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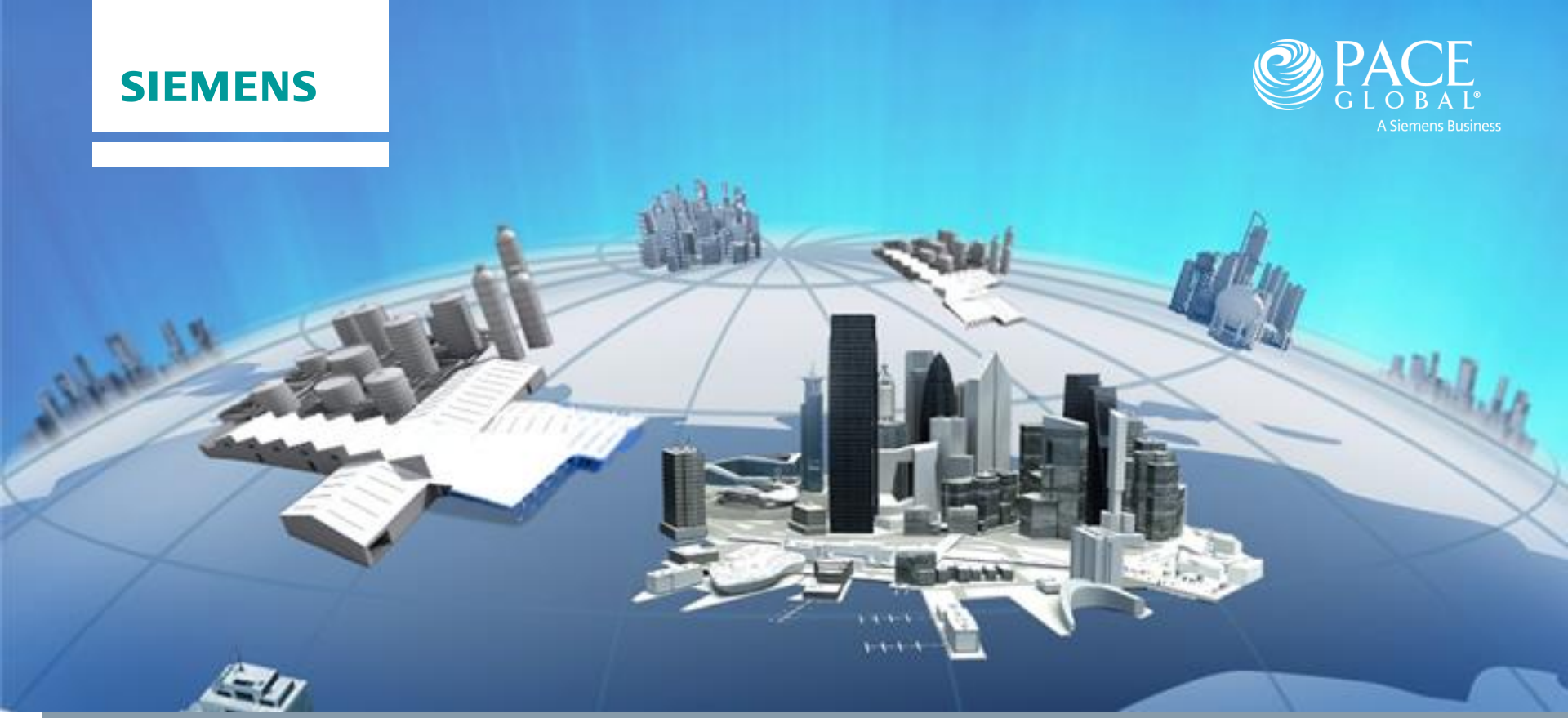
Zero Net Carbon Portfolio Analysis

Prepared for: Platte River Power Authority December 12, 2017

Agenda

- Background
- Methodology
- Assumptions
- Cases
- Findings and Recommendations



Background

Background – Scope of the assignment

Platte River Power Authority retained Pace Global, a Siemens business, to provide an independent assessment of the feasibility of Platte River achieving and maintaining a zero net carbon (ZNC or carbon-neutral) generation supply portfolio by 2030.

Objectives:

- Determine the least-cost portfolio of generation resources that can achieve ZNC by 2030.
- Assess at a high level, the risks and risk mitigation measures associated with achieving or exceeding ZNC.

This study was primarily designed to assess the production costs of a ZNC portfolio and aid in future planning decisions for Platte River and its member-owners.

Key definitions

Carbon Emissions Objective	Definition
Zero Carbon Portfolio	A portfolio where energy is produced and delivered to end-users with generation sources that yield no carbon output. Resources such as wind, solar, and battery storage would comprise this type of system. This system would accommodate no market (carbon-producing) purchases and would operate largely in isolation of the regional grid.
Zero Net Carbon (ZNC or Carbon Neutral) Portfolio	A portfolio consisting of excess carbon-free (or lower carbon) generation that, when sold in a market, can offset carbon produced by fossil fuel-fired generation, producing "zero net carbon (ZNC) or carbon neutrality."
Carbon Offset	An action or activity that compensates for the emission of carbon dioxide or other greenhouse gases to the atmosphere

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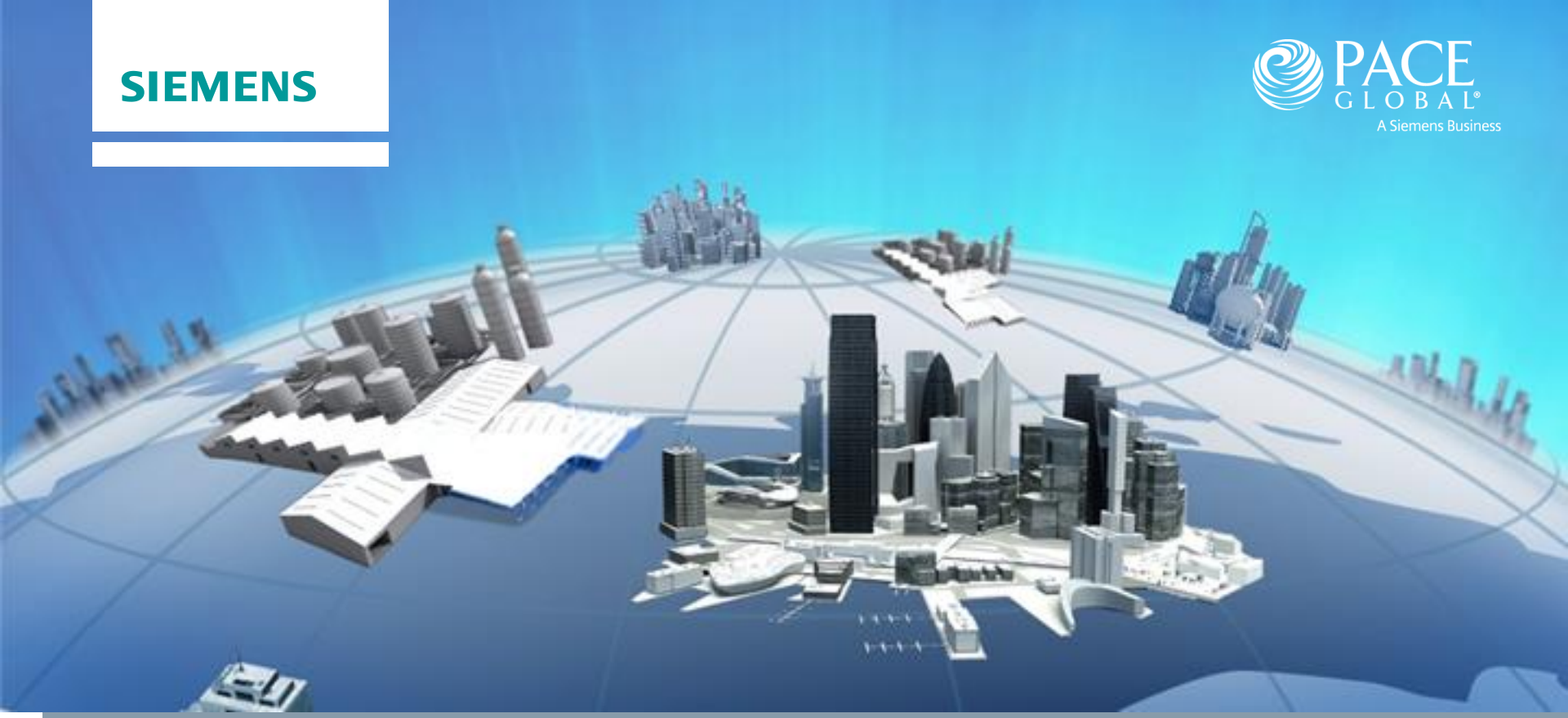


Methodology

Modeling approach

Two primary cases were studied using the AURORAxmp dispatch model:

Case 1	**Platte River's Integrated Resource Plan (IRP) Portfolio**
Case 2	**Zero Net Carbon Portfolio**

- AURORAxmp is an industry-standard model, used by both Pace Global and Platte River, that can determine the least-cost portfolio of generation assets that meets defined constraints.
- By solving for the ***least-cost*** means of meeting ZNC (carbon neutrality) and reserve margins, the costs of achieving ZNC can be compared to the costs of the 2017 IRP portfolio.
- A preliminary evaluation of a possible RTO structure is currently being developed.

Steps to determine the least-cost ZNC portfolio

Step 1	Define “market” carbon emission rate – 1,803 lb/MWh based on the market today
Step 2	Assume an initial renewable energy requirement as a percent of load
Step 3	Determine the least-cost portfolio that meets Platte River’s defined reserve margin requirements (15%)
Step 4	Determine if ZNC requirement is met in 2030 and beyond
Step 5	Adjust renewable energy requirement as a percent of load and repeat Steps 3 and 4 until the ZNC requirement is met

Carbon accounting methodology

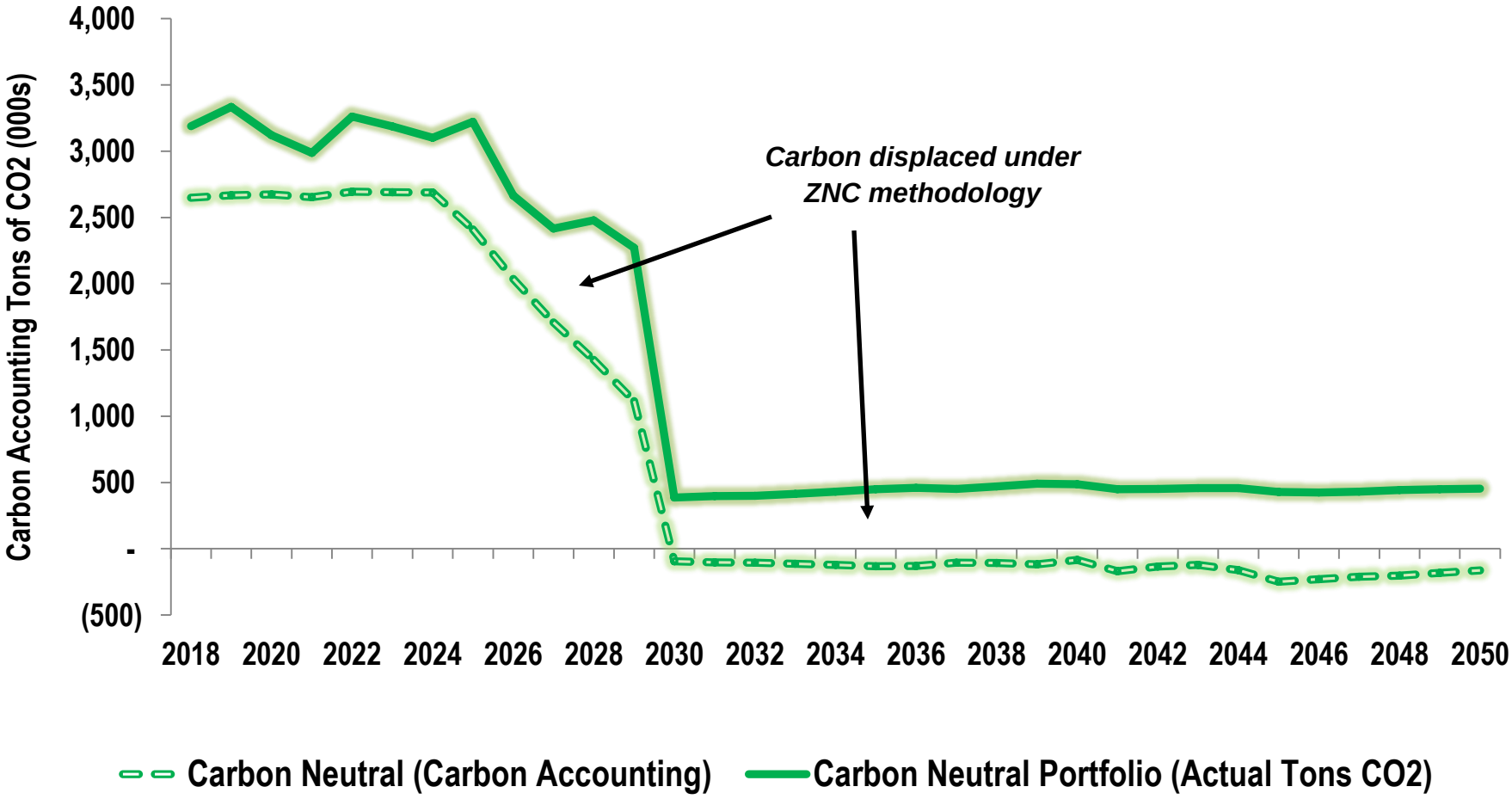
	2030 Annual Generation (MWh)	Emissions Rate (lb/MWh)	Accounting Tons of Carbon*
Coal	0	2,087	-
CT	18,713	1,351	12,641
CC	941,129	794	373,628
Hydro	611,793	0	-
Solar	1,026,798	0	-
Wind	1,385,805	0	-
Total Plant Generation	3,984,238		386,269
Exports	586,287	(1,803)	-528,537
Imports	47,658	1,803**	42,964
Net Carbon Emissions			(99,305)

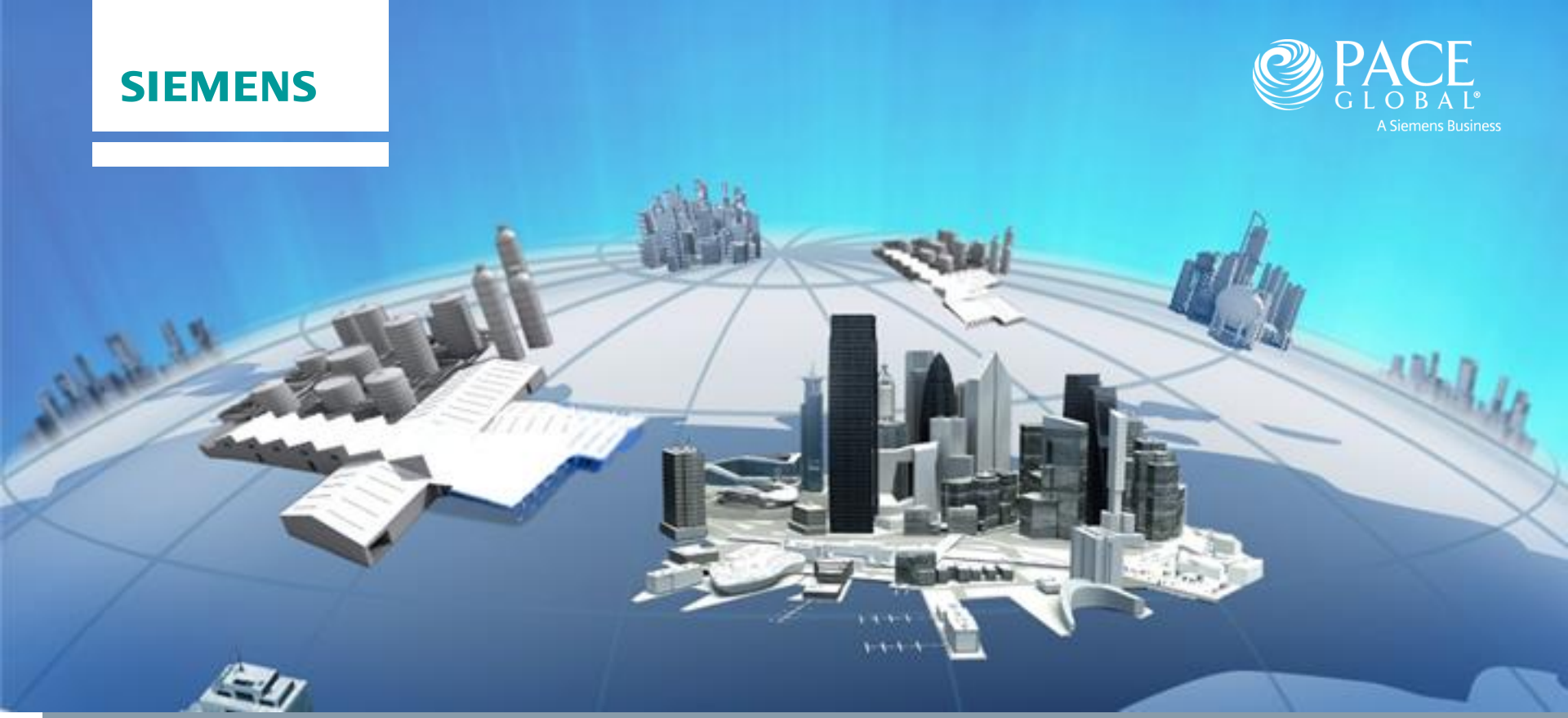
Net carbon emissions

Σ(Energy$_{\text{unit type}}$ x Emissions rate$_{\text{unit type}}$) / 2,000 – (Market sales x 1,803 lb/MWh/) / 2,000 + (Market purchases x 1,803 lb/MWh)/2,000

* The optimal level of renewables to achieve the carbon-neutral goal was considered in all years from 2030-50 in the build decision to balance the portfolio.
** 1,803 lb/MWh is the eGrid Rockies data for non-baseload generation

Carbon accounting methodology



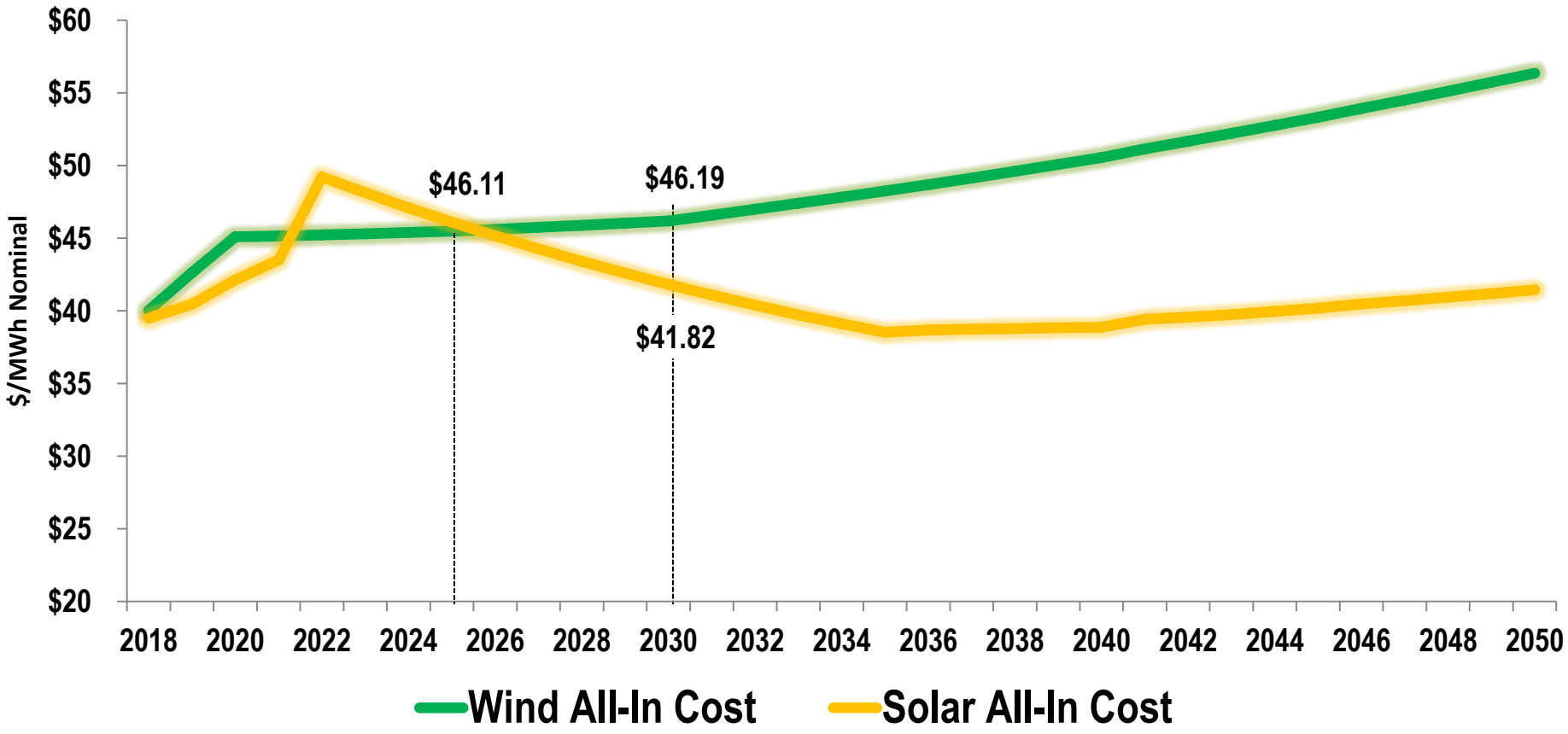


Assumptions and Key Inputs

Key assumptions provided by Platte River

- All coal generation is to be retired by 2030
- Maintain required resource adequacy / reserve margin of 15%
- Maintain existing hydro power positions
- Maintain existing renewable positions and add as necessary to meet ZNC targets
- Retain existing CTs as a “free capacity option”; however, the units are not required to run
- Battery peak credit of 75% for 4-hour lithium ion battery
- Determine the least-cost feasible generation mix that achieves the ZNC target considering a range of technology options (e.g. solar, wind, gas combined cycle, combustion turbines, reciprocating engines, lithium ion battery storage)

In a bilateral market, solar is more economic than wind over the long-term due to lower transmission costs, continuation of tax benefits, and lower capital costs

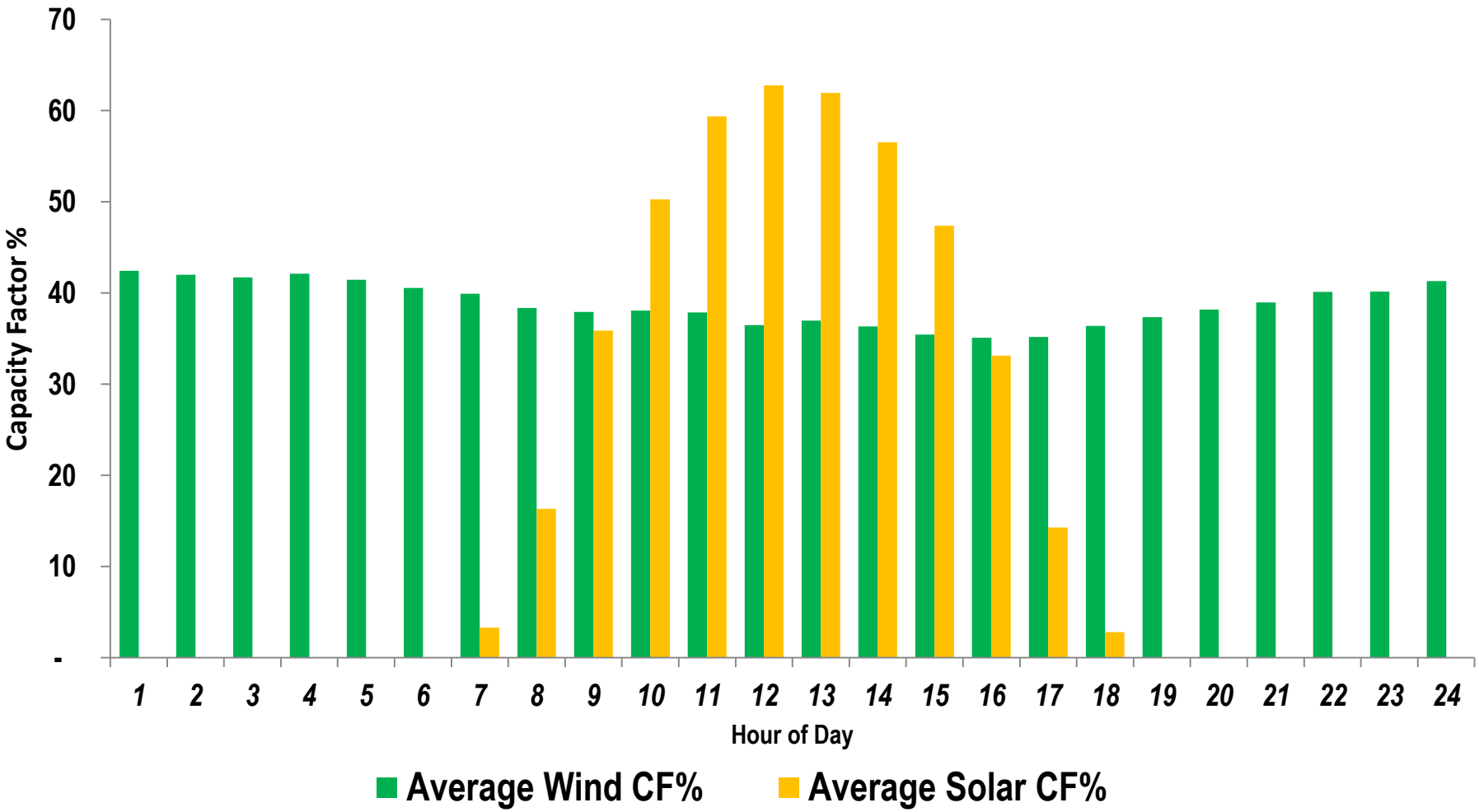


Composition of “all-in” wind and solar costs in the ZNC case

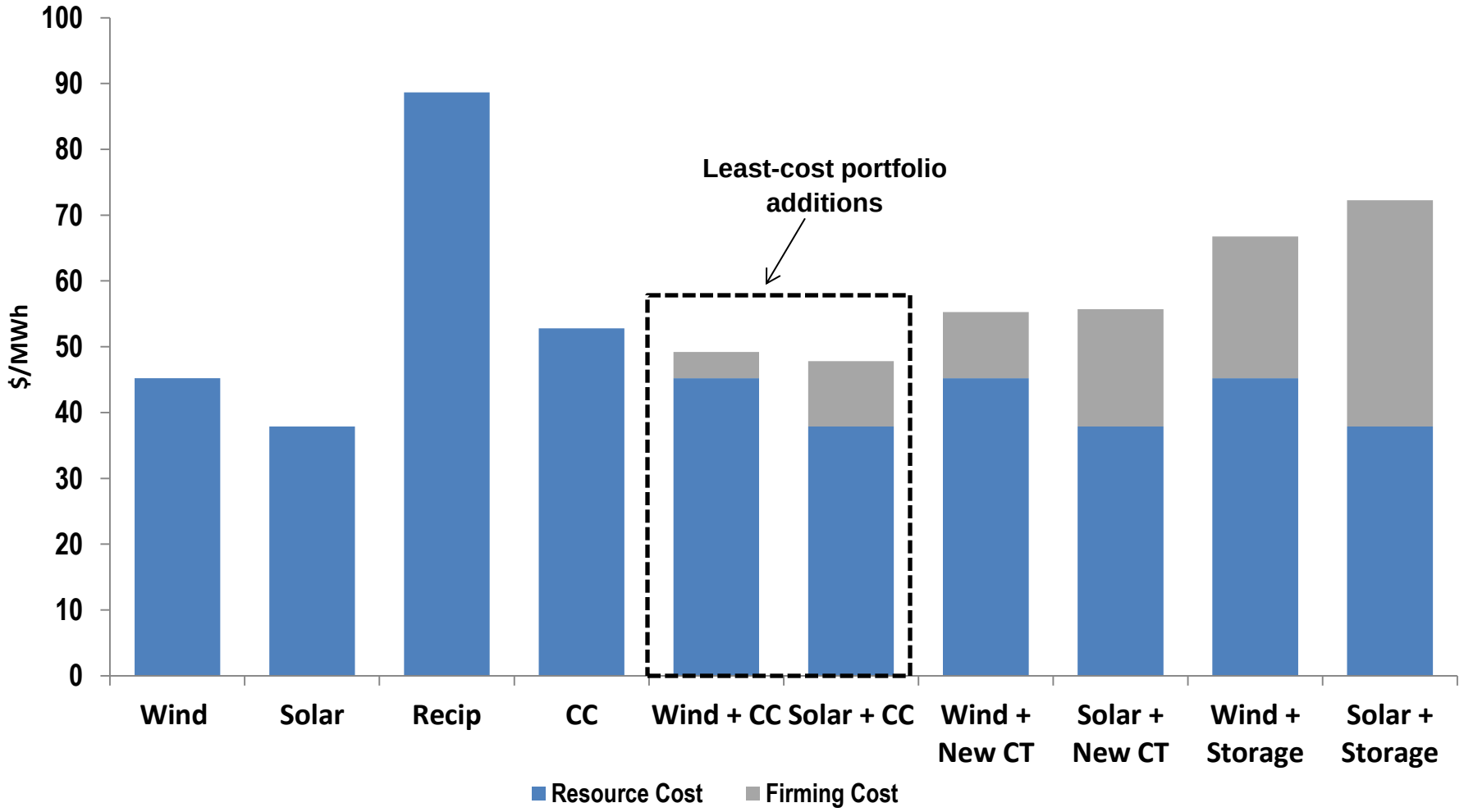
Renewable Costs ($MWh)*	Wind	Solar
PPA in (2018)	$23.00	$32.50
PPA in (2030)	$24.61	$32.95
Transmission (2018/2030)	$12.52/$15.87	$2.50/$3.17
Integration (2018/2030)	$4.50/$5.71	$4.50/$5.71
Congestion Costs	$0.00	$0.00
Total (2018)	$40.02	$39.50
Total (2030)	$46.19	$41.82

* Impact of safe harbor provisions could extend wind and solar tax credits by two years

Although solar is cheaper, the variability of wind and solar requires a diverse portfolio that includes dispatchable resources to help achieve ZNC



On a levelized cost of energy basis, CC is only slightly cheaper, but provides superior capacity benefit to CT and especially to battery storage



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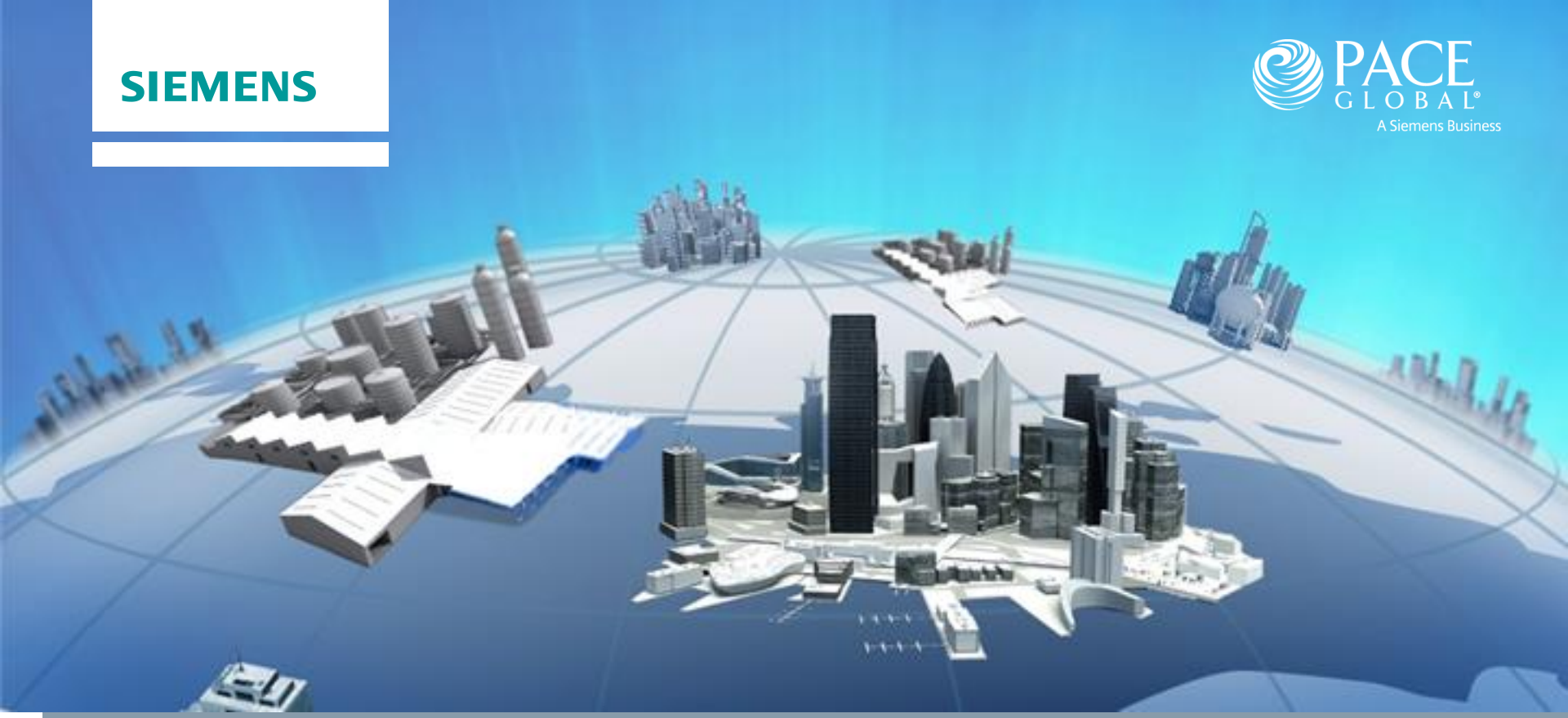
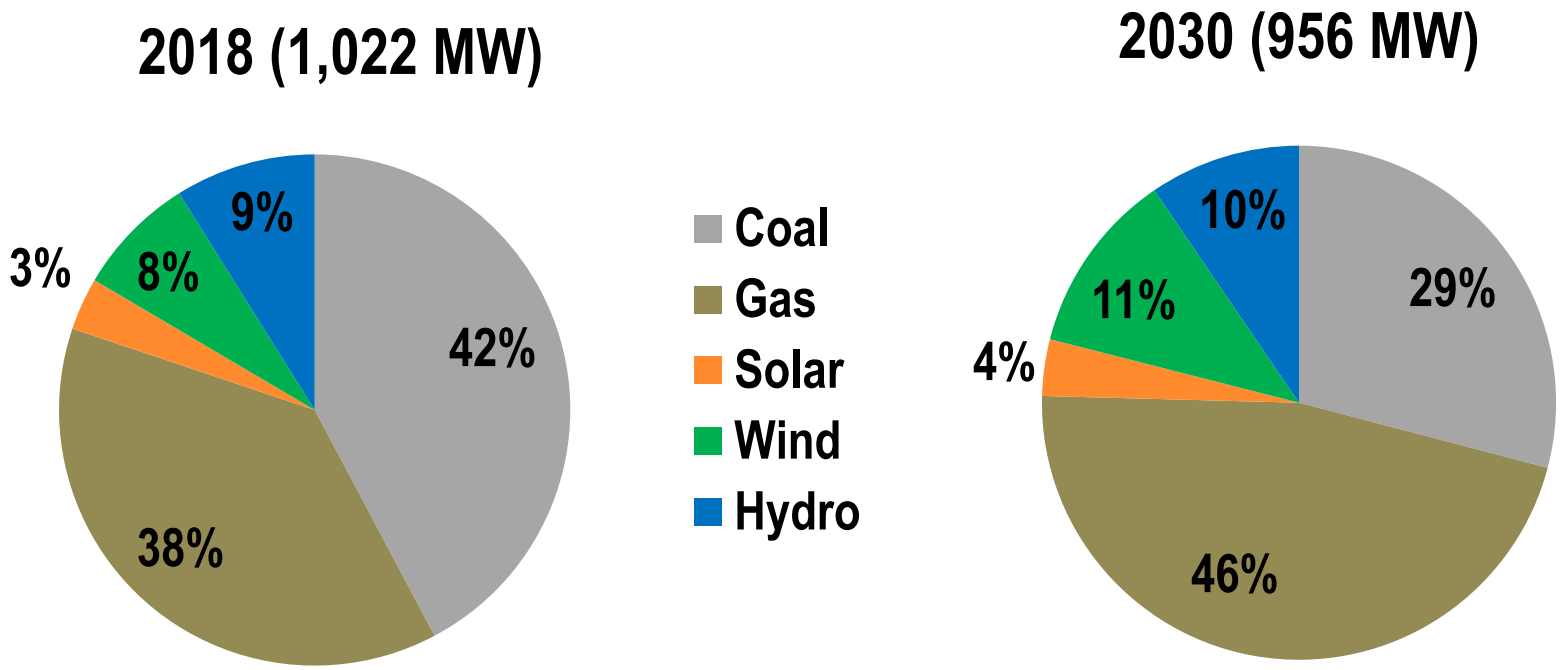
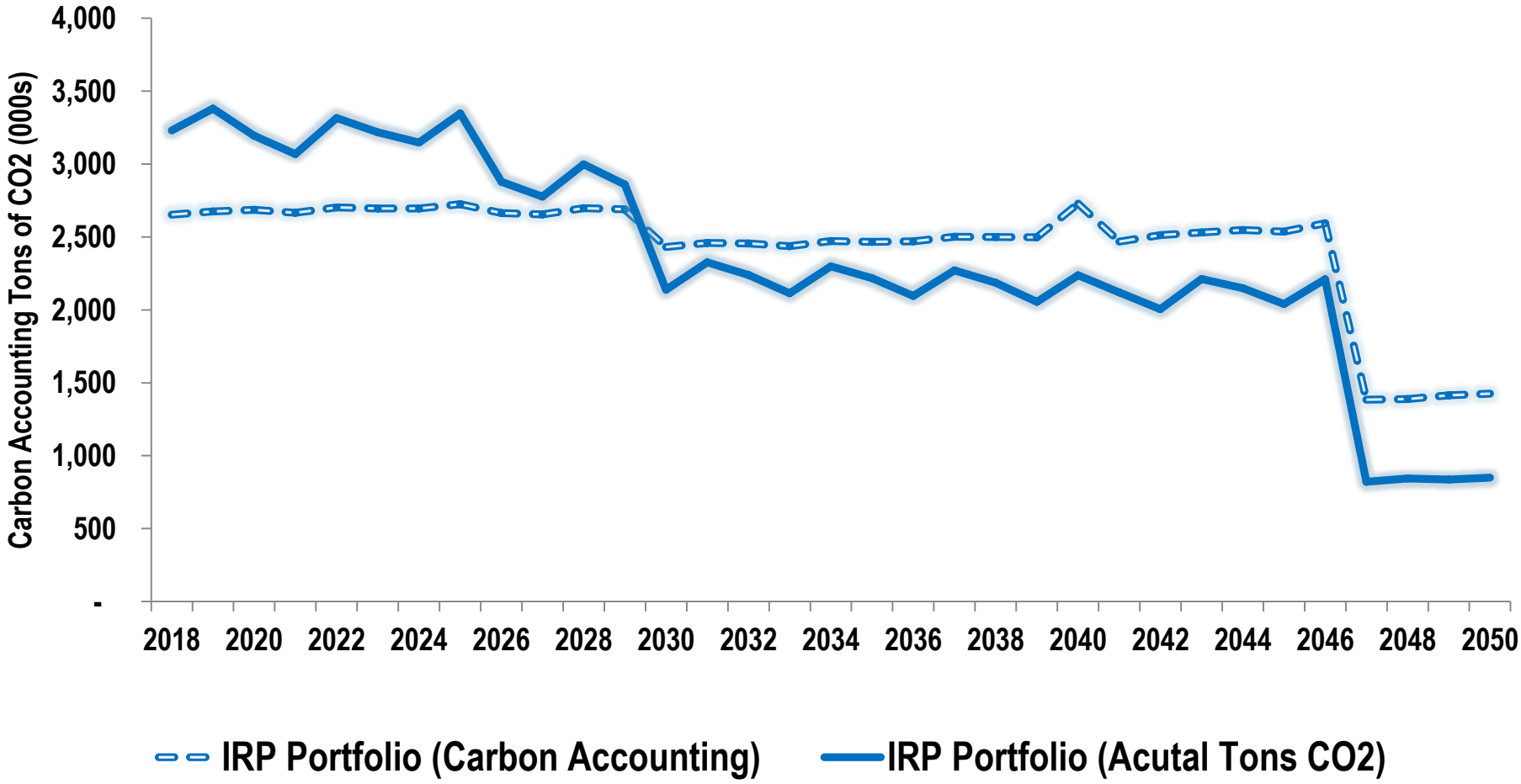


IRP Portfolio

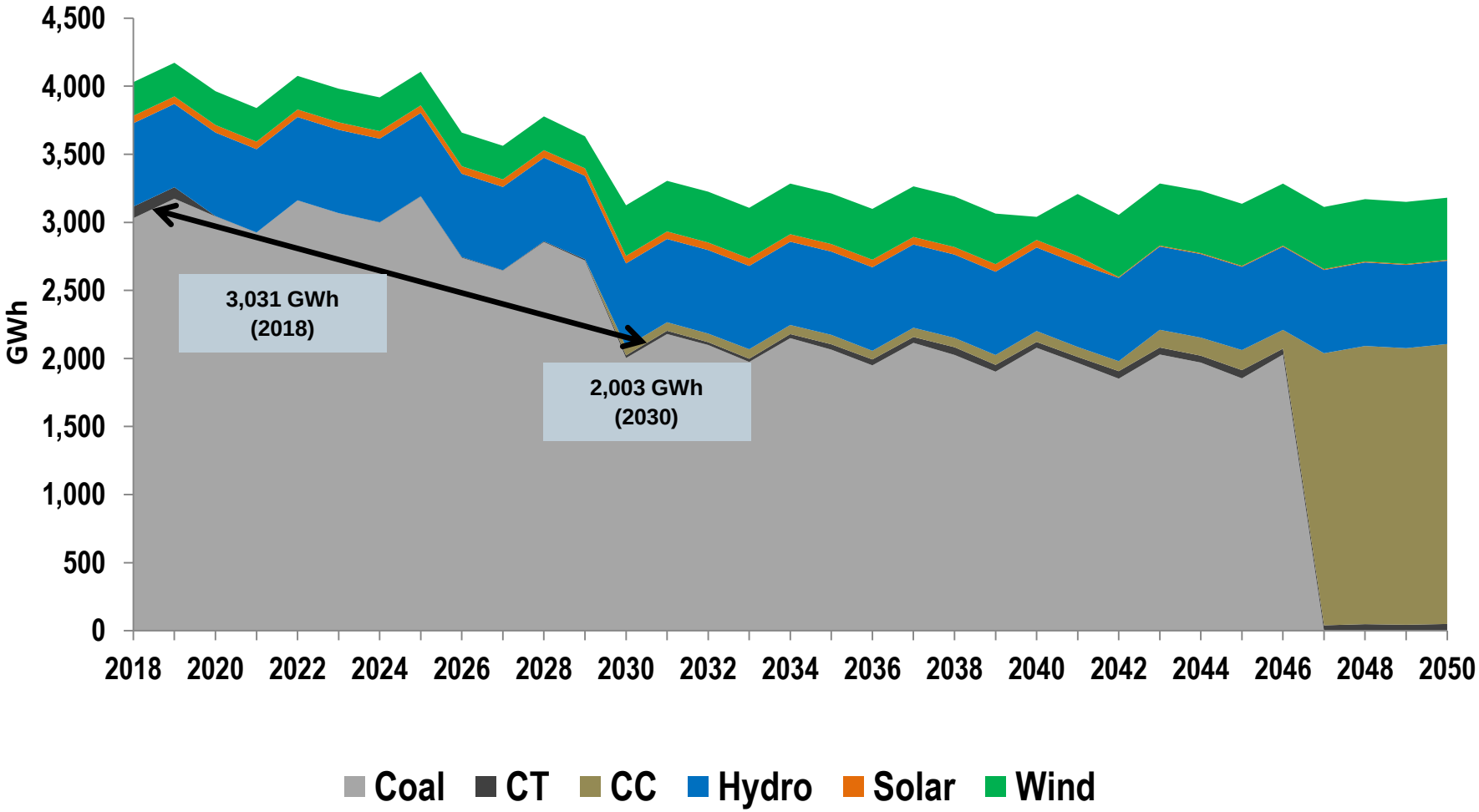
In the IRP scenario, coal capacity is replaced primarily with gas generation—Capacity declines over time



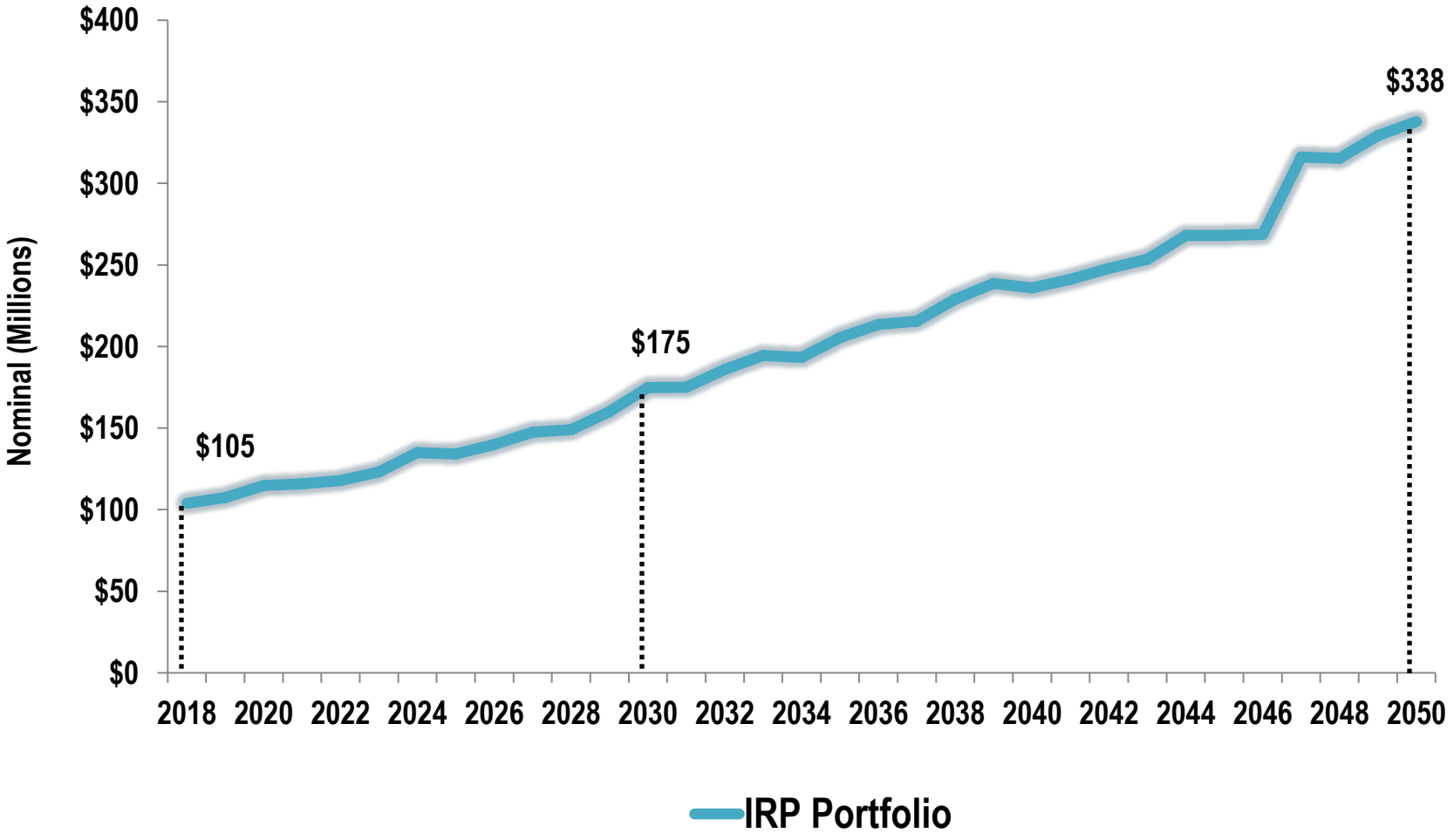
IRP portfolio reduces carbon emissions by 2030—Platte River is a net purchaser of energy



Under the IRP scenario, coal generation drops by 1/3 by 2030



Under the IRP scenario, costs increase by 70% by 2030—Inflationary factors include commodity prices, emissions costs, O&M, capital, and power prices



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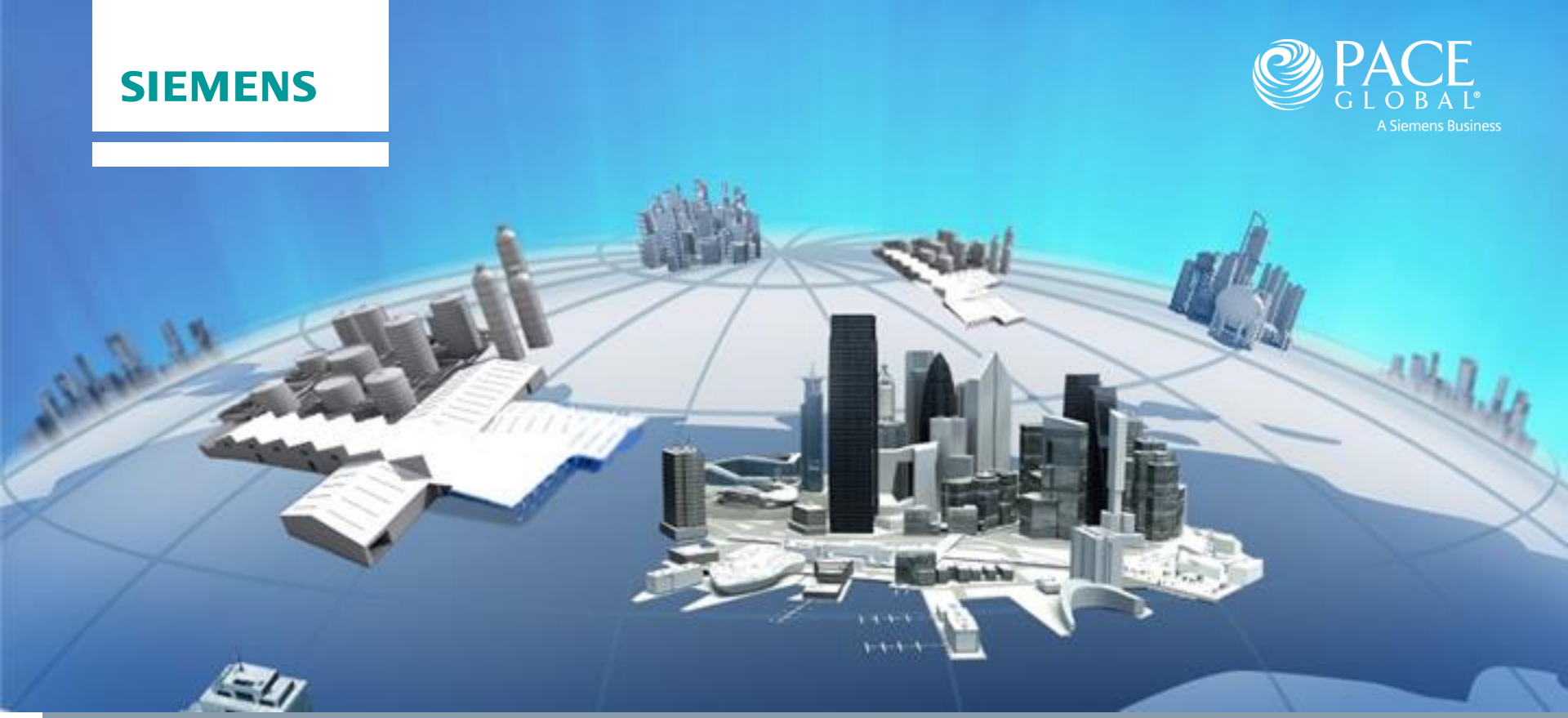
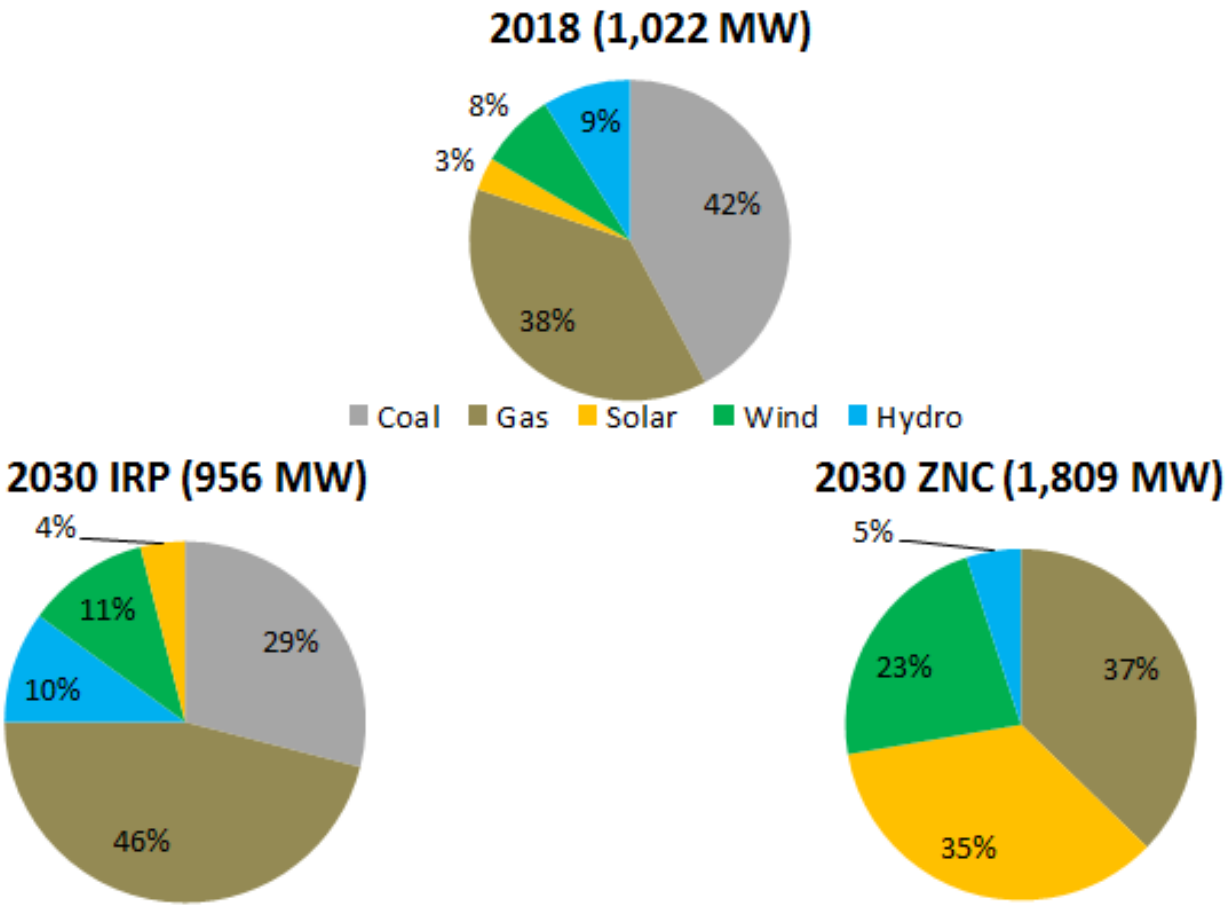


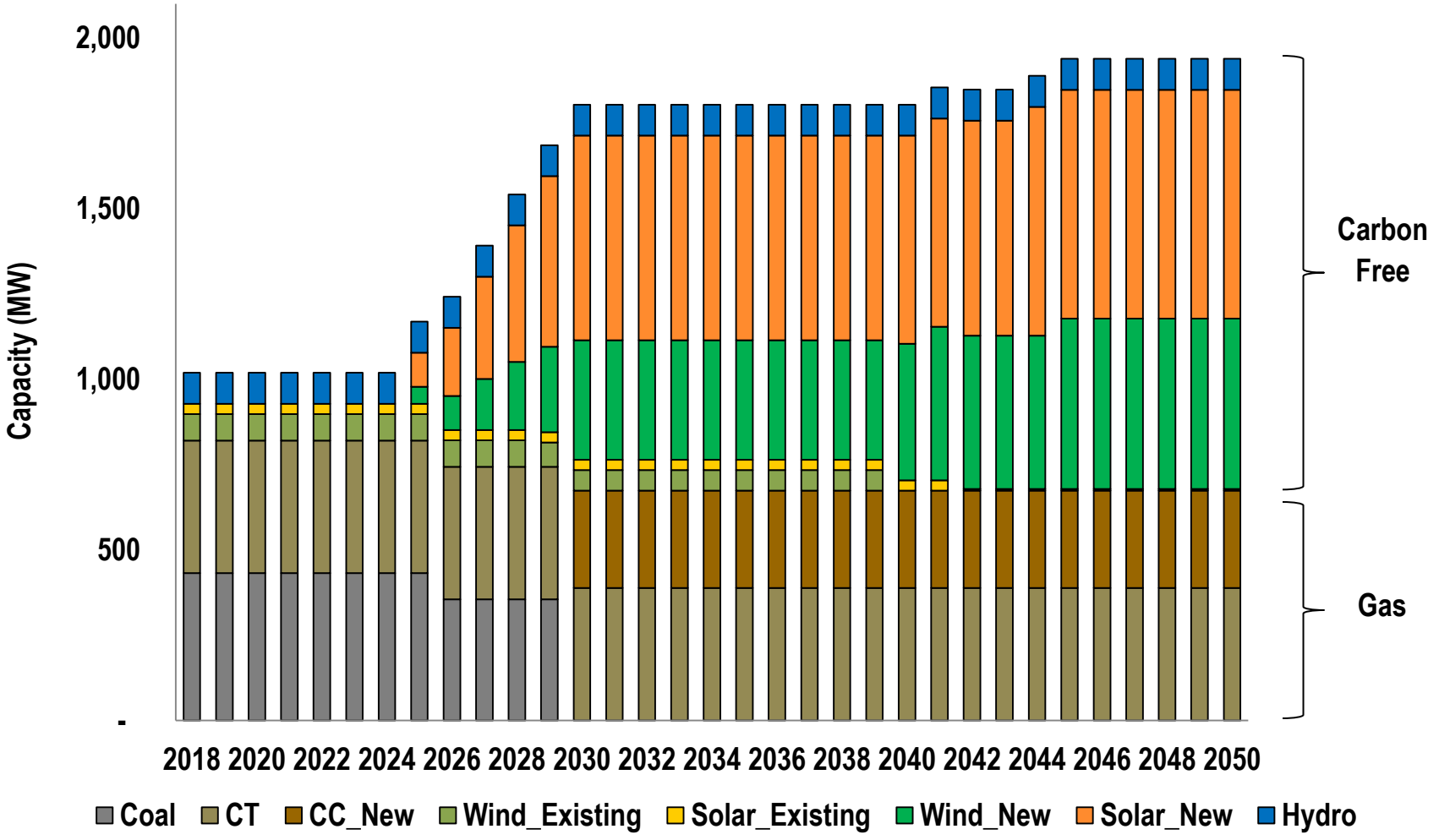
Zero Net Carbon Portfolio

Generating capacity under the ZNC portfolio is nearly double the capacity of the IRP portfolio

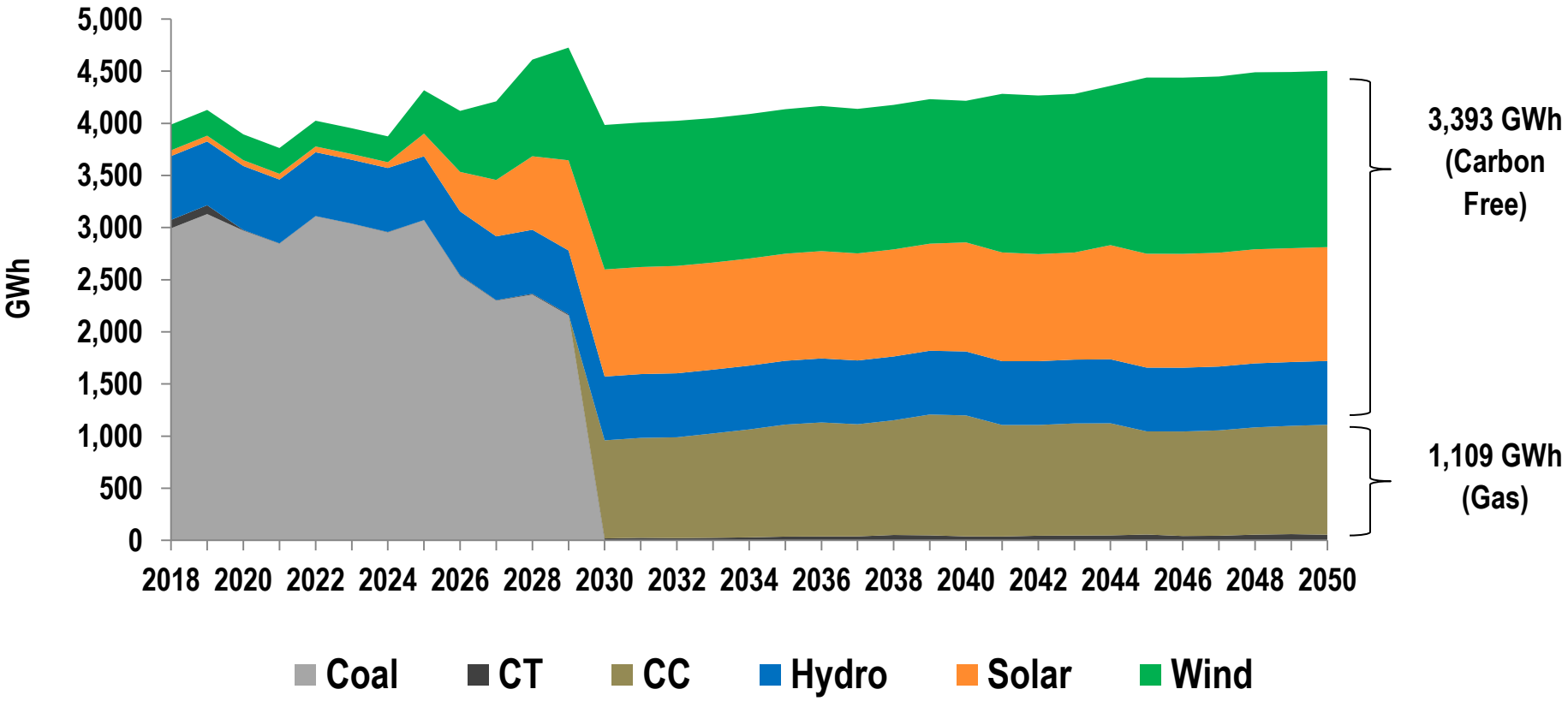
Gas generation is added but remains a similar percentage share of the larger portfolio



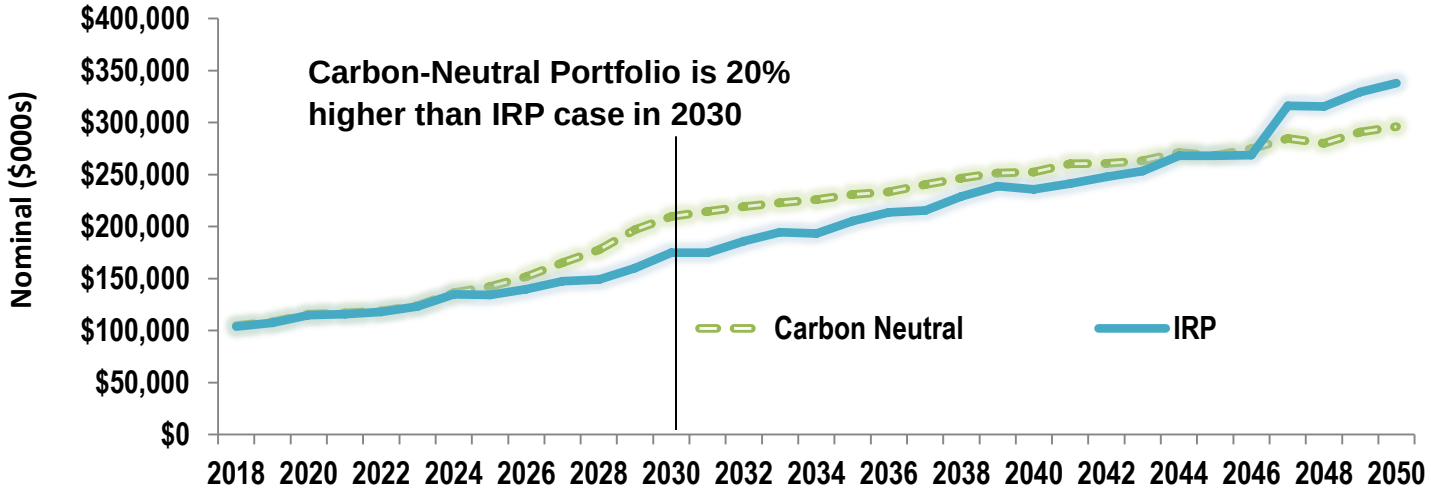
Under the ZNC, capacity mix shifts to renewables—600 MW solar, 350 MW wind, 286 MW gas added by 2030



Generation becomes a balanced mix of wind, solar, hydro, and gas resources—75% carbon free

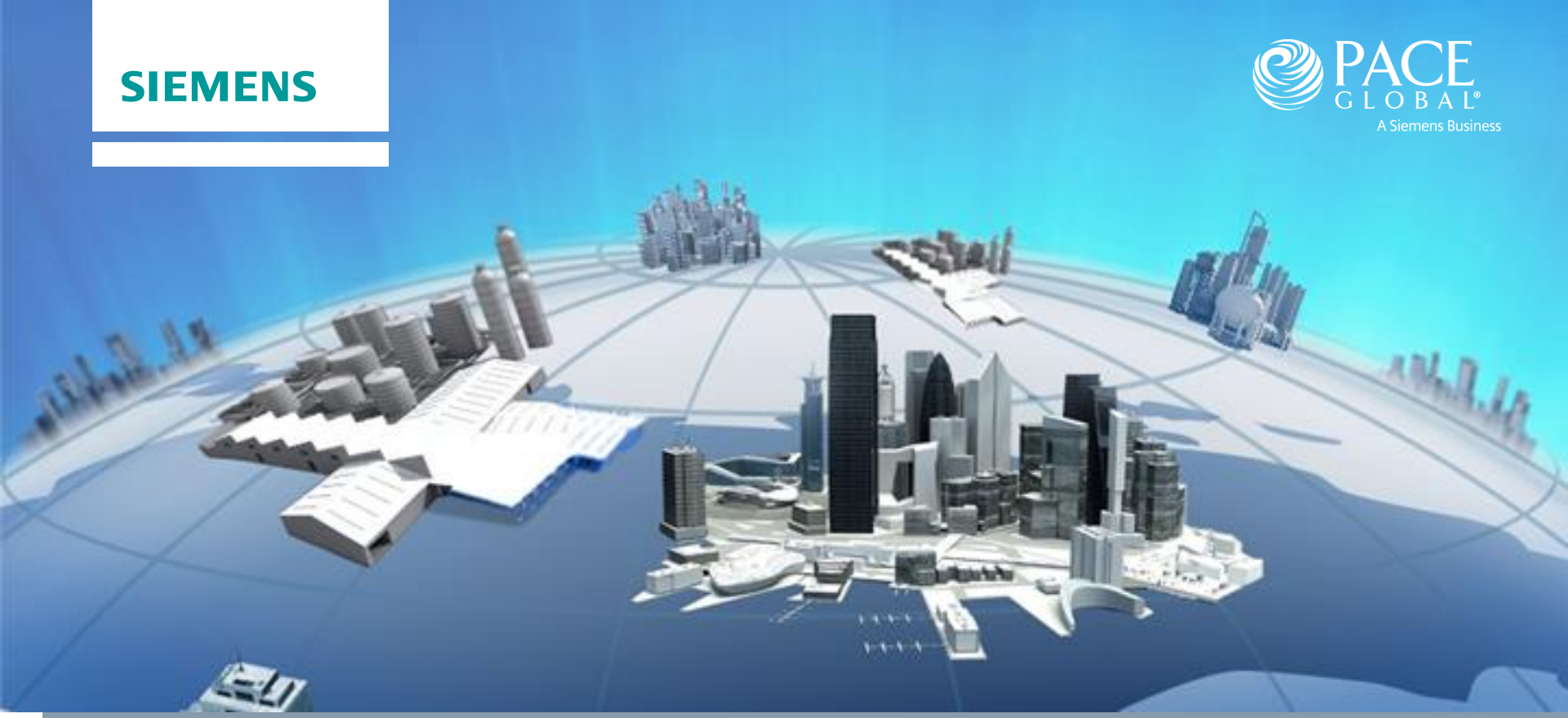


Cost of ZNC portfolio is 20% above IRP in 2030 and 8% higher NPV over planning horizon
(about 10% higher NPV from 2030-2050)



	2030 Annual Cost	% Change	2050 Annual Cost	% Change
Carbon-Neutral Case	$209,606	20%	$296,214	-12%
IRP Case	$174,788		$337,926	

	2018 - 2050 NPV	% Change	2030 - 2050 NPV	% Change
Carbon-Neutral Case	$2,938,219	8%	$2,495,799	10%
IRP Case	$2,717,718		$2,278,986	



Findings

The ZNC study is a positive first step toward demonstrating feasibility of a carbon-free portfolio

1. ZNC could be implemented but will require investment, higher cost, and additional market risk.
2. Platte River would serve about 75% of load with zero carbon generation and would offset the remaining 25% with sales of zero carbon generation to the market.
3. Platte River would buy about 600 MW of solar and 350 MW of wind by 2030 and build about 286 MW of new gas-fired generation.
4. Lithium ion battery storage is not economic for meeting firming and capacity needs at this time.
5. A zero carbon (rather than zero net carbon) portfolio would be more expensive because of the added cost of storage and the limited capacity credit attributable to intermittent resources (much more renewables and batteries would be required).
6. Higher rates are required to achieve a ZNC portfolio as compared to the IRP portfolio.

Additional risk considerations for ZNC

1. This study focused on Platte River achieving carbon neutrality assuming others in Colorado were not simultaneously pursuing this same goal.
   - If others pursue the same goal, there will be more sellers of renewables, fewer buyers, lower market prices, reduced carbon offset values, and more renewables will have to be built to achieve ZNC, at higher investment and cost than modeled here.
   - The impact on system integration costs of higher regional levels of renewables in the broader market (Colorado) remains uncertain.
2. Committing to renewables early in the planning period may result in foregoing opportunities to capitalize on lower renewable costs later in the planning period (need to strike the right balance).
3. Future costs are uncertain, and this uncertainty increases further in the future.
4. Selling higher quantities of power in a bilateral market imposes higher risks than in an RTO-based market.

Risk mitigation measures for carbon neutrality

1. Joining an RTO could reduce the cost of achieving ZNC as it reduces transmission costs and makes sales more competitive (assuming others are not simultaneously committing to ZNC).
2. Platte River could incent both distributed and utility scale renewables in a way that minimizes grid costs.
3. Through diversity and investment deferrals, Platte River could maintain the flexibility to utilize batteries, and additional demand response and energy efficiency measures as they become cost effective.
4. Maintaining existing CTs provides additional flexibility to meet intermittent firming load needs if cost effective.

RTO assessment has been initiated but is not complete

Joining an RTO is uncertain and difficult to model as accurately as the current bi-lateral market:

- Approval of the RTO is uncertain
- The market rules are uncertain
- Who will ultimately join the RTO is not clear
- Whether participants will move more aggressively to renewables is unclear

Directionally, however, several things are clear:

- Transactions with market participants are easier and more likely to occur
- Transmission costs for remote sources will drop since wheeling charges will be eliminated
- Remote wind will be become more economic relative to local solar
- Overall costs should be expected to fall with an RTO

Pace Global has begun to analyze this option for Platte River and will refine the analysis as more information becomes available