his Master's in Public Policy from Harvard University's John F. Kennedy School of Government, and his Master's in Economics from the University of Maryland, College Park. His Juris Doctor was earned at the University of Maryland School of Law in 2003.

Experience

CHAIRMAN & CEO, SAGE POLICY GROUP, INC.
2004-
- Founder
- Chief economist
- Responsible for securing contracts
- Responsible for successful execution of projects and quality management
- Sole equity holder
- Responsible for representing the firm through public speaking and in the media

CHAIRMAN & CEO, OPTIMAL SOLUTIONS GROUP, LLC
2002-2004

- Co-founder
- Chief Economist
- Responsible for successful execution of projects and quality management
- Major equity holder

DIRECTOR, APPLIED ECONOMICS & SENIOR ECONOMIST, RESI/TOWSON UNIVERSITY
1992-2002

- Directed all research/consulting projects with heavy economic content
- Authored numerous publications, including *Outlook Maryland & Mid-Atlantic Economic Quarterly*
- Secured numerous contracts with private, public and non-profit entities, including the Maryland Department of Human Resources, BP, St. Paul Companies, Maryland Department of Business and Economic Development, Baltimore City Public School System, Maryland Office of the Comptroller, the Baltimore Symphony Orchestra Players' Committee, Baltimore County Chamber of Commerce and Mayor's Office of Baltimore City.

Education

J.D., UNIVERSITY OF MARYLAND SCHOOL of Law, 2003 *(passed MD Bar Exam, 7/03)*

- Graduated with honors
- Awarded the Larry B. Shoba Prize for Top Evening Student
- Concentration in General Business Law & International Trade

M.A., MATHEMATICAL ECONOMICS, UNIVERSITY OF MARYLAND, 1998

- Concentrations in Public Finance & Industrial Organization
- Thesis: The Objective Function of Big City Mayors

M.P.P., JOHN F. KENNEDY SCHOOL OF GOVERNEMENT, HARVARD UNIVERSITY, 1992

- Concentrations in International Development & Business and Government
- Thesis: The Impact of the 1986 Tax Reform Act on Commercial Real Estate Values in the Boston Metropolitan Area

B.S., FOREIGN SERVICE, GEORGETOWN UNIVERSITY, 1990

- Concentration in International Relations, Law & Organization
- Certificate in Asian Studies

List of Publications

May, 2009 On behalf of MacKenzie Commercial Real Estate Services, "MacKenzie Market Report"
http://www.mackenziecommercial.com/marketreport/

2008, 2009 On behalf of the Associated Builders and Contractors, http://www.abc.org/Hot_Links/ConstructionEconomicsIndex.aspx (see monthly articles listed under "Articles" on this link)

2008, 2009 On behalf of the Maryland Association of Realtors, Bimonthly article on the housing market appearing in the MD REALTOR magazine
http://www.mdrealtor.org/PublicationsPhotos/MDREALTORMagazine/tabid/104/Default.aspx

2007, 2008, 2009 On behalf of the Baltimore Ravens and the Maryland Stadium Authority, see list below:

- Economic and Fiscal Impacts of the 2008 Navy-Notre Dame Game
- Economic and Fiscal Impacts of the 2008 Kenny Chesney Concert Music Festival
- Economic and Fiscal Impacts of the 108th Army-Navy Game
- The Impact of the Hippodrome Theater on Maryland's Economy, FY2008
- The Impact of the Hippodrome Theater on Maryland's Economy, FY2007
- The Impact of Ocean City's Roland E. Powell Convention Center on Maryland's Economy, FY2008
- The Impact of Ocean City's Roland E. Powell Convention Center on Maryland's Economy, FY2007
- The Impact of Ocean City's Roland E. Powell Convention Center on Maryland's Economy, FY2006
- The Impact of the Montgomery County Hotel and Conference Center on Maryland's Economy, FY2008
- The Impact of the Montgomery County Hotel and Conference Center on Maryland's Economy, FY2007
- The Impact of the Montgomery County Hotel and Conference Center on Maryland's Economy, FY2006
- The Impact of the Baltimore Convention Center on Maryland's Economy, FY2008
- The Impact of the Baltimore Convention Center on Maryland's Economy, FY2007
- The Impact of the Baltimore Convention Center on Maryland's Economy, FY2006
- Baltimore Convention Center Future Impacts Related to the New Convention Center Headquarters Hotel
- The Impact of M&T Bank Stadium on Maryland's Economy, 2006

2008 On behalf of the Maryland Association of Realtors, "The Role of Real Estate in Maryland's Economy"
http://www.mdrealtor.org/LinkClick.aspx?fileticket=NFqG8DHNHGQ%3d&tabid=349

2008 On behalf of the University of Maryland, College Park, "Impacts of the University of Maryland, College Park"
http://www.newsdesk.umd.edu/uniini/release.cfm?ArticleID=1907

2006 On behalf of Howard County, Maryland, "Howard County Human Services Master Plan 2005-2010"
http://www.howardcountymd.gov/CitizenServices/csdocs/HSMP_WithForeignBornMAY2006.pdf

1999 On behalf of Towson University, "Maryland Economic Quarterly" (4 issues)

1999 On behalf of Towson University, "Virginia Economic Quarterly" (4 issues)

Expert Witness Experience

2008 On behalf of Dumbarton Improvement Association, Dumbarton Improvement Association, Inc., et al. v. Druid Ridge Cemetery Co. et al., Circuit Court of Baltimore County

2006 On behalf of Catalyst Rx, Catalyst Rx v. the State of Maryland, Maryland State Board of Contract Appeals

Impacts of Constellation Energy Group

Introduction

The following discussion summarizes the primary economic and fiscal impacts of the Constellation Energy Group, Inc. (CEG) with respect to:

- Economic and fiscal impacts of current operations defined as all company activities in 2008;
- Impacts associated with the partial sale of CENG to EDF;
- Impacts related to the construction of a third plant at Calvert Cliffs; and
- Permanent impacts related to operating a third plant at Calvert Cliffs.

Impacts of current operations

Current (i.e., 2008) operations of all CEG operating divisions encompassed 7,640 positions held by Maryland residents. Payroll for these Marylanders was $953 million.

Exhibit 1. CEG total employment and compensation, 2008 (millions)

	Maryland Residents	*Maryland Resident Payroll*
GRAND TOTAL	7,640	$953.1

Source: CEG

In addition to payroll spending in Maryland, CEG through its various operating divisions spent over $800 million in Maryland for services provided by Maryland-based companies, companies with substantial presences in the state, or other firms with employees who spent substantial time and money in Maryland.

Exhibit 2. Estimated non-payroll spending in MD, 2008 (millions)

Type of services purchased	*Fossil*	*Nuclear*	*Corporate*	*BGE*	*Total*
Engineering services	$116.0	$170.1			$286.1
Craft labor	$45.1	$14.9			$60.0
Fuel		$49.1			$49.1
Staff augmentation	$1.0	$2.2	$33.1		$36.2
Consulting services		$2.4			$2.4
Environmental services	$7.8				$7.8
Health insurance			$48.3		$48.3
Real estate			$24.1		$24.1
Landscaping services				$24.4	$24.4
Construction--substation				$1.8	$1.8
Construction--underground lines					$17.4

Outdoor lighting				$26.0	$26.0
Demand response services				$10.3	$10.3
Mailing services				$7.5	$7.5
Other	$75.8	$16.2	$14.3	$93.4	$199.7
Total	$245.7	$254.8	$119.9	$180.7	$801.0

Source: CEG

Economic impacts of current operations derive from two major activities. One is the CEG payroll for Maryland residents. These residents spend much of their income on consumer goods and services that support business sales and a significant number of jobs in the state (these are termed induced effects). The second source of economic impacts is CEG spending of over $800 million on services provided by firms in Maryland. This spending supports jobs and income in these firms and additional firms in Maryland that are suppliers of the firms CEG uses. All these effects are considered indirect effects. This spending supports the income of many Maryland workers who in turn spend money in the consumer economy creating additional induced effects. In total these economic impacts include 23,730 jobs with income of $1.8 billion. Not including the revenue CEG receives from its operations in Maryland, CEG operations support $2.2 billion in business sales in the state.

Exhibit 3. Economic impacts of CEG current operations in Maryland

Type of impact	*Jobs (FT+PT)*	*Income (millions)*	*Business sales (millions)*
Direct Effects	7,640	$953.1	N.A.
Indirect Effects	6,453	$423.2	$1,041.8
Induced Effects	9,638	$394.7	$1,175.5
Total	23,730	$1,771.0	$2,217.2

Source: Sage

CEG through its various operating divisions paid over $256 million in Maryland state and local taxes in 2008.

In addition, CEG, primarily through BGE, collects local energy taxes and sales taxes that are ultimately conveyed to Maryland state and local governments. These taxes totaled approximately $123 million in 2008.

Exhibit 4. Fiscal impacts of CEG current operations in Maryland (thousands)

	CEG Companies Excluding BGE 2008	*BGE 2008*	*Total 2008 Estimated MD State & Local Tax*
Maryland State and Local Taxes Paid	**$72,649**	**$183,382**	**$256,031**
Maryland State and Local Taxes Collected	**$10,856**	**$111,732**	**$122,588**
Total Maryland State & Local Taxes Paid & Collected	**$83,505**	**$295, 114**	**$378,619**

Source: CEG.
Note: The Maryland State and Local Taxes collected by CEG consists of the Maryland sales tax and County energy taxes that are imposed on electricity and gas retail customers and collected by BGE and Constellation NewEnergy, Inc.

The income earned by CEG workers and the income associated with the multiplier effect of the CEG payroll and CEG's non-payroll spending in Maryland generates income and sales taxes for Maryland state and local government. In 2008, these taxes totaled over $135 million.

Exhibit 5. Income and sales taxes of CEG workers and the multiplier effect from CEG spending in Maryland (thousands)

Type of tax	*Value*
State income tax	$60,116
Local income tax	$40,220
Sales tax	$35,059
Total	$135,395

Source: Sage

In total, CEG operations in Maryland supported $390 million in tax revenue in 2008. Not included in this total are the over $122 million in taxes that are collected by CEG on behalf of state and local governments in Maryland.

Exhibit 6. Total taxes generated in Maryland as a result of CEG operations (thousands)

Source of taxes	*Value*
Tax direct by CEG	$256,031
Income, sales tax from CEG workers and multiplier effect	$135,395
Total	$391,426

Source: Sage

Impacts associated with the partial sale of CENG to EDF

The sale of almost half of CENG to EDF would generate a one-time tax event and would also lead to several significant contributions to the state economy. The sale of a share of CENG to EDF would generate an estimated $129 million in income taxes for Maryland. EDF has also publicly stated that, on the completion of the sale, EDF would:

- Establish its U.S. headquarters in Maryland from which EDF would implement its substantial nuclear power development program in this country;
- Contribute $20 million for an environmental center at Calvert Cliffs, creating both a significant construction project and a permanent addition to tourism attractions in Calvert County; and
- Contribute $36 million to the CEG Foundation

Impacts related to the construction of a third plant at Calvert Cliffs

The construction of a third nuclear power plant at Calvert Cliffs is likely to be, if not the largest construction project ever undertaken in Maryland, certainly one of the largest. For the sake of comparison, the recent project to replace the Woodrow Wilson Bridge over the Potomac River cost $2.5 billion, and the costs of a new nuclear plant would be far in excess of that project.

The impacts of construction to the economy of Maryland will be determined by a number of factors primarily including the extent to which labor, materials, equipment, and other goods and services required by the project can be obtained from the Maryland workforce or Maryland businesses and other sources. The typical method of estimating impacts of construction is to identify the different types of spending on goods and services that would occur in Maryland and use data on the state economy that allows for measuring the multiplier effect of this spending.[1]

The multiplier effect includes two major components. One is the indirect effect of the direct spending based on the business-to-business transactions that occur as a result of the direct spending. For example, a contract which pays $1 million to a Maryland electrical contractor will generate business for the suppliers to that contractor. These suppliers might include electrical equipment supply firms, accounting firms, office supply businesses, and other Maryland-based companies that the electrical contractor typically relies on to conduct business. These suppliers will use some of the revenues received from the electrical contractor in turn to purchase the goods and services they need to operate from other Maryland firms. The totality of this cascading set of business-to-business transactions between Maryland firms is the indirect impact of the original spending on the contract with the electrical contractor.

The second component of the multiplier effect of the original expenditure is the induced impact. When workers encompassed in the direct and indirect impacts spend their income on goods and services in Maryland, this consumer-oriented spending supports jobs, income, and businesses in the state. The types of economic activity supported by this spending are highly varied from groceries to gasoline to housing to birthday gifts.

Detailed final budgets for the proposed plant are not available. For purposes of this analaysis, I have assumed a preliminary estimate of $10 billion, whichwould covers a broad range of costs including engineering, procurement, and construction (EPC) activities, owner's costs encompassing a miscellany of support activities (e.g., canteens, warehousing), contingencies, and an escalation factor that adjusts costs over the almost 6-year construction period.

Preliminary estimates are available of the labor required over the 68-month construction period and some information on the concrete required by the project. Other labor will include a substantial amount of engineering services involved in the design and development of the project which predates construction and, which, in fact, is already underway, as well as other professional services required throughout the total project required to develop, construct, and operationalize the nuclear plant. Based on discussions with CEG staff, total labor costs are expected to represent roughly 30 percent of the construction cost.

[1] This analysis uses software and data from IMPLAN a product of the Minnesota IMPLAN Group, Inc. that is considered the industry standard for estimating these types of economic impacts.

As detailed in the Calvert 3 technical report's discussion of socioeconomic impacts from construction, the full-time equivalent (FTE) construction workers required by the project start are estimated at 350 in the first quarter of the first year, peak at 3,950 FTE workers in part of Year 4 and Year 5, and wind down to 768 FTE workers in the final two months of the project. Over the life of the project, this construction labor requirement totals an estimated 15,612 years of full-time work by a range of occupations from craft trades (e.g., electricians) to professionals. At an estimated $34 per hour of average compensation (excluding benefits), these workers will earn $1.1 billion over the life of the project.[2] These are direct labor impacts of the construction project.

In considering the labor market that would be tapped for these workers, prior assessments looked at the construction industry within a 50-mile radius from the construction site. This radius would stretch from southeastern Delaware to northern Virginia, from northern Anne Arundel County to the Northern Neck of Virginia. That 50-mile radius currently includes an estimated population of 3.5 million,[3] a substantial population with a wide range of skills. Prior assessments estimated that 9 percent of the peak workforce of 3,950 would commute on a daily basis from outside of the labor market area closest to the site (Calvert and St. Mary's counties). The remaining 91 percent of the peak workforce would either be permanent residents of the local labor market or workers who would commute on a weekly or longer basis. That analysis also considered a range of workers who would commute on a weekly or longer basis. At the peak of demand for construction workers, a minimum of 20 percent and a maximum of 35 percent of the total workforce will be those who commute on a weekly or longer basis.

The extent to which all construction workers are resident in Maryland and the extent to which the consumer spending of all construction workers occurs in Maryland will be major factors in determining the economic impacts of the construction project in Maryland. Based on the prior assessment of the peak construction workforce, that workforce can be grouped as shown in the following table. Using the midpoint it is clear that the majority (63.5 percent) of the peak workforce would be from the local labor market in Maryland. If almost all daily commuters drove no more than one hour to the construction site, then the vast majority of these workers would also be from Maryland. With the exception of a slight section of southeastern Washington, D.C. and a similarly small sliver of the city of Alexandria near the southern terminus of the Woodrow Wilson Bridge, all of the area within an hour's drive of the Calvert Cliffs site is within Maryland.[4] Those who will commute on a weekly or longer basis are likely to come from a larger area including many areas outside of Maryland. Some longer-term commuters will likely be Maryland residents, while others will have their principal residences elsewhere. Even workers whose primary residence is located outside of Maryland will reside much of the time during construction in Maryland and consequently spend much of their income on housing, food, and other services and goods in Maryland. If 90 percent of daily commuters reside in Maryland and one-half of the consumer spending of longer-term commuters is spent in

[2] Section 5.7 Socioeconomic impacts from construction. CCNPP Unit 3 CPCN Technical Report in Support of CPCN Application. UniStar Nuclear Development, LLC. August, 2008.
[3] Population estimate from Decision Data, a proprietary source of demographic information.
[4] Area encompassed by one hour drive of Calvert Cliffs based on Decision Data assessment.

Maryland, then the spending in Maryland by the construction workforce would range from 81.6 percent to 89.1 percent of their total consumer expenditure. For this analysis, the approximate midpoint in this range--85 percent--is used as the estimate of Maryland consumer spending by the construction workforce.

Exhibit 7: Source of construction workers at peak

Location of worker	*20% in migrants*	*35% in migrants*	*Midpoint*
Resident of local labor market	71%	56%	63.5%
Daily commuter	9%	9%	9.0%
Weekly or longer commuter	20%	35%	27.5%
Total	100%	100%	100%

In addition to the direct project-related jobs, there will be other jobs supported by the construction activities. This multiplier effect can be estimated by using the typical ratio of indirect and induced jobs for industrial, highway, and similar construction activities in Maryland. For the state of Maryland there are an estimated 68.98 indirect and induced jobs supported by each 100 direct construction jobs. Construction jobs are typically well-paid while indirect and, especially, induced jobs (e.g., retail and service jobs) are not as well paid. The average compensation of the indirect and induced jobs supported by these direct construction jobs is roughly 76 percent of the average construction job compensation.

For the total project period, a total of over 42,000 years of direct construction work will be created by the project. The total compensation associated with these direct jobs is $3 billion, assuming total labor costs are expected to represent roughly 30 percent of the assumed plant construction cost. The total multiplier effect of this direct impact will be an additional 29,000 years of work with associated income of $1.6 billion. Given the estimate that 85 percent of the spending of the direct workers will occur in Maryland, these impacts can be seen as the equivalent of over 36,000 years of direct project work for Maryland residents with associated income of over $2.5 billion and a multiplier effect in Maryland of almost 25,000 years of work for Marylanders with associated income of over $1.3 billion. In total, the design, development, construction, and operationalization of a third nuclear plant at Calvert Cliffs will support directly or through the multiplier effect almost 61,000 years of labor, generating associated income of almost $3.9 billion. These impacts are summarized in the following table. It should be stressed that these one-time impacts that occur over the estimated 68 month period of construction.

Exhibit 8: Construction jobs and income and related multiplier effects

Type of impact	*Total impact*	*Impact in Maryland*
Direct jobs	42,421	36,058
Direct income (millions)	$3,000	$2,550
Multiplier jobs	29,261	24,872
Multiplier income (millions)	$1,566	$1,331
Total jobs	71,682	60,930
Total income (millions)	$4,566	$3,881

These impacts will also result in income and sales tax revenue for state and local governments in Maryland. During the project period, the $3.9 billion income impact in Maryland will generate almost $300 million in tax revenue over the project period.

Exhibit 9: Fiscal impacts associated with construction jobs and related multiplier effects

Type of tax	*Value (millions)*
State income tax	$132
Local income tax	$88
Sales tax	$77
Total	$297

As substantial as these impacts are, the direct project labor is estimated to represent roughly only 30 percent of the total project cost. Much of the remaining cost goes to material and equipment needed by the project. For example, the project will require an estimated 500,000 cubic yards of concrete and will entail the creation of two temporary concrete batch plants. Construction will also require the purchase of engineering and other services in addition to the direct project labor.

A substantial portion of these project costs will be spent for goods and services produced outside of Maryland, creating no economic impacts in the state. For those goods and services purchased in state, however, jobs and income will be created that are in addition to the direct construction jobs and their multiplier effects. For example, Bechtel and Arvea are currently conducting engineering studies for the proposed plant. Both companies which are also suppliers in support of current operations at Calvert Cliffs, have offices and major presences in Maryland. While current estimates of non-payroll spending in Maryland are not available, estimates of the direct and multiplier impacts of this spending can be made on the basis of bundles of goods and services required by construction that could be purchased in Maryland. If $1 billion of the roughly $7 billion for non-labor costs were spent in Maryland on a variety of construction materials, equipment, and services, over 5,000 direct jobs and almost 6,000 multiplier effect jobs would be created in the state. As with the direct project jobs, these impacts would include indirect and induced impacts and would be one-time effects occurring only during the construction period.

Exhibit 10: Estimated impacts of $1 billion of purchases of construction materials, goods, and services in Maryland

Type of impact	*Employment (full- and part-time jobs)*	*Income (millions)*	*Business sales (millions)*
Direct impacts	5,251	$341	$1,000
Multiplier impacts	5,897	$269	$754
Total impacts	11,148	$610	$1,754

The fiscal impacts associated with $1 billion of purchases of goods and services from Maryland suppliers would total approximately $47 million during the construction period.

Exhibit 11: Fiscal impacts associated with $1 billion of purchases of construction materials, goods, and services in Maryland

Type of tax	*Value (millions)*
State income tax	$21
Local income tax	$14
Sales tax	$12
Total	$47

The construction of a third nuclear plant at Calvert Cliffs would be an enormous construction project, likely the largest ever undertaken in Maryland. Accordingly, the economic impacts are substantial. Direct project labor and its multiplier effects could support almost 61,000 years of full-time work for Marylanders and $3.9 billion in associated income. Any additional spending in Maryland on goods and services for the project would only increase these impacts.

Permanent impacts related to operating a third plant at Calvert Cliffs

Once operational, the third plant is expected to require an estimated 360 permanent workers. Based on current payroll expenses at Calvert Cliffs, these workers would earn over $38 million in today's dollars.[5] In addition, a third plant would generate an estimated $127 million in non-payroll spending in Maryland based on current Calvert Cliffs' experience.[6] In total, another nuclear plant would generate annual spending of $166 million in Maryland.

Exhibit 12. Third plant operations (millions)

Type of spending	*Value*	
Payroll without any benefits, fringe		$38.3
Non-payroll spending		$127.4
Engineering services	$85.0	
Craft labor	$7.4	
Fuel	$24.6	
Staff augmentation	$1.1	
Consulting services	$1.2	
Other	$8.1	
Total payroll plus spending in Maryland		$165.7

Source: CEG, Sage

The multiplier effects associated with this third plant are based on payroll paid directly to CEG employees and non-payroll spending in the state. Over 2,300 jobs with associated income of $151 million would be supported by the operation of a third plant. That plant would also support

[5] The 2008 payroll for 870 Calvert Cliffs employees averaged over $106,000 per employee.

[6] The 2008 non-payroll expenditures for CEG nuclear activities that occurred in Maryland totaled over $254 million for the two existing nuclear power units. This analysis assumes a third unit would require half of this spending. Given that the proposed unit would equal the generating power of both existing units, this assumption is likely conservative and understates the new spending in Maryland that would occur because of a third plant at Calvert Cliffs.

business sales of $274 million for Maryland establishments, not including the value of sales of the third plant to Maryland customers itself.

Exhibit 13. Third plant operational impacts

Type of impact	*Jobs (FT+PT)*	*Income (millions)*	*Business sales (millions)*
	Jobs	*Income*	*Output*
CEG direct	360	$38.3	N.A.
Indirect from CEG spending	1,176	$80.7	$177.8
Induced	789	$32.3	$96.1
Total	2,325	$151.2	$274.0

Source: Sage

Based on discussions with CEG staff, the current rough estimate for Calvert County and Maryland property taxes is between $40 and $50 million annually. For this analysis the mid-point of $45 million was chosen.

As with current operations, additional taxes would be generated by new CEG employees, new MD spending by CEG, and the multiplier effects of these activities. In total fiscal impacts from a third plant would annually contribute over $56 million to state and local government in Maryland.

Exhibit 14. Third plant fiscal impacts (thousands)

Property tax for third plant	
Calvert County and Maryland	$45,000
Taxes on income supported by third plant	
State income tax	$5,132
Local income tax	$3,434
Sales tax	$2,993
Total	$11,559
Total taxes	
Property tax for third plant	$45,000
Total income, sales tax from CEG workers and multiplier effect	$11,559
Total	$56,559

Source: Sage

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Some may refer to solar and wind power as "free energy."

But when it comes to making the solar panels and wind turbines that convert natural energy into electricity that lights up homes and powers computers, there is nothing free about it.

Commercial-scale 2-megawatt turbines installed around the country today cost about $3.5 million each, including construction, according to Windustry, a Minneapolis-based nonprofit that promotes renewable energy use.

Construction costs are much higher for off-shore wind farms than for upland wind farms, according to Jason Fredette, director of investor and media relations for American Superconductor Corp., manufacturer of superconductor wires based in Devens. So in order to make wind power more readily available for consumers, off-shore wind farms would want to build as few turbines as possible to generate needed power.

American Superconductor says it has figured out how to do it: by making ultra-light generators.

AMSC Windtec, a wholly-owned subsidiary of American Superconductor, is working with the U.S. Department of Energy's National Renewable Energy Laboratory and its National Wind Technology Center to validate the economics of a 10-megawatt class superconductor wind turbine. A 10-megawatt wind turbine is unheard-of -- most turbines installed today are 1.5 to 2 megawatts, with 5 to 6 megawatts being "very cutting-edge," according to Fredette.

The biggest impediment to increasing the megawatt

sizes has been the weight of the accompanying generator. The more electricity a generator is capable of producing, the bigger and heavier it gets. For a 10-megawatt turbine, a generator system alone would weigh 300 tons. It's impossible to truck such a big and heavy generator, put it on top of a windmill and balance it, Fredette said.

But, it's a different story if you can make a generator with materials that aren't as heavy as copper. That's where American Superconductor's expertise comes in.

The company is known for its hair-thin high-temperature superconductor wire made from liquefied ceramic. These ultra-light wires can be put underground and carry more electricity than conventional overhead copper wires could.

For example, the company has worked with the Navy for the past two years to produce a superconductor motor. The 36.5-megawatt, 49,000-horsepower motor that had a successful test result last year weighs 75 tons when its copper-made counterpart would weigh 300 tons.

American Superconductor is projecting that its 10-megawatt class wind turbine generator system would weigh about 120 tons.

A 1-megawatt wind turbine costs 1 million euros, or about $1.42 million, and can power 300 to 400 homes, according to Fredette. And it would be super-economic if you could generate 10 times as much electricity to power 3,000 to 4,000 homes with just one turbine.

In addition, American Superconductor's product comes with a refrigeration feature to keep wires cool and prevent energy loss.

Fredette said the technology won't likely be ready for commercial use until 2014 or 2015.

"Our plan is to have this technology available when the off-shore wind power market really starts taking off," Fredette said.

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A Coupled Wind-CAES Base Load Power Plant Model: Comparative Economic Analysis of Base Load Power Plant Options

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Abstract

This study evaluates the economic feasibility of deploying coupled wind and CAES (compressed air energy storage) power plants for base load capacity. Due to inherent variation in wind speeds, wind plants even with geographic dispersion cannot be assigned full load capacity credit and must be supported by thermal power plants to balance and firm variable wind electricity supply in order to maintain grid reliability, which is the purpose of coupling wind and CAES power plants. A coupled wind-CAES plant model is compared to other types of base load capacity power plants: wind with backup natural gas plants; natural gas combined-cycle (NGCC) plants with and without carbon capture and storage (CCS) systems; a pulverized steam coal plant without a CCS system; a coal integrated gasification combined cycle (IGCC) plant with a CCS system; and a nuclear plant. The coupled wind-CAES plant model has the lowest retail electricity price estimate of the wind plant options. Coupled wind-CAES plants achieve a breakeven electricity price with NGCC plants without CCS systems when the price of natural gas is \$9.10/MMBtu. The low fuel consumption rate of coupled wind-CAES plants insulates electricity price from future increases in natural gas prices, which will provide significant long-term economic benefits. The cost of CO_2 emissions reduction for coupled wind-CAES plants compared with conventional pulverized coal plants without CCS systems is \$33/tonne or a \$0.024/kWh (26%) increase in retail electricity price. In conclusion, this study finds that coupled wind-CAES plants are an economically viable option for base load capacity.

Table 5. Results: Comparative Analysis of Base Load Power Plants (Per Unit of Load Capacity Credit).

	Wind with NGCT (Optimized)[a]	Wind with NGCC (Optimized)	Wind with CAES (Optimized)	NGCC	NGCC w/CCS	Steam Coal without CCS	Coal IGCC with CCS	Nuclear
Retail Electricity Price (\$/kWh)	0.133	0.126	0.116	0.104	0.134	0.092	0.142	0.145
Capital Cost (\$/kW)	2,579	2,800	3,833	857	1,683	1,833	3,031	5,000
CO_2 Emissions (g/kWh)	355	282	78	392	132	806	70	0
Fuel Consumption (Btu/kWh)	6,837	5,010	1,439	7,196	8,613	8,844	9,713	0
CO_2 Reduction Cost (\$/t)	91	65	33	29	63		67	66

Notes:

a. Abbreviations: NGCT = natural gas combustion turbine; NGCC = natural gas combined-cycle; CAES = compressed air energy storage power plant; CCS = carbon capture and storage system; IGCC = coal integrated gasification combined-cycle.

I. Introduction: Base Load Capacity Power Plants.

This study evaluates the economic efficacy of deploying coupled wind and compressed air energy storage (CAES) power plants for base load capacity. By 2030, the U.S. will need to build approximately one hundred gigawatts (GW) of base load capacity to retire aging plants and to accommodate demand growth [1]. Base load power plants supply electricity to meet the daily minimum load, which means they operate at full power output, 24/7. In addition, the U.S. Department of Energy (DOE) agencies, Office of Energy Efficiency and Renewable Energy (EERE) and the National Renewable Energy Laboratory (NREL), are developing plans for wind power plants to supply 20-30% of total U.S. electricity generation by 2030, which is 800-1200 TWh (terawatt-hours) of electricity produced by approximately 300 GW of wind power plants [2, 3].

The Midwest plains states from the Canadian border to the Texas Panhandle and the Atlantic Ocean are the two largest and highest quality sources of wind energy in the U.S. This study investigates the economics of building coupled wind-CAES plants in the Midwest and then transporting the electricity to markets throughout the U.S. via long distance transmission lines (refer to Fig. 1). The purpose of this study is to establish a baseline model for coupled wind-CAES plants located at sites in the Midwest with a minimum Class 4 wind regime and to compare the results with other sources of base load power. The evaluation of offshore Atlantic Ocean wind plants is beyond the scope of this study.

At present, the conventional types of base load power plants are pulverized coal plants, nuclear plants, and natural gas combined-cycle (NGCC) plants. This study extends the analysis of base load capacity power plants to include wind power plants that are combined with backup natural gas combustion turbine and combined-cycle power plants and CAES air turbine power plants. Due to inherent variation in wind speeds, studies indicate that the effective load carrying capacity (ELCC) of wind power plants ranges from 5% to 30%, which means that wind power plants by themselves are not able to replace conventional base load capacity power plants [2]. The ELCC estimates hold even in the case of aggregate electricity production by geographically dispersed wind plants. In other words, wind plants are primarily an energy source that reduces the operational time and fuel consumption of fossil fuel plants and are assigned only marginal capacity credit.

If wind plants are to be assigned full base load capacity credit, then they must be able to reliably supply a pre-determined quantity of electricity on demand. Because of wind's variability, the only way to assign full load capacity credit to wind plants is at the system level, which consists of combining wind plant capacity with supporting thermal power plant capacity to balance and firm variable wind electricity supply. This study evaluates two wind base load capacity models: 1) a wind plant with supporting natural gas plant model; and 2) a wind plant with supporting CAES plant model. In the wind with natural gas plant model, the wind plants are assigned a 15% ELCC, which is a realistic expectation for a Class 4 wind resource regime [3]. Two types of backup natural gas power plants models are specified; a natural gas combustion turbine (NGCT) plant model and a natural gas combined-cycle (NGCC) plant model.

The wind plant with supporting NGCT plant model is the conventional backup power plant model to balance and firm variable wind electricity supply. In addition, this study includes the application of NGCC power plants to balance and firm variable wind electricity supply. The task is to maximize wind electricity supply and to minimize operation of supporting natural gas plants through the use of wind forecasts. Another issue that needs to be taken into account with the wind and natural gas plant model is the amount of time that the supporting natural gas plants must operate in spinning reserve mode in lieu of wind forecasting uncertainty about wind electricity production levels.

The third wind model and the focal point of this study is a coupled wind-CAES plant model. Several studies have been published in recent years documenting CAES power plants as a viable means to resolve the intermittency problem of wind and solar energy [4, 5, 6, 7, 8]. The basic idea is to transport a portion of wind electricity production to a CAES plant where it is used to power compressors and compress air. The compressed air is then stored in large underground reservoirs such as aquifers, depleted gas wells, or salt domes. The compressed air is released on demand from the storage reservoir to power the plant's turbine/generator unit. A CAES plant schematic is presented in Fig. 2. The volume of the air storage reservoir is selected to insure that an adequate supply of compressed air is available for the CAES plant to maintain a constant supply of electricity to the grid under all wind plant electricity production conditions. The turnaround wind energy storage efficiency is approximately 70%, which is comparable to the turnaround energy storage efficiency of other types of electricity storage systems [9].

For coupled wind-CAES plants, the objective is to maximize the grid distribution of wind electricity and to minimize CAES electricity production. In the coupled wind-CAES model, wind plant capacity is over-sized at a level to enable the assignment of a predetermined portion of peak wind electricity production to grid distribution and the remaining portion of wind electricity to the CAES plant. The size of the CAES plant and the volume of the air storage reservoir are designed to insure that the coupled wind-CAES plants are able to deliver a constant, pre-determined quantity of electricity to the grid.

A CAES combustion turbine power plant is similar to a conventional combustion turbine power plant but consumes about 58% less fuel. The difference in the CAES plant design is the separation of the air compressors from the turbine's air expansion unit. A conventional combustion turbine power plant consumes more energy to power the air compressors than the energy it uses for air expansion. In fact, two-thirds of the energy consumed by a conventional combustion turbine power plant is used to power the air compressors to create the air density and velocity to power the turbines and generate electricity. In contrast, the CAES power plant design separates the air compressors from the turbine/generator unit, which reduces fuel consumption by 58% since wind or some other external energy source is used to power the air compressors.

CAES is a proven technology with a 290-MW CAES plant operating in Germany since 1978 and a 110-MW CAES plant operating in Alabama since 1991 (refer to Fig. 3). The Alabama CAES plant was the only Gulf Coast power plant in operation during Hurricane Katrina in 2005. The McIntosh, Alabama CAES plant stores compressed air in an underground salt dome. The volume of stored compressed air is sufficient to generate electricity for twenty-six hours without recharging the air storage reservoir.

The geologic formations suitable for air storage reservoirs are porous rock formations such as deep saline aquifers, depleted natural gas fields, and salt formations. The distribution of favorable geologic formations for CAES suggests that there is ample air storage capacity for CAES plants in areas of the U.S. with Class 4 and higher wind resources (refer to Fig. 4) [9]. According to EPRI (Electric Power Research Institute) energy storage cost estimates, which are presented in Table 1, CAES is the lowest form of large-scale energy storage [10].

For CAES plants located in the Midwest, deep saline aquifers are the likely choice for air storage reservoirs. The air storage volume potential of aquifers is large compared with other types of storage reservoirs. It may be possible for a single aquifer to store a volume of compressed air to support gigawatts (GW) of CAES plant capacity, which would significantly reduce air storage cost.

One of the central questions of this study is whether the application of CAES power plants to shape and firm variable wind power results in a lower retail electricity price compared with the current method of using backup natural gas power plants. Then, the results of the wind models are compared with the results for the other base load power plant options. Also, a sensitivity analysis is performed to evaluate the effect of natural gas price increases on the retail prices of electricity produced by natural gas fired power plants.

II. Specification of Base Load Power Plant Models.

The specifications of wind and supporting thermal power plant models used in this study are informed by a review of studies conducted in recent years that are laying the groundwork for the large-scale production of wind electricity in the U.S. In 2007, the Office of Energy Efficiency and Renewable Energy (EERE) released the "20% Wind Energy by 2030" report [2]. The EERE study is being followed by the DOE/NREL sponsored Eastern Wind Integration and Transmission Study (EWITS) for the Eastern Interconnect region, which is studying 20-30% wind penetration levels. In December 2008, the initial EWITS report, JSCP'08 Economic Assessment, was released by the Joint Coordinated System Plan (JCSP) [3]. JCSP is composed of regional Independent Service Organizations (ISO) and electric utilities that manage and coordinate the nation's regional electricity transmission systems.

The largest source of high quality inland wind resources, Class 4 and higher, are located in the Midwest states from the Canadian border to the Texas Panhandle. Obviously, the cost of wind electricity is dependent on the quality of the wind resource, but long-distance transmission costs need to be factored into the cost assessment. The 2008 JCSP'08-EWITS study states that there may be economic benefits from the transmission of Midwest wind electricity to northeastern and southeastern states, but more research is required. The JCSP'08-EWITS report is the first step in planning the development of a national electricity transmission system for the U.S.

At present the EWITS program does not include a coupled wind-CAES plant scenario. While the JCSP'08 report acknowledges the issue of energy storage for wind power, the need for energy storage is rejected with assertions about possible solutions without providing supporting data.[1] This study extends the JCSP'08-EWITS report by specifying and evaluating the economic merits of an optimized wind-CAES model that is derived from a review of Succar and Williams 2008 wind CAES study [9].

The JCSP'08-EWITS study has two wind plant scenarios for 2024 power plant capacity allocations: 1) wind producing 5% of total U.S. electricity generation, i.e., 200 TWh of electricity; and 2) wind producing 20% of total U.S. electricity generation, i.e., 800 TWh of electricity. The JCSP'08-EWITS power plant capacity allocations are presented in Tables 2 and 3.

In the 5% wind scenario, there is 58 GW of wind power plant capacity and 77 GW of base load steam generating capacity. In contrast, the 20% wind scenario calls for 229 GW of wind power plant capacity and 37 GW of base load steam generating power plant capacity. Also, the 20% wind scenario calls for a 21 GW increase in natural gas combustion turbine plant capacity compared with the 5% wind scenario. The 21 GW increase in natural gas power plant capacity balances, shapes, and firms the variable wind electricity produced by the 171 GW increase in wind plant capacity.

From the JCSP'08-EWITS capacity allocations, it possible to deduce the wind and backup natural gas power plant allocation that results in a unit reduction in base load steam generating plant capacity. The objective is to estimate the allocation of wind and natural gas power plant capacity that is required to supply a unit of base load capacity with the same reliability standards of fossil fuel plants. Power plant

[1] One of the energy storage solutions mentioned in the JCSP'08 study is the use of pluggable hybrid electric vehicles. While this is an intriguing idea, there are many unanswered questions such as the quantity of energy available in the batteries of fleet vehicles at the end of the day, which corresponds with summer and winter peak demand periods. Also, the large number of vehicles in use during the afternoon drive period also corresponds with the winter and summer peak demand period. While research is needed to rigorously evaluate this form of energy storage, it is beyond the scope of this study.

capacity that meets load capacity standards, meaning it supplies electricity on demand, is the relevant definition of power plant capacity.

Since the 171 GW increase in wind power plant capacity results in a 40 GW reduction in base load steam generating plant capacity, it follows that 4.32 units of wind capacity, which is to be combined with a yet to be determined backup natural gas plant capacity, is equivalent to a unit of base load steam generating plant capacity (171 GW divided by 40 GW). To determine the backup natural gas plant capacity, there is a 21 GW increase in natural gas combustion turbine plant capacity along with the 40 GW reduction in base load steam generating plant capacity, which is a ratio of 0.52 units of combustion turbine plant capacity per unit of base load steam generating plant capacity (21 GW divided by 40 GW). The conclusion derived from this capacity allocation is that 4.32 units of wind plant capacity combined with 0.52 units of backup combustion turbine plant capacity provides one unit of base load capacity credit.

Prior research suggests that the JCSP'08-EWITS allocation of wind and backup natural gas power plant capacity to replace base load steam generating plant capacity stated above is not an optimum allocation [9]. This conclusion is based on the capacity specifications of an optimized wind with natural gas plant model and an optimized wind with CAES plant model from the Succar and Williams wind CAES study, which are presented in Table 3 [9]. The Succar-Williams capacity specification for an optimized base load wind with natural gas plant model is a load capacity ratio of 1.0 units of wind plant capacity to 0.85 units of natural gas plant capacity and 0.12 units of reserve natural gas plant capacity. The optimized wind with backup natural gas plant model has a 15% effective load carrying capacity (ELCC) for wind power and a reserve capacity of 15%, which are consistent with the JCSP'08-EWITS' ELCC and reserve capacity assumptions. The electricity supply mix of the optimized wind with natural gas plant model is 50% from the wind plants, 49% from the natural gas power plants, and 1% from the reserve natural gas simple combustion turbine plants. This specification is used for a NGCT model and a NGCC model.

The capacity specification for Succar-Williams optimized base load wind with CAES plant model is 1.57 units of wind plant capacity to 0.64 units of CAES plant capacity. The electricity supply mix of the optimized wind with CAES plant model is 69% from the wind plants and 31% from the CAES plants. The volume of compressed air in the storage reservoir supports 88 hours of CAES power plant operation without reservoir recharging, which is sufficient to maintain a firm 85% capacity factor rating for annual electricity production by the coupled wind-CAES plant.

III. Financial Assumptions.

All findings are reported in metrics that are scaled to a unit of base load capacity credit. Power plant cost, performance, and modeling parameters are presented in Table 4. Levelized retail electricity prices are estimated by the net present value, cash flow method. A levelized price is the price that generates a constant revenue stream to recover all capital investments and expenses over the capital recovery period. The net present value, cash flow method is characterized by the formula

$$NPV = \sum_{t=1}^{N} \frac{NCF_t}{(1+k)^t} - I_0 . \tag{1}$$

where: NPV = net present value of the investment project; NCF_t = net cash flows per year for the project; k = cost of capital, which is a weighted average cost of capital (WACC); $(1 + k)^t$ = the discount rate to convert annual net cash flows to their present value; N = number of years for capital recovery; and I_0 = shareholder investment in the project. The levelized electricity price is $/kWh of electricity that creates a revenue stream generating a sum of annual discounted cash flows equaling a zero NPV over the specified construction and capital recovery period.

The financial assumptions, which are consistent with JCPS'08-EWITS, are as follows. The real discount rate is a weighted average cost of capital and is based on the following: a capital structure of 55% debt and 45% equity; rates of return on capital of 9% for debt and 12% for equity; a 39% tax rate; and a 3% average annual inflation rate. The capital recovery periods are: 25 years for wind plants, 30 years for thermal power plants, HVDC transmission lines and DC-to-AC converter stations. The construction period is three years for natural gas and CAES plants, six years for coal plants, and seven years for nuclear plants. Depreciation is a fifteen year MACRS. A simplifying assumption is that base load power plants have an 85% annual capacity factor. Fuel costs are $7/MMBtu for natural gas, $1.94/MMBtu for coal, and $0.70/MMBtu for uranium.[2]

The wind, natural gas, and coal power plant capital costs, fixed and variable O&M costs, and plant performance parameters are from the JSCP'08 study [3]. The wind capital cost estimate of $2,000/kW is the JCSP'08 estimate of actual 2008 wind plant capital cost. Nuclear plant fixed and variable O&M cost and plant performance estimates are also from JCSP'08 study. But the projected nuclear plant capital cost for Nth plant of $5,000/kW is original to this study and is approximately 30% less than the projected next plant capital cost of more than $7,000/kW, which are the reported bids recently submitted for proposed Ontario, Canada nuclear power plants [11]. The reported Canadian nuclear power plant capital cost estimates are consistent with the reported capital costs for a Finnish nuclear power plant that is under construction by the French company Areva [12]. CAES capital cost estimates are original to this study, but the fixed and variable O&M costs and performance parameters are from Succar-Williams wind CAES study [9]. A simplifying assumption is that base load power plants have an 85% annual capacity factor.

The coupled wind-CAES plant model assumes that both wind and CAES plants are located in the Midwest and that the electricity is transported to local markets nationwide via high voltage DC (HVDC) transmission lines at an average distance of 1,600 kilometers and one DC-AC converter station. HVDC and DC-AC converter station costs are from DLR and converted to 2009 U.S. $ [13]. The cost of transmission lines for natural gas, coal, and nuclear plants are included in the retail electricity price estimates as a local electric company cost component since the conventional base load power plants are generally located within the transmission network of the local electric company.

The local electric company cost component in the end-user retail electricity price, which includes expenses such as local electricity transmission and billing, is assumed to be $0.035/kWh. The local electric company cost is a ballpark estimate derived from analyses of EIA reported average retail electricity prices for 2008, levelized electricity price estimates for new generation, and a report on the revenues and expenses for a EIA sample of investor owned electric companies [1, 14]. While the retail electricity price estimates reported in this study are not definitive since they are sensitive to the underlying assumptions, they are appropriate to make comparative inferences since the assumptions are applied consistently to all the power plant models evaluated in this study.

The CO_2 emissions reduction cost estimates are in reference to the CO_2 emissions of a pulverized coal plant, which is assumed to emit 806 g CO_2/kWh of electricity generated [3]. The CO_2 emissions reduction cost estimates are calculated by subtracting the retail electricity price of the power plant with lower CO_2 emissions from the retail electricity price of the pulverized coal plant; then the retail electricity price difference is divided by the quantity that CO_2 emissions are reduced per kWh of electricity. For the natural gas and coal plants with carbon capture and storage systems (CCS), the estimated CO_2 transport and storage cost is $0.004/kWh [9, 15].

[2] The fuel price estimates are for 2015, which is the earliest date for plants to come online if construction were to begin today.

For the wind with natural gas plant models, it is assumed that the supporting natural gas plants are in spinning reserve mode at a rate equivalent to 20% of total wind electricity production [3, 16]. The time spent in spinning reserve mode is in addition to the time spent in electricity generation mode. When a natural gas combustion turbine plant is in spinning reserve mode, the fuel consumption rate is 16% greater than when in electricity generating mode [17]. When plants operate in spinning reserve mode, they receive revenues in the amount of the variable O&M and fuel expenses incurred.

IV. Findings: Comparison of Wind Plant Models with Natural Gas, Coal, and Nuclear Plants.

Capital costs, retail electricity prices, retail electricity price sensitivity to increases in fuel price, fuel consumption rates, CO_2 emissions rates, and CO_2 emissions reduction cost estimates are presented in Table 5 and Figs. 5-10. The capital cost of the JCSP'08-EWITS wind with natural gas model is $8,944/kW of base load capacity. The corresponding levelized retail electricity price is $0.164/kWh. In contrast, the capital cost of the optimized wind with backup NGCT and NGCC plant models are $2,579 and $2,800/kW of base load capacity respectively, and the retail electricity prices are $0.133/kWh and $0.126/kWh respectively. These findings support the contention that the JCSP'08-EWITS' wind plant capacity allocation is sub-optimum in terms of both capital cost and retail electricity price.

The capital cost of the wind with CAES plant model is $3,833/kW of load capacity, and the retail electricity price estimate is $0.116/kWh. While the capital cost of wind-CAES base load capacity is greater than the optimized wind with natural gas plant models, the retail electricity price is less. The capital cost differential between the wind-CAES model and the wind-NGCT model is recovered in ten years from the electricity price savings, and for the wind-NGCC model the capital cost differential is recovered in fourteen years. At a 20% wind penetration level, which is 800 TWh of annual electricity production, the wind-CAES electricity price savings over the forty-year operating life of the power plants are approximately $400 billion, which covers the total investment cost of a 100 GW wind-CAES base load power plant system.

An important factor to take into account is the impact of expected increases in future natural gas prices. The reason this is important is because the aggregate fuel consumption rate of electricity produced by coupled wind-CAES plants is much less than that for the electricity produced by wind with natural gas plants. A sensitivity analysis of the effect of natural gas price increases on retail electricity prices is performed, and the results are presented in Fig. 7. An increase in natural gas price from $7/MMBtu to $14/MMBtu increases the electricity price difference between the coupled wind-CAES plant model and the wind with NGCC plant model from $0.010/kWh to $0.023/kWh, which increases the annual savings in spending on electricity from $8 billion to $18 billion at the 20% wind penetration level.

In conclusion, the coupled wind-CAES plant model has a lower retail electricity price and lower CO_2 emissions compared with the optimized wind with backup natural gas plant model. Also, the low fuel consumption rate of the coupled wind-CAES plant model is important in insulating electricity prices from expected increases in future natural gas prices. While the capital cost of the coupled wind-CAES plant model is greater than that of optimized wind with natural gas plant model, the discounted annual cash flow balances result in lower retail electricity price, due largely to the lower fuel consumption rate.

Next, the coupled wind-CAES plant model is compared with the NGCC, NGCC with CCS, steam coal; coal IGCC with CCS, and nuclear plants. The retail electricity price estimates for the NGCC, NGCC with CCS, coal IGCC with CCS, and nuclear plants are $0.104/kWh, $0.134/kWh, $0.092/kWh, $0.142/kWh, and $0.145/kWh respectively. The CO_2 emissions reduction cost estimates for the NGCC, NGCC with CCS, coal IGCC with CCS, and nuclear plants are $29/tonne, $63/tonne, $67/tonne, and $66/

tonne respectively. In comparison, retail electricity price estimate for the coupled wind-CAES plant model is \$0.116/kWh, and the CO_2 emissions reduction cost is \$33/tonne.

Once again, the coupled wind-CAES plant model compares favorably with the conventional base load power plant options. While the retail electricity price estimate for NGCC is \$0.012/kWh less than that for the coupled wind-CAES plant model, the fuel consumption rate of NGCC plants leads to greater electricity price exposure to future increases in natural gas price; refer to the sensitivity findings presented in Fig. 7. The breakeven electricity price between the coupled wind-CAES plant model and the NGCC without CCS plant model occurs when natural gas price increases to \$9.10/MMBtu, which was surpassed in 2008.

While the retail electricity price for steam coal without CCS is the lowest of all base load power plant options, the CO_2 emissions rate of type of power plant is unacceptable in a carbon constrained world. For coal plants with CCS systems, conventional pulverized steam coal plants are replaced by coal IGCC plants with CCS systems. For the coal IGCC with CCS plant model, the electricity price is \$0.026/kWh greater than the wind-CAES electricity price. At the 100 GW capacity level, the annual electricity price differential between the electricity prices of the wind-CAES and coal IGCC with CCS models is about \$20 billion. Future increases in coal prices increase the economic disparity. Hence, the coupled wind-CAES model is economically competitive with the coal IGCC with CCS model. On a final note, the findings indicate that the wind-CAES model is economically competitive with the nuclear plant model.

V. Conclusion.

The findings of this study support the conclusion that coupled wind-CAES plants are an economically viable base load power plant option. An important finding is the lower electricity price and low CO_2 emissions reduction cost of the coupled wind-CAES plant model compared with those for wind with natural gas plants, the coal IGCC with CCS plant, and the nuclear plant models. Since wind is free, the low fuel consumption rate of CAES plants will insulate wind-CAES electricity prices from future increases in natural gas and coal prices.

It is noteworthy that the findings of this study call into question the economic feasibility of supporting the variable power production of wind plants with electricity produced by backup natural gas plants. Coupling wind plants to CAES plants is a less complex, more reliable, and more efficient electricity production and distribution system. In addition, coupled wind-CAES plants reduce CO_2 emissions by 90% compared with the CO_2 emissions rate of pulverized coal plants, whereas the wind with natural gas model reduces CO_2 emissions by only 69%. The 90% CO_2 emissions reduction rate of coupled wind-CAES plants is needed if the U.S. is to actually achieve an 80% reduction in CO_2 emissions by 2050. For CO_2 emissions reduction, it is important to realize that plants built today will still be in operation in 2050.

The DOE sponsored planning for wind to provide 20% of U.S. electricity generation in 2030 translates to 300 GW of wind plant capacity and 800 TWh of electricity generation. If the 300 GW of wind plants are coupled to CAES plants for base load capacity, then 190 GW of coupled wind-CAES base load capacity can be built by 2030. This base load capacity is sufficient to replace the deployment of all other plants.

For 100 GW of base load wind-CAES capacity, only 157 GW of wind plants and 64 GW of CAES plants are required. The total capital cost of a 100 GW base load wind-CAES system is \$416 billion, which includes \$32 billion for twenty-three 5-GW HVDC transmission lines and DC-AC converter stations. For this scale of coupled wind-CAES deployment, a national program will be required to develop air storage reservoirs on an ongoing basis similar to the national natural gas underground storage program.

One final issue is the concern in those areas of the country supplied by inexpensive coal power about electricity price increases that will result from CO_2 emissions reduction schemes. The retail electricity price estimate for a new pulverized coal plant without CCS is \$0.092/kWh. The \$0.116/kWh retail electricity price for coupled wind-CAES plants represents a \$0.024/kWh increase in retail electricity price, which is a 26% increase or \$24/month/1000 kWh of electricity. However, people fail to take into account the external health and global warming costs associated with coal power plant emissions. The health and global warming costs are at least \$0.06/kWh, which is readily derived from recent studies on the health and global warming costs related to coal power plant emissions [18, 19]. The external costs are considerably greater than the increase in electric bills caused by coupled wind-CAES plants. Therefore, the increase in electricity prices caused by coupled wind-CAES plants actually represents a significant savings in terms of aggregate economic costs. In conclusion, the argument that CO_2 emissions reduction costs will lead to financial hardship is without merit.

Summary of Wind-CAES Benefits and Reasons to Build Wind-CAES Plants Today

1) Intermittent wind electricity creates greater variability in electricity supply for the local grid, which increases the complexity and costs of electricity supply regulation. Also, only a small fraction of intermittent wind electricity can be assigned load capacity credit, which means that wind power plants cannot replace fossil fuel plants to meet load capacity requirements. And, the addition of intermittent wind capacity increases reserve capacity requirements. Therefore, intermittent wind capacity increases system operational complexity and costs, which results in higher end-user electricity prices. In conclusion, the coupling of wind plants to CAES plants resolves wind's intermittency problems, improves system reliability, lowers system costs, and maximizes CO_2 emissions reduction by enabling replacement of fossil fuel power plants.

2) CAES gas turbine plants will achieve capital cost reductions. To date, only two CAES plants have been built, which means that next plant costs are artificially high due to the high cost of manufacturing one-of-a-kind components. Nth plant and learning curve cost reductions will occur with a moderate CAES plant adoption rate, and the trajectory of the Nth plant and learning curve cost reductions should be steep. At present, next plant costs are comparable to natural gas combined-cycle power plants, which are 50% greater than the costs of a natural gas simple cycle power plant. Since CAES plants are modifications of simple cycle gas turbine, Nth CAES plant costs should be about 30% lower than current next plant cost.

3) The low dispatch cost, i.e., variable operating costs including fuel cost, of wind-CAES plants gives them a bid-in advantage over fossil fuel and nuclear plants in de-regulated electricity markets. In de-regulated electricity markets, electricity with the lowest dispatch cost is sold first. Since the dispatch cost of wind-CAES plants is lower than fossil fuel and nuclear power plants, wind-CAES plants will be able to realize full capacity utilization. At present, the lowest dispatch cost providers for base load electricity are coal and nuclear plants. Hence, the adoption of wind-CAES plants can alter the mix of base load electricity supply.

4) If wind in the Midwest is to supply over a hundred gigawatts of power, which is well within its potential, then the coupling of wind and CAES plants is important since it will require only half the number of transmission lines required to transport the Midwest wind electricity to eastern seaboard markets, which also reduces transmission costs.

5) Wind-CAES plants utilizing aquifer and depleted gas field storage reservoirs should be built as soon as possible in order to gain experience with this air storage medium before installation of Midwest wind capacity is fully scaled up.

6) It is important for the U.S. be a leader in wind-CAES technology. With the development of wind-CAES technology, the technology can be exported to countries with natural gas and/or coal supply constraints such as Europe, China, and India.

7) In conclusion, there is an immediate need to create State and Federal legislation and regulatory rules to define CAES as an enabling technology for wind and PV electricity production and to include CAES in renewable energy incentive programs.

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Table 1. Energy Storage Cost Estimates [11].

	\$/kW +	[\$/kWh[a] x	Hours] =	Total Capital (\$/kW)
Compressed Air:				
- Large (100 MW plus)[b]	924	2	88	1,100
- Small (20 MW minus)	700-800	200-250	4	1,500-1,800
Pumped Hydro (100 MW plus)	1,500-2,000	100-200	10	2,500-4,000
Battery (10 MW):				
- Lead Acid	420-660	330-480	4	1,740-2,580
- Advanced (Target)	450-550	350-400	4	1,850-2,150
- Flow (Target)	425-1,300	280-450	4	1,545-3,100
Flywheel (100 MW Target)	3,360-3,920	1,340-1,570	0.25	3,695-4,315
Super-Conducting Magnetic Storage (1 MW)	200-250	650,000-860,000	1/3600	380-490
Super-Capacitors (Target)	250-350	20,000-30,000	1/360	310-435

Notes:

a. This capital cost is for the storage "reservoir," expressed in \$/kW for each hour of storage. For battery plants, costs do not include expected cell replacements. The cost data are in 2008 \$ and are updated periodically by EPRI (updated August 20, 2008). Costs do not include permits, contingencies, interest during construction, and the substation.

b. The large compressed air energy storage cost estimate is original to this study and is in 2008 \$. It should be noted that the large compressed air storage cost estimates are 47% greater than EPRI high cost estimate. The CAES cost estimate is a next plant estimate, and Nth plant cost should be about 30% less since the turbo-train is very similar to a conventional combustion turbine plant.

Table 2. JCSP'08 Data from Executive Summary, p. 6, Table 1-1.

New Generation Capacity (GW)	5% Wind	20% Wind	% Change
Wind	58.0	229.0	295%
Base Load Steam	76.8	37.2	-52%
Gas CT	49.2	69.6	41%
Gas CC	4.8	4.8	0%
Other Fossil	1.2	1.2	0%
Total	190.0	341.8	80%

Electricity Production (TWh)	5% Wind	20% Wind	% Change
Wind	242	764	216%
Base Load Steam	2,160	1,741	-19%
Gas	210	301	43%
Other	1,356	1,371	1%
Total	3,968	4,177	5%

Table 3. Specification of Wind Models to Provide Load Capacity Credit.[a]

	Capacity (W/W Load Capacity)	Capacity Factor (%)	Electricity to Grid (kWh/yr)	Fuel Consumption (Btu/kWh)	CO_2 Emissions (g/kWh)	Capital Cost ($/W Load Capacity)
JCSP'08 Wind-NG Model[b]						
Wind	4.32	40%	5.88		11	8.64
NG CT	0.52	35%	1.57	4,335	246	0.31
Totals			7.45	4,335	256	8.94
Optimized Wind-NG Model[b]						
Wind	1.00	42%	3.70		3	2.00
NG CC	0.85	49%	3.63	4,796	238	0.73
Reserve NG CT	0.12	11%	0.12	173	9	0.07
Totals			7.45	4,969	250	2.80
Optimized Wind-CAES Model[b]						
Wind	1.57	37%	5.14		5	3.13
CAES	0.64	41%	2.31	1,411	77	0.70
Totals			7.45	1,411	82	3.83

Notes:

a. Abbreviations: W = Watt; kWh = Kilowatt-Hour; CO_2 = Carbon Dioxide; g = Grams; NG = Natural Gas; CT = Combustion Turbine; CC = Combined-Cycle.

b. The JCSP’08 wind with natural gas model is derived from the JCSP’08 study [3], and the optimized wind with natural gas and wind with CAES models are derived from the Succar and Williams wind CAES study [9].

Table 4. Power Plant Cost and Performance Parameters.[a]

	Capital Cost ($/kW)	Heat Rate (Btu/kWh HHV)	Cost of Fuel Use ($/ kWh)	Fixed O&M ($/ kW)	Variable O&M ($/ kWh)	CO_2 Emissions (g/kWh)
NG Combustion Turbine	597	10,842	0.076	17.72	0.00366	570
* NG CT Spinning Reserve		12,637	0.088			664
NG Combined-Cycle	857	7,196	0.050	34.01	0.00211	392
NG Combined-Cycle with CCS	1,683	8,613	0.060	41.61	0.00301	70
Pulverized Coal	1,833	8,844	0.017	28.22	0.00470	806
Pulverized Coal with CCS	3,800	13,724	0.027	37.38	0.00936	86
Coal IGCC	2,118	8,309	0.016	39.62	0.00298	735
Coal IGCC with CCS	3,031	9,713	0.019	46.64	0.00455	132
Nuclear	5,000	10,400	0.013	69.57	0.00051	0
Wind	2,000	0		15.91	0.00500	7
CAES Gas Turbine	1,100	4,550	0.032	4.00	0.00600	248

HVDC Transmission	Capital Cost (million $)	Electricity Loss Rate	O&M (% of Capital)	Gross Unit Capacity (GW)	Net Unit Capacity (GW)	Voltage
HVDC Lines (per 1000 km)	550	2.5%	1.0%	5.0	4.5	± 800 kV
DC-AC Converter Station	550	0.9%	1.0%			

Notes:

a. Power plants consume some of the electricity that they produce, which is commonly referred to as parasitic power losses. In the estimation of retail electricity prices, NETL [15] parasitic power loss estimates are taken into account. Also, it is assumed that the maximum capacity of HVDC power lines is 90% of rated capacity.

Table 5. Results: Comparative Analysis of Base Load Power Plants (Per Unit of Load Capacity Credit).

	Wind with NGCT (Optimized)[a]	Wind with NGCC (Optimized)	Wind with CAES (Optimized)	NGCC	NGCC w/CCS	Steam Coal withou t CCS	Coal IGCC with CCS	Nuclear
Retail Electricity Price ($/kWh)	0.133	0.126	0.116	0.104	0.134	0.092	0.142	0.145
Capital Cost ($/kW)	2,579	2,800	3,833	857	1,683	1,833	3,031	5,000
CO_2 Emissions (g/kWh)	355	282	78	392	132	806	70	0
Fuel Consumption (Btu/kWh)	6,837	5,010	1,439	7,196	8,613	8,844	9,713	0
CO_2 Reduction Cost ($/t)	91	65	33	29	63		67	66

Notes:

a. Abbreviations: NGCT = natural gas combustion turbine; NGCC = natural gas combined-cycle; CAES = compressed air energy storage power plant; CCS = carbon capture and storage system; IGCC = coal integrated gasification combined-cycle.

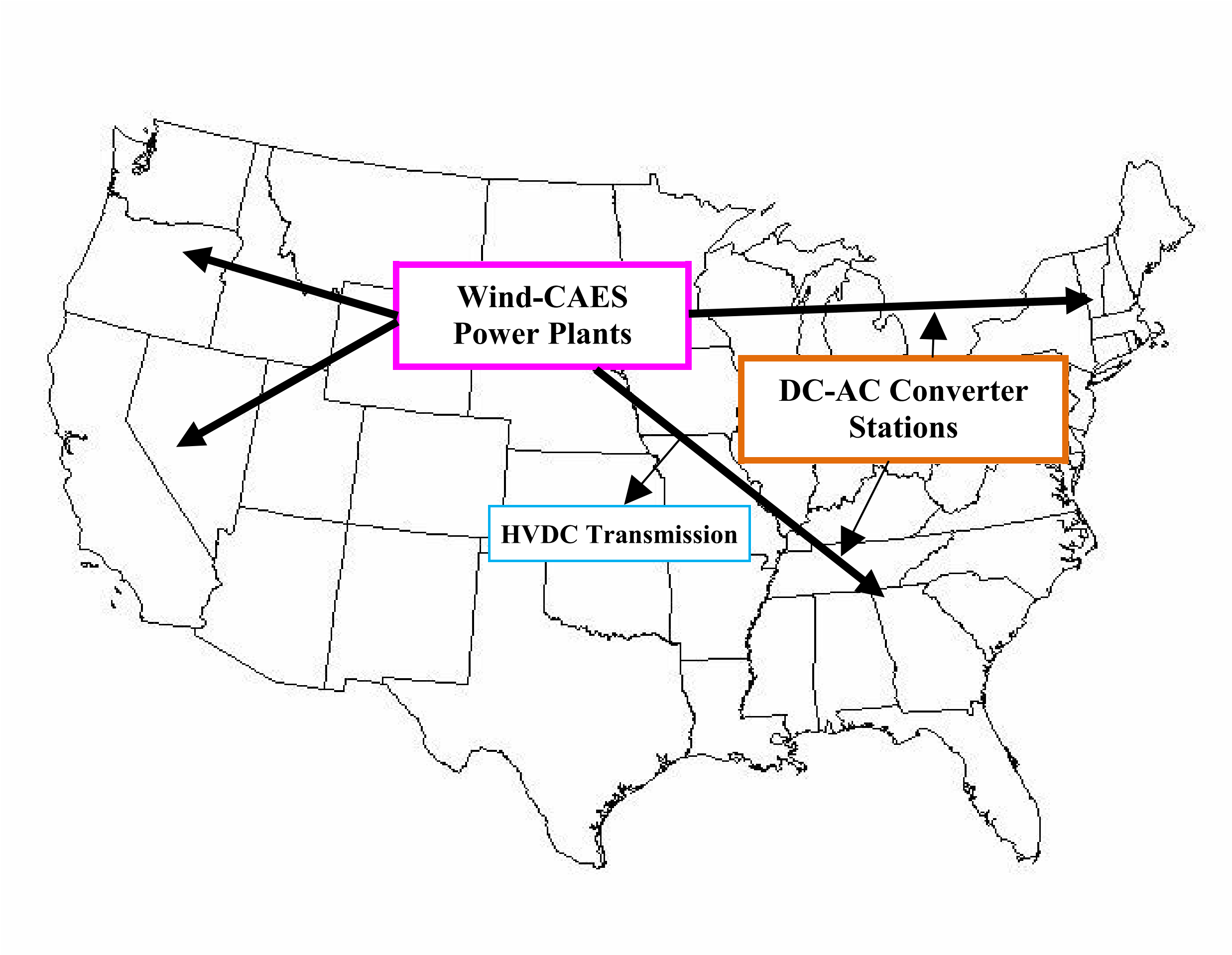

Figure 1. A national wind-CAES electricity production and distribution system.

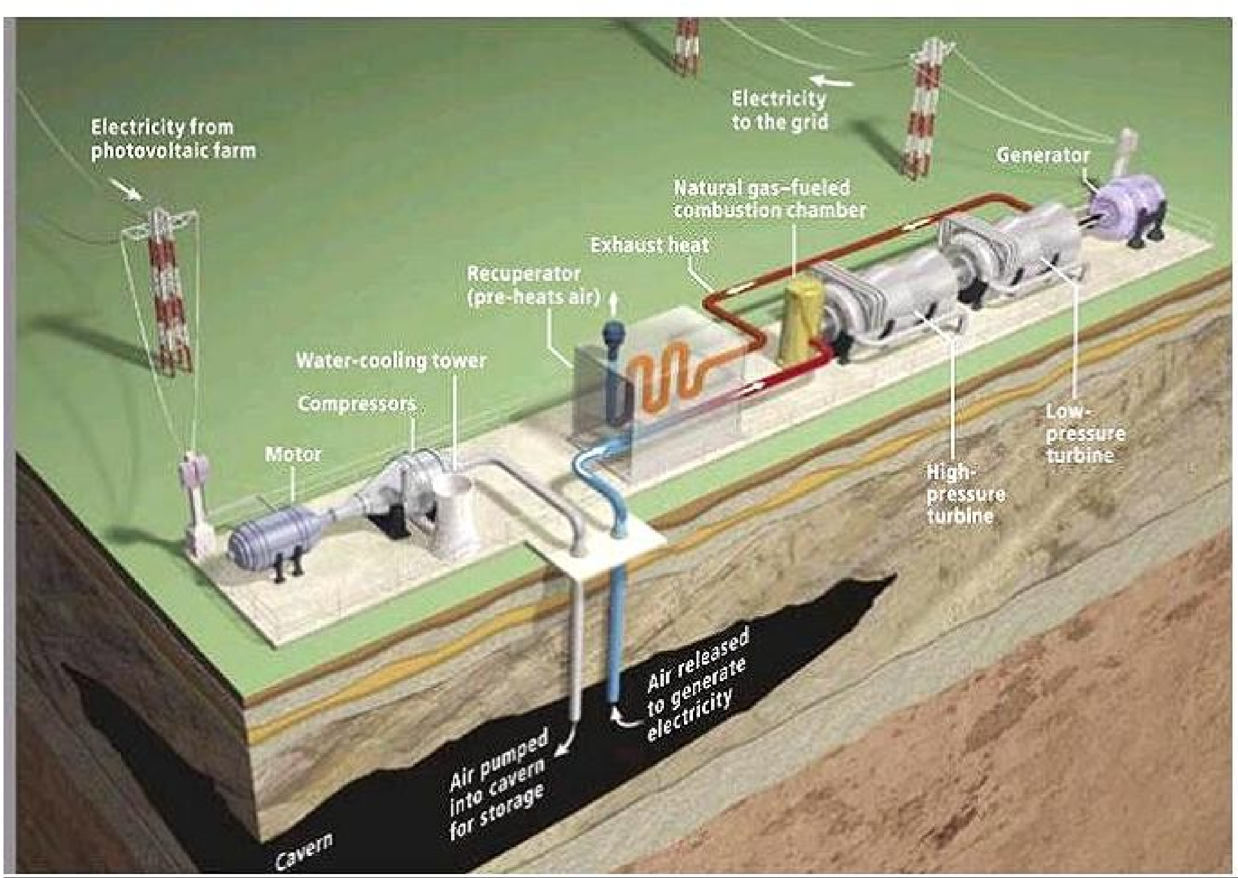

Figure 2. Schematic of a CAES air turbine power plant.

Figure 3. The Alabama Electric Cooperatives' McIntosh, Alabama 110-MW CAES power plant with compressed air well-head on the right. The power plant has been in continuous operation since 1991.

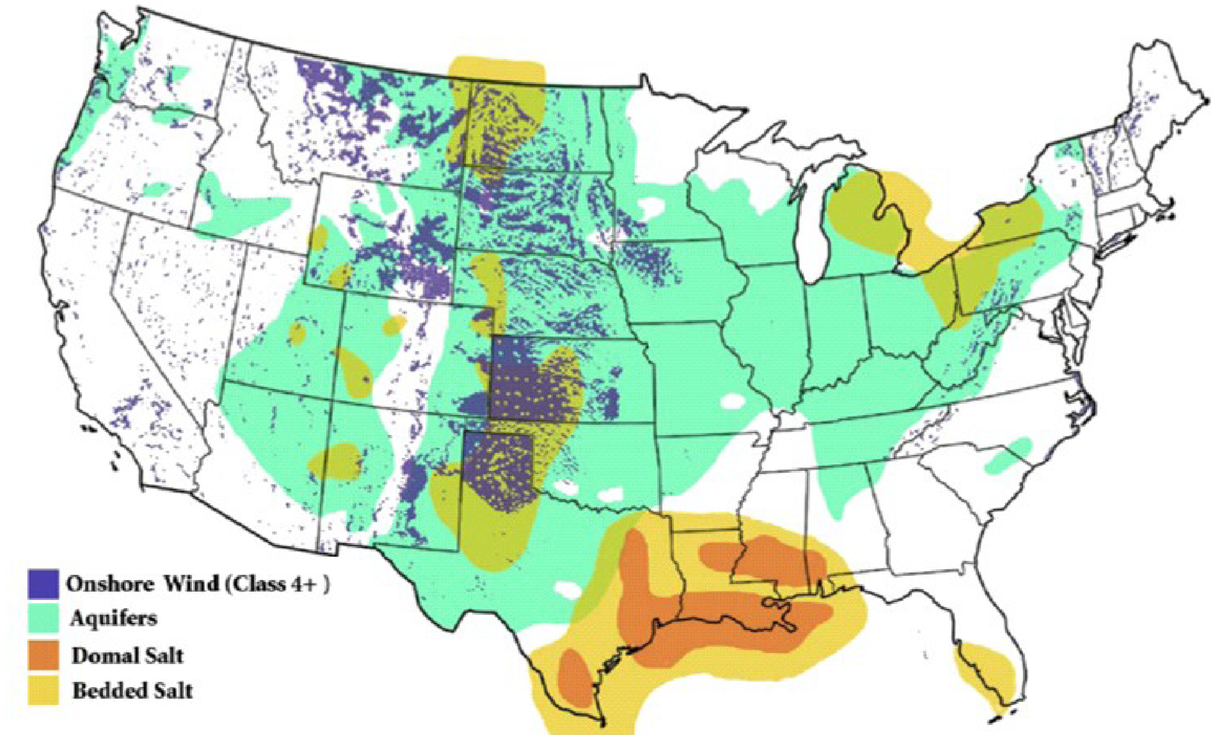

Figure 4. Map of U.S. showing areas with Class 4 or higher wind resources and areas with geology suitable for underground air storage reservoirs.

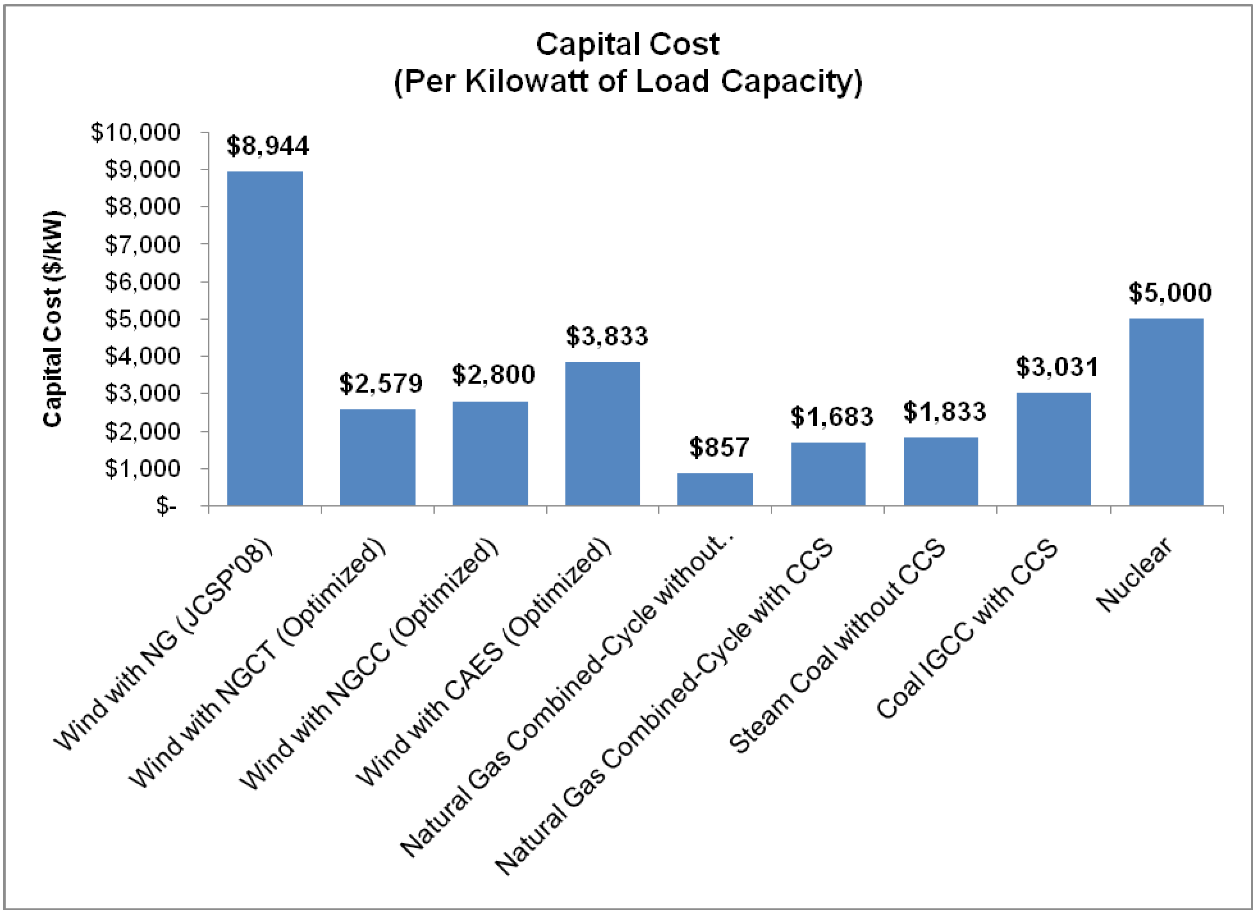

Figure 5. Capital cost per kilowatt of load capacity.

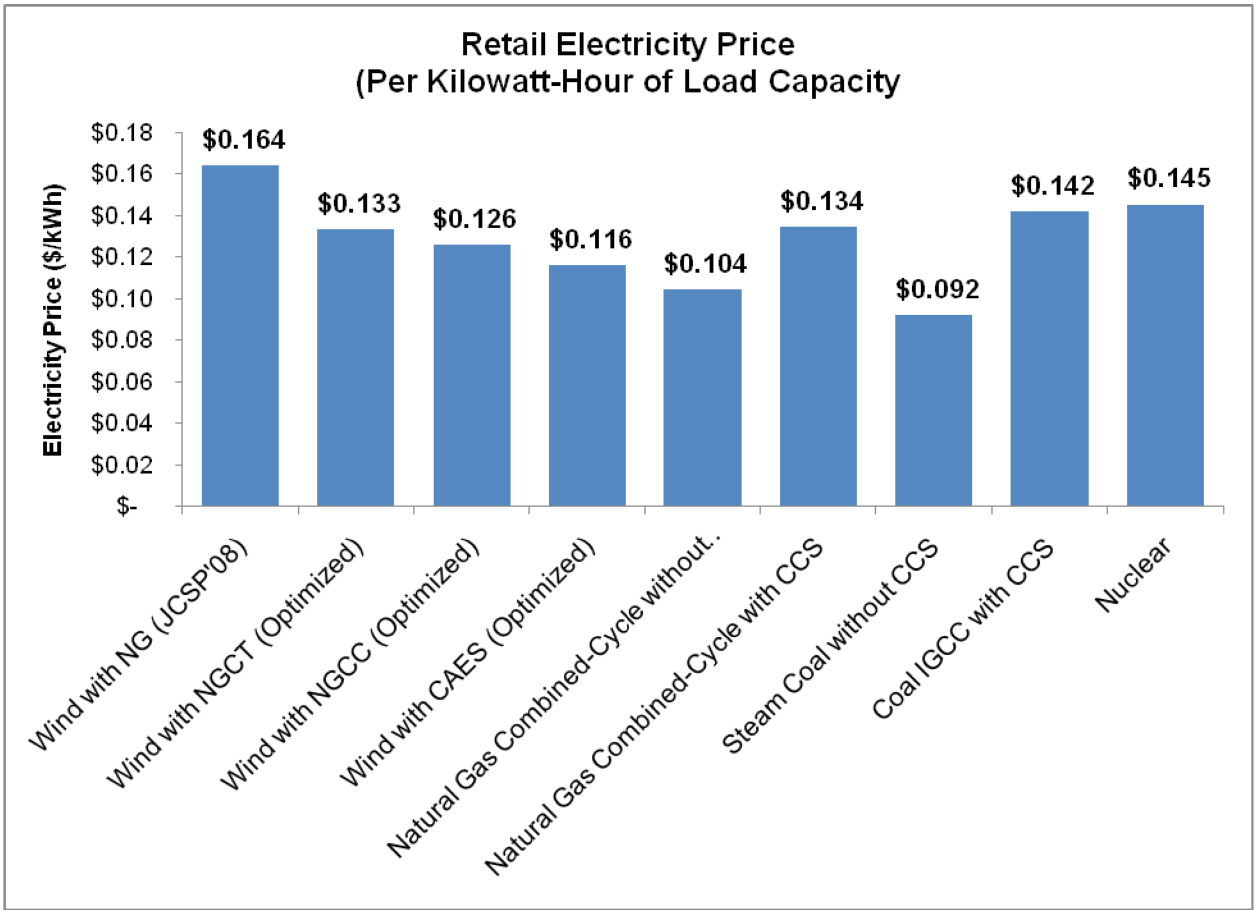

Figure 6. Levelized retail electricity price estimates.

Notes:

a. Financial assumptions for the levelized retail electricity price estimates are: capital structure of wind plants, thermal plants, and HVDC transmission lines = 55% debt capital and 45% equity capital; rates of return on capital = 9% on debt capital and 12% on equity capital; book life of assets: wind plants = 25 years, thermal power plants = 30 years, and HVDC transmission lines = 30 years; composite tax rate = 39%; average annual inflation rate = 3%; and fuel prices: natural gas = $7/MMBtu; coal = $1.94/MMBtu ($40/short ton); uranium = $0.70/MMBtu. Nuclear costs include: fuel processing = $0.006/kWh; spent fuel disposal = $0.0015/kWh; and plant decomissioning = $0.0015/kWh.

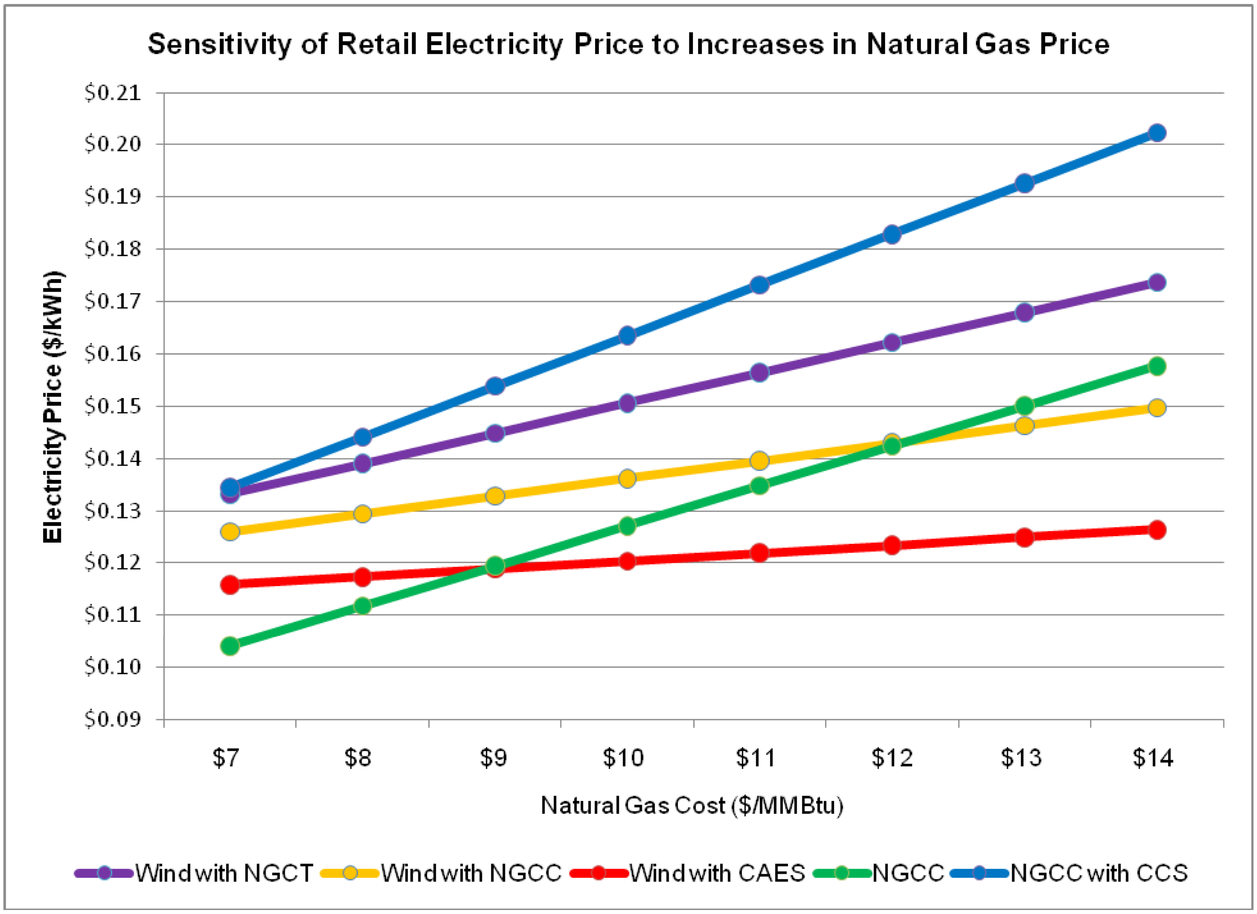

Figure 7. Sensitivity of retail electricity price to increases in natural gas prices to electricity producers.

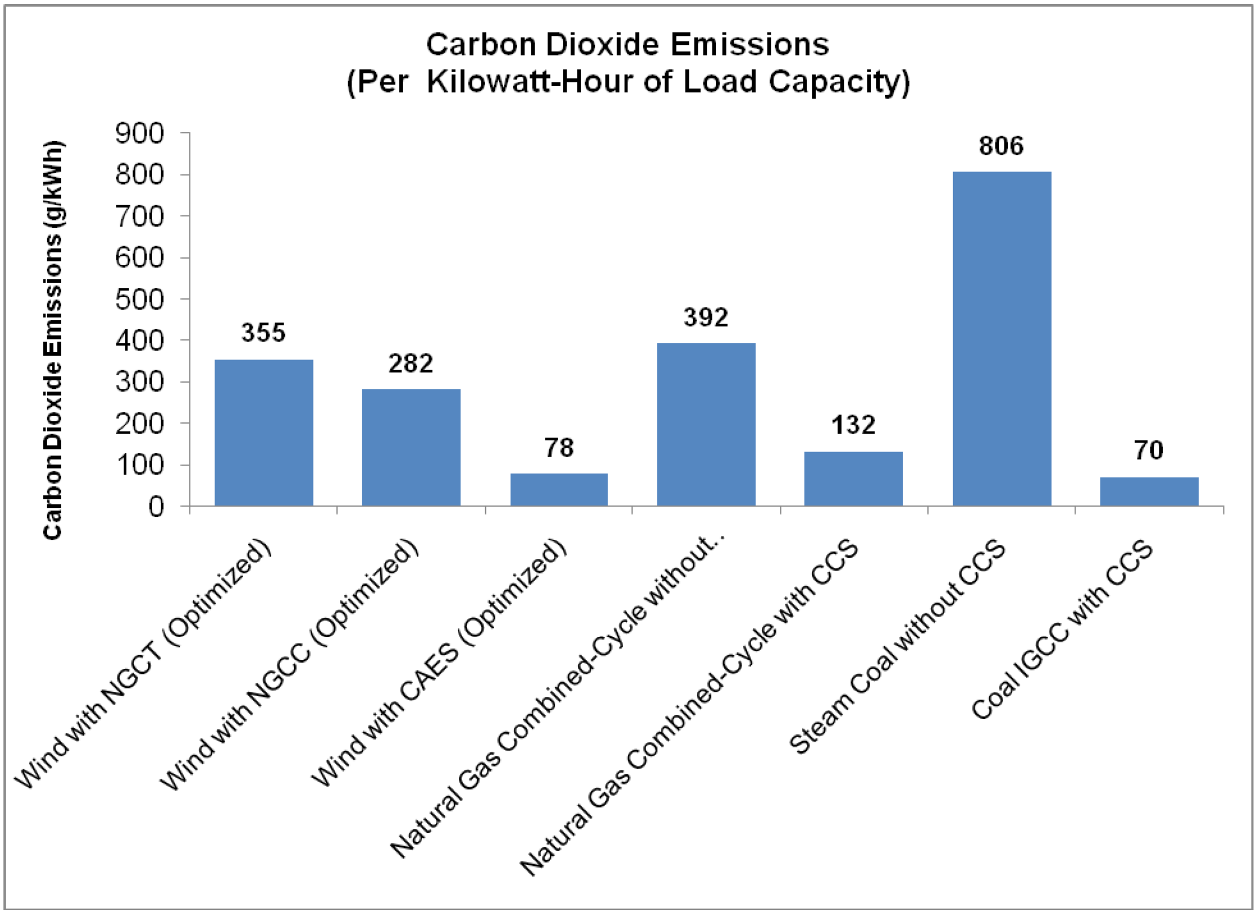

Figure 8. Carbon dioxide emissions.

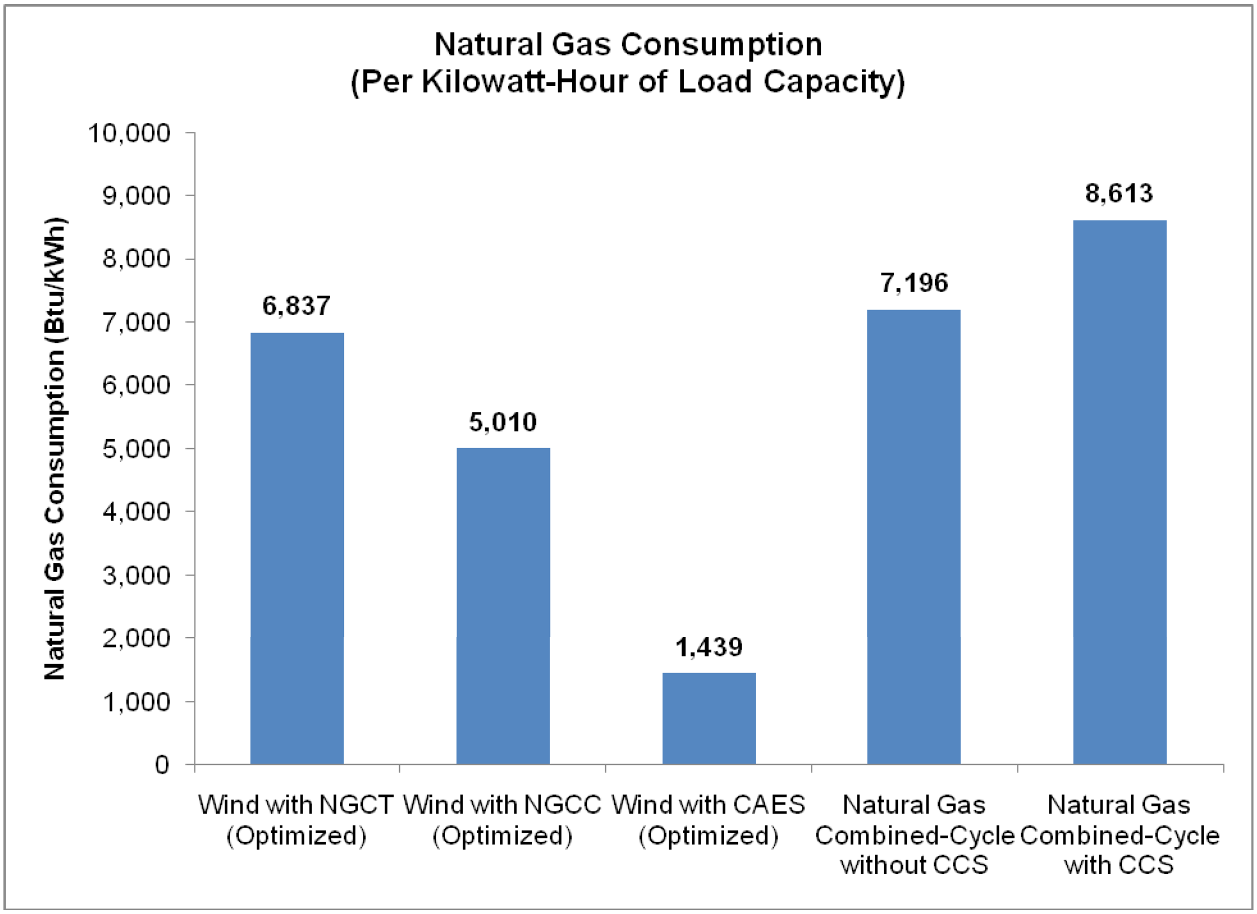

Figure 9. Natural gas consumption rates for power plants using natural gas.

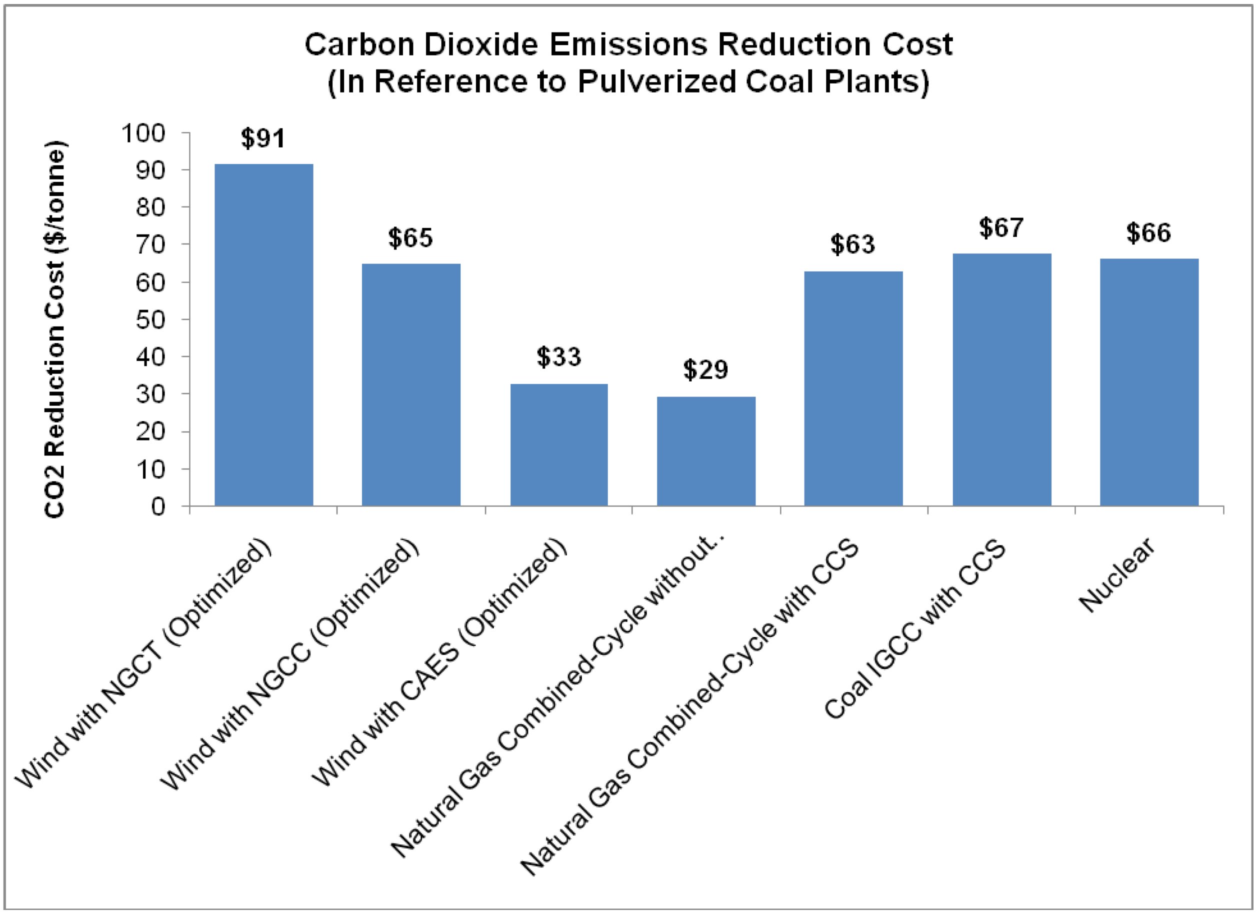

Figure 10. Cost of carbon dioxide emissions reduction in reference to a base load pulverized steam coal plant.