CEE CENTER FOR ENERGY ECONOMICS

Bureau of Economic Geology,
The University of Texas at Austin

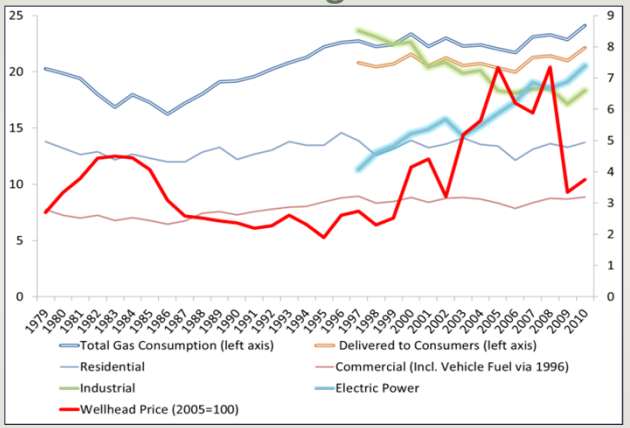
Gas-Power Linkages

Observations from Electricity Market Modeling

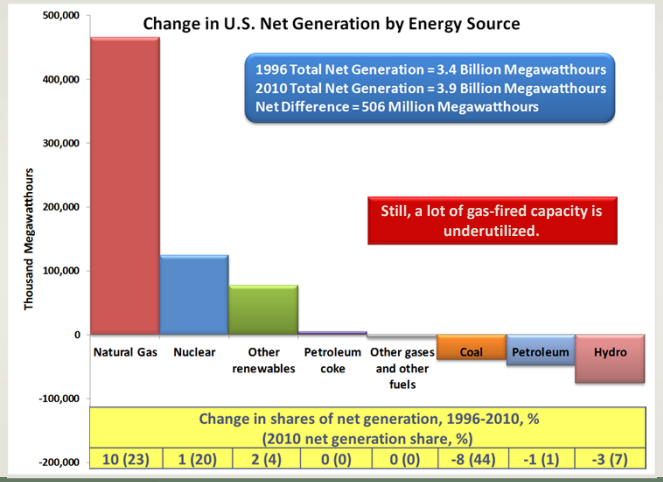
Table of Contents

Introduction

Power Sector – Largest User of Gas



Compiled by CEE based on EIA data



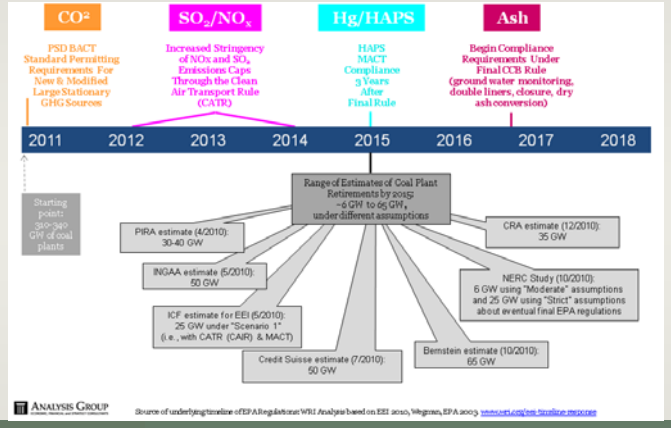
Compiled by Dr. Foss (CEE) based on EIA data

More Risk for Coal

- Pending EPA regulations on CO_2, SO_2/NO_X, mercury, ash
- 6 GW to 65 GW of coal capacity may retire 2011-15*
- Planned coal capacity declined from ~18 GW for 2010-14 to ~10 GW for 2011-15 (EIA data)

**World Resources Institute, review of various studies.*

EPA Regulations ➔ Coal Retirement

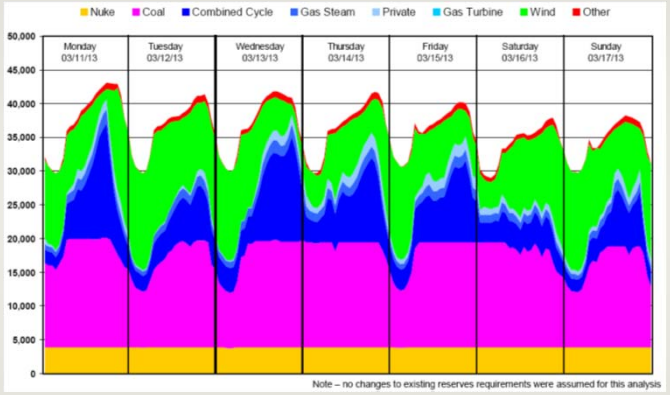


Source: World Resources Institute

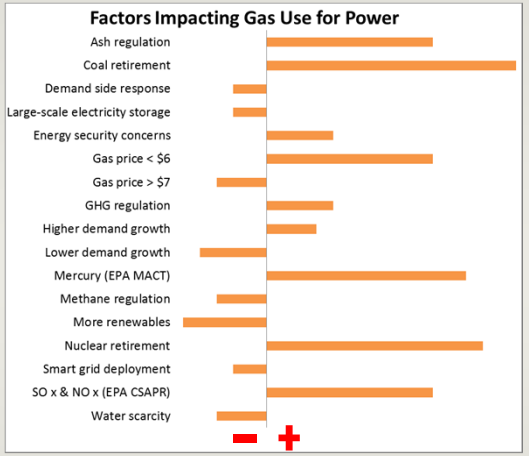
Nuclear Not Clear Cut

- The disaster in Fukushima only increases the awareness and potential concerns about US re-licensing of the existing nuclear fleet.
- Nuclear waste issue still not resolved.

Impact of wind – high wind '13



Source: ERCOT



The graphic is for illustration purposes only – not to scale.

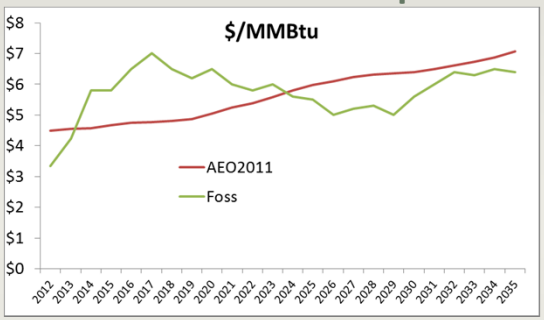
Conclusions

Six Different Runs w/ AURORAxmp

1. The "baseline" – World without regulation (WWR)
2. The WWR case with nuclear units failing to renew upon their license.
3. CSAPR case
   a. CSAPR for NO_X and SO_2
   b. MACT, HAPS for mercury & others
   c. CO_2 ($14/t in 2018 to $40/t in 2030)
   d. Renewable incentive of $15/MWh
4. Natural gas price spike (CSAPR-CEE)
5. CSAPR– CEE No CO2 case
6. CREZ in ERCOT

- Modeled only the Eastern Interconnect & ERCOT
- All runs used the latest new build cost estimates from EIA
- All reviewed against WWR
  - No emission regulation nor subsidies for renewables

Natural Gas Price Inputs

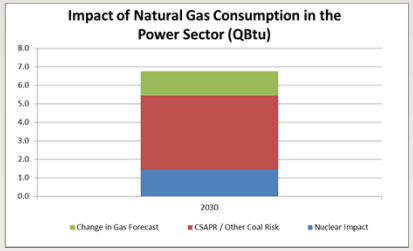


- EIA Annual Energy Outlook 2011 was used in both WWR and CSAPR case.

Conclusions

- Significant potential for gas consumption in the power sector.
- Gas generation could be the dominant generation source for the United States by 2020.
- Biggest driver in power prices is natural gas prices.
- Significant investment is needed in generation. These decision will be made with future risk of CO_2 price whether it transpires or not.
- CREZ by itself will not stimulate new renewable builds. Subsidies will still be required.

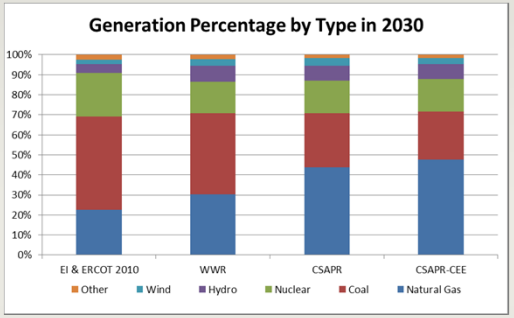
Gas Consumption Impact



The model was tested based on the EIA 2010 actuals. The model slightly under estimated gas demand in 2010.

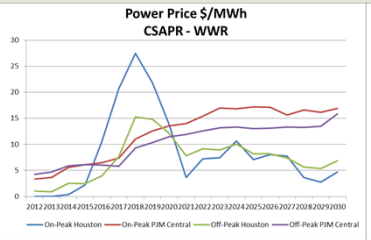
- Failure to re-license nuclear units will impact gas demand, but not nearly as much as pending regulations and the various risk to coal.
- Nuclear re-license issue, gas price forecast, and regulation / policy has the potential to double the current natural gas usage in the power sector in less than 10 years.

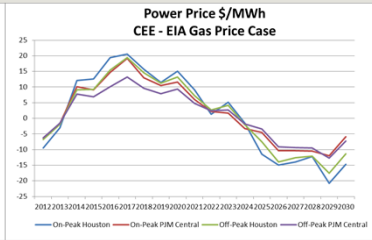
Power Generation



- In all cases, generation shifts to more natural gas.
- With EIA low gas price projection in the near future, the CSAPR case has gas being the majority contributor to power generation by 2020.

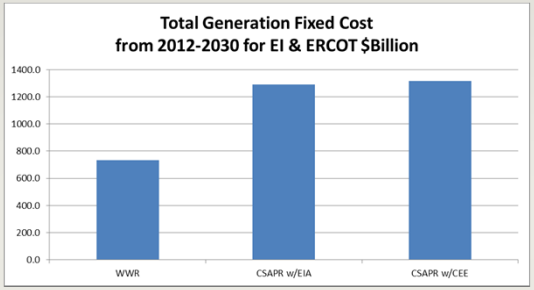
Power Price Changes





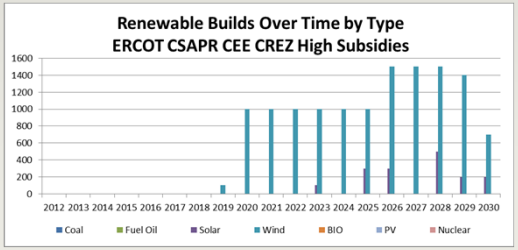
- CSAPR will increase power prices as retirements take time for the market to adjust.
- However a gas price change of a dollar can result in much more prolonged changes in power prices.

Fixed Investments in Generation



- Even without regulation ~750 billion dollars is needed over the next 18 years in just generation related expenses.
- CSAPR case will almost double the need for fixed expenses relative to WWR. (Includes Control Equipment, New Builds, O&M)

CREZ and Renewable Incentives



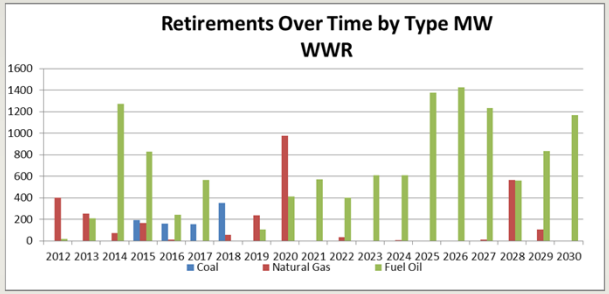
- CREZ by itself does not lead to commercial decision to build renewables.
- CREZ with high subsidies will result in more renewables.
- Renewable builds occurred when CO_2 prices were introduced.

Case Description & Output

World Without Regulation (WWR)

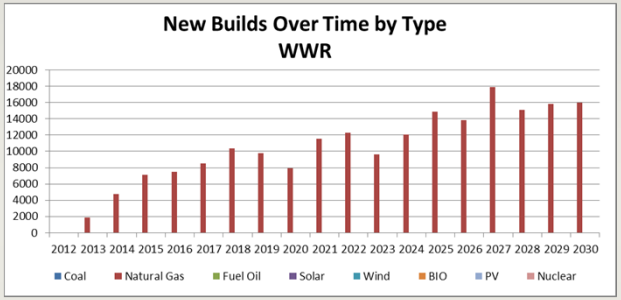
- Unreal, but easily understood case.
- No regulations or policy.
- No renewable subsidies.
- EIA AEO 2011 Gas Price Forecast.

Retirements



- Limited retirements

New Builds

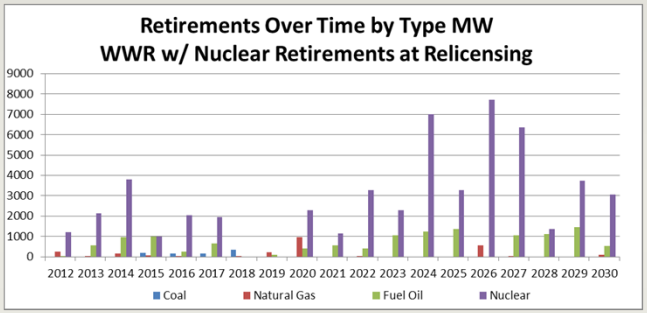


- Only gas units expected to fill the demand growth

World Without Regulation (WWR) without Nuclear Relicense

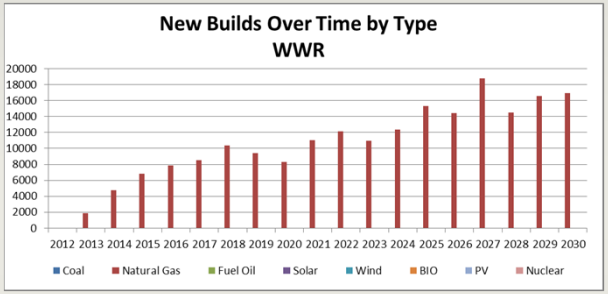
- WWR case except nuclear units were not allowed to renew their license

Retirements



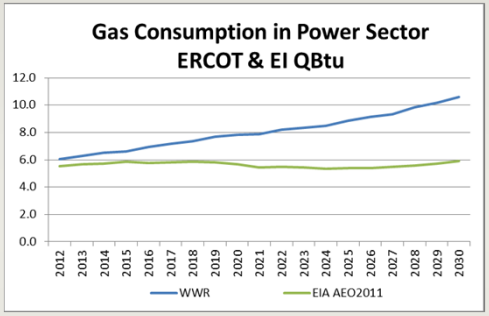
- Nuclear re-licenses are due for several units over the next few years.

New Builds



- Gas units are expected to fill the demand growth and loss of nuclear generation.

Gas Consumption



- Gas consumption immediately climbs relative to the EIA forecast.
- Coal consumption rises 18% from 2012 to 2030.

Cross State Air Pollution Rule (CSAPR)

- EIA AEO 2011 Gas Price Forecast
- Renewable subsidy of $15/MWh – proxy for REC and/or PTC
- EPA latest ruling on CSAPR applied
- Required multiple iterative runs to converge on emission price and emission limits

Emission Regulations

- CSAPR has 2 groups of states.
- Trading within groups allowed in 2012 & 2013.
- Banking is allowed.
- MACT and HAPS will likely require all coal plants to install control equipment by 2018.
- $600/kW is the capital cost of control equipment (10-year recovery period).
- Coal units older than 55 were not given the choice to install scrubber. They were automatically retired around the 2018 period.
- Calibrated price of NO_X and SO_2 in each state to comply with CSAPR limits in 2012 & 2014.

Emission Price & Bank 2012

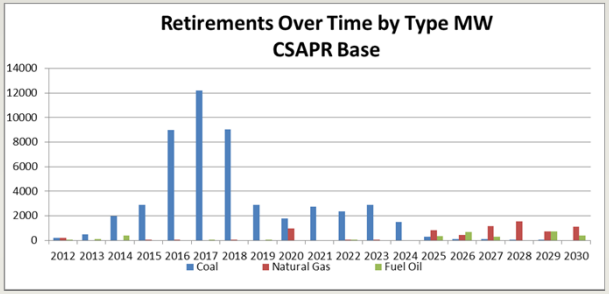
GROUP 1	Bank	Price	GROUP 2		Price
IA	-4750.1	1200	AL	160057.8	800
IL	30175.31	1200	GA	95591.24	800
IN	73623.56	1200	KS	2635.91	800
KY	39762.97	1200	MN	-4327.24	800
MD	8061.764	1200	NE	-11709.2	800
MI	8375.646	1200	SC	69632.81	800
MO	35529.54	1200	TX	-128778	800
NC	86885.79	1200	Sum	183103	800
NJ	3570.376	1200			
NY	10172.09	1200	Ratio to Limit	20%	
OH	28393.65	1200			
PA	43638.61	1200			
TN	73648.12	1200			
VA	41848.54	1200			
WI	-1940.37	1200			
WV	35599.55	1200			
Sum	512595	1200			
Ratio to Limit	21%				

- 20% ratio to limit allows for risk adverse utilities.

SO_2 Emission Price & Bank 2014

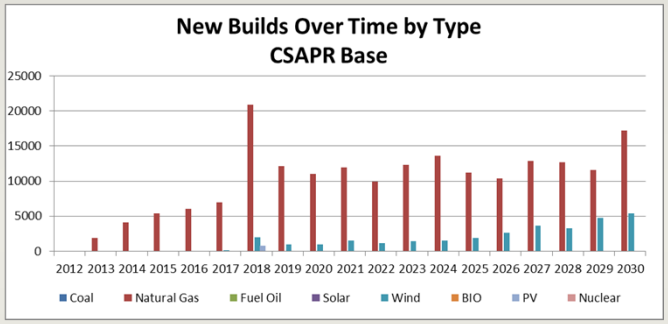
- By 2014 limited trading to 18% of state allowance occur.
- This necessitate individual states achieve close to their targets.
- Multiple iterations occurred leading to some states to just achieve a 0% bank prices over $3,000/ton of SO_2.
- Similar process was done for NO_X.

Retirements



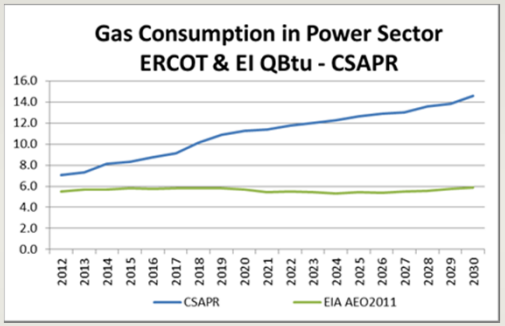
- The peak coal unit retirement more of a function of meeting MACT and HAPS.
- Over 50 GW retire by 2030. Most retirements occur before 2020 - ~40GW.

New Builds



- Gas still the dominant choice.
- Wind grows as subsidy and other issues increase the cost of power.

Gas Consumption



- A 36% increase in gas demand is needed relative to the WWR case by 2030
- Coal consumption falls nearly 20% from 2012 to 2030

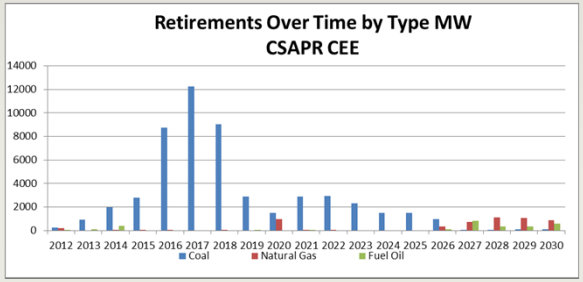
Cross State Air Pollution Rule (CSAPR) with CEE Gas Forecast

- Gas price forecast altered with mid-term gas prices higher, but longer term lower relative to the EIA AEO 2011.
- Resulted in needing to raise the emission prices as high prices increase the threshold for coal plants to dispatch more.

Emission Impact

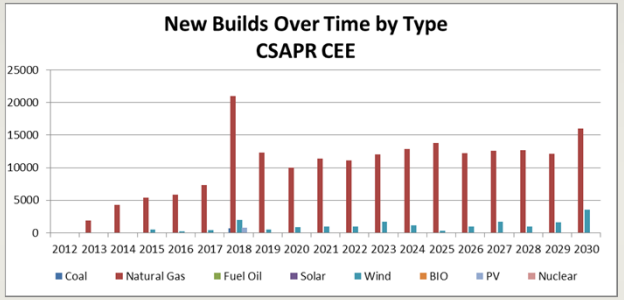
- With higher gas price increase in emission price needed.
- Over $1000/ton increase in price still did not achieve the same level of banks as in the CSAPR case.

Retirements



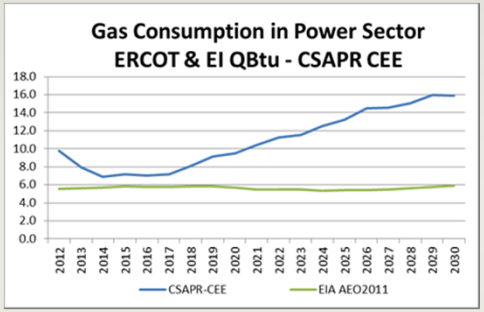
- Similar results as CSAPR

New Builds



- Similar results as CSAPR

Gas Consumption

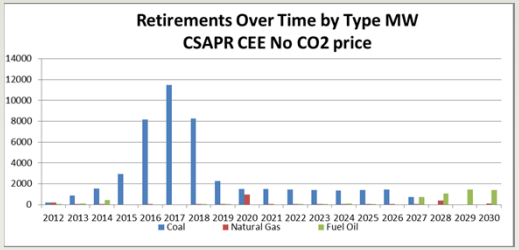


- Mid-term gas price lower dispatch occurred for gas units.
- Outer years, greater gas consumption than CSAPR.
- Coal declines by only 7%.

Cross State Air Pollution Rule (CSAPR) with CEE Gas Forecast & No CO_2 Price

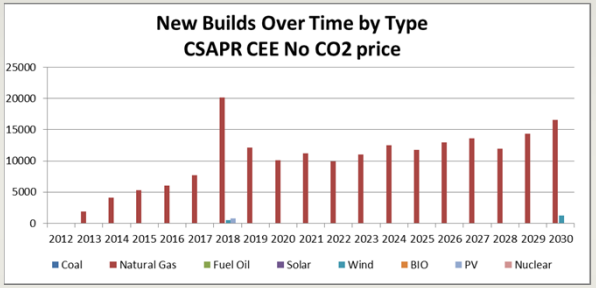
- Removed the CO_2 price which starts in 2018 at $14/ton and climbs to over $40/ton by 2030

Retirements



- 6 GW less coal retirement occurred compared to CSAPR-CEE

New Builds

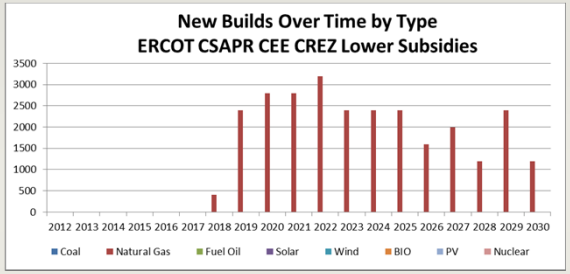


- Less renewables as a result of no CO2.

CREZ

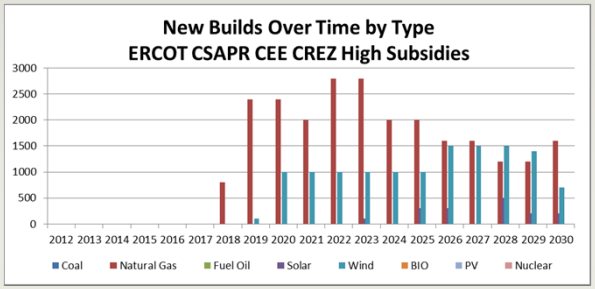
- Two CREZ cases run.
  - CREZ expansion in the CSAPR-CEE case
  - CREZ expansion along with an increase in subsidies for renewables
    - Wind from $15/MWh to $25/MWh
    - Solar/PV from $15/MWh to $35/MWh

New Builds



- CREZ by itself did not generate additional renewable even with subsidies of $15/MWh.

New Builds



- High subsidies drive additional renewable build with CREZ.
- 12.7 GW of wind and 1.6 GW of solar
- Total cost of subsidies $9 billion dollars from 2019-2030