Escalation for Construction: Sensitivity Analysis Using CSPER-C

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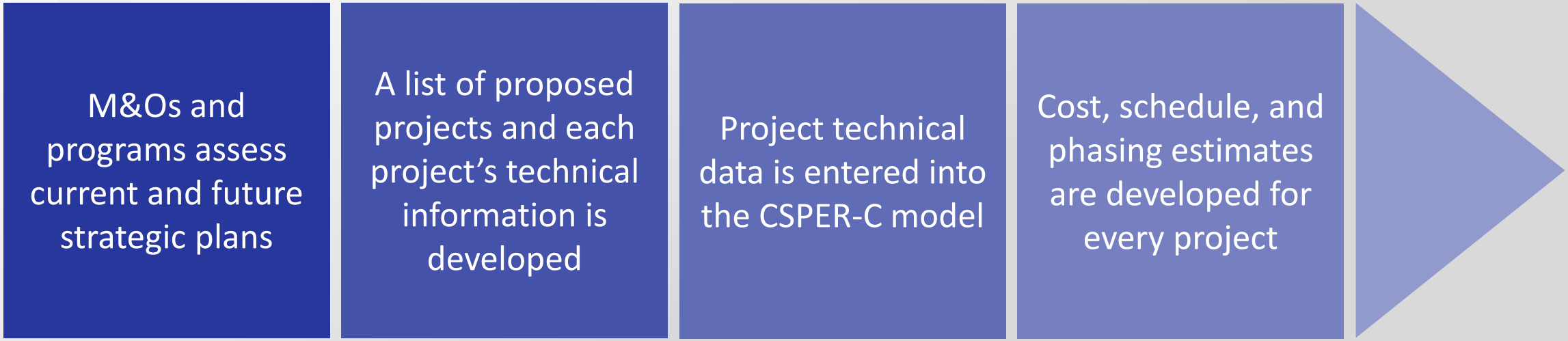
Background

- The NNSA Office of Programming, Analysis, and Evaluation (PA&E) is responsible for providing programmatic cost estimating
- The CSPER-C model was developed by PA&E in 2017 to support the NNSA Capital Acquisition Planning Process



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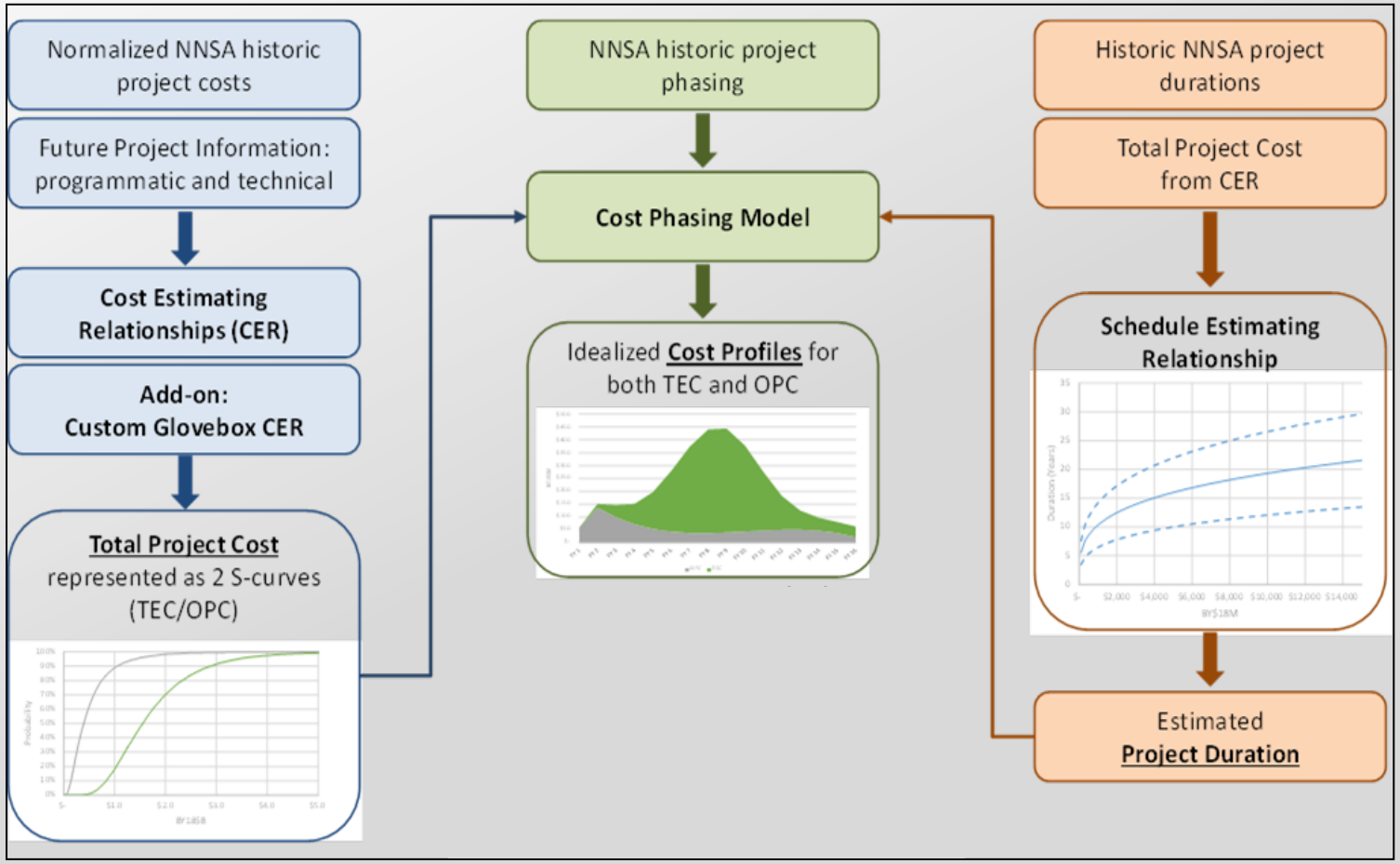
CSPER-C Model

Model Components

- Two cost estimating relationships (CERs)
- One for Total Estimated Costs (TECs) and one is for Other Project Costs (OPCs)
- An add-on CER for complex gloveboxes
- A schedule estimating relationship (SER) that estimates project duration and key milestone dates
- Two phasing estimating relationships (PERs) to estimate the year-by-year cost profiles for TEC and OPC



Cost Estimating Relationship

Example Multiplicative Functional Form Cost Estimating Relationship (CER)

Independent Variables

TEC in BY$/GSF= $aGSF^{b}\,Hazcat^{c}\,EquiComp^{d}$

OPC as % TEC = $eGSF^{f}\,Hazcat^{g}\,EquipComp^{h}$

Technical Cost Drivers

GSF – Gross Square Feet
Hazcat – Hazard Category Bin
*EqComp – Equipment Complexity**

**Only for New Construction with or without Process Equipment*

- TEC is calculated first using the above equation
- OPC is calculated from TEC as a percent using the following equation
- TPC is calculated by summing TEC and OPC
- Output estimate range driven by:
  - **Technical uncertainty** based on per project SME technical input (GSF range from 3 points – low, most likely, high)
  - Underlying **cost uncertainty** based on historic NNSA project actuals

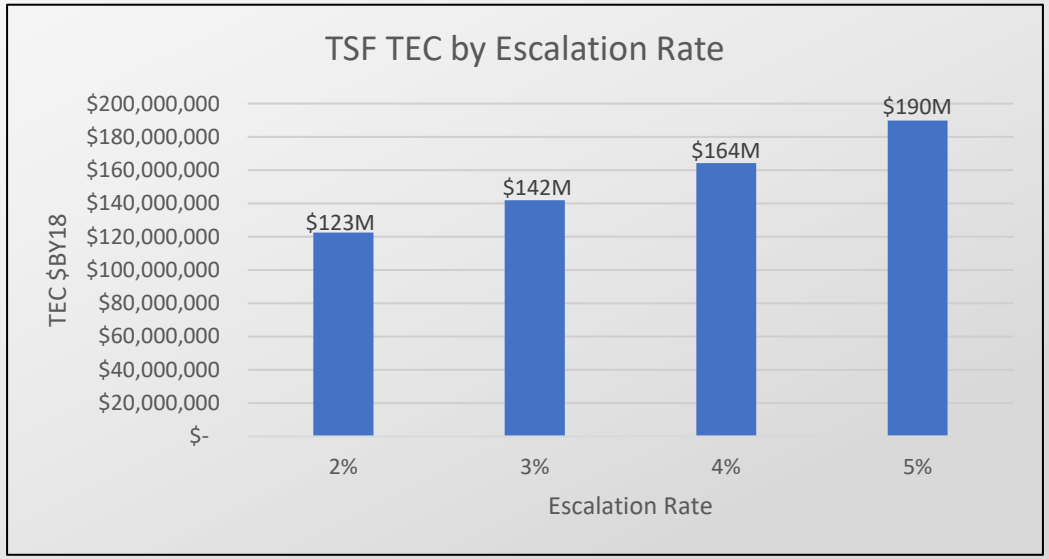
Escalation

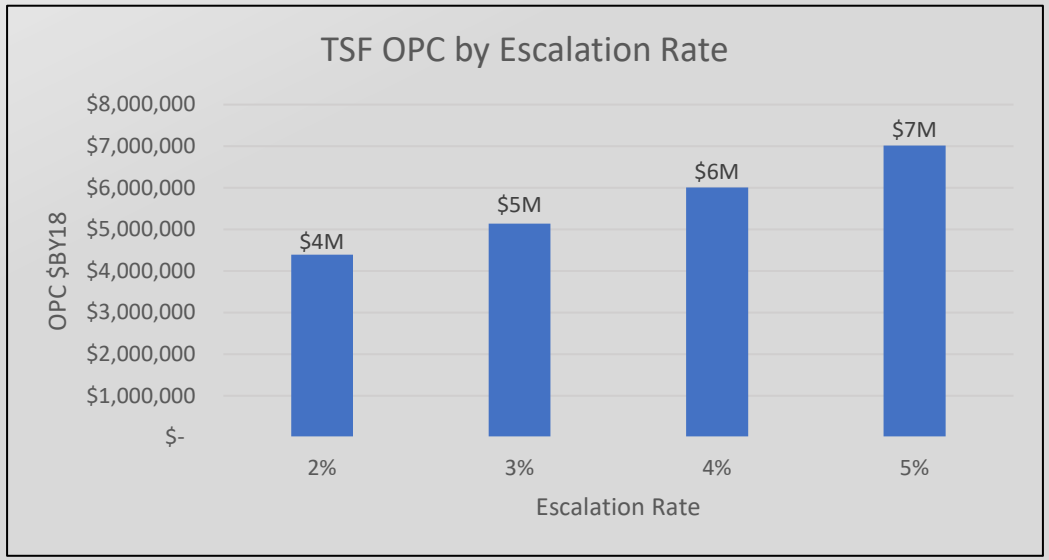
- The value of money changes over time
  - The category of goods or services also impacts value
- Various escalation indices can be used to measure this change over time
- Since the CSPER-C model is used to estimate project cost spanning over many years, escalation is a fundamental aspect
- Based on PA&E's Escalation Study for DOE NNSA's Capital Acquisition Projects, the Engineering New-Record (ENR) Construction Cost Index (CCI) is currently used to normalize historic project data
- Various offices have used difference indices over time
- To understand the **impact of normalizing historic data** based on ENR CCI versus other indices, a sensitivity analysis was performed on the CSPER-C model

Data Normalization

- Three additional historical escalation indices were analyzed
- Flat rates ranging from 2% – 5% were also tested
- The escalation rate can have a **multimillion-dollar impact** on total base year (BY) cost of the historical project

Escalation Index	Average Annual Rate
ENR CCI	3.0%
ENR BCI	2.8%
OMB	2.0%
PPI Industrial Construction	2.4%





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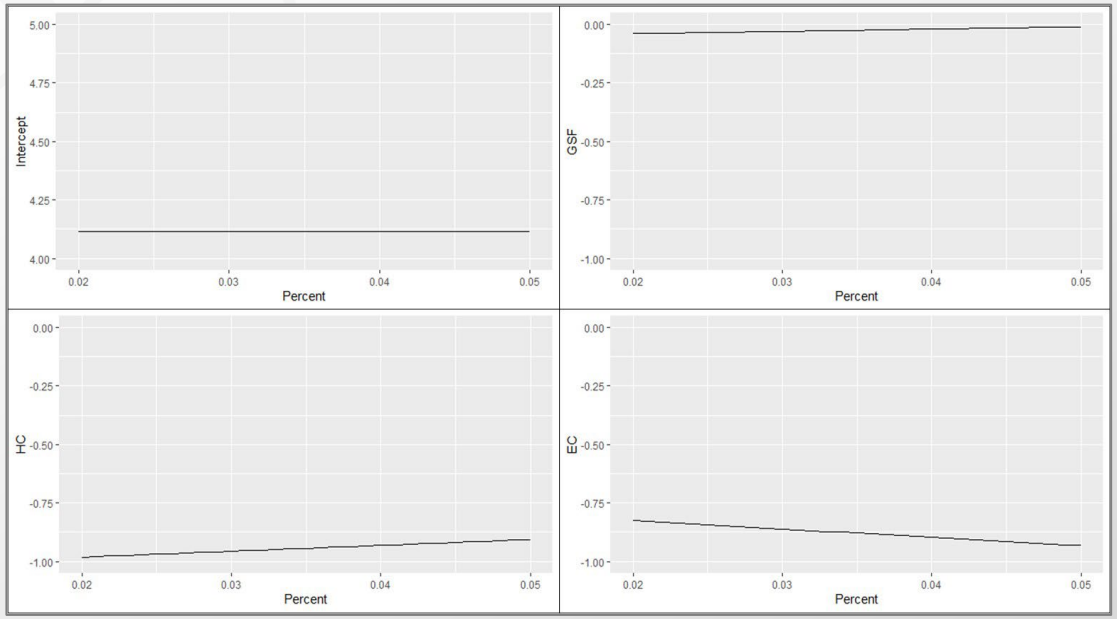
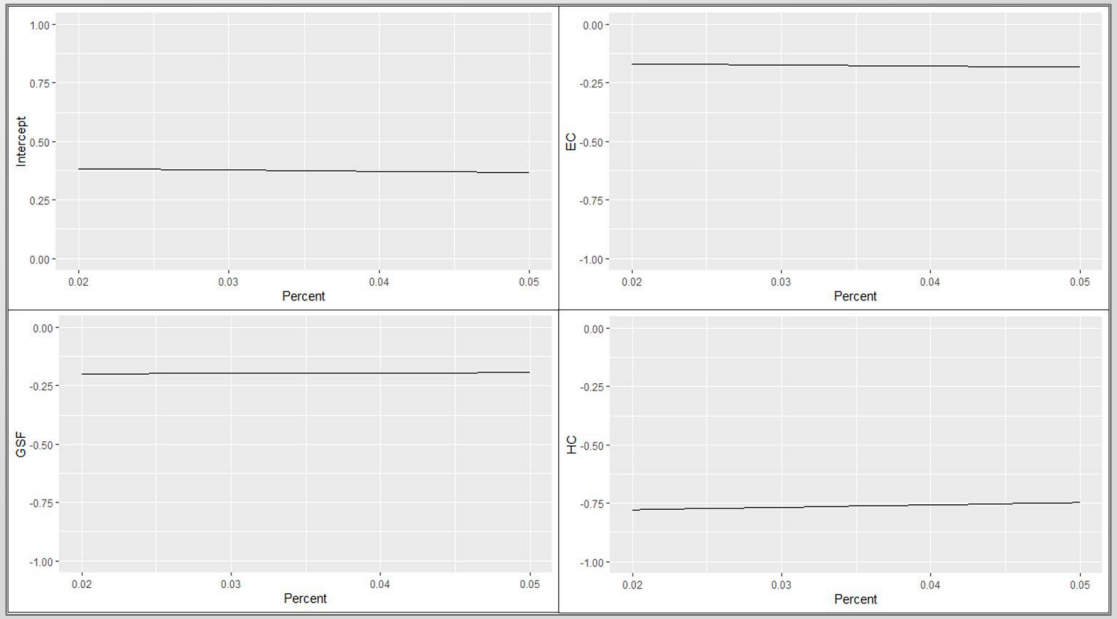
CER Development

- For each normalized dataset, new CERs were created
- The changes in coefficients were plotted against a 2% – 5% scale

TEC Coefficients vs. Escalation Rate



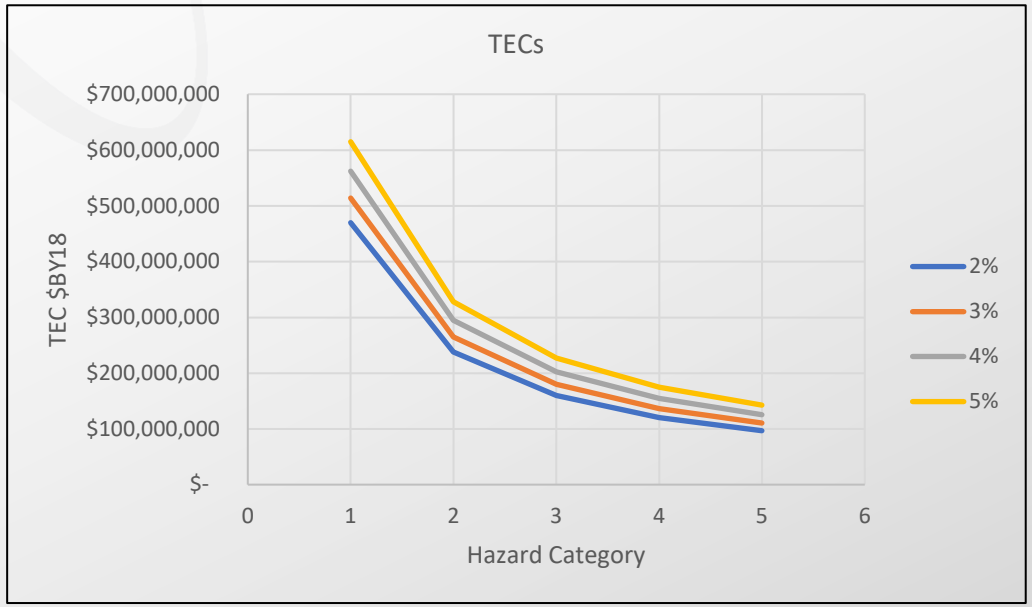
OPC Coefficients vs. Escalation Rate

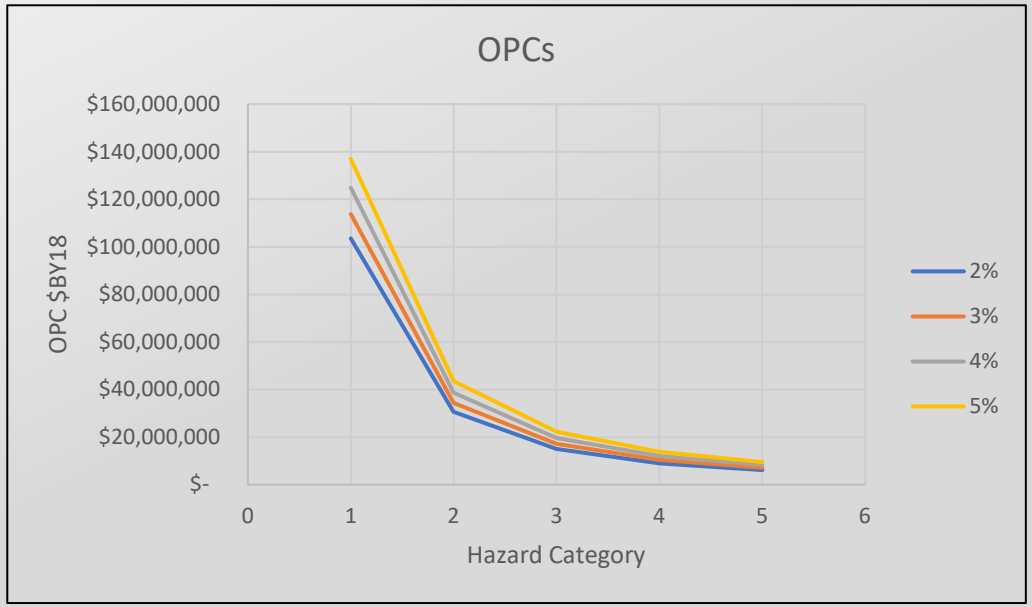


The largest impact on a coefficient is in the equipment complexity coefficient for the TEC CER, which decreases by just over one-tenth.

Impact on Estimates – Flat Rates

- An example facility was run through each new CER to understand how different escalation indices impact cost estimates
  - The example facility used was a 100,000 SF building with medium equipment complexity





Although different indices have a minimal affect on CER coefficients, they have a significant impact on the resulting cost estimates.

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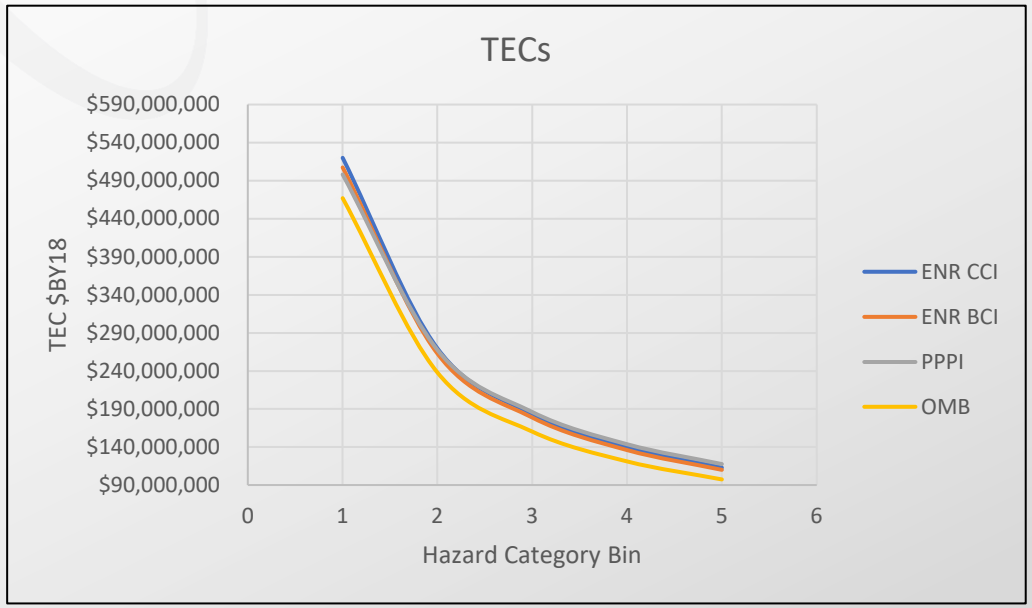

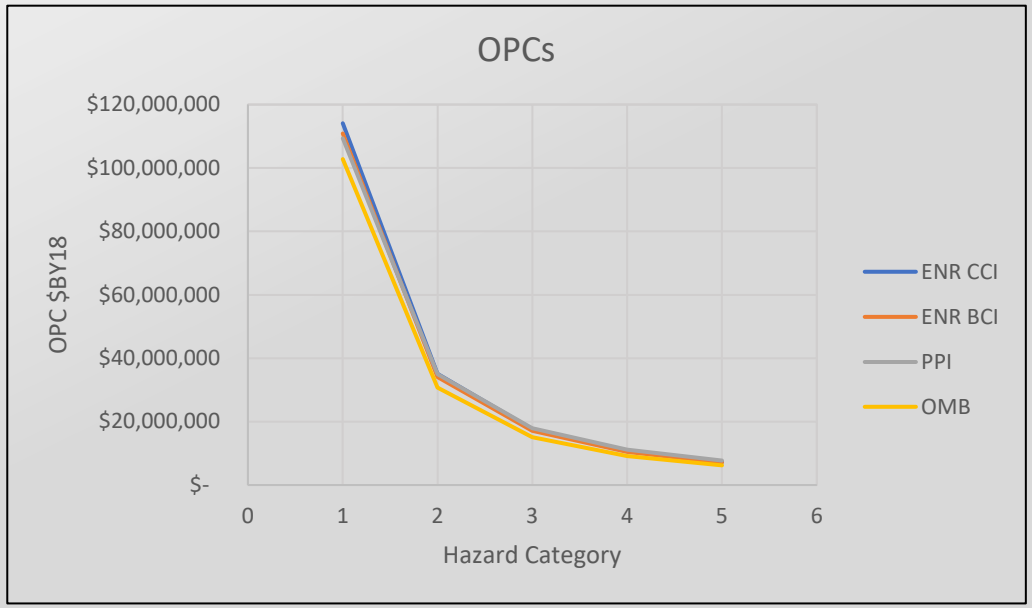

Conclusion

- The use of historical construction escalation indices in modeling capital acquisition project costs and schedules are largely non-differentiating
- In terms of flat escalation rates, the index used to normalize historic data has a significant impact on future cost estimates
- PA&E recommends using a historic escalation index when developing cost estimates for capital acquisition projects

For more information, we have developed a whitepaper on our methodology and findings. Please contact Jennifer.Vandervort@nnsa.doe.gov if you are interested in accessing this paper.