



Pennsylvania Carbon Pricing Options

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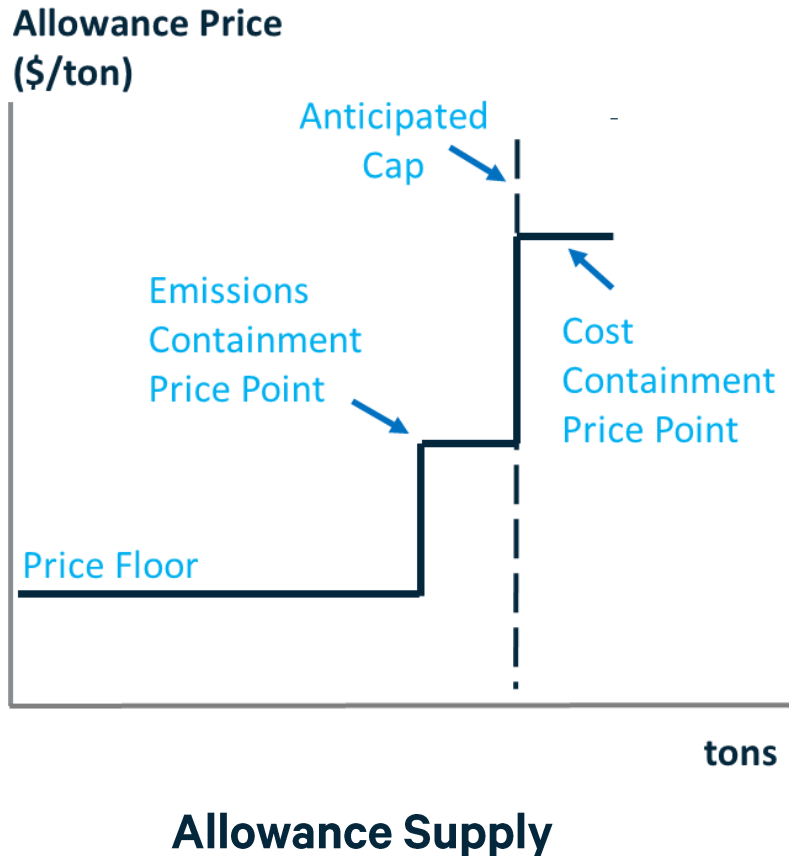
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Pennsylvania Carbon Pricing Analysis

- Previous analysis examined the opportunity of carbon pricing in six new states including Pennsylvania
 - State Policy Options to Price Carbon from Electricity
- The current analysis considers Pennsylvania linking to the Regional Greenhouse Gas Initiative (RGGI)



The Regional Greenhouse Gas Initiative Model



The Basics

- Cap and trade applied to power sector CO₂ emissions beginning in 2009
- Currently includes PJM states Maryland and Delaware
- New Jersey on board to rejoin in 2020

Price Responsive Supply of Emissions Allowances

- Beginning in 2020 through 2030 the anticipated cap declines at 3% per year
- No allowances sell below the price floor of \$2.38 in nominal dollars in 2021 increasing by 2.5%/year (\$2.05 in 2015 dollars throughout our model)
- 10% of allowances do not sell below the emissions containment reserve beginning at \$6 in 2021 increasing at 7%/year
- An additional 10% of the cap could enter at the cost containment price of \$13 in 2021 increasing at 7%/year
- Allowances can be banked for use in future years



RFF's Haiku Electricity Market Model

- Analysis is conducted with a highly parameterized state-level model of the electricity system
- The model solves for capacity investment and retirement, and operation of the electricity system, with price-responsive electricity demand and other detail
- In the business-as-usual baseline from 2020 to 2026, the model projects annual emissions in:
 - Pennsylvania increase by 25 million tons (27%)
 - The eleven RGGI states decrease by 47 million tons (31%)
 - RGGI *plus* Pennsylvania decrease by 22 million tons (9%)
- Various climate policy designs are explored including alternative uses of carbon revenue proceeds
- Results are reported for 2026 with all values given in 2015 dollars



Policy Dimensions We Examine

- A. Allocation of emissions allowances to producers, consumers, or the general fund
- B. Eligibility of various producers for free allocation under *updating* Output Based Allocation (OBA)
- C. Changes to the Alternative Energy Portfolio Standard (AEPS)



Impacts We Examine

- CO₂ emissions
- Renewable electricity generation
- Coal and gas generation
- Electricity prices
- RGGI allowance price

We consider each of these outcomes in Pennsylvania and across the electricity system for the year 2026



General Results

We model 15 scenarios and find that in 2026, when Pennsylvania links with RGGI:

- **CO₂ emissions** in PA fall by 28-32 million tons (24-27%) relative to business-as-usual. Emissions in the 12- state RGGI region (including PA) fall by 41 million tons (18%). Nationally, emissions decline by 1.5%-2.1%
- Electricity generation by **renewable sources** in PA and in the 12-state RGGI region will increase unless the AEPS is cancelled. Nationally and in PJM, RE generation may not increase, though it would if the AEPS is expanded
- **Coal and gas**-fired electricity generation in PA and in the 12-state RGGI region will decline. National gas-fired generation will also decline. Coal-fired generation may increase nationally, but any change will be less than 0.5%
- Retail **electricity prices** in PA rise by at most 0.4%, and may fall
- RGGI **allowance prices** will rise to as high as \$3.44 if all PA allowance value goes to the general fund. If PA allocates allowances within the power sector, allowance prices will be lower, but still above the price floor

Two factors in the RGGI policy play a big role in these results:

- The emissions containment reserve (low prices) leads to emissions reductions that are greater than 3% per year in the 12-state RGGI region
- Linking with RGGI enables a regional shift in generation and emissions shares under the cap, away from the other RGGI states into Pennsylvania



Eligibility of Producers for Free Allocation

Updating **output-based allocation (OBA)** distributes emissions allowances for free to *eligible* producers in proportion to their share of electricity generation

OBA is expected to incentivize an increase in production

We find that making all generators eligible for free allocation, compared to allocation of allowance value to the general fund:

1. Increases power exports and generation from both renewable energy and emitting sources, leading to an increase in emissions in PA, but...
2. ...Overall emissions within RGGI are unchanged

The net effect on US emissions is small

In some scenarios, targeting OBA eligibility to specific technologies leads to fewer US emissions



Allocation to Consumers

Allocation to consumers uses the allowance value to fund energy efficiency and rate relief

Energy efficiency spending is expected to decrease consumption, emissions and the allowance price. But rate relief is expected to have the opposite effect

We find this combination of spending on behalf of consumer:

1. Leads to a reduction in retail prices and consumption in-state, but...
2. ...Negligible changes in emissions and generation mix in- or out-of-state compared to directing allowance value to the general fund



Changes to the AEPS

The Alternative Energy Portfolio Standard (AEPS) guarantees that a certain percentage of PA electricity consumption comes from specified sources, which we represent as wind and solar

We consider the interaction of carbon pricing with changes to the AEPS

- If the AEPS is cancelled, we find...
 - Renewable energy credits (RECs) created in Pennsylvania could be used for compliance in other states displacing renewable investments, causing the reduction in PJM emissions to be less
 - Preventing generators from selling RECs to other states would increase emissions reductions in PJM
- If the AEPS is expanded to 15 percent, we find...
 - PJM emissions will decline
 - Choices about directing allowance value to consumers, producers, or the general fund, or producer eligibility under output-based allocation, will have effects as previously described



Further Detail

- Scenario descriptions
- Figures and results
- Spreadsheets



Scenario Descriptions (A-I)

Scenario Name	Allocation to Producers/Consumers/General Fund	Eligibility for Output-Based Allocation	Alternate
A: Business as Usual (BAU)	NA	NA	Status Quo
B: No Allowance Allocation (No AA)	100% General Fund	NA	Status Quo
C: 100% Cons	100% Consumers	NA	Status Quo
D: 25% OBA All, 75% Cons	25% Producers, 75% Consumers	All Generation	Status Quo
E: 50% OBA All, 50% Cons	50% Producers, 50% Consumers	All Generation	Status Quo
F: 75% OBA All, 25% Cons	75% Producers, 25% Consumers	All Generation	Status Quo
G: 100% OBA All	100% Producers	All Generation	Status Quo
H: No AEPS, PA sells RECs	100% Producers	All Generation	AEPS dropped, PA RE generators can sell RECs
I: No AEPS, No PA RECs	100% Producers	All Generation	AEPS dropped, PA RE generators CANNOT sell RECs



Scenario Descriptions (J-P)

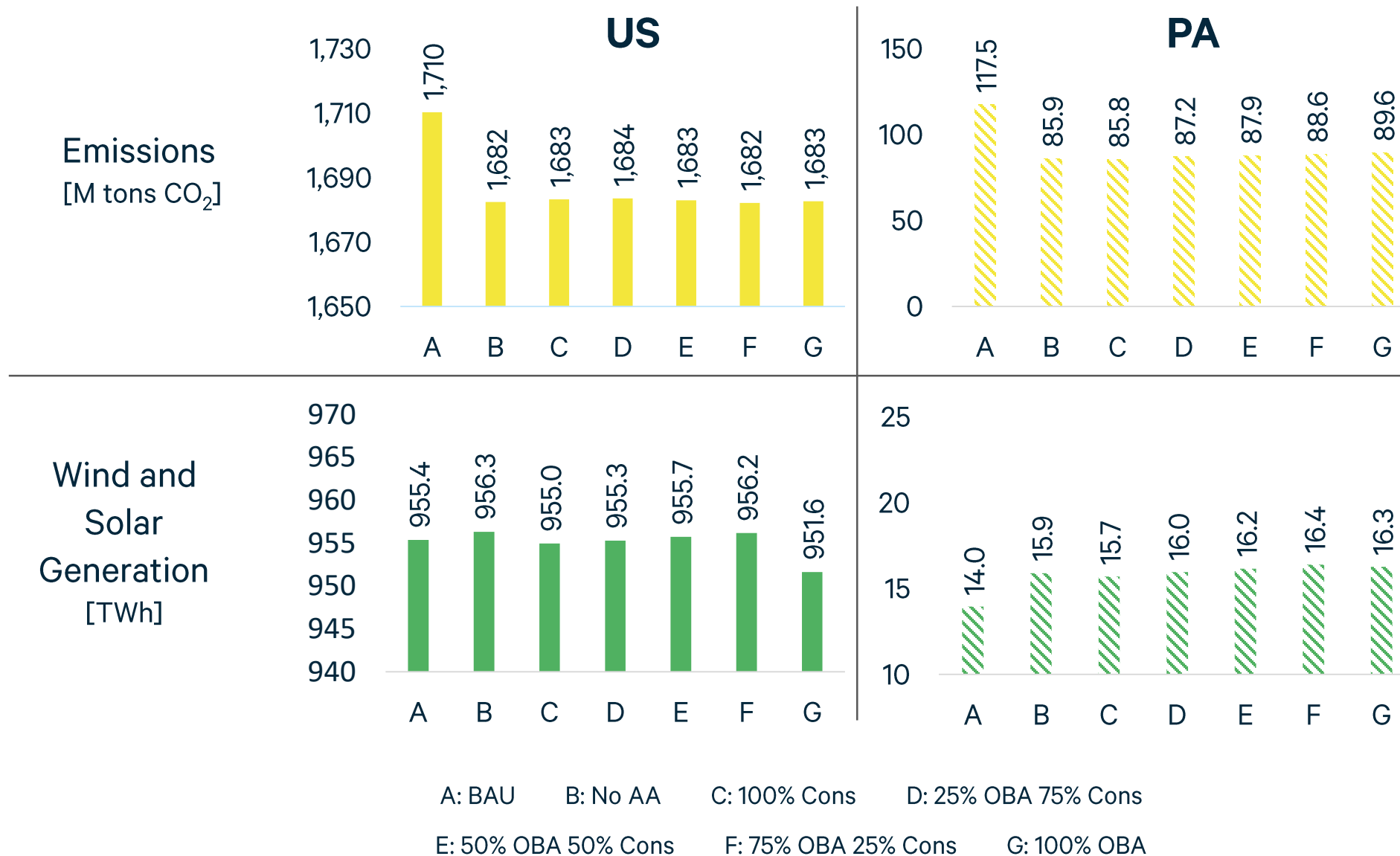
Scenario Name	Allocation to Producers/Consumers/General Fund	Eligibility for Output-Based Allocation	Alternate
J: 100% OBA	100% Producers	All Generation Except Coal and Existing Renewables	Status Quo
K: 50% OBA, 50% Cons	50% Producers, 50% Consumers	All Generation Except Coal and Existing Renewables	Status Quo
L: 100% OBA All, 15% AEPS	100% Producers	All Generation	15% AEPS
M: 100% Cons, 15% AEPS	100% Consumers	NA	15% AEPS
N: No AA, 15% AEPS	100% General Fund	NA	15% AEPS
O: 100% OBA All Non-Emitting	100% Producers	All Non-Emitting Generation (Wind, Solar, Hydro, Nuclear)	Status Quo
P: 50% OBA All Non-Emitting, 50% No AA	50% Producers, 50% General Fund	All Non-Emitting Generation (Wind, Solar, Hydro, Nuclear)	Status Quo



A. Allocation of emissions allowances to producers, consumers, or the general fund



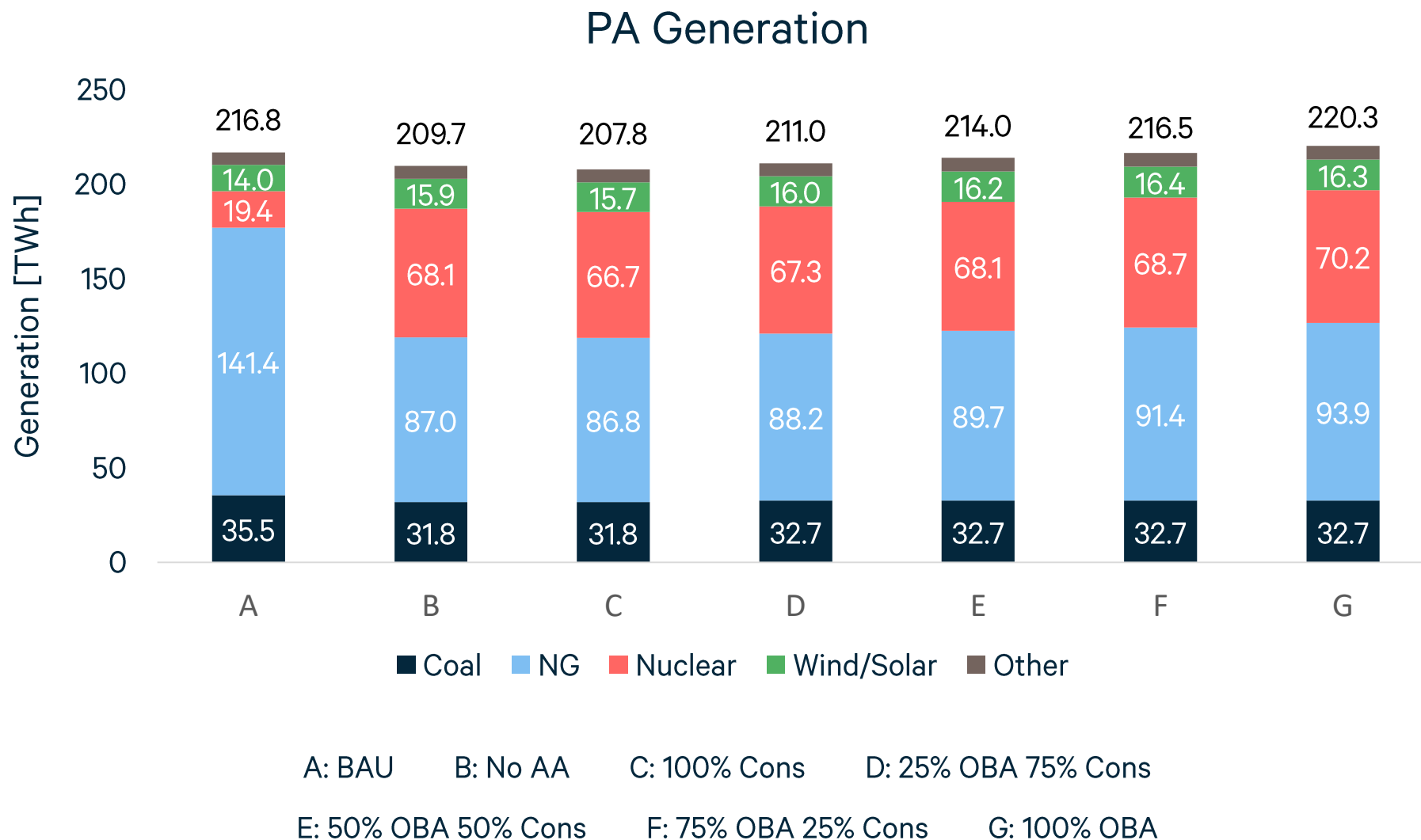
1. Allocation to producers increases PA emissions but national emissions remain relatively constant as generation shifts from other states to PA compared to allocation to general funds or consumers



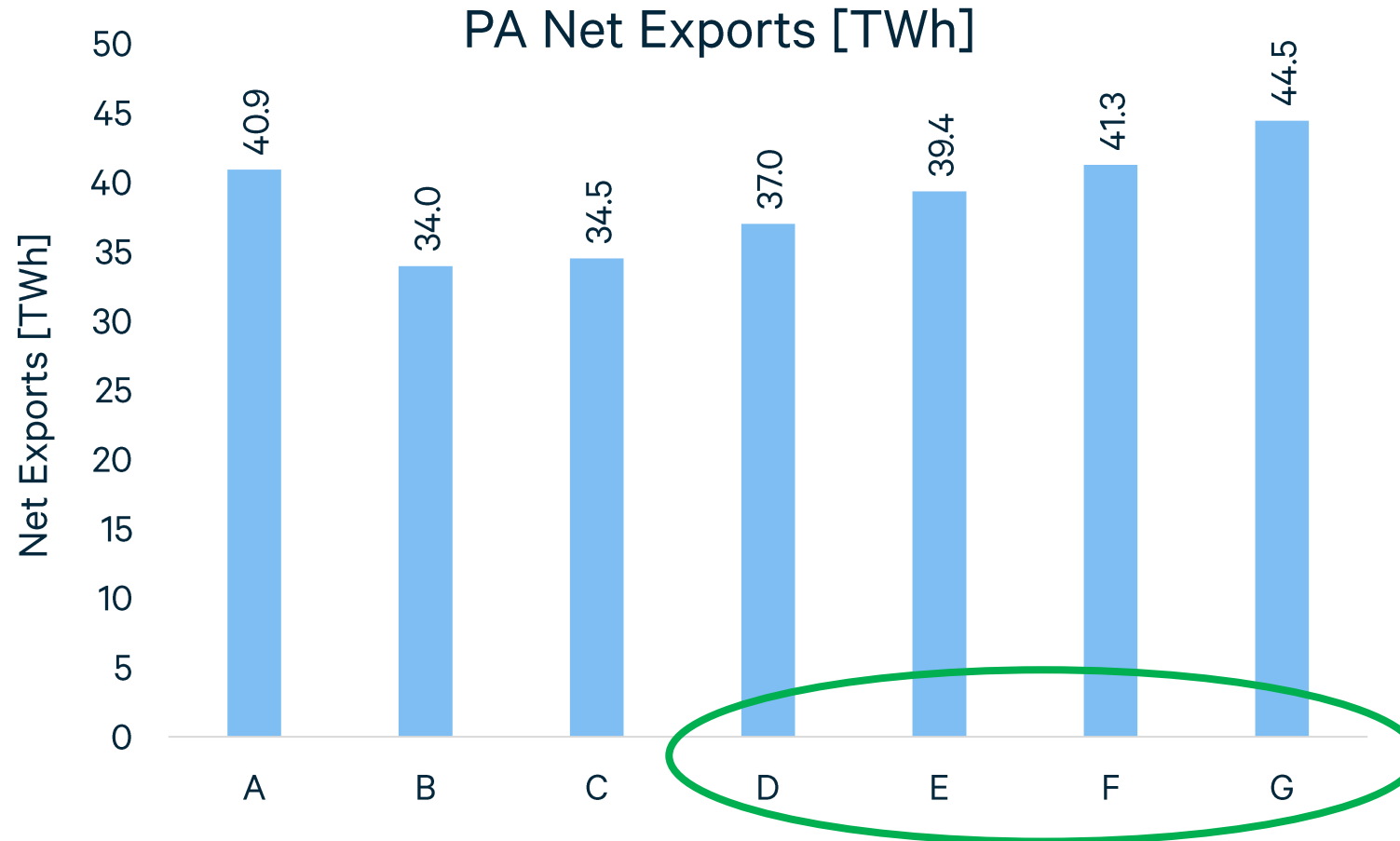
2. Carbon pricing leads to a net increase in coal use nationally. Allowance allocation to producers increases gas generation in PA.



3. A modest carbon price substantially expands nuclear generation. At 100% OBA we see the greatest amount of total generation, nuclear generation, and gas generation in PA. We see a concurrent decline in renewables at the national level.



4. As allowance allocation to producers (OBA) increases, electricity exports also increase



A: BAU B: No AA C: 100% Cons D: 25% OBA 75% Cons
E: 50% OBA 50% Cons F: 75% OBA 25% Cons G: 100% OBA



B. Eligibility of various producers for free allocation under *updating* Output Based Allocation (OBA)



5. Shifting eligibility for output based allocation (OBA) away from emitting sources (G to J and O) decreases PA and US emissions slightly and increases the quantity of renewable generation



A: BAU

B: No AA

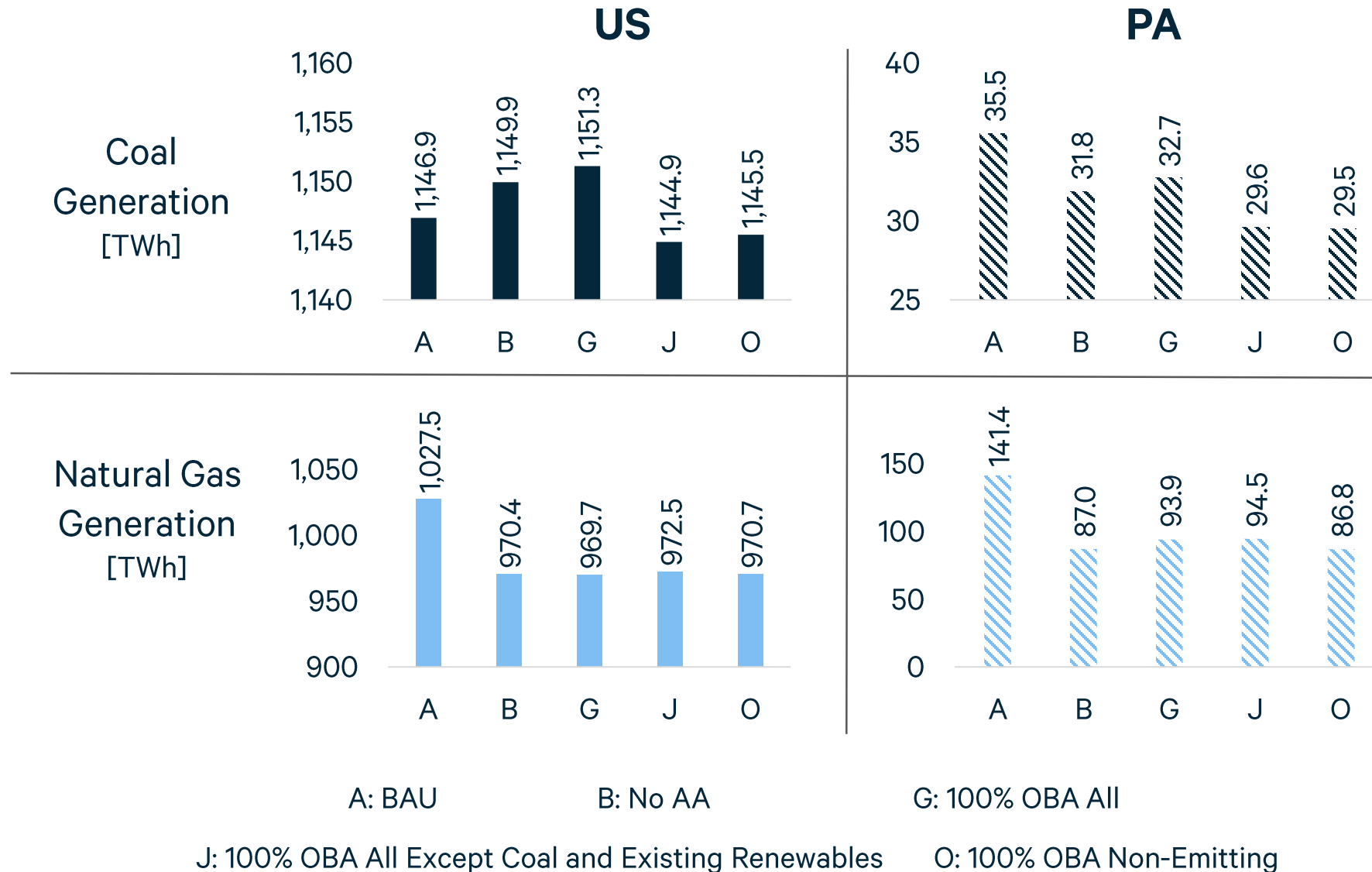
G: 100% OBA All

J: 100% OBA All Except Coal and Existing Renewables

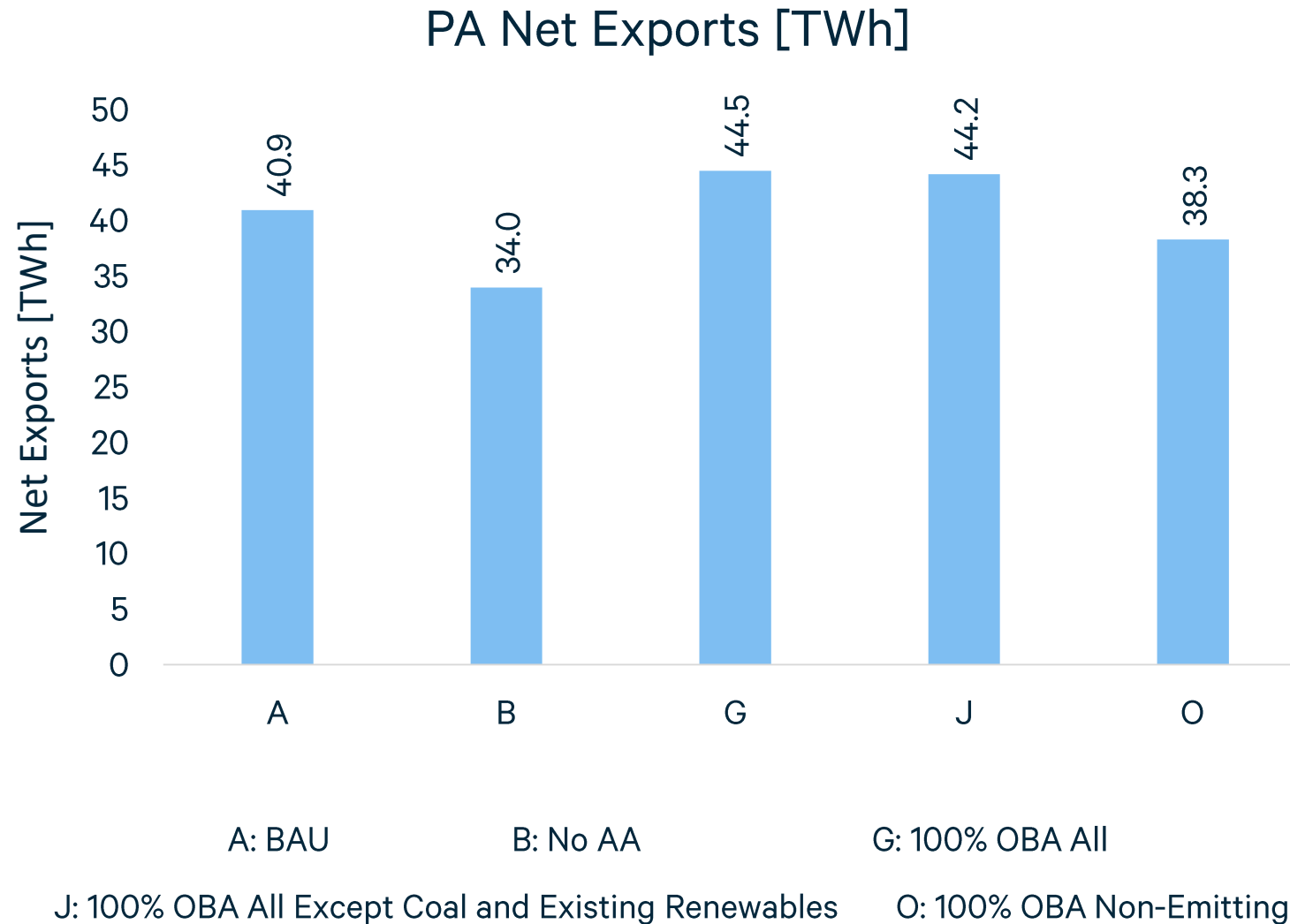
O: 100% OBA Non-Emitting



6. Shifting allowance allocation away from coal decreases its generation share within PA. Shifting allocation away from gas is not as straight forward.



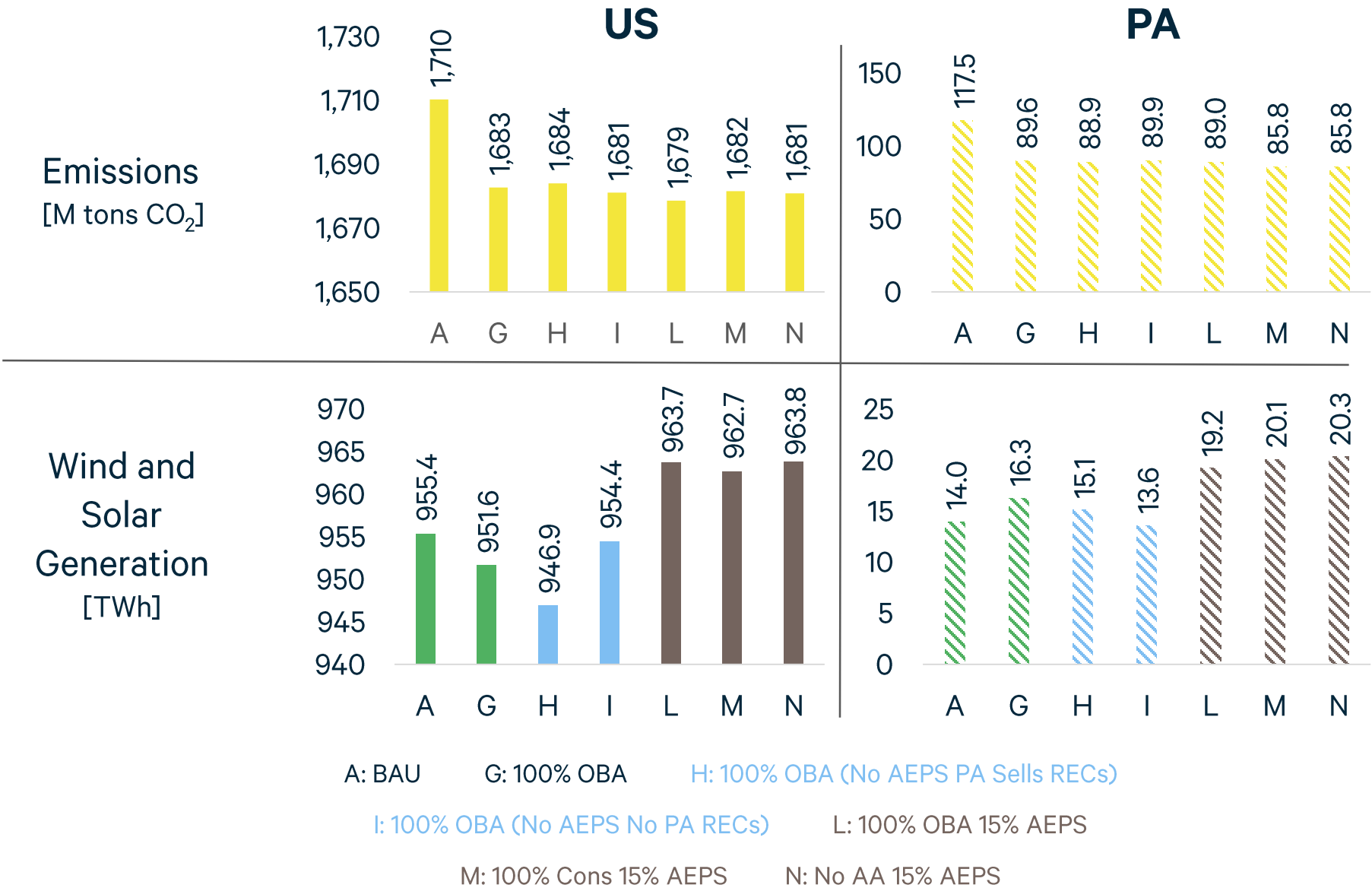
7. Output based allocation (OBA) increases exports even compared to no carbon pricing. Shifting OBA eligibility away from emitting sources reduces this affect, but still results in more in-state generation than no OBA.



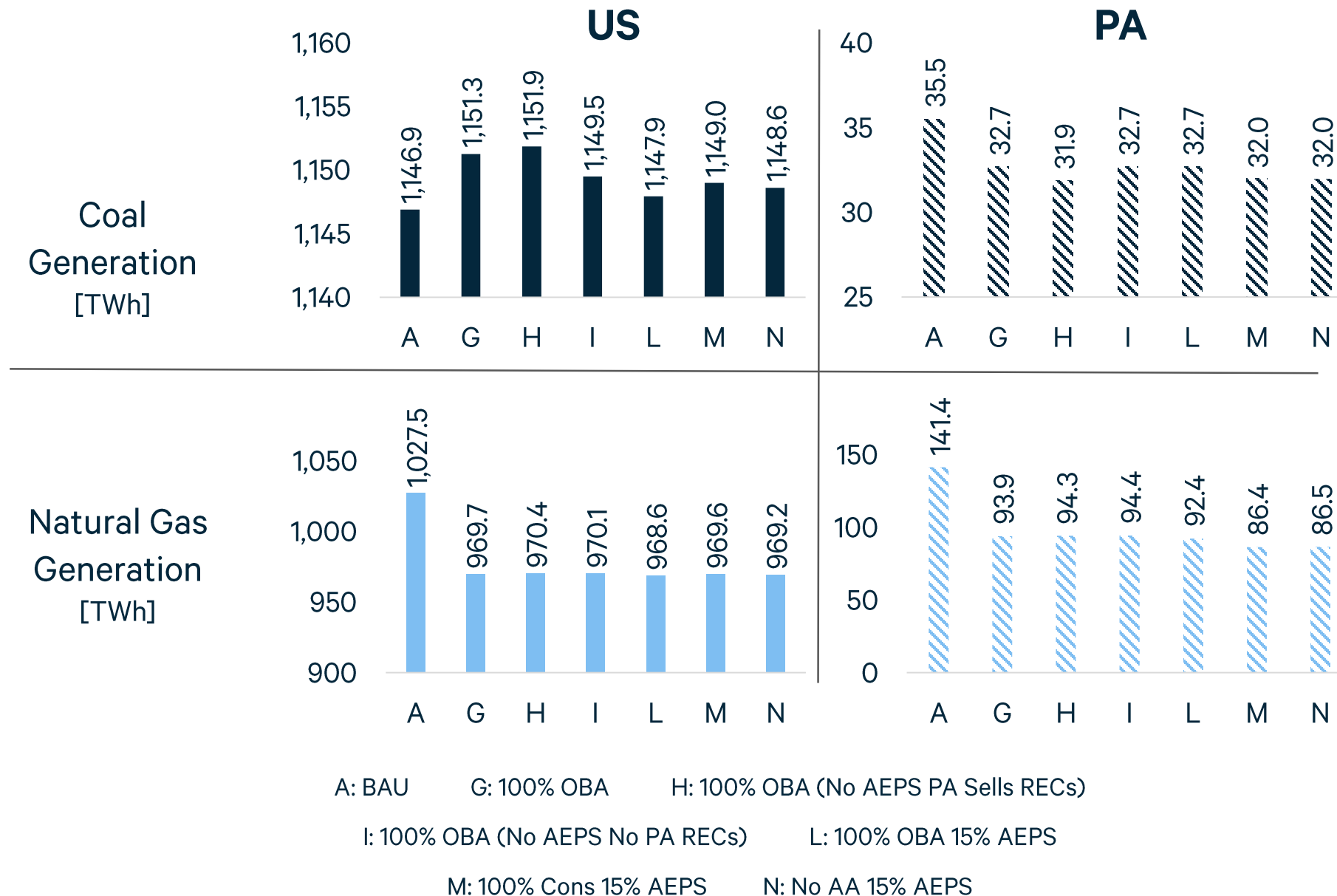
C. Changes to the Alternative Energy Portfolio Standard (AEPS)



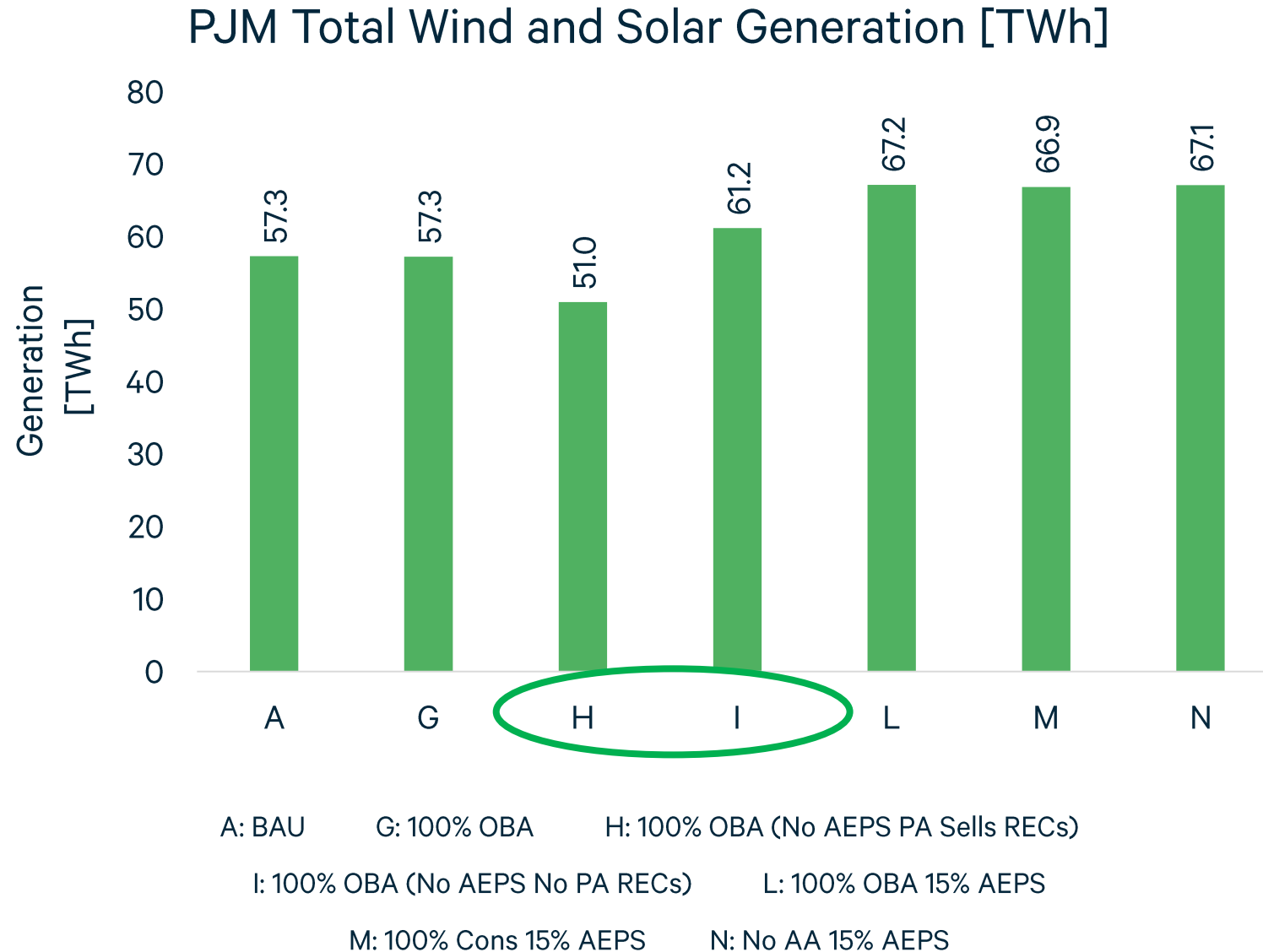
8. Cap and trade does more to reduce emissions than the AEPS (from A to G and I). A strong AEPS guarantees renewable growth (L, M, N). Removing the AEPS without making provision for REC sales decreases renewables nationally (H).



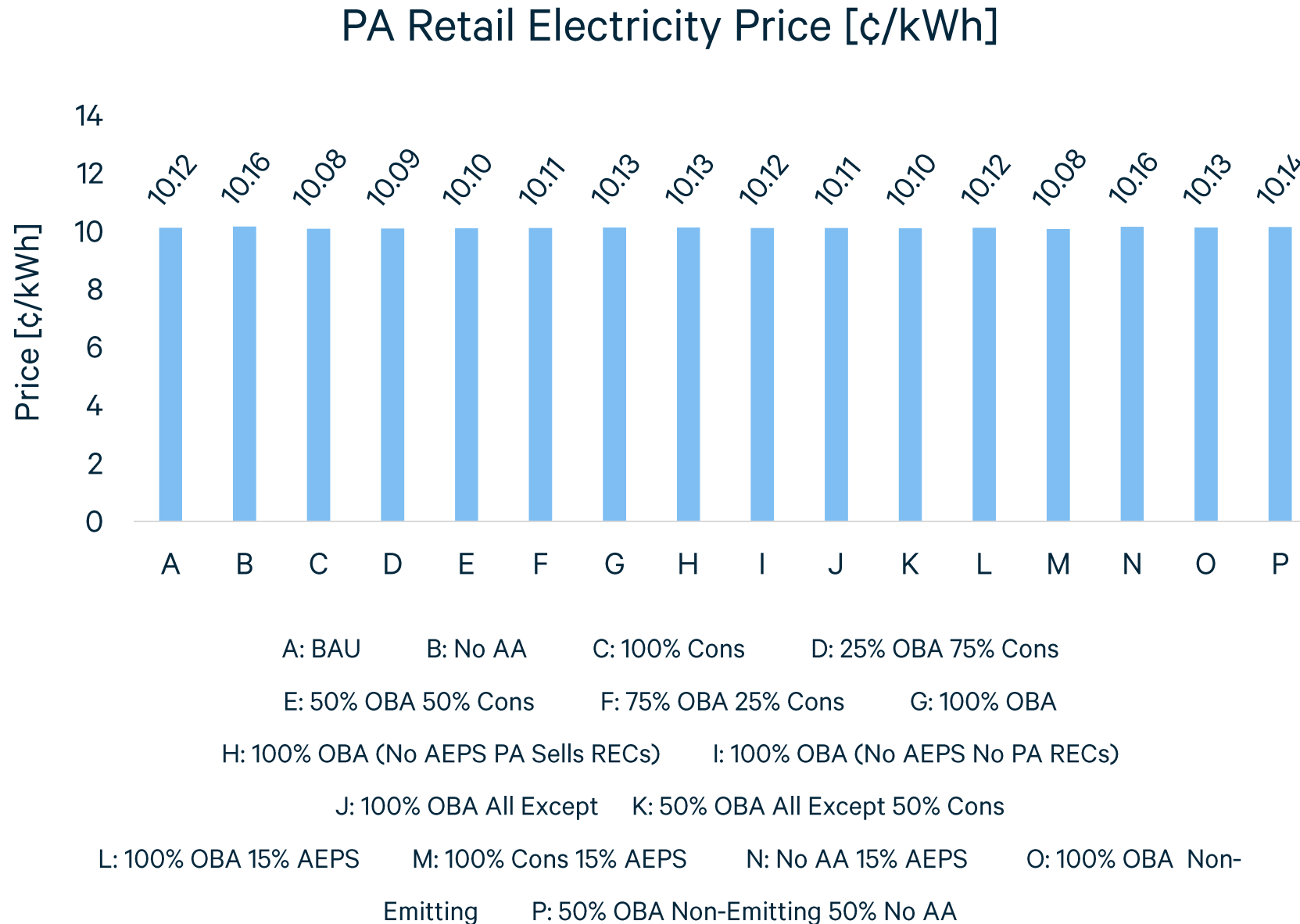
9. Increasing the AEPS (L,M,N) lowers coal and gas generation in PA.



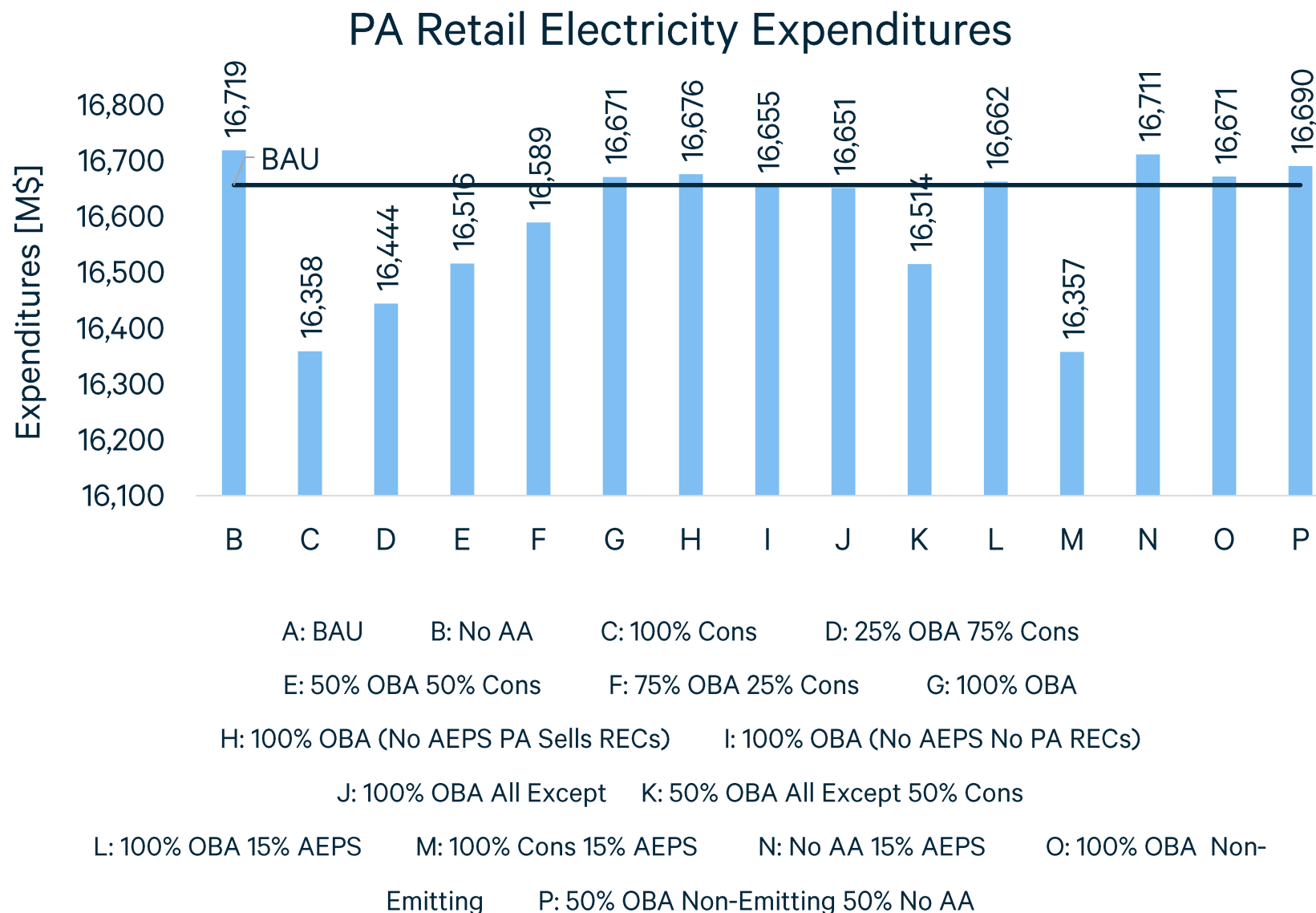
10. Rules governing the sales of RECs are as important as AEPS stringency for renewable outcomes in PJM.



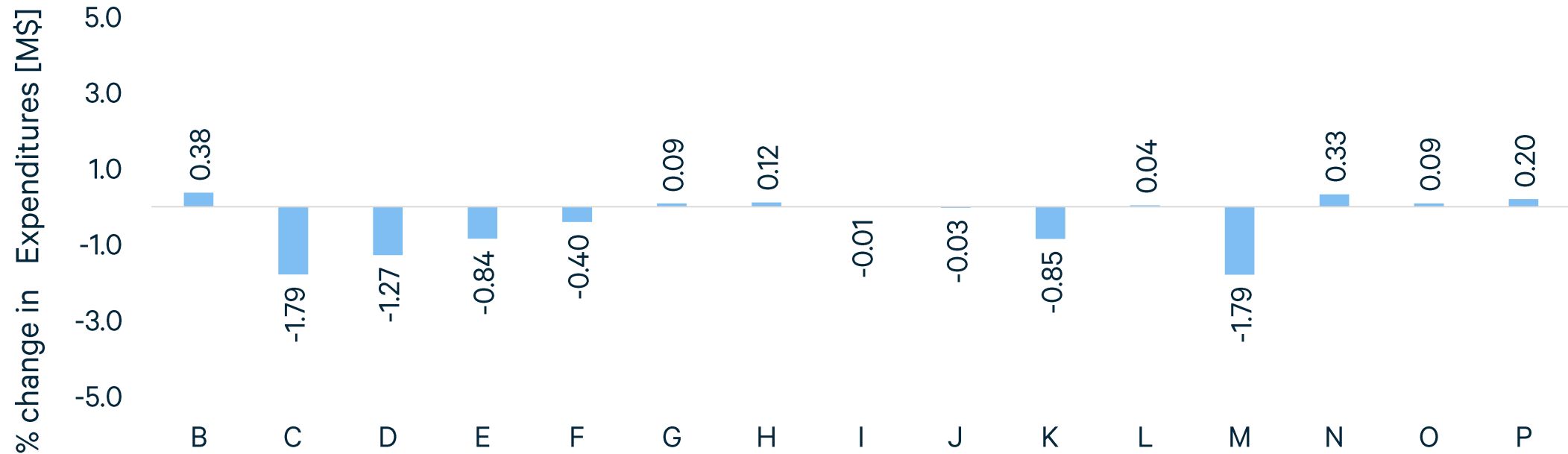
11. None of the policies have a strong effect on prices.



12. None of the policies have a strong effect on expenditures, although giving allowance value to consumers in the form of energy efficiency and rate relief does reduce expenditures slightly.



% Change in PA Retail Electricity Expenditures Relative to Business as Usual



A: BAU

B: No AA

C: 100% Cons

D: 25% OBA 75% Cons

E: 50% OBA 50% Cons

F: 75% OBA 25% Cons

G: 100% OBA

H: 100% OBA (No AEPS PA Sells RECs)

I: 100% OBA (No AEPS No PA RECs)

J: 100% OBA All Except

K: 50% OBA All Except 50% Cons

L: 100% OBA 15% AEPS

M: 100% Cons 15% AEPS

N: No AA 15% AEPS

O: 100% OBA Non-

Emitting

P: 50% OBA Non-Emitting 50% No AA



Thank you.

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