Coal Retirement Analysis

Assessment and Recommendations

NCUC Technical Conference

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Agenda

- Describe primary elements of the critique of Duke's coal retirement analysis
- Point out challenges in performing fleet-wide retirement analyses
- Detail capacity optimization model (i.e., EnCompass) abilities with respect to endogenous retirements
- Describe methodologies from other utilities' retirement analyses (PacifiCorp, NIPSCO)
- Present a recommended pathway for Duke

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Valuation of Existing Facilities

- The purpose of an Integrated Resource Plan is to help determine what set of resources, both **supply and demand-side**, and **existing** and **new**, best serve customer requirements.

Do the coal plants economically serve customer requirements?

- Is there a combination of other existing and new resources that can meet customer requirements at a lower cost today?

Are the coal plants expected to operate economically in the future?

- Is there a time at which the forward costs of the plants exceed the cost of replacement?

What is the best combination of retirement dates?

- If units don’t serve customers economically today, or at a point in the future, when can they be taken offline?

Critique of Duke’s Retirement Analysis

Illogical Retirement Order

- Rank order of retirements was based on unit capacity (smallest units first)
- Ignores fundamental economics
- Least economic units should be taken offline first

“Sequential Peaker” Embeds Assumptions

- Compares each coal unit to a new combustion turbine, valued at Net CONE
- Other replacement portfolio could provide services at lower cost
- Method embeds assumed value of energy, rather than head-to-head comparison

Replacement Analysis Held Separate

- Optimization occurs after retirements are selected (ignores potential for lower cost replacement)

Other Issues

- Lack of transparency in results
  - Not clear if lack of nearer term retirements is based on high value of coal units, or built-in barriers to replacement
- Proposed retirement dates are disconcertingly similar to depreciation dates

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Critique of Duke’s Retirement Analysis

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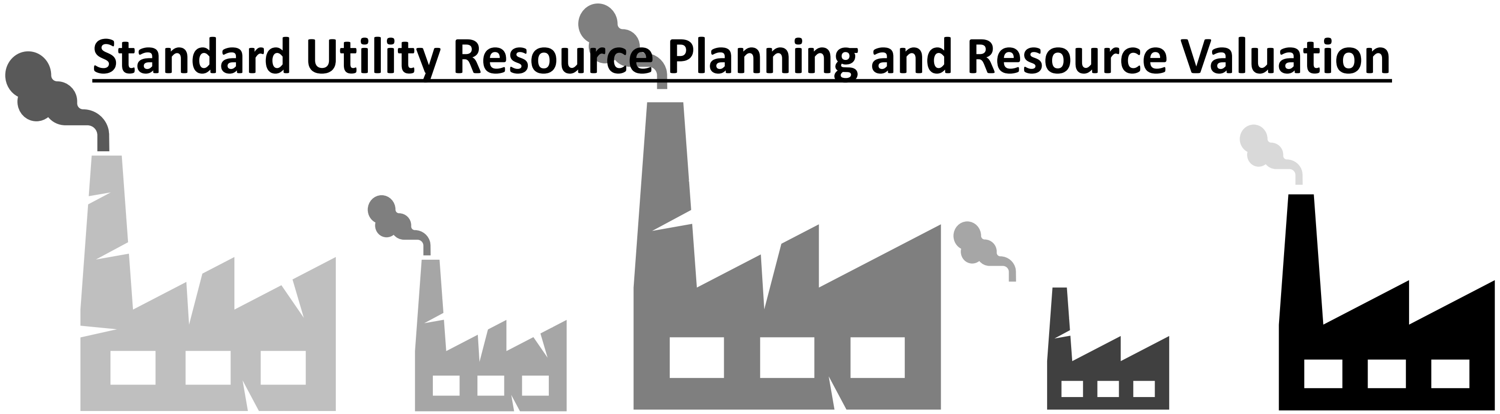
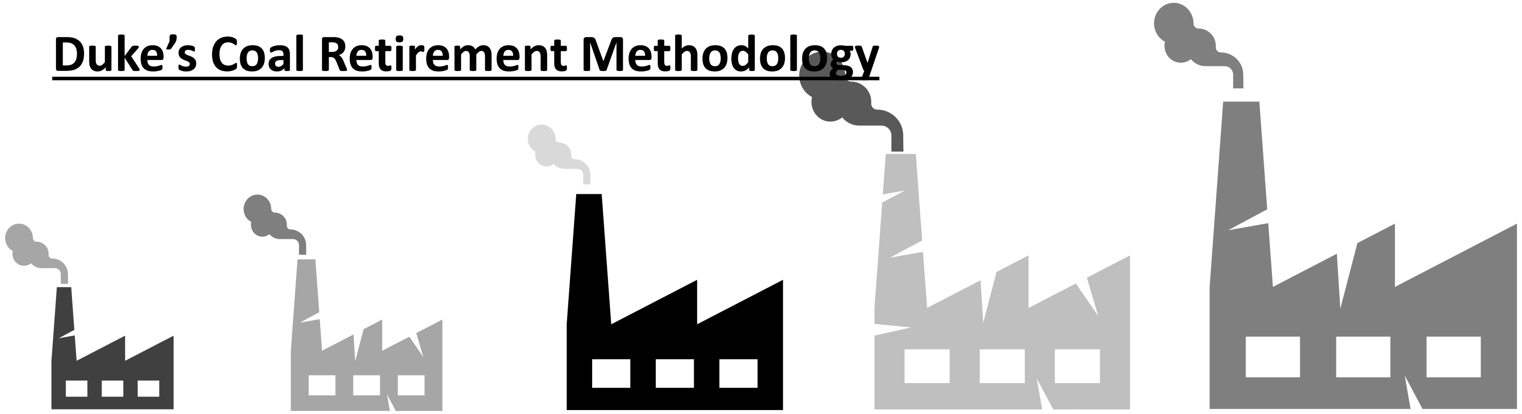
Standard Utility Resource Planning and Resource Valuation



Highest cost coal plant retires first

Least cost coal plant retires last

Duke’s Coal Retirement Methodology



Smallest coal plant retires first

Largest coal plant retires last

Critique of Duke’s Retirement Analysis

“Sequential Peaker” Embeds Assumptions

- Compares each coal unit to a new combustion turbine, valued at Net CONE
- Other replacement portfolio could provide services at lower cost
- Method embeds assumed value of energy, rather than head-to-head comparison

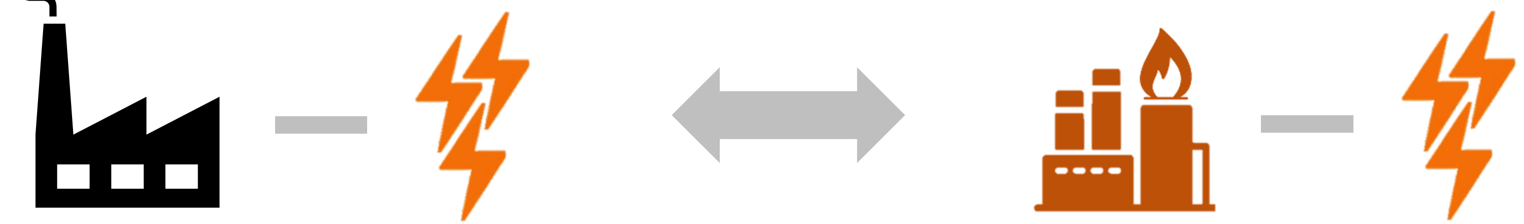
Standard Utility Resource Planning and Resource Valuation

Coal plant cost

Cost of replacement portfolio providing same services

**may include incremental generation from existing resources*

Duke’s Coal Retirement Methodology



Coal plant cost

Value of energy

Cost of coal plant capacity less energy value

Gas plant cost

Value of energy

Cost of gas peaker capacity less energy value

Challenges with Fleet-Wide Retirement Analyses

Evaluating a large number of plants is non-trivial, but feasible

- Impacts on the operations of **other existing resources** and net exchanges
- **Order of retirements** may be critical: each retirement may impact the value of the next unit assessed
- Impacts on **transmission loading** and constraints

Costs that do not scale readily can pose a challenge, but are not insurmountable

- Fixed O&M (like labor costs) at **multi-unit plants may not scale** with the retirement of one unit
- **Ramp-down of capital** towards the end of a unit's life requires care
- **Long-run fuel supply agreements** may require damage assessment (not anticipated for Duke)

Finding non-fossil coal replacement options can be harder at large scales

- Requires large-scale procurement assessment, **continual market testing**
- Best solved through rigorous **all-source procurement**

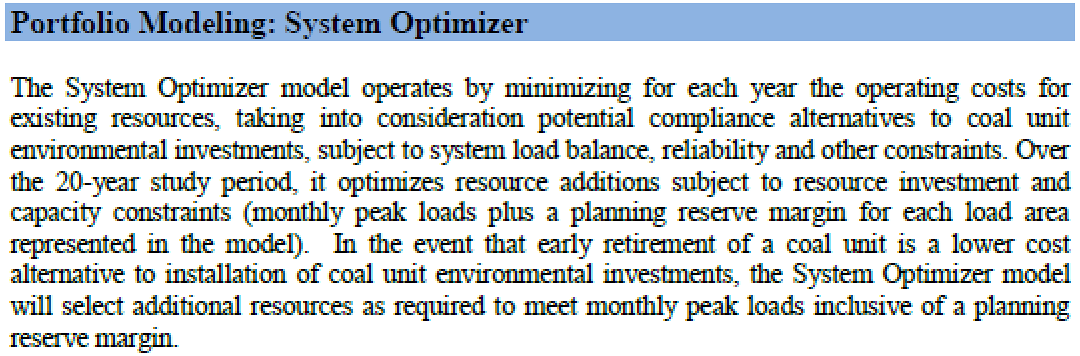
Increasingly sophisticated energy system models can endogenously evaluate – and optimize – unit retirements and cost-effective replacement

Modeling Endogenous Retirements

- **What are “endogenous retirements?”**
  - Unit retirement decisions that are internal to the model
- **EnCompass settings for endogenous retirement**
  - Can allow for economic retirement or not
  - Can specify a particular year that a unit becomes eligible for economic retirement
  - Can limit the number of MW per year that can be retired
- **When does EnCompass choose retirement?**
  - When unit fixed costs exceed unit profitability (energy, capacity, and ancillary revenues)
  - For units operating in a vertically-integrated area, “unit profitability” is cost of providing energy and ancillary services, multiplied by generation
- **Limitations to modeling endogenous retirements**
  - Does not consider how early retirement might change investment decisions at the unit

Retirement Analyses – PacifiCorp 2013

- **PacifiCorp <u>2013</u> Integrated Resource Plan**
  - Filed April 2013
  - Introduction of endogenous retirement in System Optimizer model
  - Calibrated model to internally assess forward-looking costs of plant against alternative portfolios
  - Implemented incremental capital and fuel contract solutions
- **PacifiCorp coal fleet in 2013 exceeded scope of Duke's fleet in 2021**
  - In 2013, PacifiCorp's coal fleet was 6,168 MW, or 52% of capacity
  - In 2021, DEC & DEP coal comprised 9,200 MW, or 26% of generating capacity



Portfolio Modeling: System Optimizer

The System Optimizer model operates by minimizing for each year the operating costs for existing resources, taking into consideration potential compliance alternatives to coal unit environmental investments, subject to system load balance, reliability and other constraints. Over the 20-year study period, it optimizes resource additions subject to resource investment and capacity constraints (monthly peak loads plus a planning reserve margin for each load area represented in the model). In the event that early retirement of a coal unit is a lower cost alternative to installation of coal unit environmental investments, the System Optimizer model will select additional resources as required to meet monthly peak loads inclusive of a planning reserve margin.

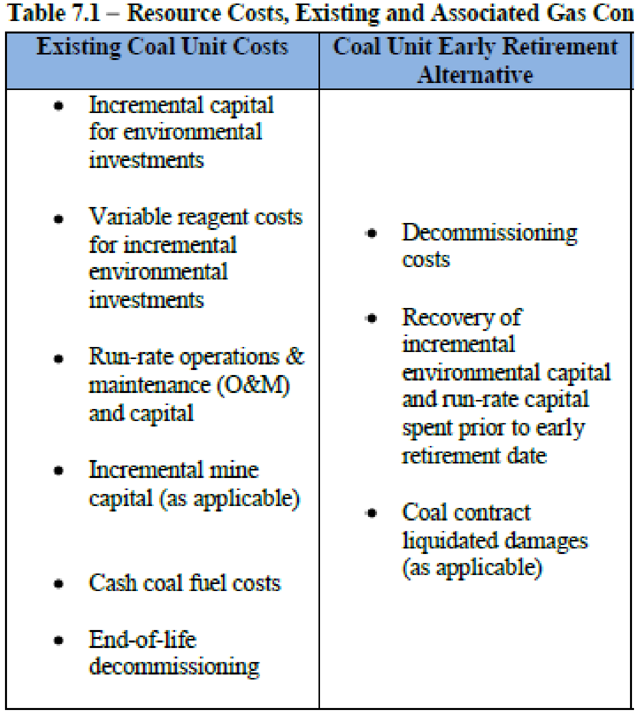


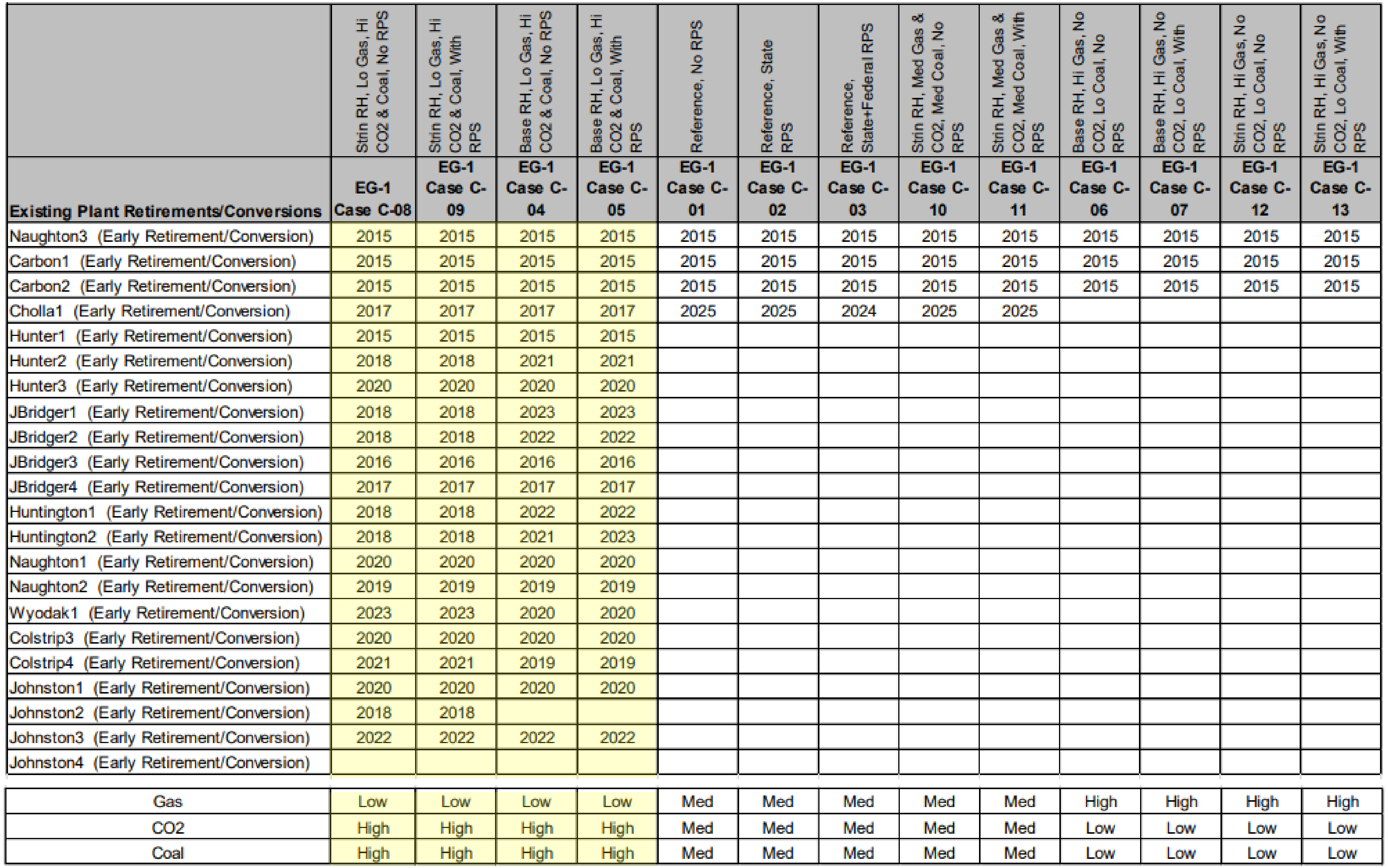
Table 7.1 – Resource Costs, Existing and Associated Gas Con

Existing Coal Unit Costs	Coal Unit Early Retirement Alternative
• Incremental capital for environmental investments • Variable reagent costs for incremental environmental investments • Run-rate operations & maintenance (O&M) and capital • Incremental mine capital (as applicable) • Cash coal fuel costs • End-of-life decommissioning	• Decommissioning costs • Recovery of incremental environmental capital and run-rate capital spent prior to early retirement date • Coal contract liquidated damages (as applicable)

Retirement Analyses – PacifiCorp 2013

- **PacifiCorp 2013 Integrated Resource Plan**
  - Endogenous retirement and replacement and **low gas / high CO2** resulted in early retirement of **all coal units prior to 2023**

- PacifiCorp subsequently rejected endogenous retirement

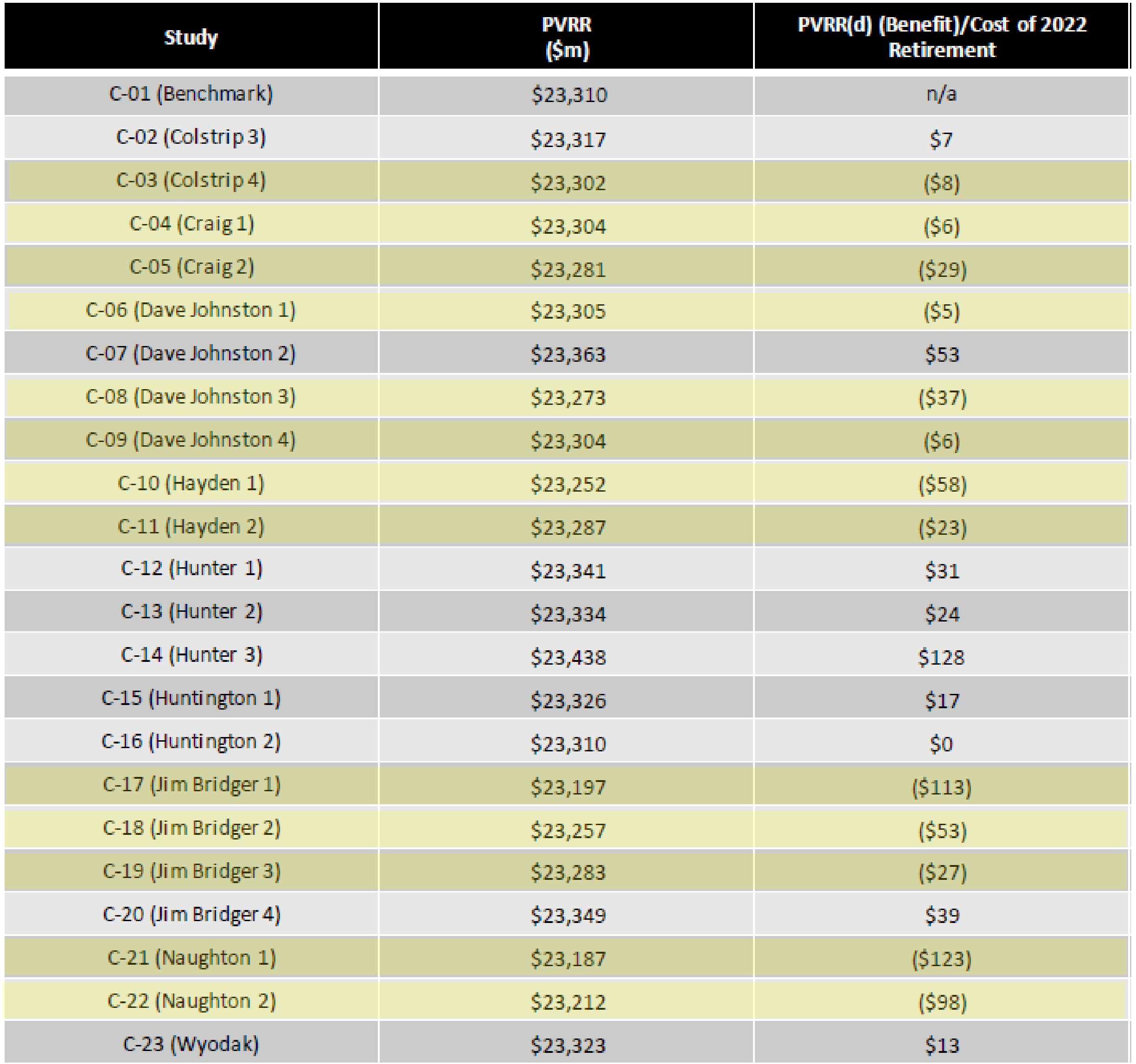


	Strin RH, Lo Gas, Hi CO2 & Coal, No RPS	Strin RH, Lo Gas, Hi CO2 & Coal, With RPS	Base RH, Lo Gas, Hi CO2 & Coal, No RPS	Base RH, Lo Gas, Hi CO2 & Coal, With RPS	Reference, No RPS	Reference, State RPS	Reference, State+Federal RPS	Strin RH, Med Gas & CO2, Med Coal, No RPS	Strin RH, Med Gas & CO2, Med Coal, With RPS	Base RH, Hi Gas, No CO2, Lo Coal, No RPS	Base RH, Hi Gas, No CO2, Lo Coal, With RPS	Strin RH, Hi Gas, No CO2, Lo Coal, No RPS	Strin RH, Hi Gas, No CO2, Lo Coal, With RPS
Existing Plant Retirements/Conversions	**EG-1 Case C-08**	**EG-1 Case C-09**	**EG-1 Case C-04**	**EG-1 Case C-05**	**EG-1 Case C-01**	**EG-1 Case C-02**	**EG-1 Case C-03**	**EG-1 Case C-10**	**EG-1 Case C-11**	**EG-1 Case C-06**	**EG-1 Case C-07**	**EG-1 Case C-12**	**EG-1 Case C-13**
Naughton3 (Early Retirement/Conversion)	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015
Carbon1 (Early Retirement/Conversion)	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015
Carbon2 (Early Retirement/Conversion)	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015
Cholla1 (Early Retirement/Conversion)	2017	2017	2017	2017	2025	2025	2024	2025	2025				
Hunter1 (Early Retirement/Conversion)	2015	2015	2015	2015									
Hunter2 (Early Retirement/Conversion)	2018	2018	2021	2021									
Hunter3 (Early Retirement/Conversion)	2020	2020	2020	2020									
JBridger1 (Early Retirement/Conversion)	2018	2018	2023	2023									
JBridger2 (Early Retirement/Conversion)	2018	2018	2022	2022									
JBridger3 (Early Retirement/Conversion)	2016	2016	2016	2016									
JBridger4 (Early Retirement/Conversion)	2017	2017	2017	2017									
Huntington1 (Early Retirement/Conversion)	2018	2018	2022	2022									
Huntington2 (Early Retirement/Conversion)	2018	2018	2021	2023									
Naughton1 (Early Retirement/Conversion)	2020	2020	2020	2020									
Naughton2 (Early Retirement/Conversion)	2019	2019	2019	2019									
Wyodak1 (Early Retirement/Conversion)	2023	2023	2020	2020									
Colstrip3 (Early Retirement/Conversion)	2020	2020	2020	2020									
Colstrip4 (Early Retirement/Conversion)	2021	2021	2019	2019									
Johnston1 (Early Retirement/Conversion)	2020	2020	2020	2020									
Johnston2 (Early Retirement/Conversion)	2018	2018											
Johnston3 (Early Retirement/Conversion)	2022	2022	2022	2022									
Johnston4 (Early Retirement/Conversion)													

Gas	Low	Low	Low	Low	Med	Med	Med	Med	Med	High	High	High	High
CO2	High	High	High	High	Med	Med	Med	Med	Med	Low	Low	Low	Low
Coal	High	High	High	High	Med	Med	Med	Med	Med	Low	Low	Low	Low

Retirement Analyses – PacifiCorp 2018

- **December 2017: Oregon Commission requires unit-by-unit assessment of PacifiCorp's coal plants**
  - June 2018, PacifiCorp provides first confidential version
  - December 2018, PacifiCorp provides public unit-by-unit assessment
- December 2018 unit-by-unit assessment shows **majority of PacifiCorp coal fleet uneconomic** in 2022



Study	PVRR ($m)	PVRR(d) (Benefit)/Cost of 2022 Retirement
C-01 (Benchmark)	$23,310	n/a
C-02 (Colstrip 3)	$23,317	$7
C-03 (Colstrip 4)	$23,302	($8)
C-04 (Craig 1)	$23,304	($6)
C-05 (Craig 2)	$23,281	($29)
C-06 (Dave Johnston 1)	$23,305	($5)
C-07 (Dave Johnston 2)	$23,363	$53
C-08 (Dave Johnston 3)	$23,273	($37)
C-09 (Dave Johnston 4)	$23,304	($6)
C-10 (Hayden 1)	$23,252	($58)
C-11 (Hayden 2)	$23,287	($23)
C-12 (Hunter 1)	$23,341	$31
C-13 (Hunter 2)	$23,334	$24
C-14 (Hunter 3)	$23,438	$128
C-15 (Huntington 1)	$23,326	$17
C-16 (Huntington 2)	$23,310	$0
C-17 (Jim Bridger 1)	$23,197	($113)
C-18 (Jim Bridger 2)	$23,257	($53)
C-19 (Jim Bridger 3)	$23,283	($27)
C-20 (Jim Bridger 4)	$23,349	$39
C-21 (Naughton 1)	$23,187	($123)
C-22 (Naughton 2)	$23,212	($98)
C-23 (Wyodak)	$23,323	$13

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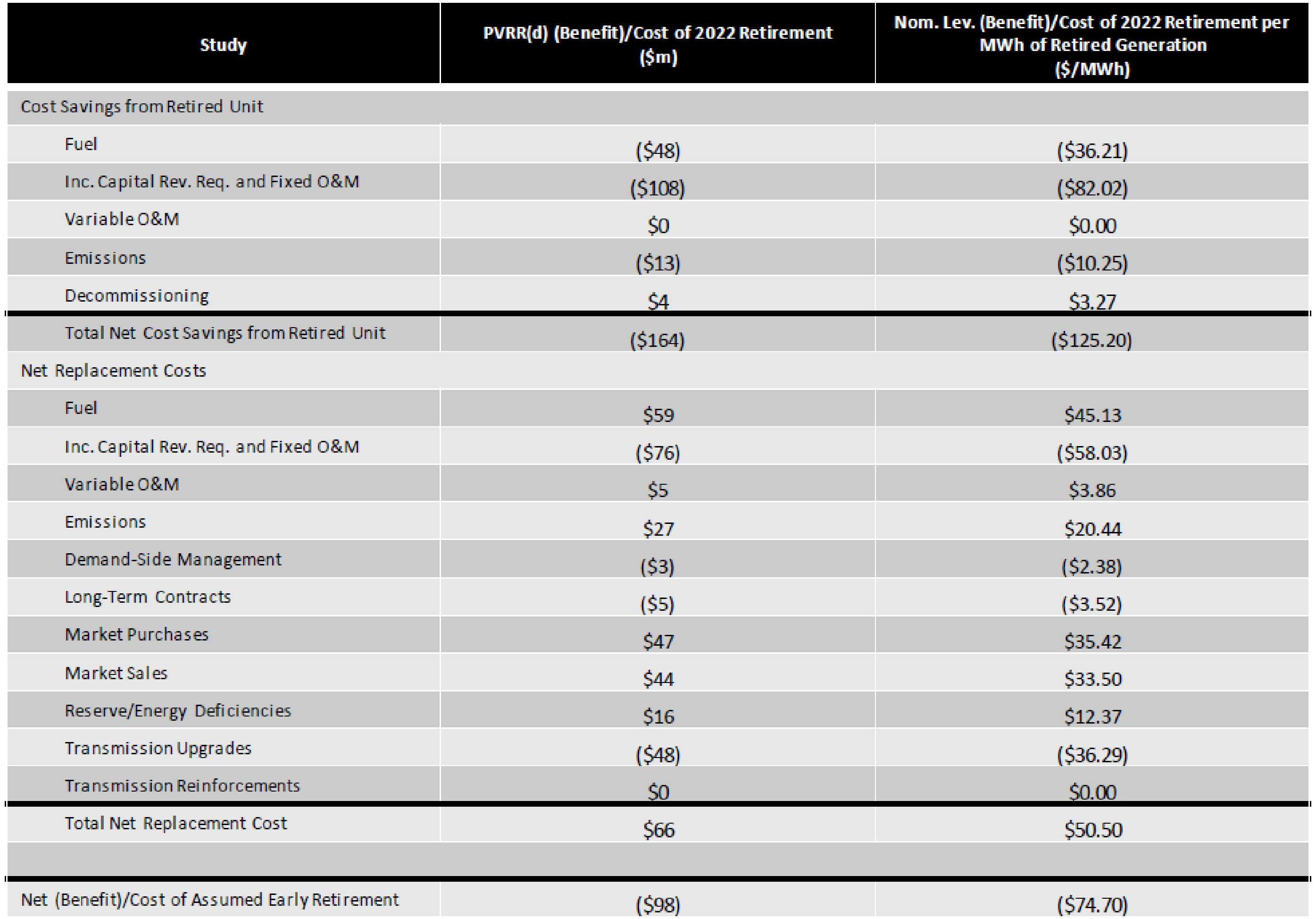
Retirement Analyses – PacifiCorp 2018

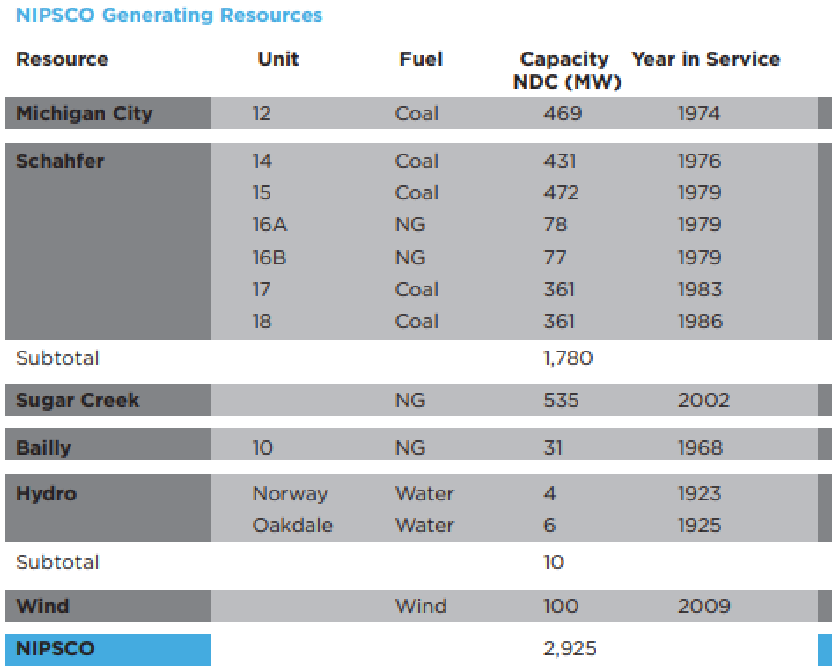
- **Unit-by-unit analysis allows for substantial transparency**
    - Isolating individual unit allows for deeper review of constraints
    - *Incremental value* to endogenous retirement assessment

Naughton 2 Case (C-22)
(PaR Base/Base Scenario)



Study	PVRR(d) (Benefit)/Cost of 2022 Retirement ($m)	Nom. Lev. (Benefit)/Cost of 2022 Retirement per MWh of Retired Generation ($/MWh)
Cost Savings from Retired Unit		
Fuel	($48)	($36.21)
Inc. Capital Rev. Req. and Fixed O&M	($108)	($82.02)
Variable O&M	$0	$0.00
Emissions	($13)	($10.25)
Decommissioning	$4	$3.27
Total Net Cost Savings from Retired Unit	($164)	($125.20)
Net Replacement Costs		
Fuel	$59	$45.13
Inc. Capital Rev. Req. and Fixed O&M	($76)	($58.03)
Variable O&M	$5	$3.86
Emissions	$27	$20.44
Demand-Side Management	($3)	($2.38)
Long-Term Contracts	($5)	($3.52)
Market Purchases	$47	$35.42
Market Sales	$44	$33.50
Reserve/Energy Deficiencies	$16	$12.37
Transmission Upgrades	($48)	($36.29)
Transmission Reinforcements	$0	$0.00
Total Net Replacement Cost	$66	$50.50
Net (Benefit)/Cost of Assumed Early Retirement	($98)	($74.70)

Retirement Analyses – NIPSCO 2018 IRP

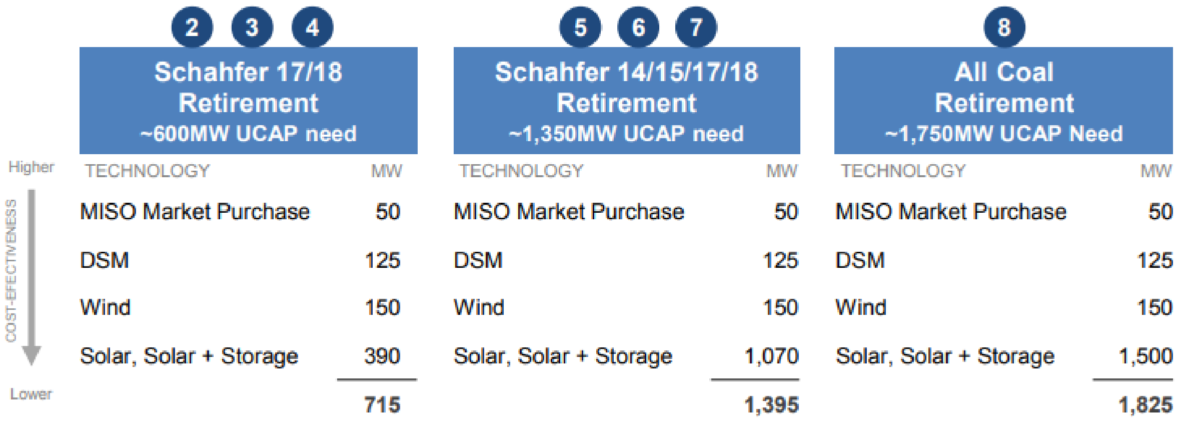


NIPSCO Generating Resources

Resource	Unit	Fuel	Capacity NDC (MW)	Year in Service
Michigan City	12	Coal	469	1974
Schahfer	14	Coal	431	1976
	15	Coal	472	1979
	16A	NG	78	1979
	16B	NG	77	1979
	17	Coal	361	1983
	18	Coal	361	1986
Subtotal			1,780	
Sugar Creek		NG	535	2002
Bailly	10	NG	31	1968
Hydro	Norway	Water	4	1923
	Oakdale	Water	6	1925
Subtotal			10	
Wind		Wind	100	2009
NIPSCO			2,925	

- **NIPSCO 2018 Integrated Resource Plan**
  - Filed October 2018
  - NIPSCO **coal >70% of capacity** in 2018
- NIPSCO resource alternatives based on responses from **2018 All Source RFP**
  - Determined low cost wind, solar, storage, & efficiency available
  - Found cost effective replacement alternatives

Figure 9-2: Summary of Least-Cost Replacement Capacity by Retirement Portfolio



② ③ ④ Schahfer 17/18 Retirement ~600MW UCAP need		⑤ ⑥ ⑦ Schahfer 14/15/17/18 Retirement ~1,350MW UCAP need		⑧ All Coal Retirement ~1,750MW UCAP Need	
TECHNOLOGY	MW	TECHNOLOGY	MW	TECHNOLOGY	MW
MISO Market Purchase	50	MISO Market Purchase	50	MISO Market Purchase	50
DSM	125	DSM	125	DSM	125
Wind	150	Wind	150	Wind	150
Solar, Solar + Storage	390	Solar, Solar + Storage	1,070	Solar, Solar + Storage	1,500
	715		1,395		1,825

Retirement Analyses – NIPSCO 2018 IRP

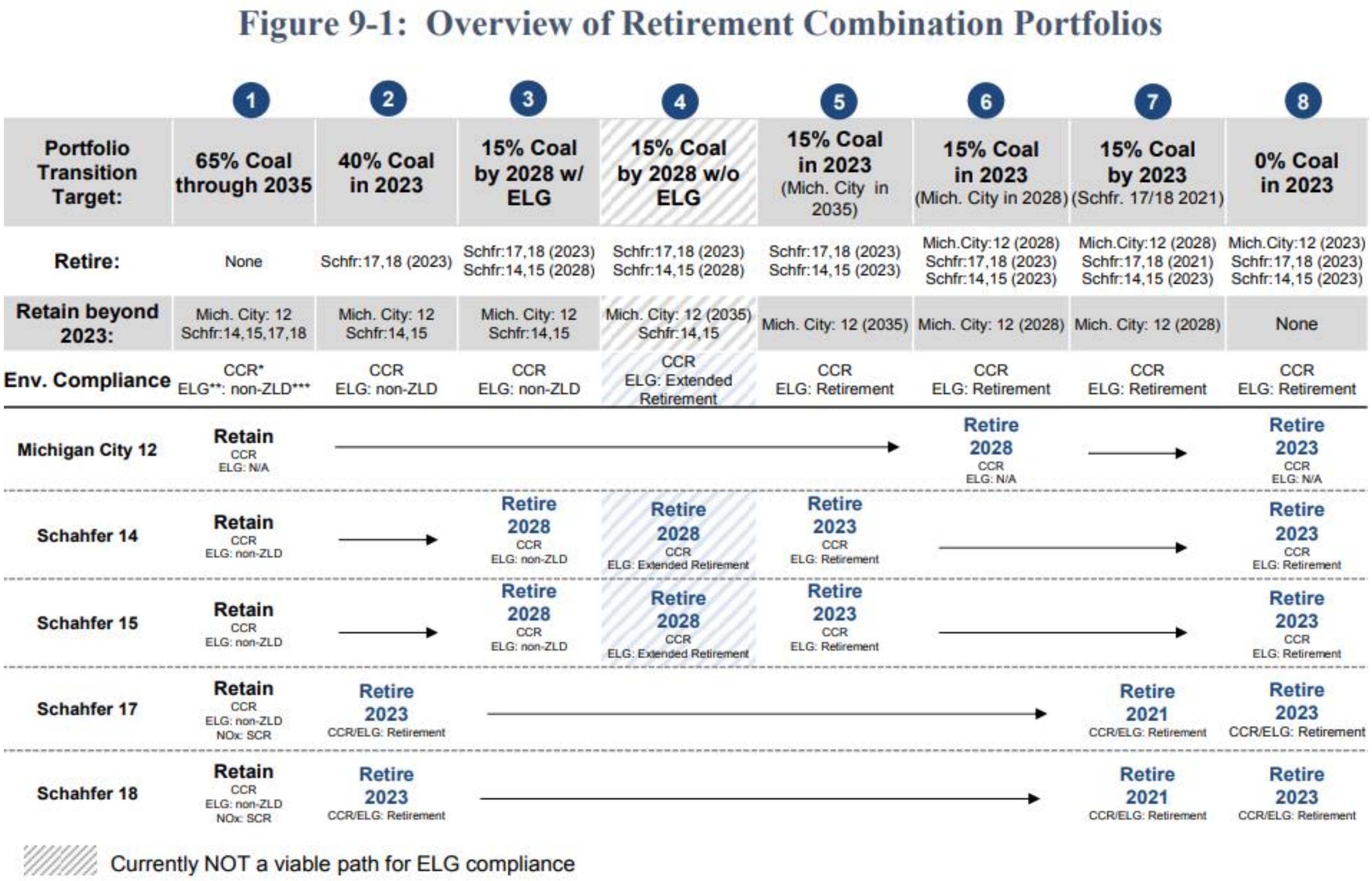


Figure 9-1: Overview of Retirement Combination Portfolios

	①	②	③	④	⑤	⑥	⑦	⑧
Portfolio Transition Target:	**65% Coal through 2035**	**40% Coal in 2023**	**15% Coal by 2028 w/ ELG**	**15% Coal by 2028 w/o ELG**	**15% Coal in 2023** (Mich. City in 2035)	**15% Coal in 2023** (Mich. City in 2028)	**15% Coal by 2023** (Schfr. 17/18 2021)	**0% Coal in 2023**
Retire:	None	Schfr:17,18 (2023)	Schfr:17,18 (2023) Schfr:14,15 (2028)	Schfr:17,18 (2023) Schfr:14,15 (2028)	Schfr:17,18 (2023) Schfr:14,15 (2023)	Mich.City:12 (2028) Schfr:17,18 (2023) Schfr:14,15 (2023)	Mich.City:12 (2028) Schfr:17,18 (2021) Schfr:14,15 (2023)	Mich.City:12 (2023) Schfr:17,18 (2023) Schfr:14,15 (2023)
Retain beyond 2023:	Mich. City: 12 Schfr:14,15,17,18	Mich. City: 12 Schfr:14,15	Mich. City: 12 Schfr:14,15	Mich. City: 12 (2035) Schfr:14,15	Mich. City: 12 (2035)	Mich. City: 12 (2028)	Mich. City: 12 (2028)	None
Env. Compliance	CCR* ELG**: non-ZLD***	CCR ELG: non-ZLD	CCR ELG: non-ZLD	CCR ELG: Extended Retirement	CCR ELG: Retirement	CCR ELG: Retirement	CCR ELG: Retirement	CCR ELG: Retirement
Michigan City 12	**Retain** CCR ELG: N/A	→	→	→	→	**Retire 2028** CCR ELG: N/A	→	**Retire 2023** CCR ELG: N/A
Schahfer 14	**Retain** CCR ELG: non-ZLD	→	**Retire 2028** CCR ELG: non-ZLD	**Retire 2028** CCR ELG: Extended Retirement	**Retire 2023** CCR ELG: Retirement	→	→	**Retire 2023** CCR ELG: Retirement
Schahfer 15	**Retain** CCR ELG: non-ZLD	→	**Retire 2028** CCR ELG: non-ZLD	**Retire 2028** CCR ELG: Extended Retirement	**Retire 2023** CCR ELG: Retirement	→	→	**Retire 2023** CCR ELG: Retirement
Schahfer 17	**Retain** CCR ELG: non-ZLD NOx: SCR	**Retire 2023** CCR/ELG: Retirement	→	→	→	→	**Retire 2021** CCR/ELG: Retirement	**Retire 2023** CCR/ELG: Retirement
Schahfer 18	**Retain** CCR ELG: non-ZLD NOx: SCR	**Retire 2023** CCR/ELG: Retirement	→	→	→	→	**Retire 2021** CCR/ELG: Retirement	**Retire 2023** CCR/ELG: Retirement

▨ Currently NOT a viable path for ELG compliance

Retirement Analyses – NIPSCO 2018 IRP

Figure 9-9: Retirement Portfolio Scorecard

Preferred Retirement Path

	1	2	3	4	5	6	7	8
Portfolio Transition Target:	**65% Coal through 2035**	**40% Coal in 2023**	**15% Coal by 2028 w/ ELG**	**15% Coal by 2028 w/o ELG**	**15% Coal in 2023** (Mich. City 2035)	**15% Coal in 2023** (Mich. City 2028)	**15% Coal by 2023** (Schfr 17/18 2021)	**0% Coal in 2023**
Retire:	None	Schfr:17,18 (2023)	Schfr:17,18 (2023) Schfr:14,15 (2028)	Schfr:17,18 (2023) Schfr:14,15 (2028)	Schfr:17,18 (2023) Schfr:14,15 (2023)	Mich.City:12 (2028) Schfr:17,18 (2023) Schfr:14,15 (2023)	Mich.City:12 (2028) Schfr:17,18 (2021) Schfr:14,15 (2023)	Mich.City:12 (2023) Schfr:17,18 (2023) Schfr:14,15 (2023)
Retain beyond 2023:	Mich. City: 12 Schfr:14,15,17,18	Mich. City: 12 Schfr:14,15	Mich. City: 12 Schfr:14,15	Mich. City: 12 Schfr:14,15	Mich. City: 12 (2035)	Mich. City: 12 (2028)	Mich. City: 12 (2028)	None
Env. Compliance	CCR ELG: non-ZLD	CCR ELG: non-ZLD	CCR ELG: non-ZLD	CCR ELG: Extended Retirement	CCR ELG: Retirement	CCR ELG: Retirement	CCR ELG: Retirement	CCR ELG: Retirement
Cost To Customer	$15,400 +$4,426 40.3%	$12,911 +$1,937 17.7%	$12,455 +$1,481 13.5%	$12,336 +$1,361 12.4%	$11,454 +$479 4.4%	$11,343 +$369 3.4%	$11,187 +$213 1.9%	$10,974 - $ - %
Cost Certainty	$15,840 +$4,708 42.3%	$13,158 +$2,026 18.2%	$12,622 +$1,490 13.4%	$12,502 +$1,370 12.3%	$11,634 +$502 4.5%	$11,504 +$372 3.3%	$11,295 +$163 1.5%	$11,132 - $ - %
Cost Risk	$17,406 +$5,750 49.3%	$14,123 +$2,467 21.2%	$13,225 +$1,569 13.5%	$13,105 +$1,449 12.4%	$12,252 +$596 5.1%	$12,045 +$389 3.3%	$11,750 +$93 0.8%	$11,656 - $ - %
Reliability Risk	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Unacceptable	Unacceptable
Employees	0	125	125	125	276	276	276	426
Local Economy	+$118M +47%	$0M -%	($23M) (9%)	($31M) (12%)	($65M) (26%)	($74M) (29%)	($74M) (29%)	($94M) (37%)

Recommendations for Duke

- Revise coal assessment methodology and update coal retirement study
  - Must be able to demonstrate that near-term capital expenditures are consistent with **economically optimal** plant lives
- Full-scale endogenous coal retirement is feasible **if forward avoidable costs and replacement costs are all correctly parameterized**
- **Unit-by-unit valuations lend transparency** to the retirement valuation process
  - For each individual unit, compare portfolio cost with unit operating until end of depreciable life vs. near-term retirement year (e.g., 2025)
  - Stacking lowest value units (i.e., most optimal retirements) helps confirm near-term no regrets pathway
- **Co-optimize coal retirements** with both supply- and demand-side resources (i.e., EE/DR, solar, wind, storage)
- **Sunk costs should not be considered** in a forward-looking analysis.

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