Effect of Regulatory Design on Performance of an Electricity Sector Tradable Performance Standard for CO_2

February 3, 2014

DRAFT DELIBRATIVE

Outline

- Comparison of tradable performance standard with a mass based approach
- Effect of including new NGCC in an otherwise existing source fossil-only policy
- Effect of differentiation in benchmark rates

Comparison of Uniform Tradable Performance Standard and Mass Based Approaches

Comparing Regulatory Designs

- Mass based (MB) regulatory designs are theoretically more cost effective than tradable performance standards (TPS) in a perfect market with only one externality and complete coverage
  - Is there an efficiency gain for this sector and pollutant?
- How does the compliance change between TPS and MB approaches that achieve the same emissions goal?
- Hypotheses:
  - More electricity demand reductions with MB due to a larger electricity price change compared to a TPS
  - Smaller demand reduction w/ TPS means the ratio of natural gas to coal generation must be greater to achieve emissions goal
    - MB could lead to more coal generation and higher SO_2 emissions
- Understanding MB compliance will help explain may provide insight on ways to improve the TPS

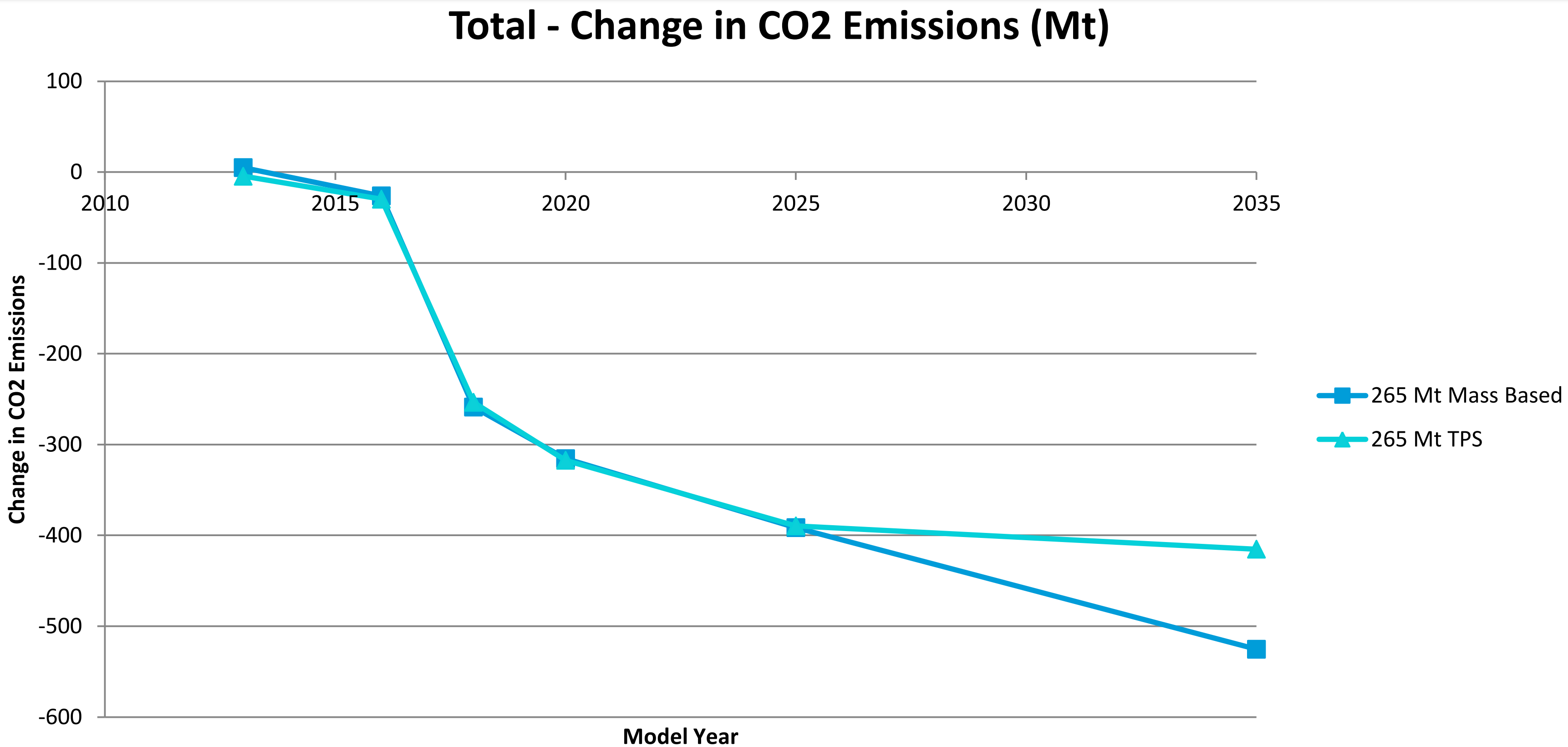
Regulatory Designs

- Both programs begin in 2018, cover all existing fossil except CTs, and allow nationwide averaging/trading
- Uniform TPS
  - Same benchmark rate for all covered units
    - We apply a common benchmark rate as other analysis had suggested this is a cost-effective approach to a TPS (more on this below)
  - Benchmark rate does not change over time
    - Benchmark rate selected to achieve 265 Mt CO_2 reductions in sector in 2018
    - 1,477 lbs/MWh benchmark rate
- MB standard
  - Annual cap that declines over time. Cap in 2018 is 1425 Mt
  - Allowances auctioned, but then revenue given gratis to consumers
- Using the Haiku electricity sector model for our analyses
  - Calibrated to AEO 2013 electricity consumption and fuel prices
- Both policies achieve a 265 Mt reduction from sector in 2018
  - 265 Mt reduction is 14% lower than 2018 Haiku baseline
  - 2018 Haiku emissions with policy are 33% below 2005 emissions

Summary of Results

- TPS yields significant net-benefits using 3% SCC value and accounting for SO_2 reductions
- Uniform TPS costs twice as much as MB program
- TPS emission reductions come more from heat rate improvements and shifts to *existing* NGCC
  - TPS incentivizes increase in existing natural gas capacity factor
- With MB approach emission reductions comes more from reduced electricity consumption and shifts to *new* NGCC
- Lower coal generation under TPS w/ fewer coal retirements
- Electricity price increase is lower in TPS, although the national average is not notably different in some simulation years
- TPS leads to slightly less sulfur dioxide than MB

CO_2 Emission Reductions



- Benchmark rate is constant over time but emission reductions track well with the declining cap

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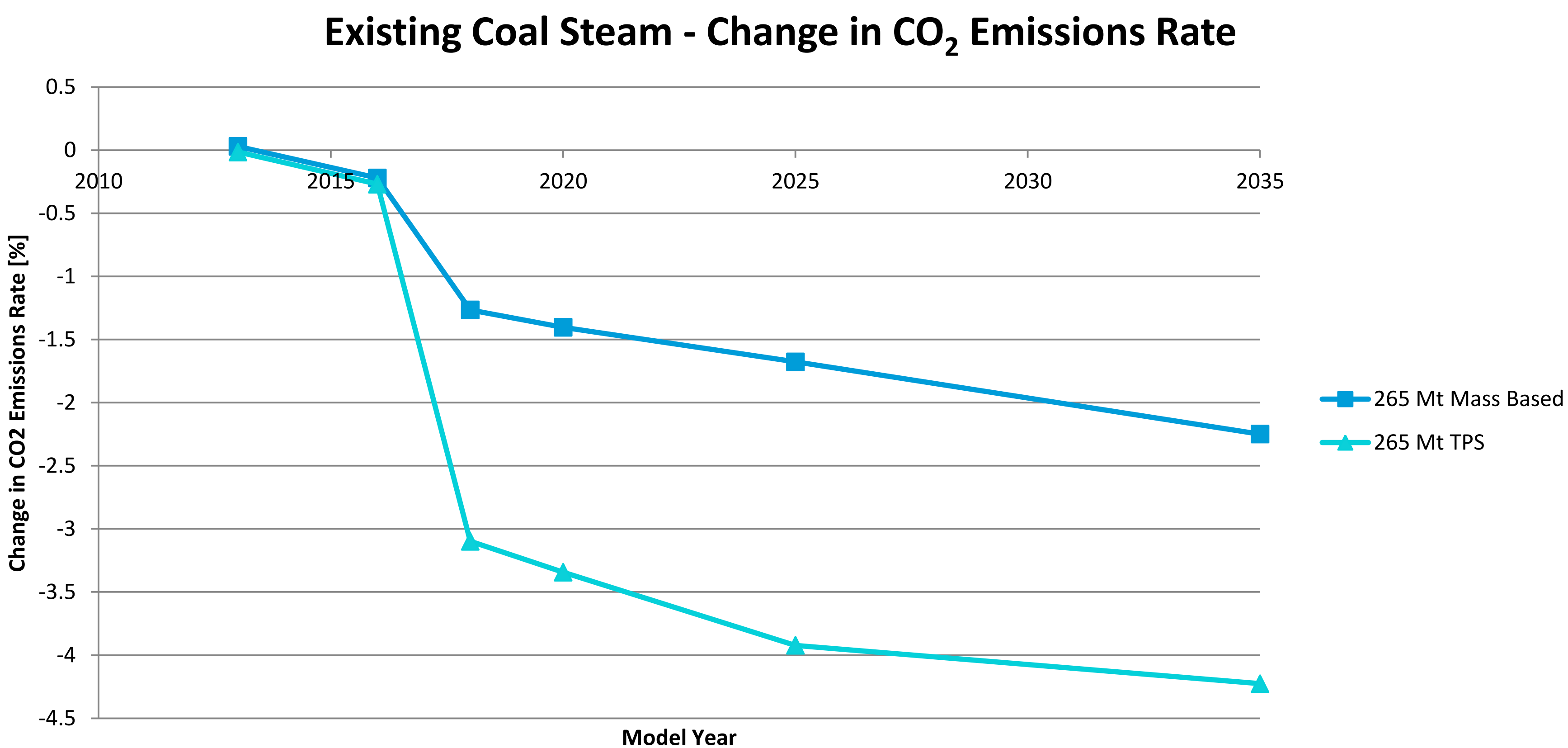
Electricity Sector Welfare Costs

	Costs (B 2010$)			
	2018	2020	2025	2035
265 Mt Mass Based	5.5	5.2	7.1	12.5
265 Mt TPS	10.6	12.2	15.3	14.1

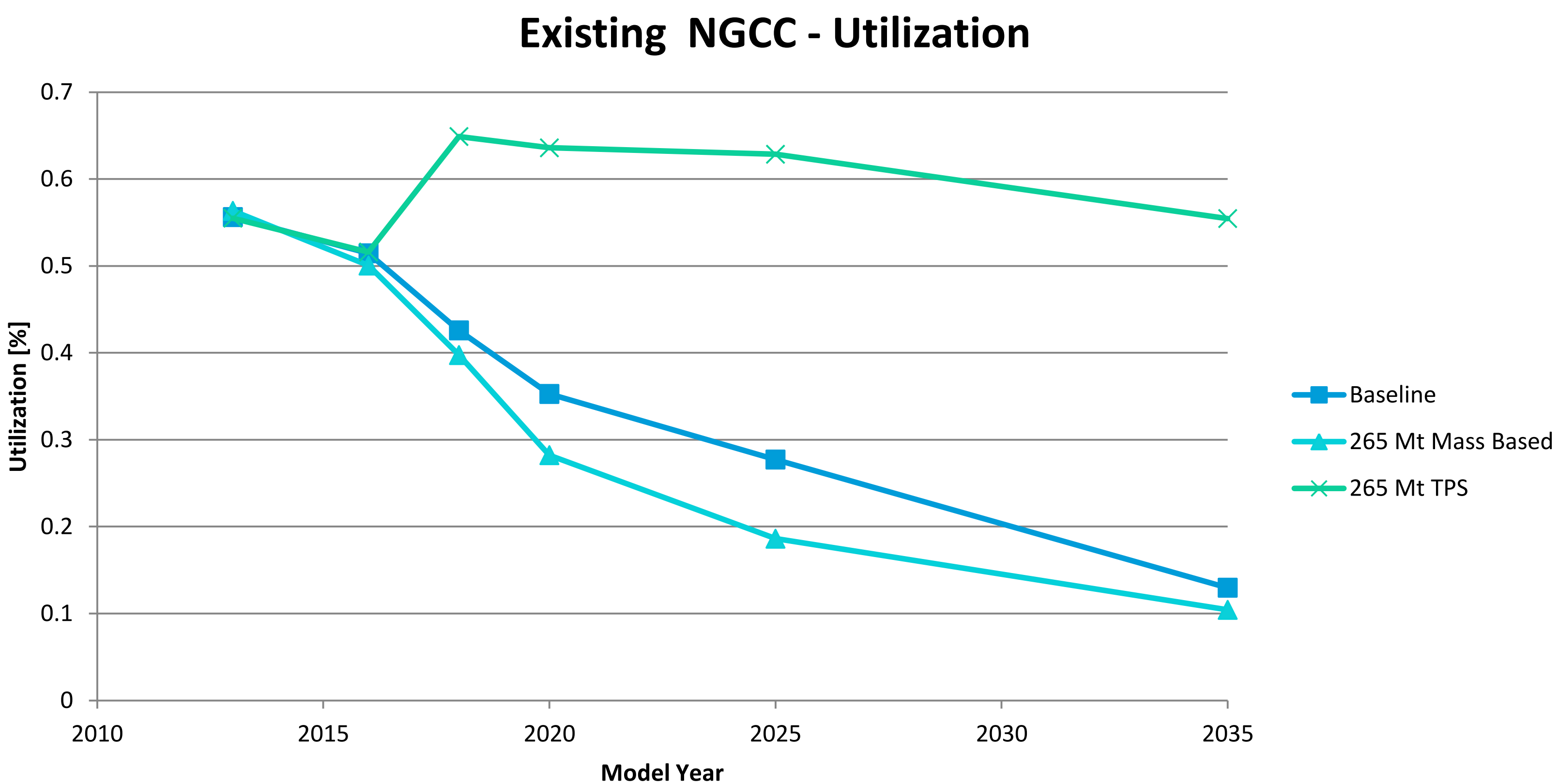
- Haiku measures "costs" as the sum of the change in profits and the reduction in consumer surplus (and the change in government revenues) in the electricity sector.

Existing Coal Emissions Rate Change



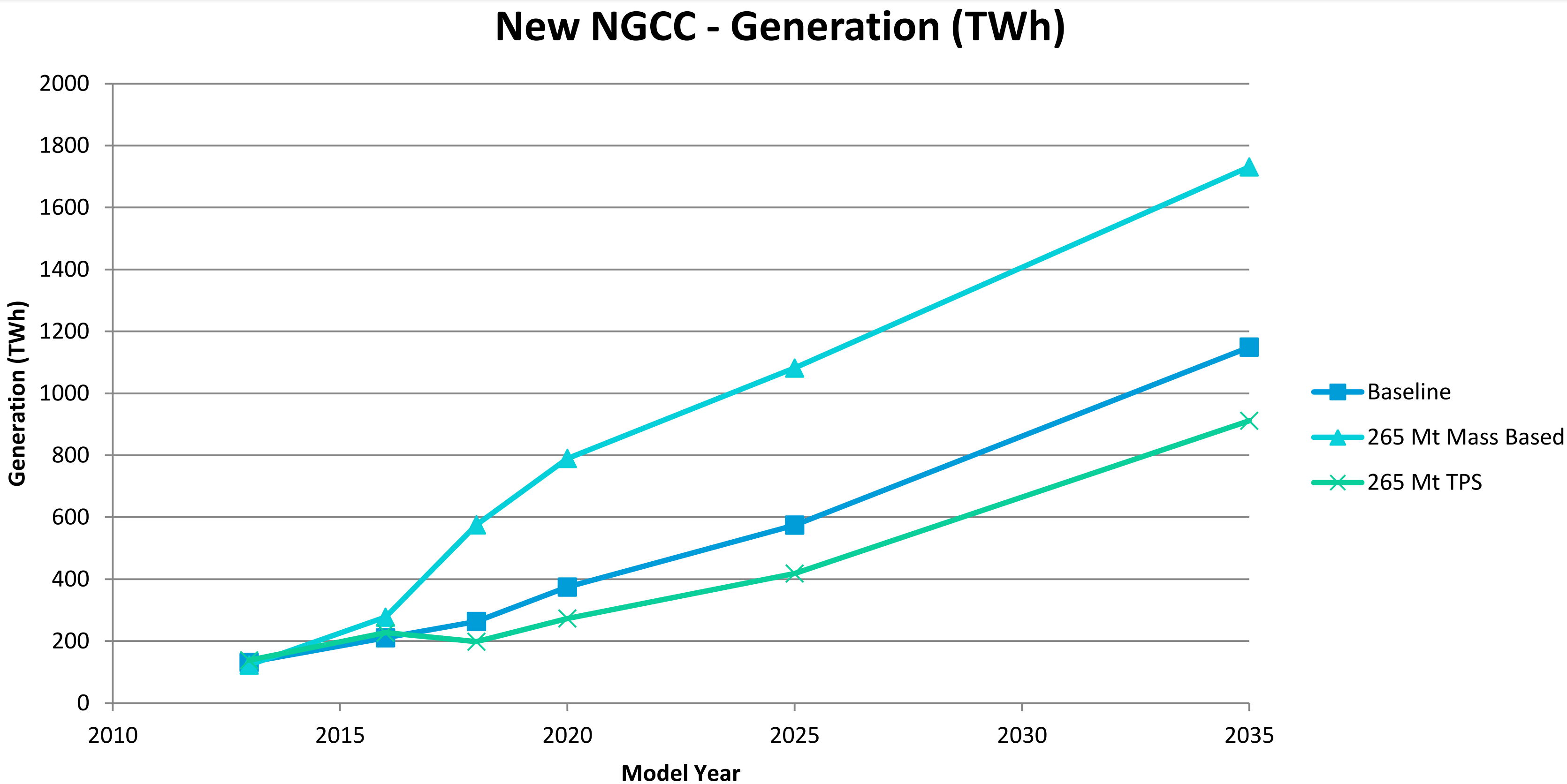
- TPS provides a stronger incentive to improve the performance of existing coal units w/ expenditures on heat rate improvements six times the amount invested under the MB program
- MB provides a stronger incentive to retire inefficient units

Existing NGCC Utilization



- Existing NGCC capacity does not change notably across model scenarios or simulation years
- Uniform TPS provides a strong incentive to shift dispatch from existing coal units to existing gas units (which make a profit selling credits)

New NGCC Generation



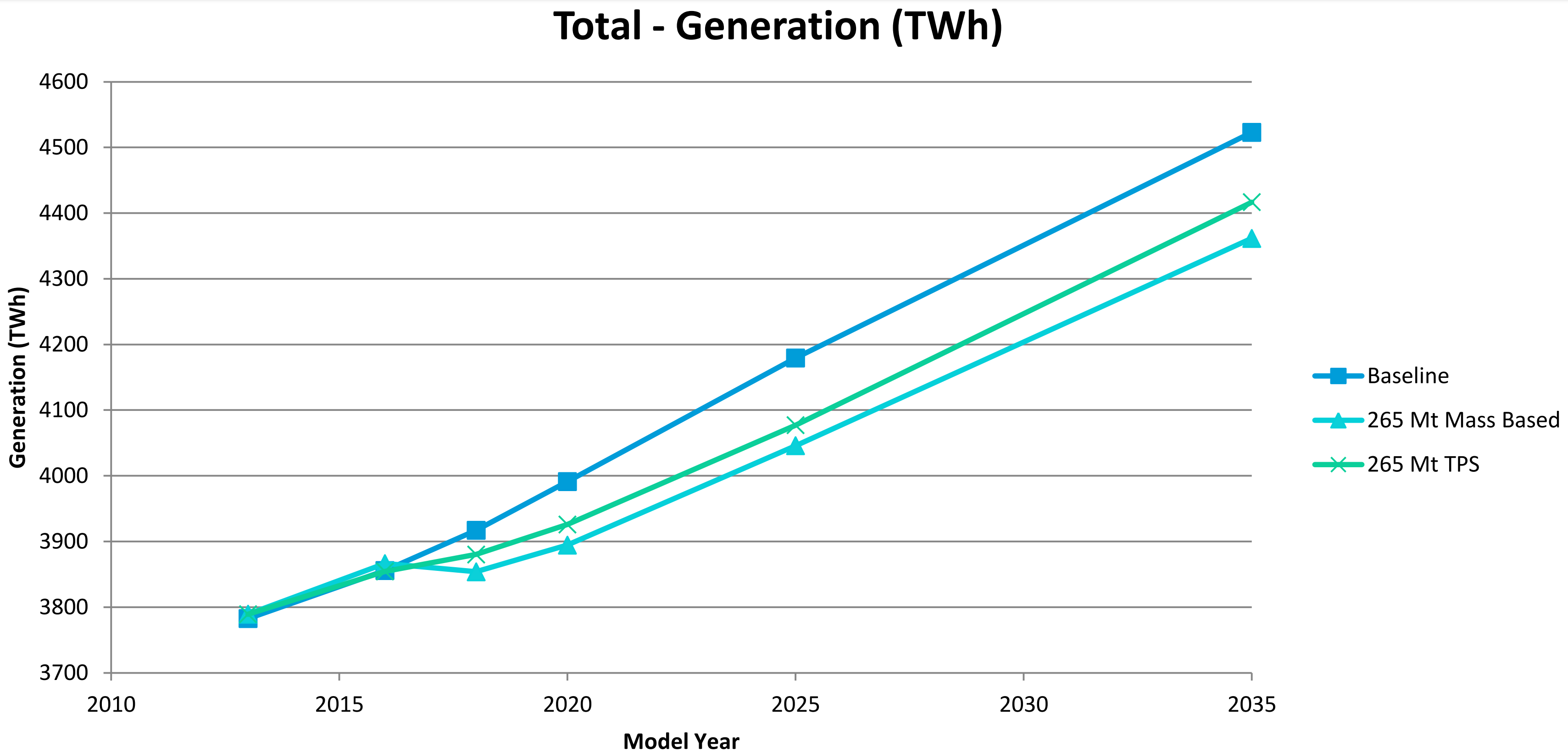
- MB program provides a stronger incentive to shift generation from existing coal units to new NGCC units outside of the program
- Under TPS the incentives provided to existing NGCC causes them to displace some new NGCC generation forecast in the baseline

Electricity Price Changes

	Change in Electricity Price [%]			
	2018	**2020**	**2025**	**2035**
265 Mt Mass-Based	6.2%	4.7%	5.1%	5.8%
265 Mt TPS	2.9%	4.1%	5.2%	4.5%

- TPS has a slightly lower electricity price change initially due to implicit subsidy to generation
- Electricity price impact falls in medium-term for the MB approach due to a lower stringency in those years relative to the declining cap

Electricity Generation



- MB program leads to a greater reduction in electricity demand
- Implicit subsidy to generation in TPS prevents the program from cultivating cost effective demand side reductions

Including New NGCC in a Tradable Performance Standard

Motivation & Regulatory Design

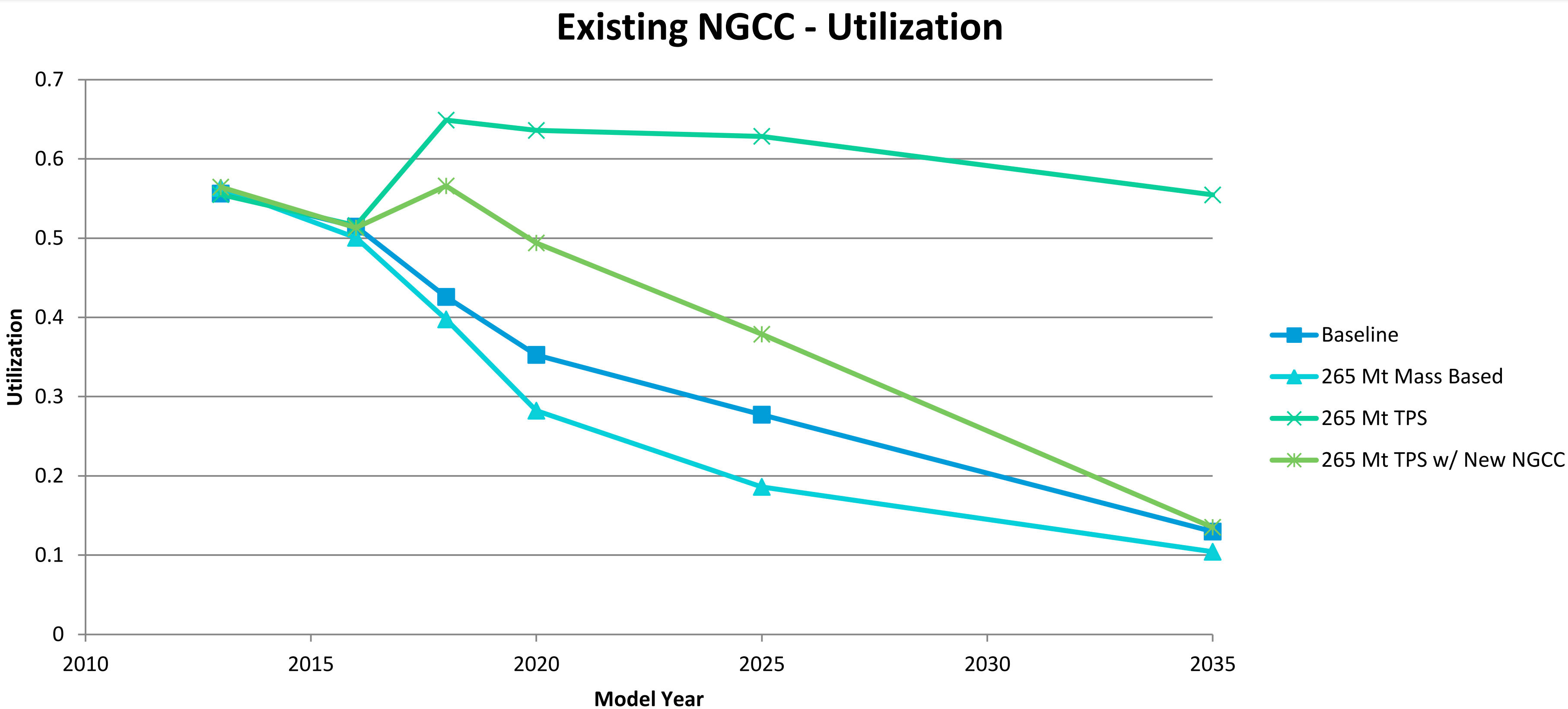
- A uniform TPS covering existing sources only incentivizes a shift from relatively cost effective new NGCC generation in the baseline to existing sources in the policy case
- Including new NGCC in the program directly addresses the inefficiency and may substantially reduce~~s~~ the costs of achieving a given level of emissions reductions
- We focus on new NGCC as modeling of an existing source TPS or MB does not affect renewables significantly
- Regulatory Design:
  - National uniform tradable performance standard with both existing and new fossil fuel sources
  - Benchmark rate is endogenously determined to achieve reductions of 265 Mt from the sector in 2018

Electricity Sector Welfare Costs

	Costs (B 2010$)			
	2018	**2020**	**2025**	**2035**
265 Mt TPS	10.6	12.2	15.3	14.1
265 Mt TPS w/ New NGCC	8.8	8.6	7.2	2.3

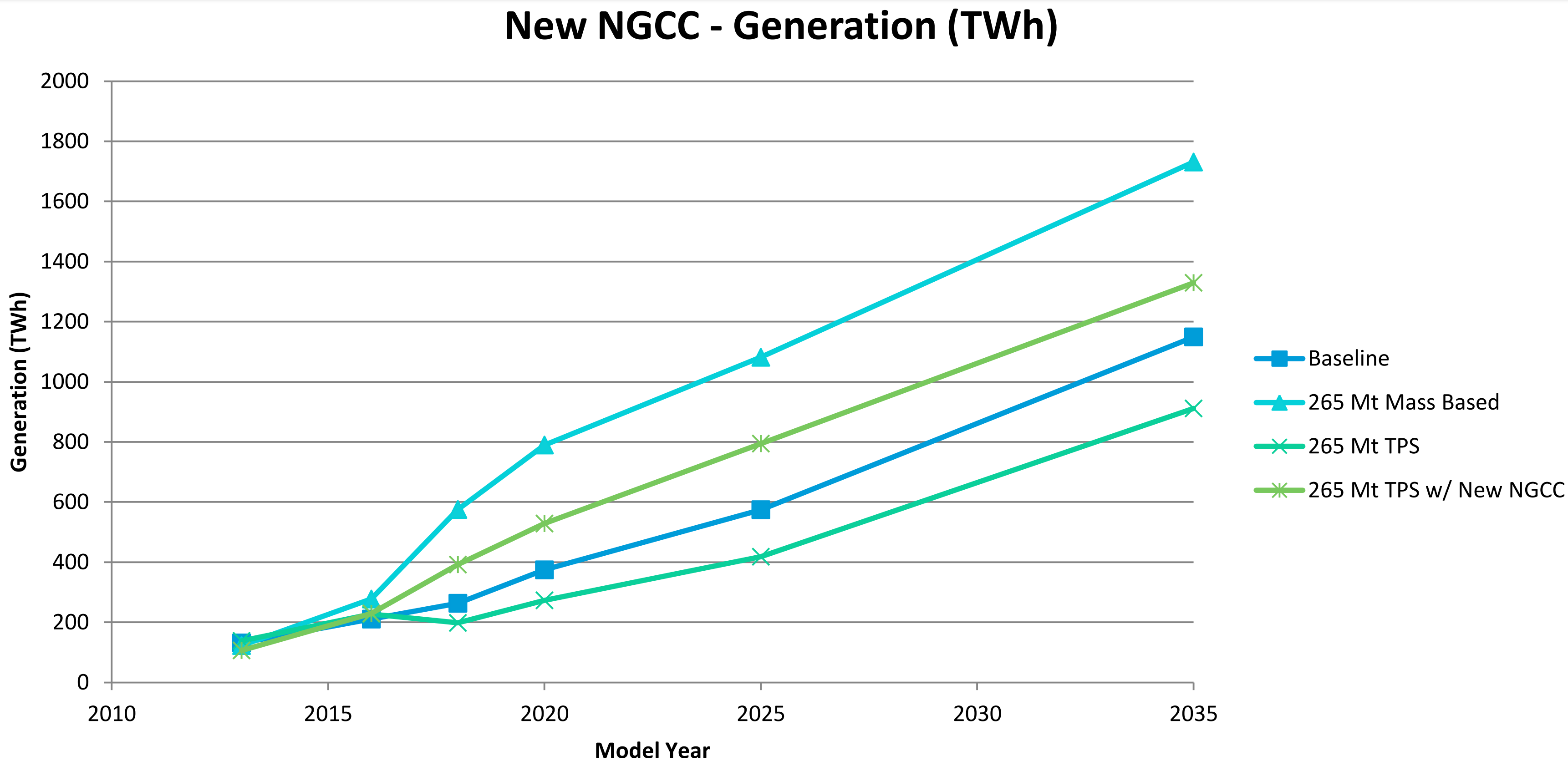
- Including new units reduce near term costs by ~20%
- Caveat: The constant benchmark rate in the scenario with new NGCC in the program achieves and 20% and 65% less emission reductions in 2025 and 2035 respectively than the existing only TPS

Existing NGCC Utilization



- Including new NGCC in TPS reduces increase in utilization of existing sources.
- However, the TPS still incentivizes increased utilization in existing NGCC relative to the baseline

Existing NGCC Utilization



- Including new NGCC units in the TPS increases their use relative to the baseline, unlike the existing only TPS which shifted dispatch to existing NGCC
- However, the incentive for new NGCC generation is not as strong as in the MB program

Implication of Including New NGCC

- We understand it is likely not possible to include new NGCC in a TPS
- BUT are there other ways to encourage new NGCC by making adjustments to the structure of an existing source only TPS?
  - Potentially through the setting of benchmark emission rates for new sources
  - And more generally, we can affect the composition of methods that are used to reduce CO_2 emissions by adjusting benchmarks

Rate Differentiation in a Tradable Performance Standard

Subcategorization

- Burtraw and Woerman (2013) show that differentiating benchmark rates based on fixed characteristics (e.g., location, fuel) can have a significant effect on the program's efficiency
  - This differentiation is also referred to as "subcategorization"
- Program is a national TPS that covers all existing fossil units
- Benchmark rates are set so sector achieves reductions of 375 Mt in 2020 in each scenario analyzed
- Modest spatial differentiation of rates had a small impact on costs and in some cases costs fell with differentiation, but significant spatial differentiation raised costs considerably
- Showed that not all forms of rate differentiation are inefficient but no strong guidance as to how differentiation can be used to improve program efficiency

Motivation

- Even if each state is provided a single benchmark rate, understanding the impacts of differentiation by fuel may be important
- State benchmark rates that are constructed from their historic generation portfolios can lead to a form of fuel differentiation nationally (as states have different generation mixes)
- Differentiation of benchmark rates can led to special sets of incentives important to understand for evaluating compliance proposed in state plans

Regulatory Design

- Compare uniform TPS w/ Fuel differentiated TPS
- Uniform TPS is the same as previously defined
- Fuel differentiated TSP
  - Existing natural gas rate = 1,000 lbs/MWh
  - Existing coal rate is determined by the model to achieve emission reductions of 265 Mt from the sector (1939 lbs/MWh)
- Emissions and generation of natural gas co-fired in coal steam units is compared against the natural gas rate
  - Comparing natural gas co-firing against the coal rate could lead to perverse incentives which we are currently exploring

Fuel Subcat Experiment

Fuel Subcategorization Scenarios

	Uniform TPS	Fuel Diff. TPS
Coal Standard	1,477 lbs/MWh	1,939 lbs/MWh
Natural Gas CC Standard	1,477 lbs/MWh	1000 lbs/MWh

Grey cells: Model solves for emissions standards in order to achieve the 2018 emissions target.

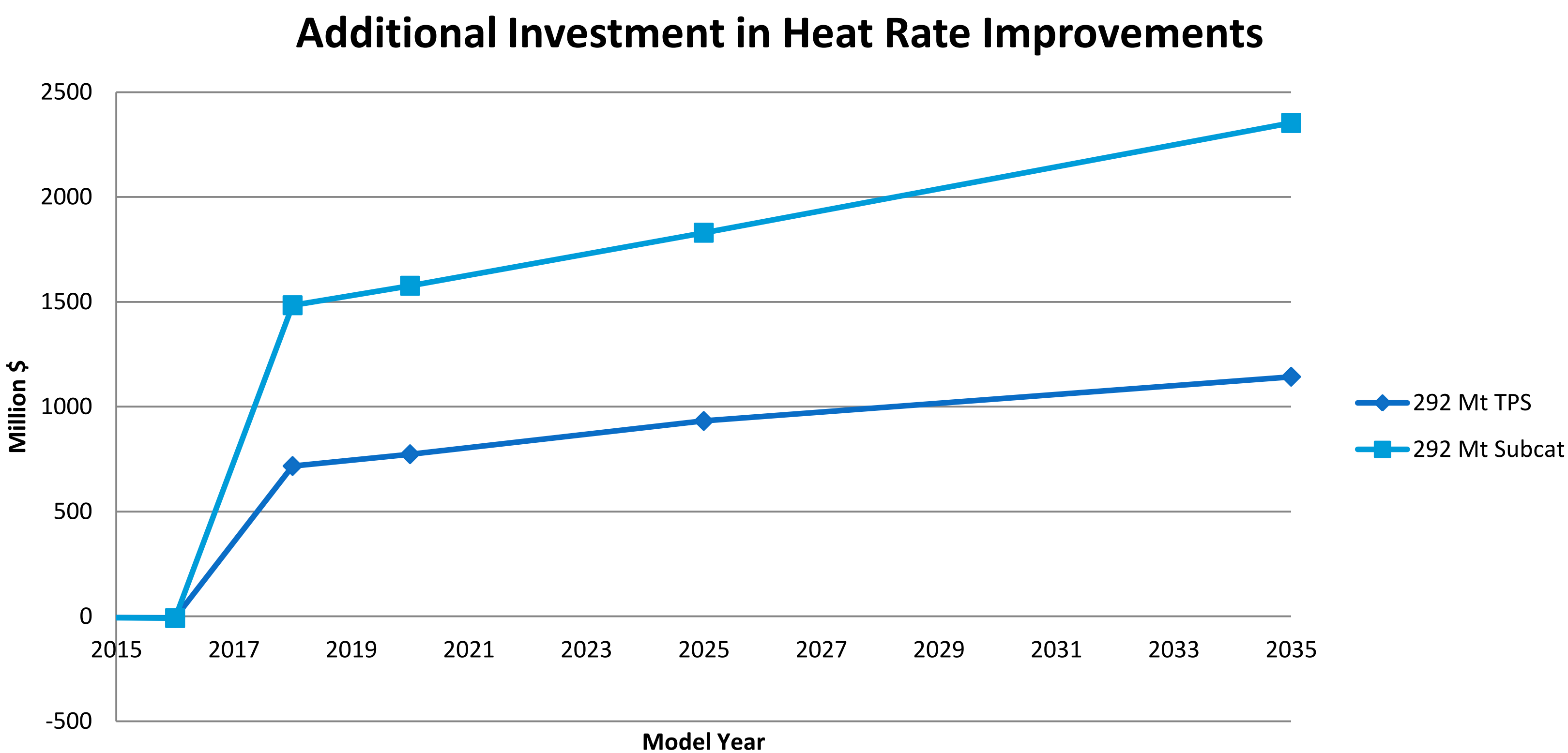
Summary of Results

- Differentiating benchmark rates based on fuel may lead to a reduction in costs
  - Cost savings can be easily eroded/reversed by the details of how compliance options are credited or unexpected compliance options
- Uniform TPS with an existing only approach incentivizes displacement of existing coal and new NGCC generation by existing gas units
  - The displacement of cost effective new generation is inefficient and raises program costs
  - Rate differentiation may be able to help address this short coming of incomplete coverage without eroding the incentives to displace existing coal generation

Electricity Sector Costs

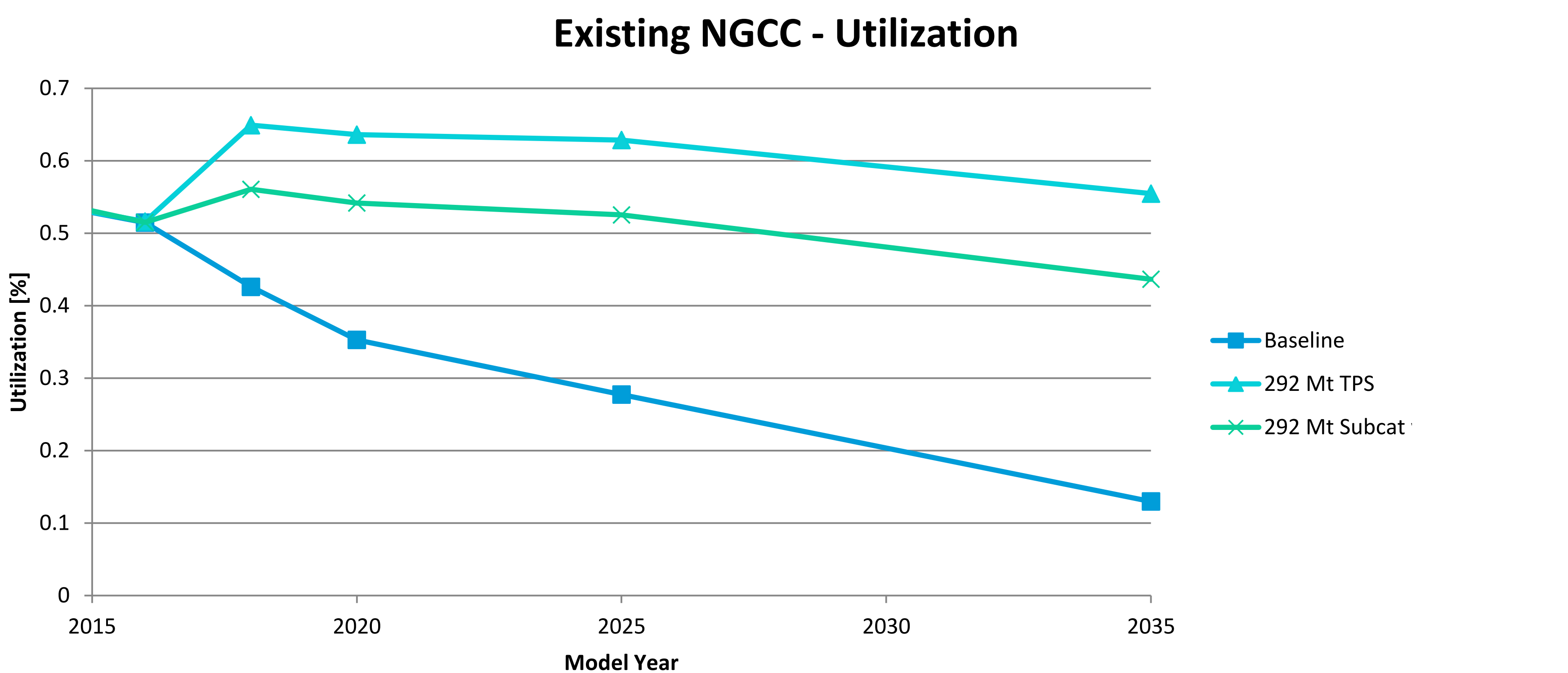
	Costs (B 2010$)			
	2018	**2020**	**2025**	**2035**
292 Mt TPS	10.6	12.2	15.3	14.1
292 Mt Subcat	8.92	9.82	12.7	10.2

Investments in Existing Coal Fleet



- The higher benchmark rate for coal units encourages greater investments in the existing coal fleet

Existing NGCC Utilization



- Lower NG benchmark provides a lower incentive to existing NGCC units to provide credits, so lower existing NGCC utilization
  - Implies that more coal generation is displaced by new NGCC generation in the differentiation than in the uniform TPS

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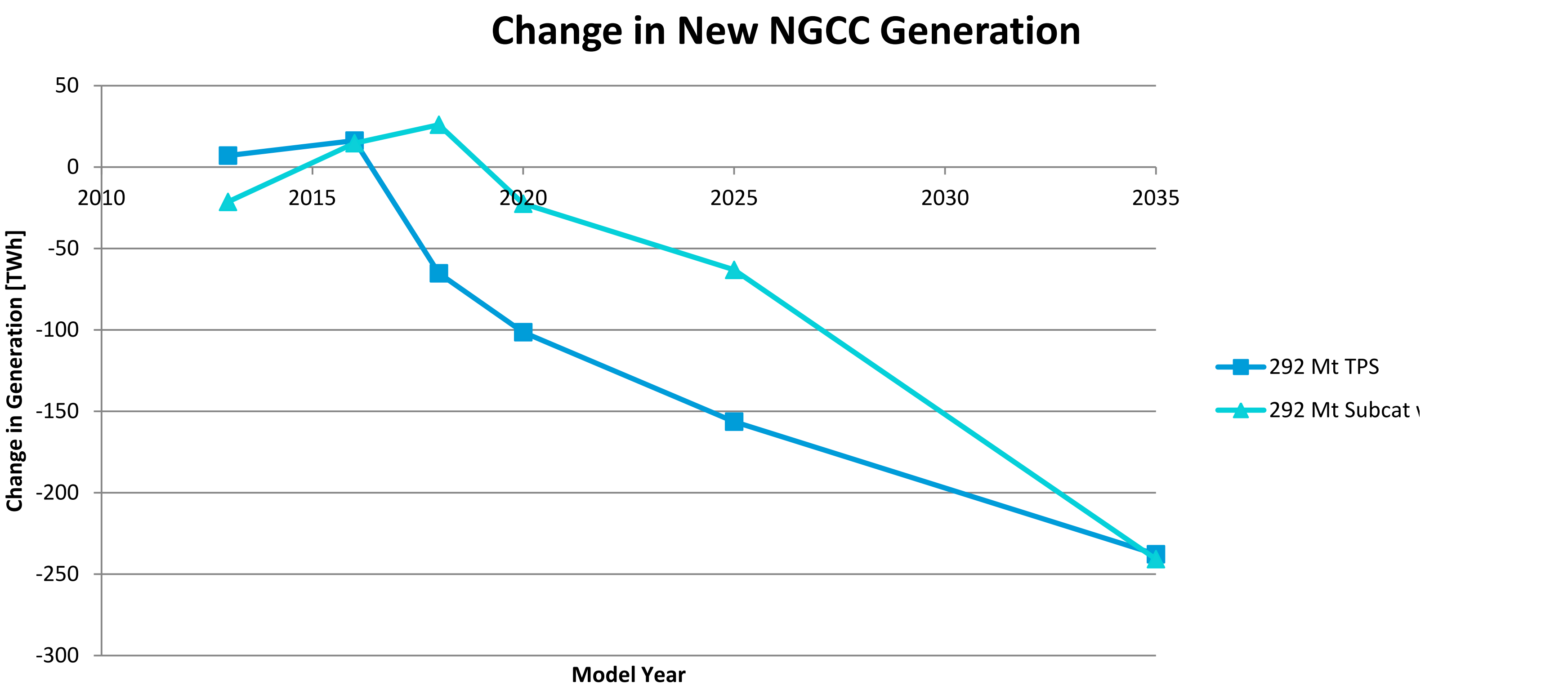
New NGCC Generation



- Lower NG benchmark provides a less incentive to existing NGCC units to increase generation to earn more credits
  - Implies more new NGCC used to service load

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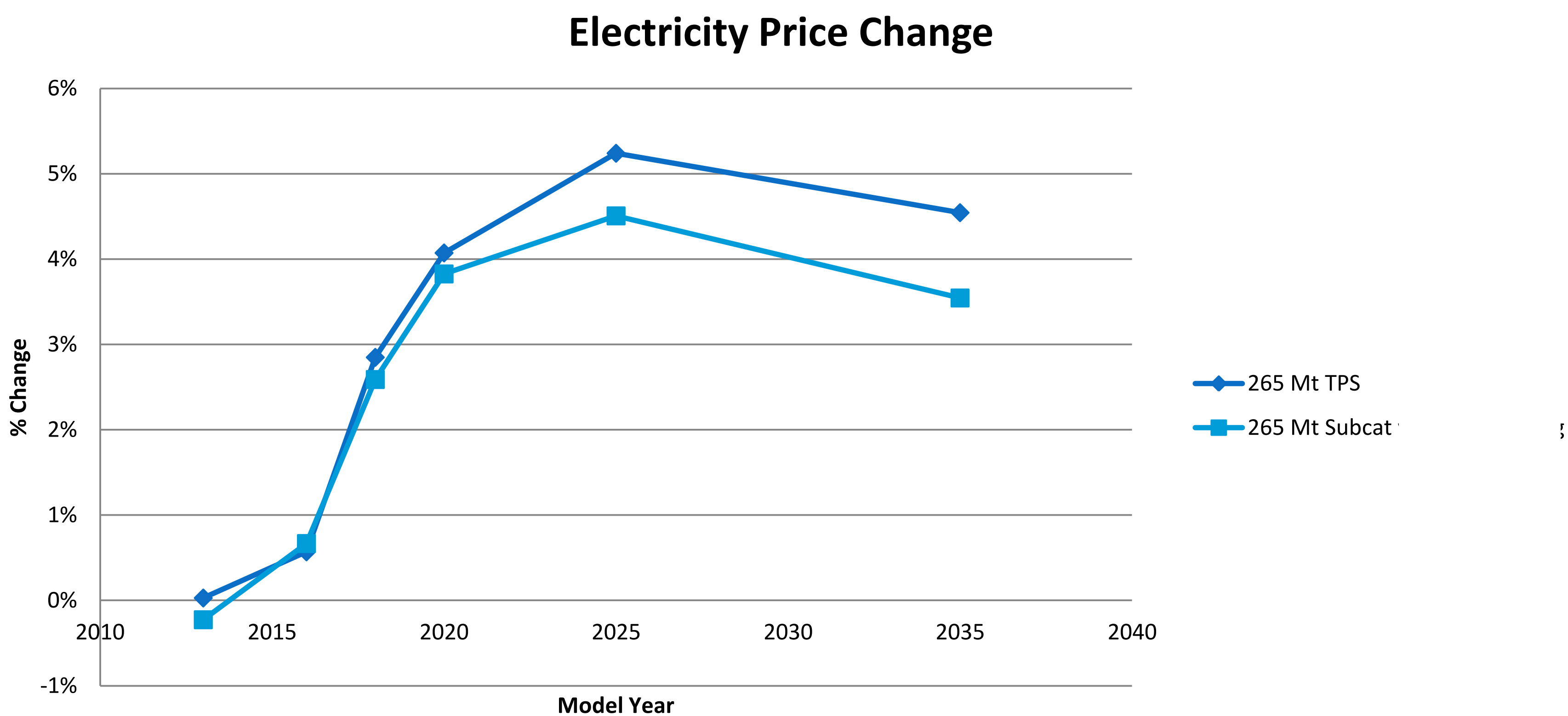
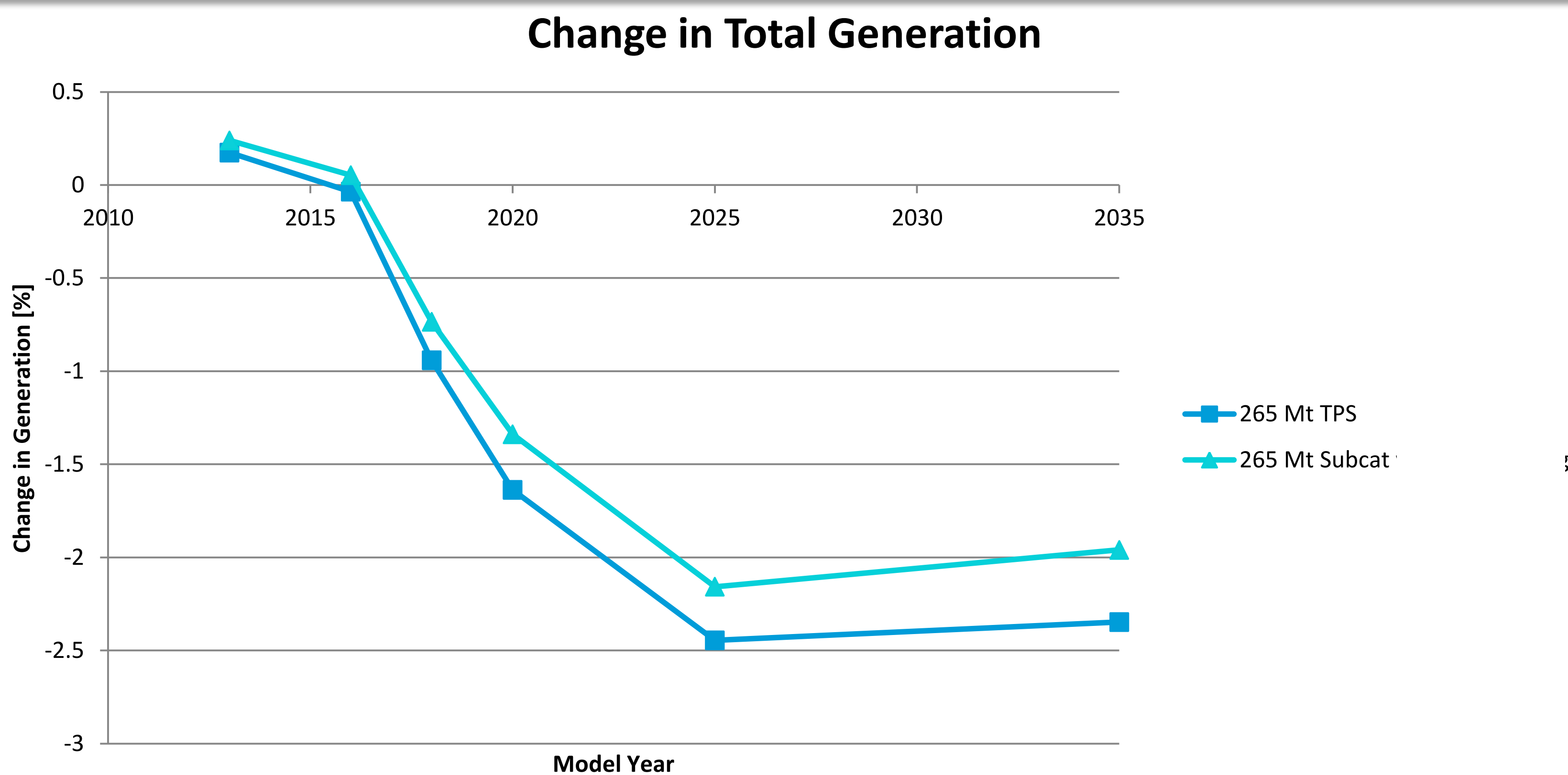
Electricity Price Changes



- Less displacement of cost effective new NGCC generation in the differentiated benchmark rates w/o co-firing case may lead to lower electricity price changes compared to the uniform benchmark case
- Inefficient use of natural gas raises the electricity price

Electricity Generation



- Slight difference in electricity price between uniform and differentiated benchmarks leads to a small difference in the demand response

Ideas for additional analysis?

1. Sensitivities around compliance costs?
2. Effects of phase in/banking in a TPS?
3. Alternative growth baselines (i.e., EE, but with system-wide rebound modeled)
4. Improve analysis described in this deck by assuring common emissions over multiple simulation years (and not just early years)
5. What states might want to use TPS vs. MB?
6. Interaction of existing source standard and modification standard?

Supplemental Slides

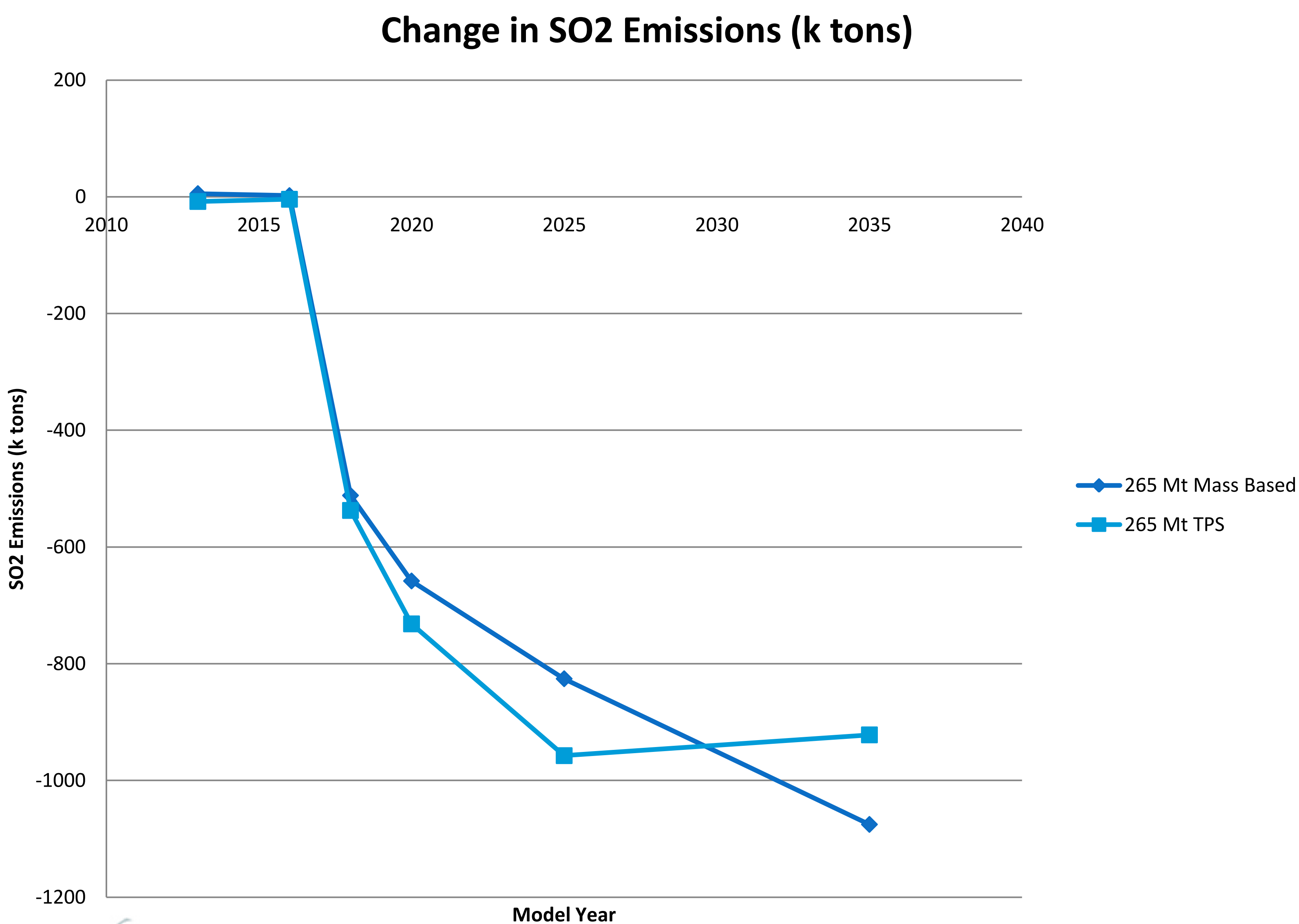
Existing Coal Capacity and Generation

	Change in Coal Capacity (GW)					
	2013	**2016**	**2018**	**2020**	**2025**	**2035**
265 Mt Mass-Based	-7	-16	-42	-52	-52	-52
265 Mt TPS	-9	-15	-16	-16	-17	-17

Baseline capacity in Haiku in 2016 and following simulation years is 315GW. In IPM v5.13 it is about 244GW in 2016 and subsequent years.

	Reduction **in Coal Generation (TWh)**					
	2013	**2016**	**2018**	**2020**	**2025**	**2035**
265 Mt Mass-Based	0	34	367	427	520	729
265 Mt TPS	12	39	403	488	579	604

Change in SO_2 Emissions



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Supplemental Slide: Implicit Subsidy

- Under a TPS, the more a source generates, the more emissions credits it needs, but *it also gets more emissions credits*
- Economists call this the “implicit subsidy” of a TPS
- By contrast, under a program like Title IV, if a source generates more it needs more allowances, *but it does not get more allowances*
- The implicit subsidy can be quite big with even a modest TPS
- Understanding the implicit subsidy is requisite to understanding how a TPS policy and market for credits will perform
  - Increasing a source’s benchmark emissions rate both lowers its compliance obligation AND increases its implicit subsidy, all else held equal
  - Likely effect of implicit subsidy in cost-of-service areas warrants further consideration

Supplemental Slide: Subsidy, Con't

Implicit subsidy:

$$credits\ created\left[tons\right] = performance\,benchmark\left[\frac{tons}{MWh}\right] * production\left[MWh\right]$$

Compliance obligation:

$$credits\ needed\left[tons\right] = actual\,emissions\,rate\left[\frac{tons}{MWh}\right] * production\left[MWh\right]$$

- For a unit that has a performance benchmark of 2000lbs/MWh with a credit of $32/ton, the implicit subsidy is worth $32/MWh (If $110/ton, subsidy is $110/ton)
- If the unit's actual emissions rate is 1900lbs/MWh, the net value of the subsidy is $1.6/MWh (If $110/ton, $3.4/Mwh)
- Compare this value to historic wholesale electricity prices: $32 to $72/Mwh

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The Haiku Electricity Sector Model

- Multi-region forward-looking dispatch model of U.S. electricity sector
- Borrows heavily from IPM and NEMS inputs
- Developed by staff at Resources for the Future
- Unique features:
  - Endogenous representation of demand
  - Representation of cost-of-service pricing
  - Costs are partial equilibrium welfare measure

Haiku-NEMS-IPM v5.13 Comparison

2018 Comparison of Haiku, AEO 2013, IPM v5.13

	Haiku	AEO 2013	IPM v5.13
Electricity Generation (TWh)	3998	4086	4143
Coal	1471	1584	1665
Natural Gas	1012	1086	1082
Nuclear	865	876	820
Non-Hydro Renewables	289	245	282
Total Capacity (GW)			
Coal	324	280	244
Natural Gas CC	225	218	227
CO2 Emissions (Mt)	1874	2081	2087
SO2 Emissions (Mt)	1.85	1.27	1.46

Haiku reports nameplate capacity; AEO reports summer capacity.
Haiku has a lower CF for existing NGCCs, and builds more new NGCC, than AEO.