



Western Electricity Coordinating Council

TEPPC 2010 Study Program Update

WECC Staff

September 9th, 2010

Today's Discussion

- Introduction—TEPPC Planning Process
- Overview of 2010 Study Program
- Update on 2029 study results report
- Summary of 2019 study results
- Development of 2020 dataset

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Webinar Format

- All lines will be muted until Q&A periods
 - After update on 2029 study results report
 - After summary of 2019 study results
 - After completion of entire presentation
- Raise hand to ask a question
 - The moderator will call on you and un-mute your line
- Written questions are accepted at any time
 - Use the “chat box”

TEPPC Planning Process

- Please see the [RTEP Process Graphic](#) describing TEPPC and SPSG activities

2010 TEPPC Study Program

2009 Dataset

2029 Study Year

Follow-up work from 2009 Study Program

2019 Study Year

Run using updated 2019 dataset

2010 TEPPC Study Program

2030 Study Year

Run using new Long Term Planning Tool

2020 Study Year

Run using new 2020 dataset

2010 Dataset

2010 TEPPC Study Program

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2030 Study Year

Run using new Long Term Planning Tool

2020 Study Year

Run using new 2020 dataset

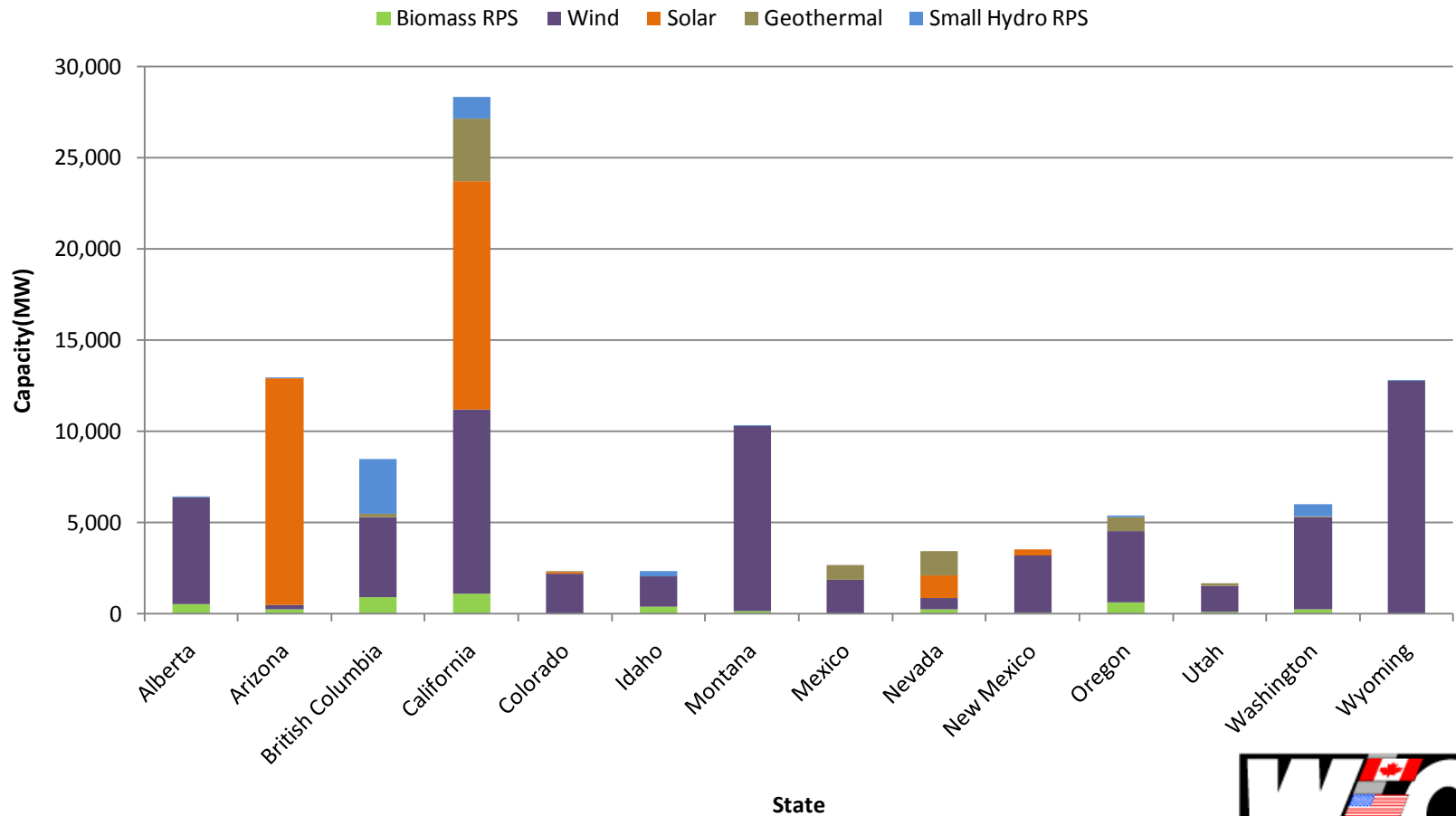
2010 Dataset

2029 TEPPC Studies

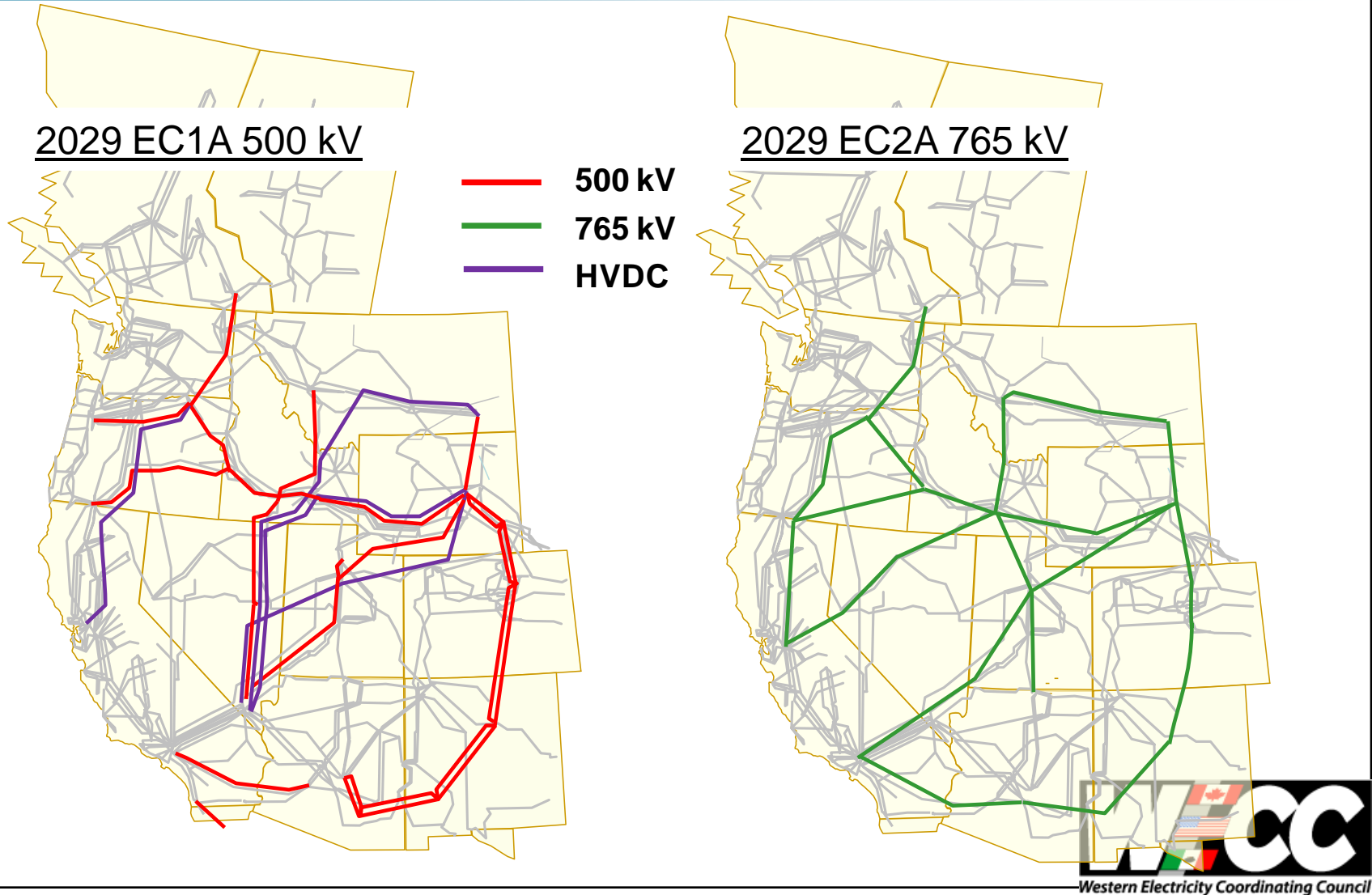
- The 2029 base case was intended to model a 33% WECC-wide penetration of renewable resources in 2029, with no additional transmission as compared to 2019
 - Renewable energy target: 376,249 GWh
- Two transmission expansion alternatives were then tested on the 2029 base case
 - 500 kV AC/DC incremental build-out of transmission
 - 765 kV AC overlay

Renewables Modeled in the 2029 Scenarios

Renewables Modeled in 2029 Scenarios



2029 Transmission Expansion Alternatives



Conclusions/Lessons Learned

- The level of renewable penetration modeled in TEPPC's 2029 base case cannot be integrated without significant transmission expansion

	Realized Renewable Penetration		
2029 33% Renewable Energy Target	2029 PC1A	2029 EC1A 500 kV	2029 EC2A 765 kV
376,249 GWh	350,058 GWh	367,059 GWh	362,826 GWh
% of RPS Target	93%	98%	96%

- In addition to transmission expansion, other methods of renewable integration should be investigated, such as:
 - The effectiveness of storage resources
 - Dynamic scheduling of renewable output
 - Curtailment of resource off-peak

Conclusions/Lessons Learned

- Few, if any, conclusions can be made about whether the 500 kV expansion was more/less effective than the 765 kV expansion
 - Both proposals would have to be adjusted to make them effective and comparable to each other
 - The 765 kV overlay proposal may need more capacity in the Montana and Wyoming areas and additional lower voltage transmission to link it the existing network
 - The 500 kV (HVAC and HVDC) overlay proposal may need more capacity into Southern California

Conclusions/Lessons Learned

- The wear-and-tear experienced by base load resources in response to heavy renewable penetrations should be quantified
 - Reporting of integration costs is incomplete without the inclusion of these costs
- All penalty factors in the data set should be coordinated so that dispatch actions occur in a logical order, for instance, wind should be curtailed before transmission limits are violated.

2029 Study Results Report

- Draft report circulated to TEPPC's Technical Advisory Subcommittee (TAS) for comment in August
- Comments and corrections received from TAS are currently being incorporated
- A second version of the draft report will be circulated to TEPPC next week

2010 TEPPC Study Program

2009 Dataset

2029 Study Year

Follow-up work from 2009 Study Program

2019 Study Year

Run using updated 2019 dataset

2010 TEPPC Study Program

2030 Study Year

Run using new Long Term Planning Tool

2020 Study Year

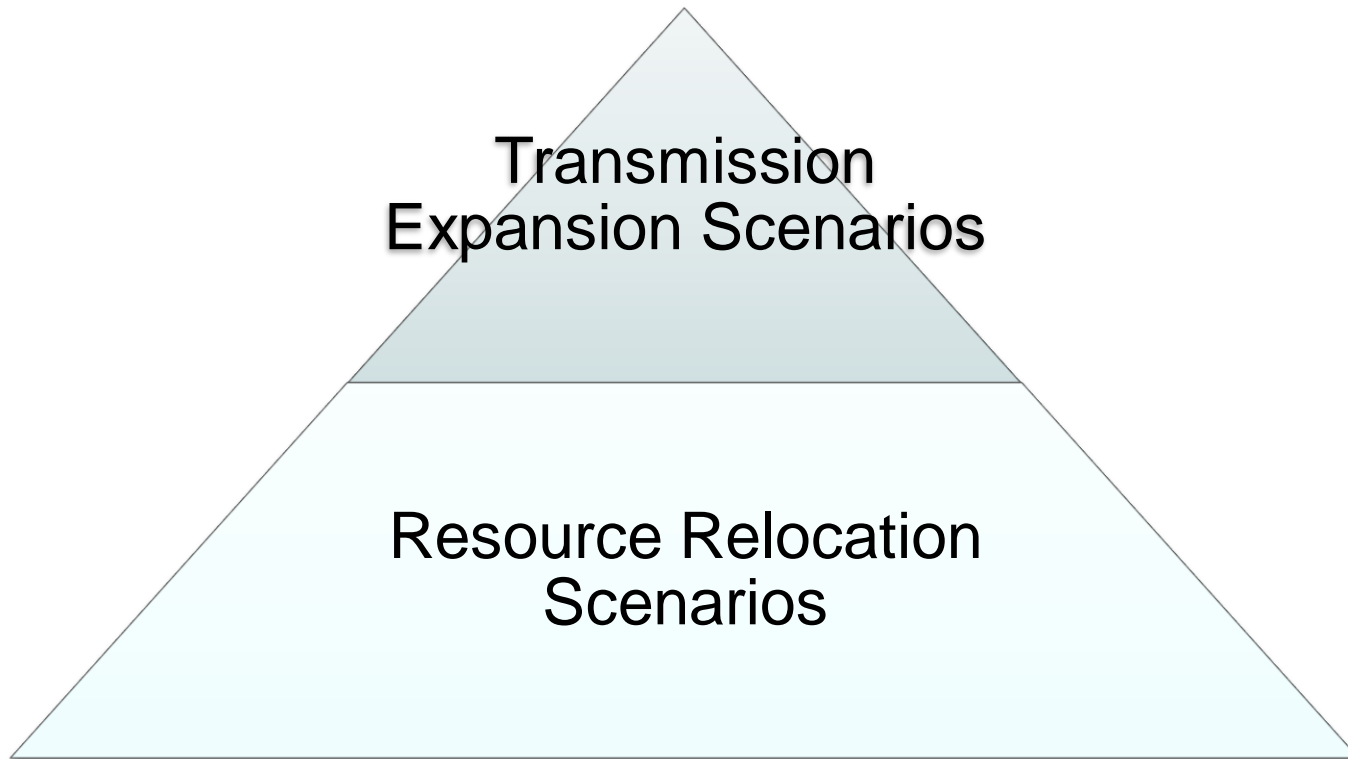
Run using new 2020 dataset

2010 Dataset

Summary of 2019 Study Results

- 2019 Resource Relocation Scenarios
 - Scenario Implementation
 - Summary of Results
- 2019 Transmission Expansion Scenarios
 - Scenario Implementation
 - Summary of Results
- [Link to Additional Information](#)

2019 Studies: Transmission and Resource Relocation Relationship



2019 Resource Relocation Scenarios

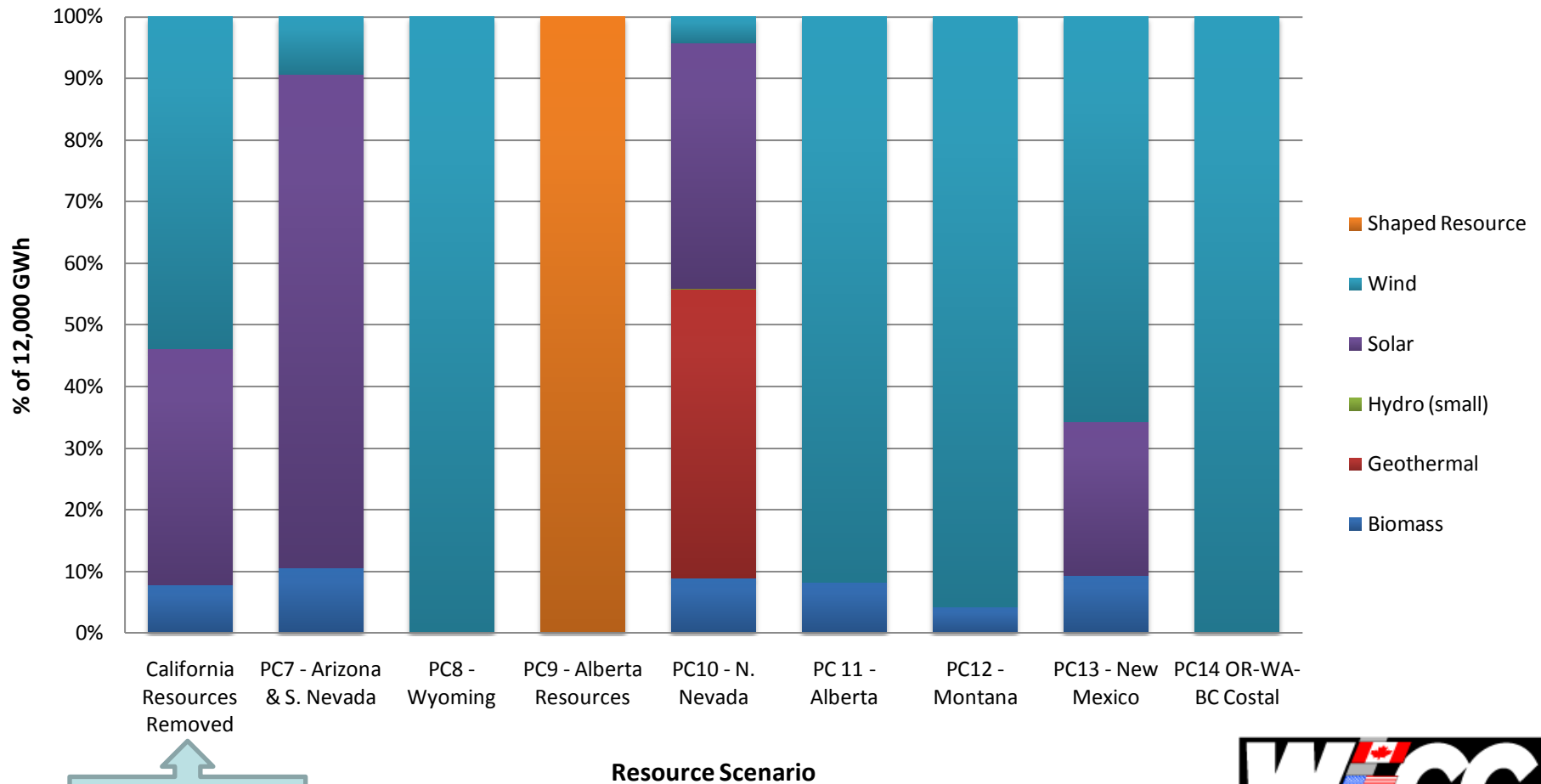
- Premise: Remove 12,000 GWh of renewables from California in 2019 PC1A (base case), and replace with 12,000 GWh of renewables located elsewhere around the WECC
 - Goal – Observe patterns of transmission congestion under different resource portfolios
- 8 resource relocation scenarios were identified to study the shift of resource from CA into:
 - Alberta
 - Arizona
 - British Columbia
 - Montana
 - Nevada
 - New Mexico
 - Coastal WA/Oregon
 - Wyoming

2019 Resource Scenario Implementation

- Resources removed from CA were selected based on their CREZ ranking in the CPUC 33% reference case which was used to build the 2019 renewable resource portfolio
- All resources (except BC shaped product and coastal wind) were identified and placed using the WREZ Peer Analysis Tool
 - Results from the WREZ tool were reconciled against existing incremental renewables in the 2019 dataset to avoid double-counting of the least cost resources
 - The SWG Resource Team agreed to decrease all biomass resources identified by the tool by 50%
- BC shaped product was specified by BC Hydro
- Coastal wind was identified using the WREZ tool and the NREL meso-scale wind data

2019 Resource Scenario Implementation

2019 Resource Implementation of 12,000 GWh by Resource Scenario



Removed

2019 Resource Scenarios – Summary of Results

- Resource Capital Cost Savings
- Changes in Variable Production Cost
- Changes in CO₂ Emissions
- Comparison of the Saturated Capacity Index (SCI)
- Trends in Most Congested Paths
- Changes in Annual Generation
- Note: Alberta resource scenario yet to be run, no results available

Resource Capital Cost Savings

CA Resources Removed from Each Resource Relocation Scenario	MW	Regional Levelized Fixed Costs (\$/kW-yr)	Levelized Fixed Costs (\$M/yr)
Removed CA Solar PV	-280	402.84	-\$112.80
Removed CA Solar CSP	-1,577	503.83	-\$794.54
Removed CA Biomass	-141	656.48	-\$92.56
Removed CA wind	-2,787	270.66	-\$754.33
Total CA Removed	-4,785		(\$1,754.2)

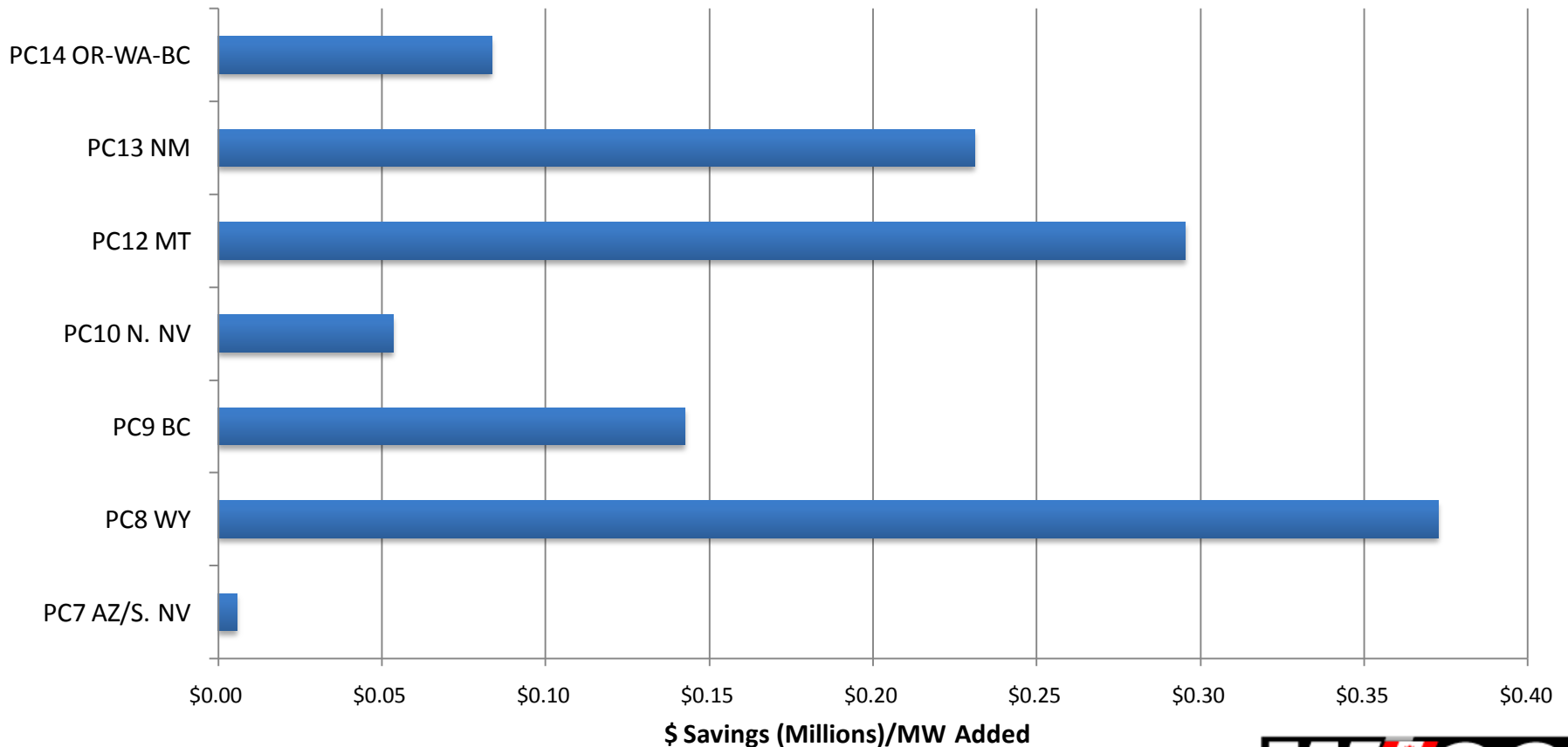
	AZ/S.NV	WY	BC	N.NV	MT	NM	Coastal OR-WA-BC
MW Added	3,278	2,913	4,566	2,586	3,256	3,090	5,299
Levelized Fixed Costs (\$M/yr)	1,735	669	1,103	1,616	792	1,040	1,311
Net Change in Resource Capital Cost* (\$M/yr)	(19.07)	(1,085.46)	(650.81)	(138.08)	(962.09)	(714.05)	(442.86)

*As compared to 2019 PC1A base case

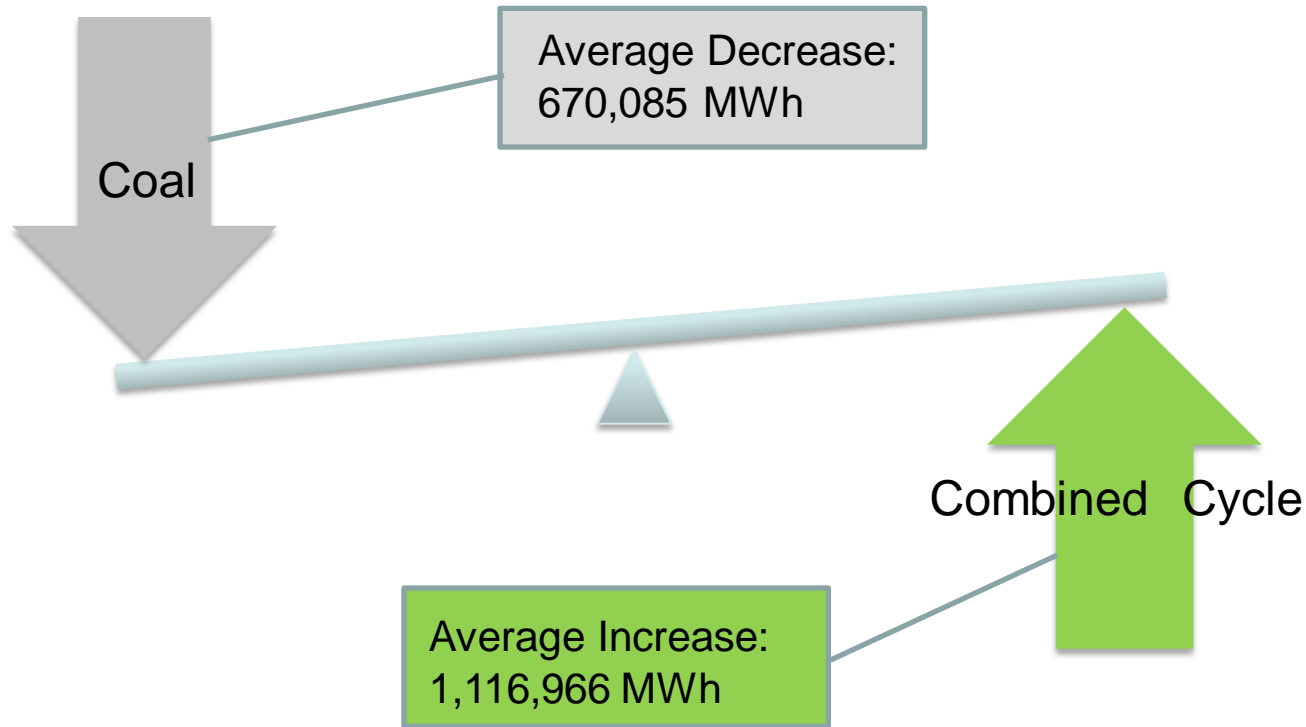
- The MW added in each scenario to achieve 12,000 GWh of energy is dependent on the capacity factor of the resources added in each scenario.
- The levelized cost of the resource additions was calculated using E3's capital cost tool, and varies by resource and by state.

Resource Capital Cost Savings

Capital Cost Savings per MW Renewables Added



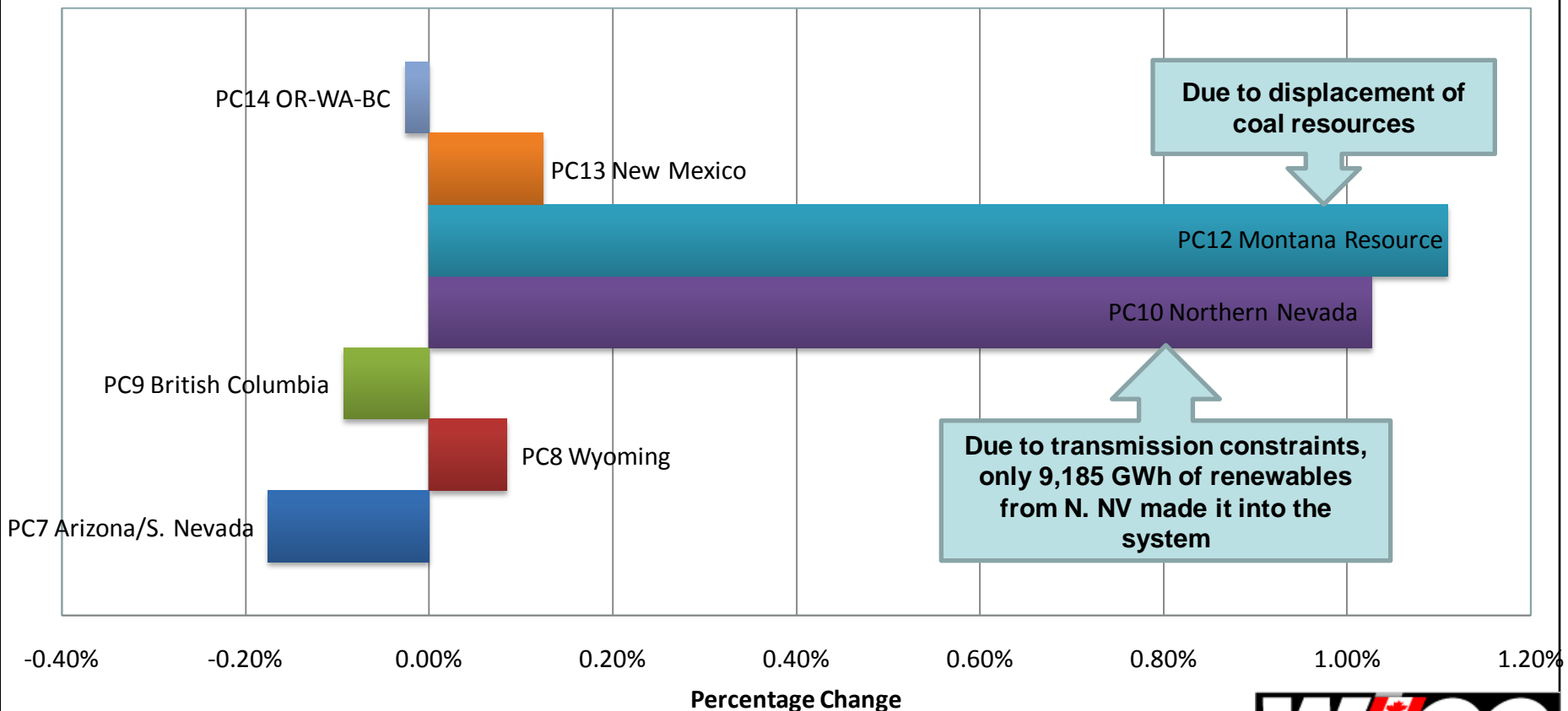
Average Change in Annual Conventional Generation WECC-Wide



- Increases in combined cycle generation were observed primarily in California, Arizona, and Nevada
- Decreases in coal generation were observed primarily in Montana and Wyoming

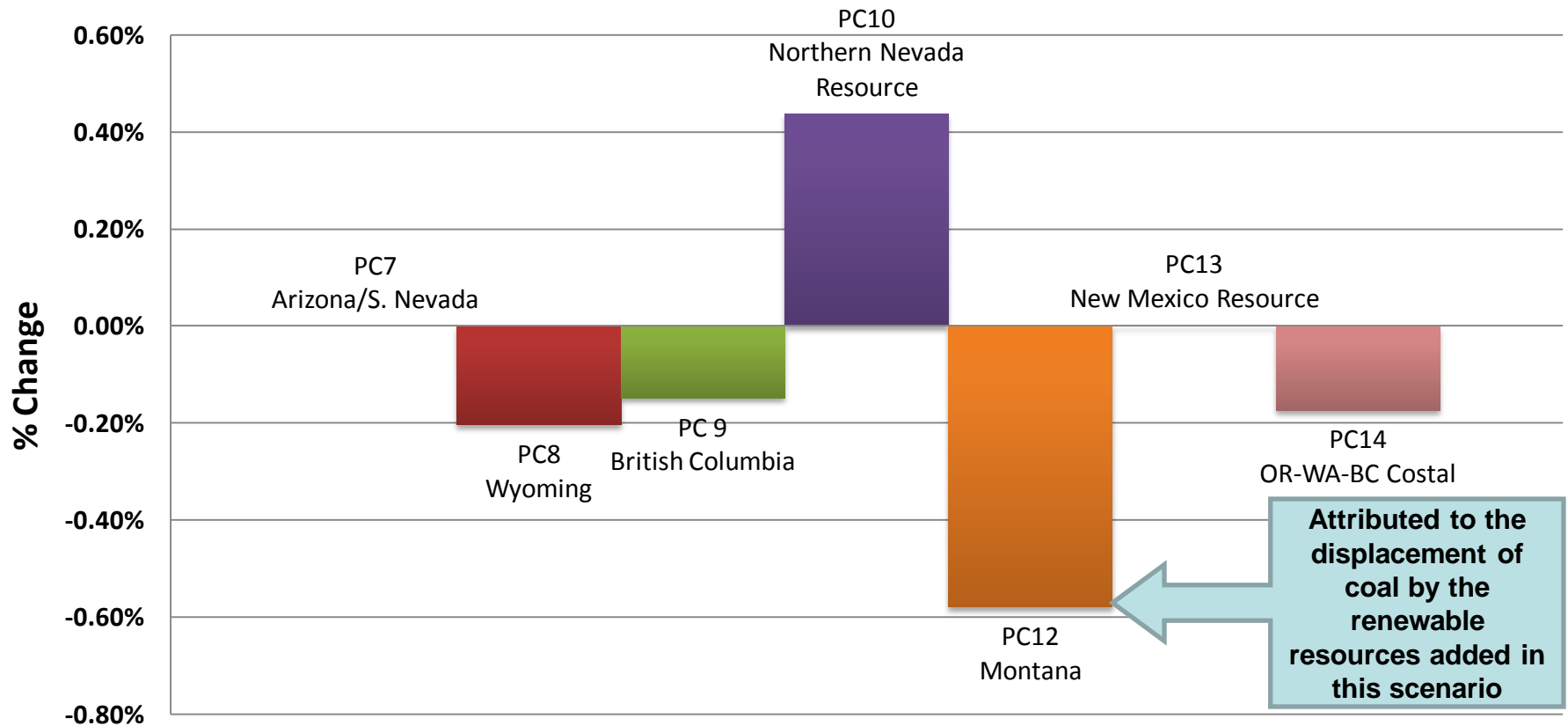
Variable Production Cost

Percentage Change in Variable Production Cost
Compared to 2019 PC1A Base Case



CO₂ Emissions

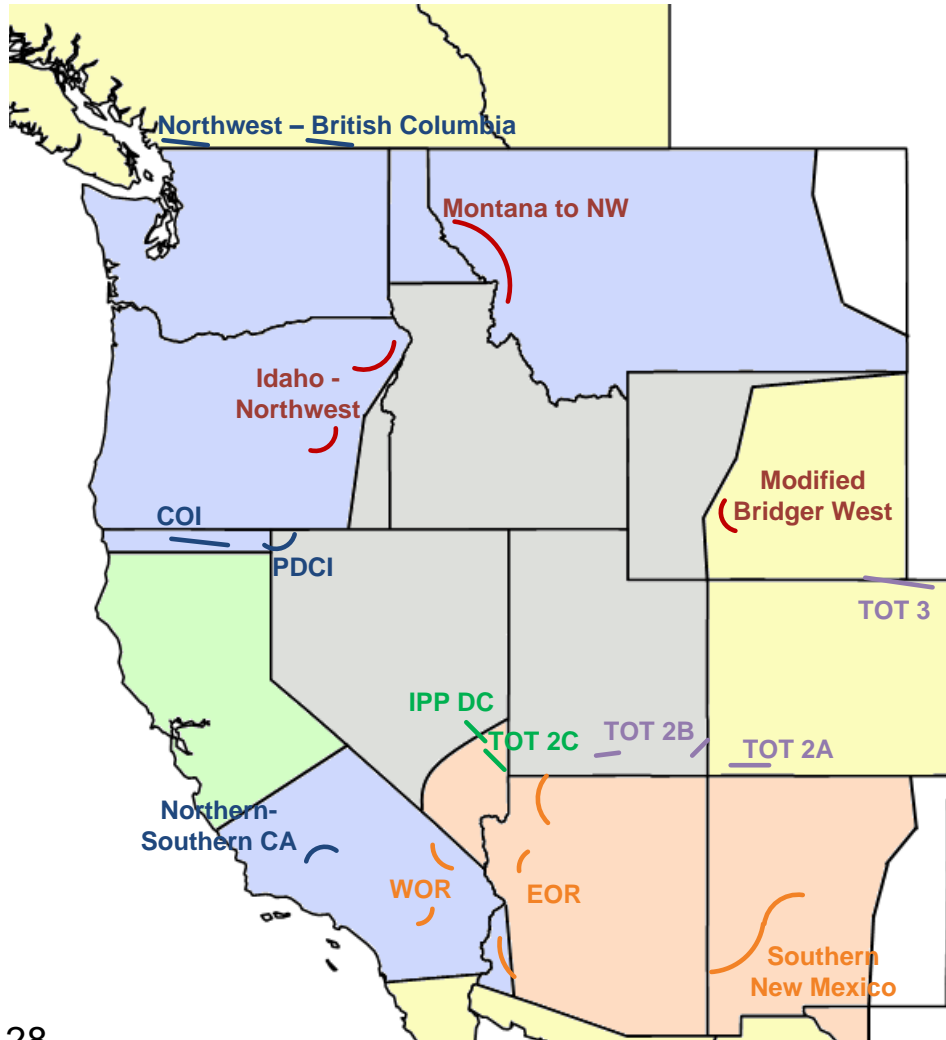
Percentage Change in CO₂ Emissions Compared to 2019 PC1A Base Case



Saturated Capacity Index (SCI)

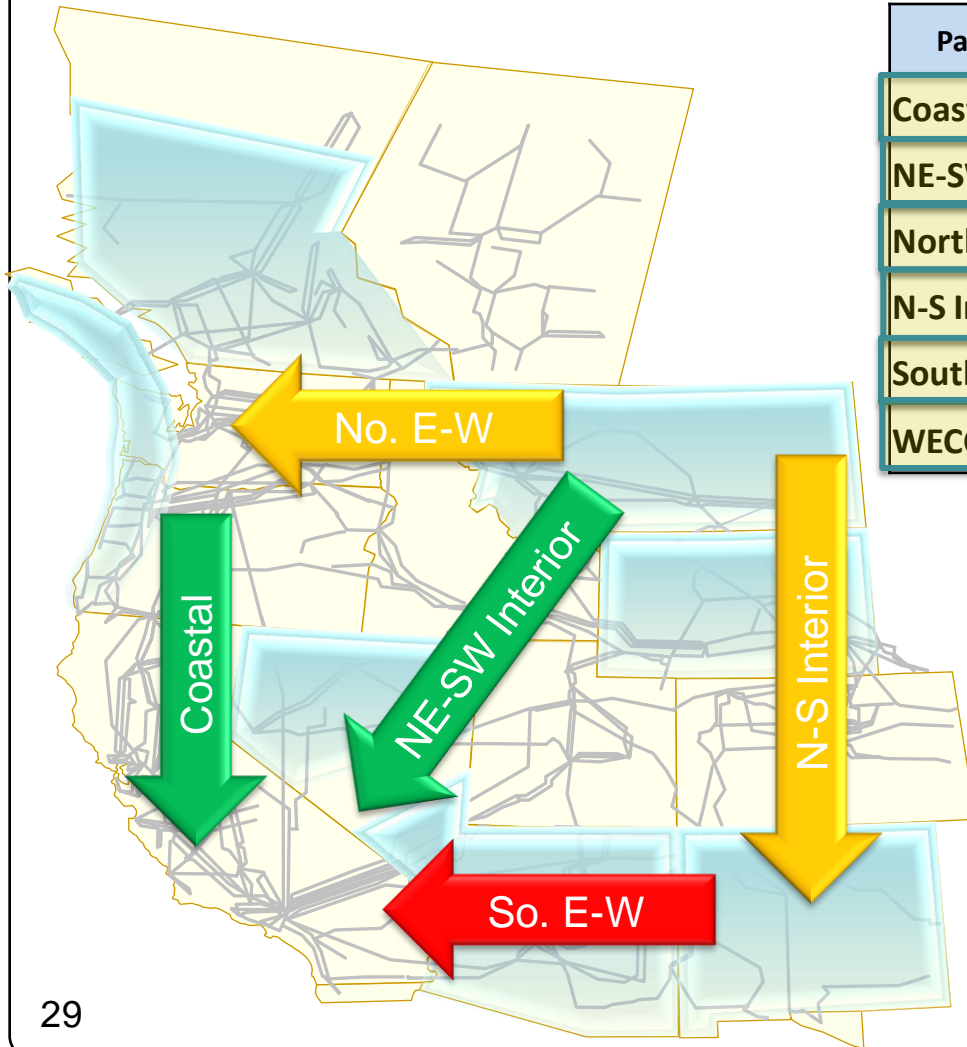
- A “Saturated Hour” is an hour in which line flow is $> 95\%$ of line rating
- These hours are summed over the course of the year, multiplied by the line rating, and are converted into an index
- SCI is a *relative measure* of congestion and indicates only an increase or decrease in congestion as compared to a reference value
 - The SCIs for the 2019 PC1A base case are all **1.0**, as these are the reference values against which the SCIs from the resource relocation cases are compared

SCI Path Groupings

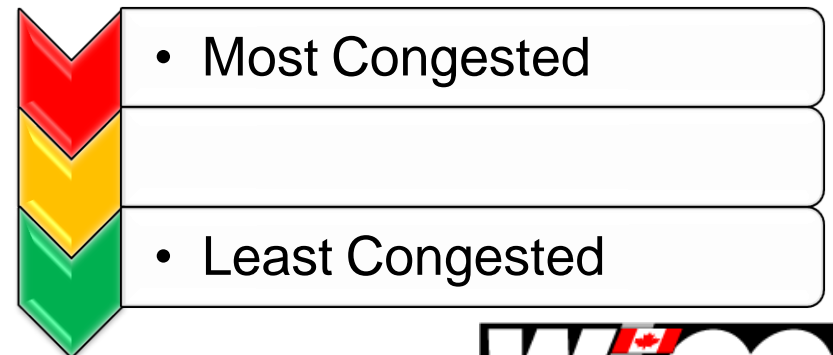


Path Grouping	Path Name
Coastal Paths	Northwest-British Columbia
	COI
	PDCI
No. E-W Paths	Northern-Southern California
	Montana-Northwest
	Idaho-Northwest
So. E-W Paths	Modified Bridger West*
	Southern New Mexico
	West of the CO River
NE-SW Interior Paths	East of the CO River
	IPP DC
	TOT 2C
N-S Interior Paths	TOT 3
	TOT 2A
	TOT 2B

Comparison of SCI: A Measure of Relative Changes in Congestion



Path Group	AZ/S.NV	WY	BC	N.NV	MT	NM	Coastal	Avg
Coastal	1.09	1.17	1.69	0.77	1.47	0.95	1.34	1.21
NE-SW Interior	1.08	2.29	1.45	3.11	1.72	1.51	1.01	1.74
North E-W	1.05	1.60	0.85	0.77	4.47	5.58	4.69	2.72
N-S Interior	0.59	17.75	1.13	1.26	1.21	3.73	7.70	4.77
South E-W	47.49	6.07	1.33	7.76	4.72	2.33	3.33	10.43
WECC SCI	1.09	1.55	1.57	1.00	1.82	1.56	1.77	1.48

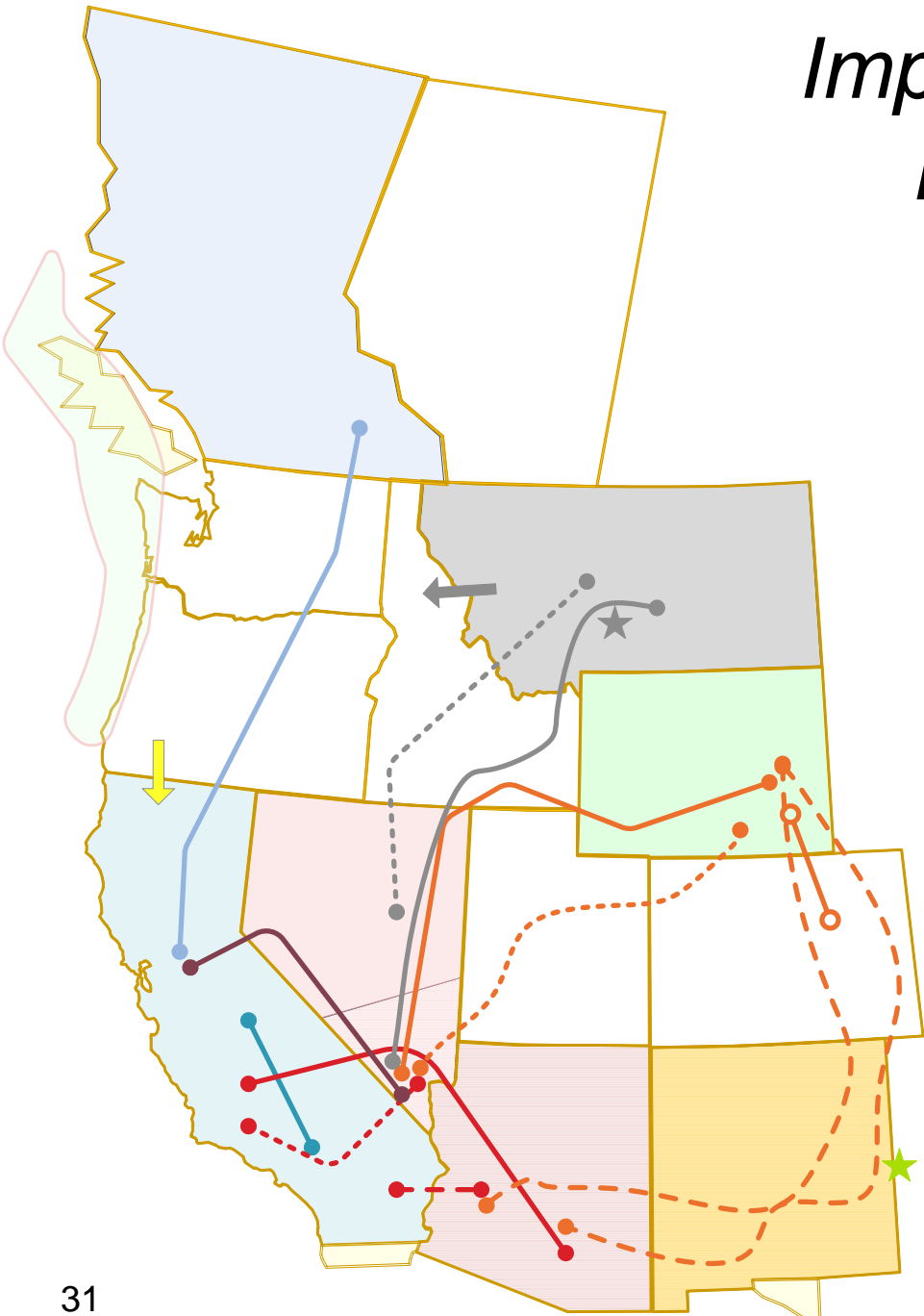


SCI Takeaways

Note - All SCI values are based off of existing congestion in the 2019 PC1A scenario

- WECC-Wide transmission congestion increased, as compared to the 2019 PC1A case, in most of the resource scenarios
- South E to W Paths experienced the greatest increase in congestion, by the SCI metric
- Coastal Paths showed the smallest increase in congestion

Implementation of 2019 Expansion Cases



Resource Scenarios

Transmission Scenarios

PC1A Base Case	<ul style="list-style-type: none"> EC1A-1 Central California Clean Energy Transmission Project
PC7 AZ/S. NV	<ul style="list-style-type: none"> EC7-1 Phoenix-Mead-Adelanto HVDC EC7-2 Green Energy Express Transmission Project Phases 2&3 EC7-3 Palo Verde – Colorado River 500kV Line
PC8 WY	<ul style="list-style-type: none"> EC8-1 Zephyr Project EC8-2 600kV HVDC C. WY to Las Vegas EC8-4 High Plains Express and SunZia EC8-6 Wyoming-Colorado Intertie
PC9 BC	<ul style="list-style-type: none"> EC9-1 Canada-PNW-Northern CA Project
PC10 N. NV	<ul style="list-style-type: none"> EC10-1 Reno to Las Vegas 500kV and Two Blackhawk to Tracy/Tesla 500 kV lines
PC12 MT	<ul style="list-style-type: none"> EC12-1 Chinook Project EC12-2 MISTI and SWIP Projects EC12-3 MT-NW Path 8 Upgrades EC12-4 Add 400MW Pumped Storage
PC13 NM	<ul style="list-style-type: none"> EC13-2 SunZia, High Plains Express Projects EC13-2-1 Tres Amigas Added
PC14 OR-WA-BC	<ul style="list-style-type: none"> EC14-3 COI Uprate Project

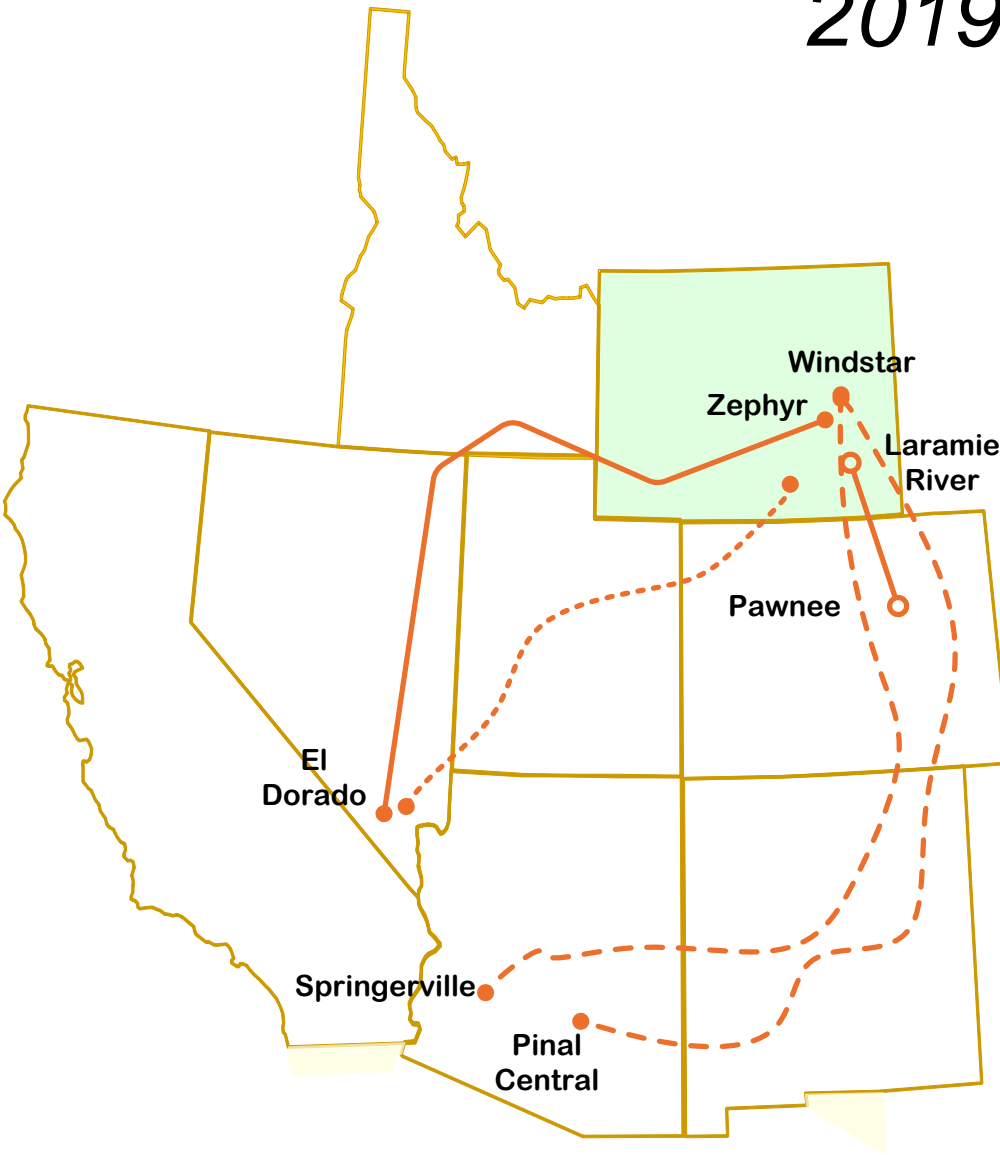


2019 Transmission Expansion Scenarios – Summary of Results

- Comparison of the Saturated Capacity Index (SCI)
- Changes in Annual Generation by State
- Changes in Variable Production Cost and CO₂ Emissions

- Results presented for Wyoming expansion cases only





2019 Wyoming Expansion Cases



Resource Scenario

Transmission Scenarios

PC8 WY

-  EC8-1 Zephyr Project
-  EC8-2 600kV HVDC C. WY to Las Vegas
-  EC8-4 High Plains Express and SunZia
-  EC8-6 Wyoming-Colorado Intertie



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Comparison of WY Transmission Expansion Scenarios

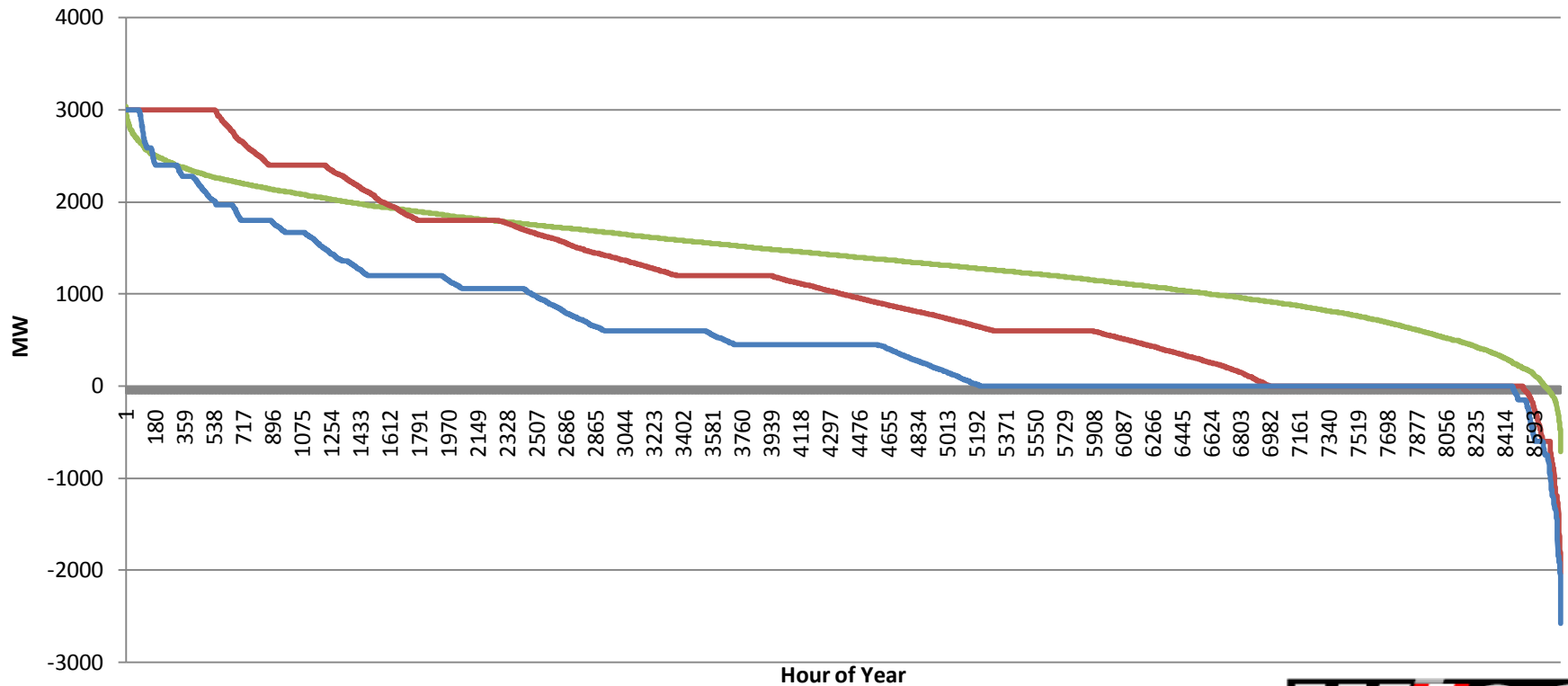
- Comparison of Annual Energy (MWh) exported from Wyoming

Project	Voltage	Pos Flow Limit (MW)	Neg Flow Limit (MW)	Max Utilization (+ Direction)	Max Utilization (- Direction)	MWh Exported from WY
Zephyr	500 kV DC	-3000	3000	100%	86.0%	5,345,027
TransWest Express (TWE)	500 kV DC	-3000	3000	100%	67.9%	9,651,943
HPX WY-CO (Laramie River – Pawnee, Windstar-Wray)	500 kV AC	-3500	3500	86.9%	20.4%	12,245,952

Comparison of WY Transmission Expansion Scenarios

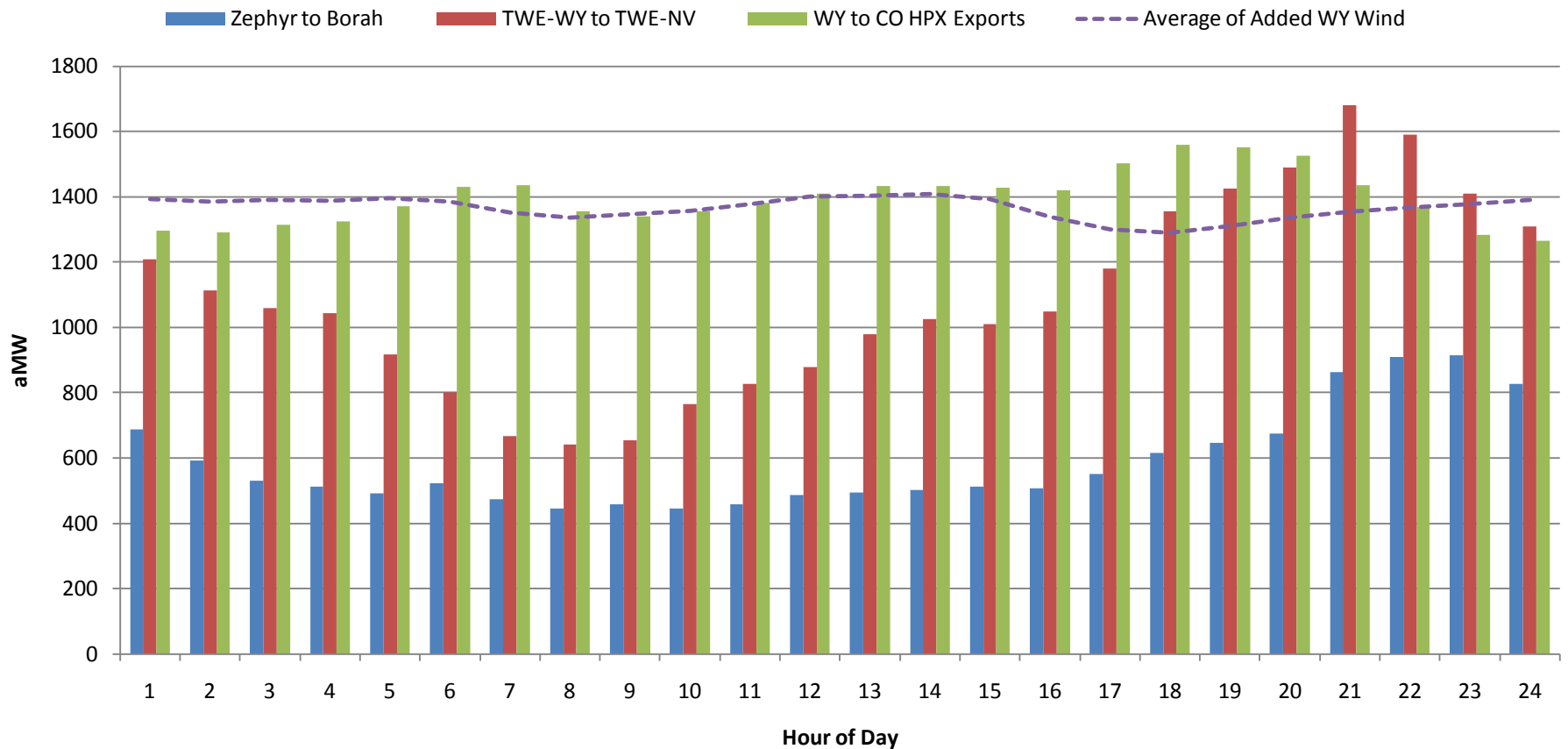
Flow Duration Plot - WY Transmission Expansion Cases

HPX WY-CO TWE-WY to TWE-NV Zephyr to Borah



Comparison of WY Transmission Expansion Scenarios

Hour of Day Flows Averaged Over the Course of the Year



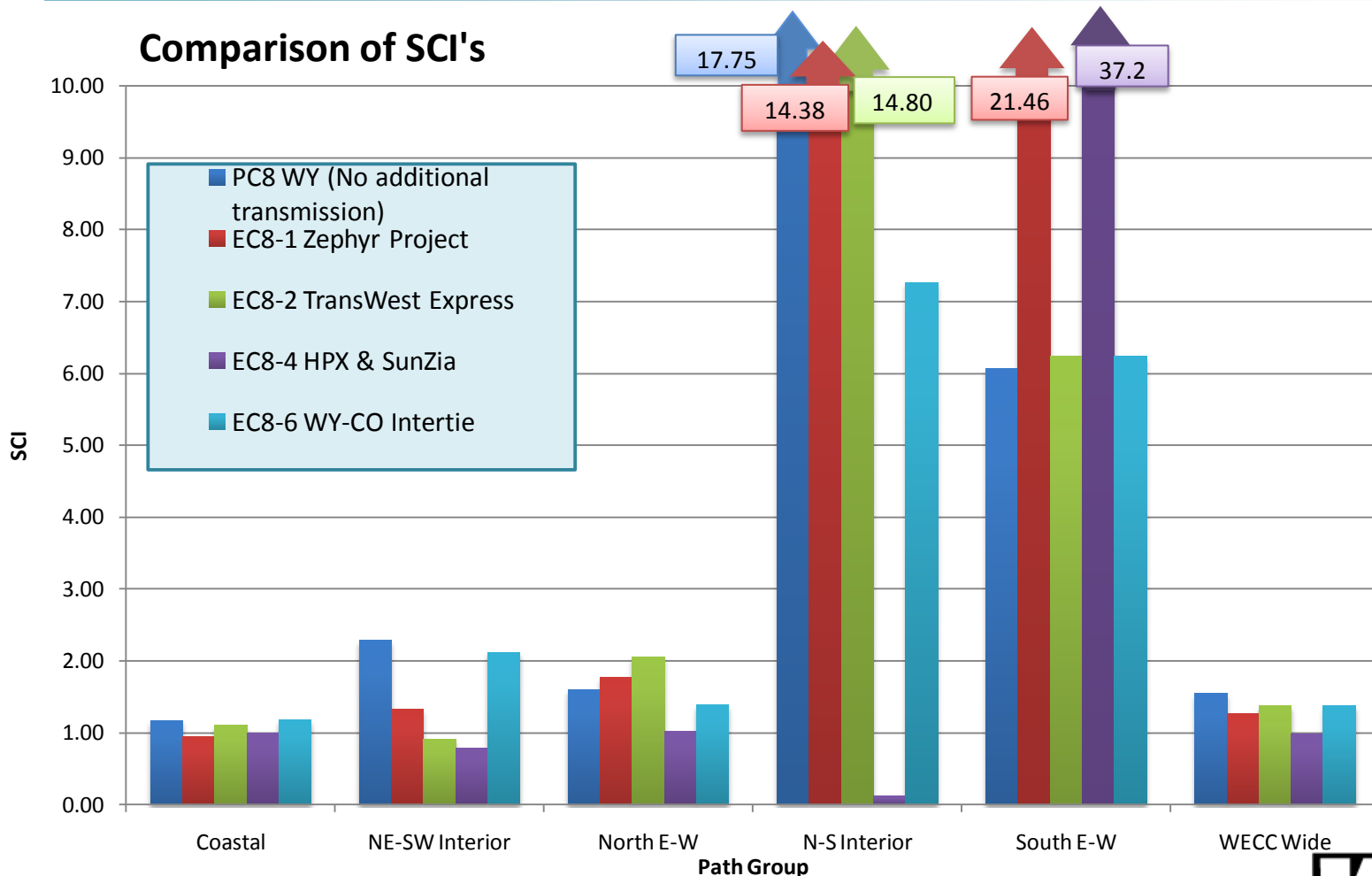
Comparison of WY Transmission Expansion Scenarios

Change in Annual Generation by State -
WY Resource Relocation and Transmission Expansion Cases Compared to PC1A Base Case



Comparison of WY Transmission Expansion Scenarios

Comparison of SCI's



Link to Additional Information

- Slide decks have been created for each resource and transmission expansion scenario run by the WECC Staff
 - As the remaining scenarios are run, slide decks with the study results will be created
- These slide decks are available on the WECC website under
 - SWG -> Documents -> 2010 Study Cycle -> 2019 Studies for 2010 Study Program*

2010 TEPPC Study Program

2029 Studies

Follow-up work from 2009 Study Program

2019 Studies

Run using updated 2019 dataset

2010 TEPPC Study Program

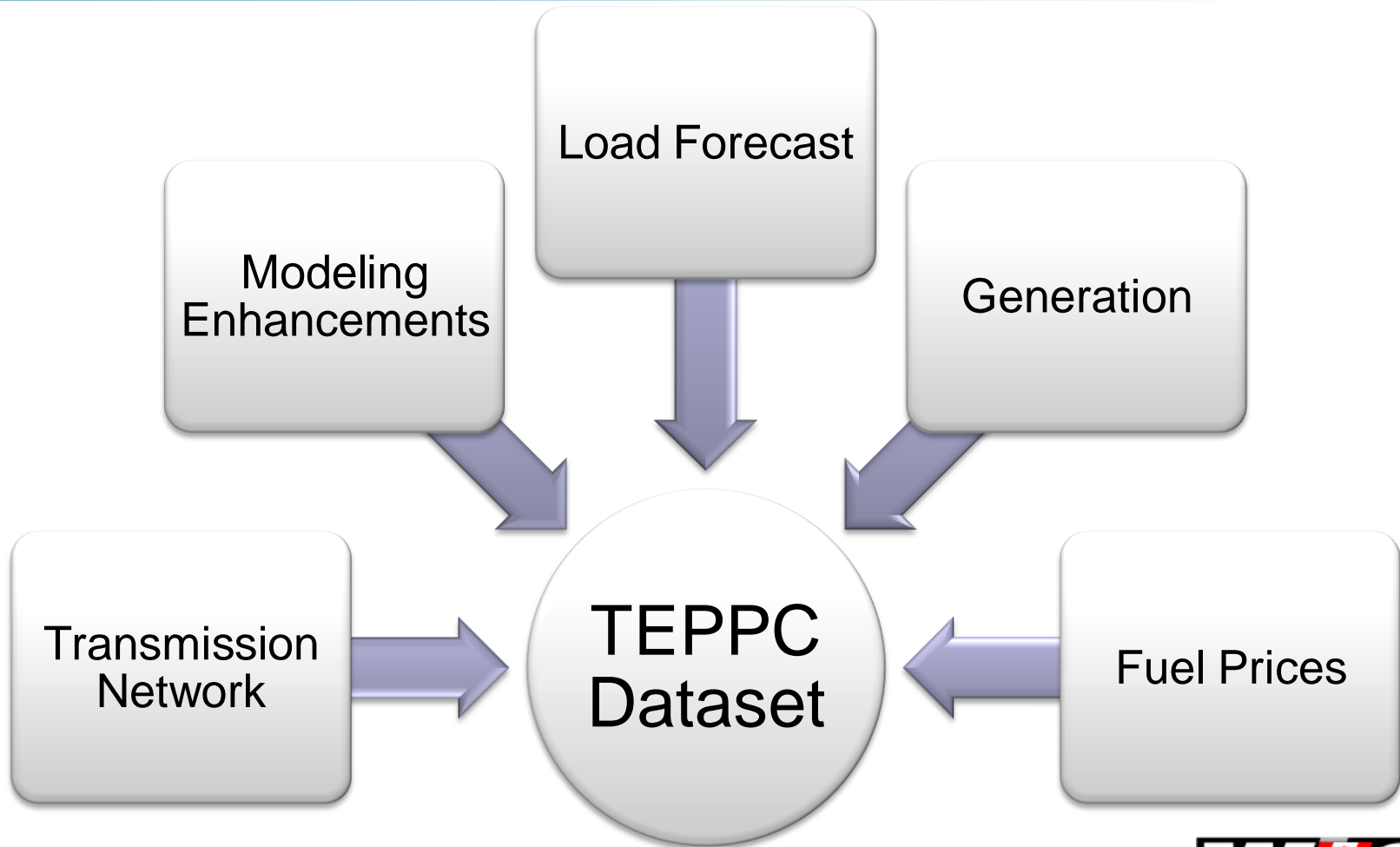
2030 Studies

Run using new Long Term Planning Tool

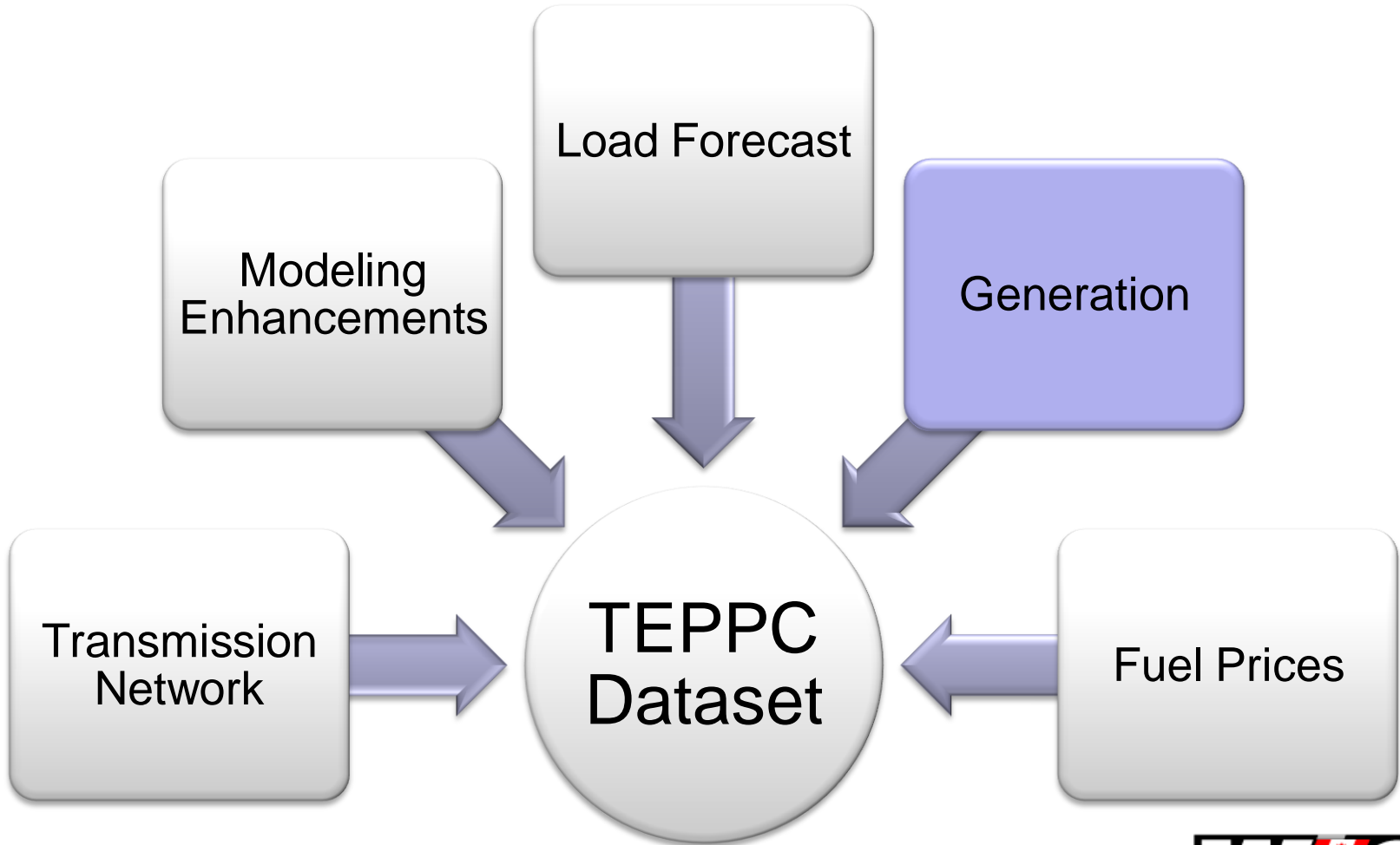
2020 Studies

Run using new 2020 dataset

2020 Dataset Update



Generation Update



Generation Update - Purpose

- Model expected generation facilities that will be available to serve load in the Western Interconnection in the year 2020
- Capture changes since previous update
- Incorporate federal and state regulatory directives, such as renewable portfolio standards and once-through-cooling

Generation Update – Data Flow

LRS

Annual Data Submittals
Additions
Retirements
Changes
Classification

DWG / MWG

Data Improvements
Modeling Changes
Validation

SWG-RG

RPS Build-out
Gap Additions
Load/Resource Balance

SPSC

IRP Analysis (LBL)
Additions
Retirements

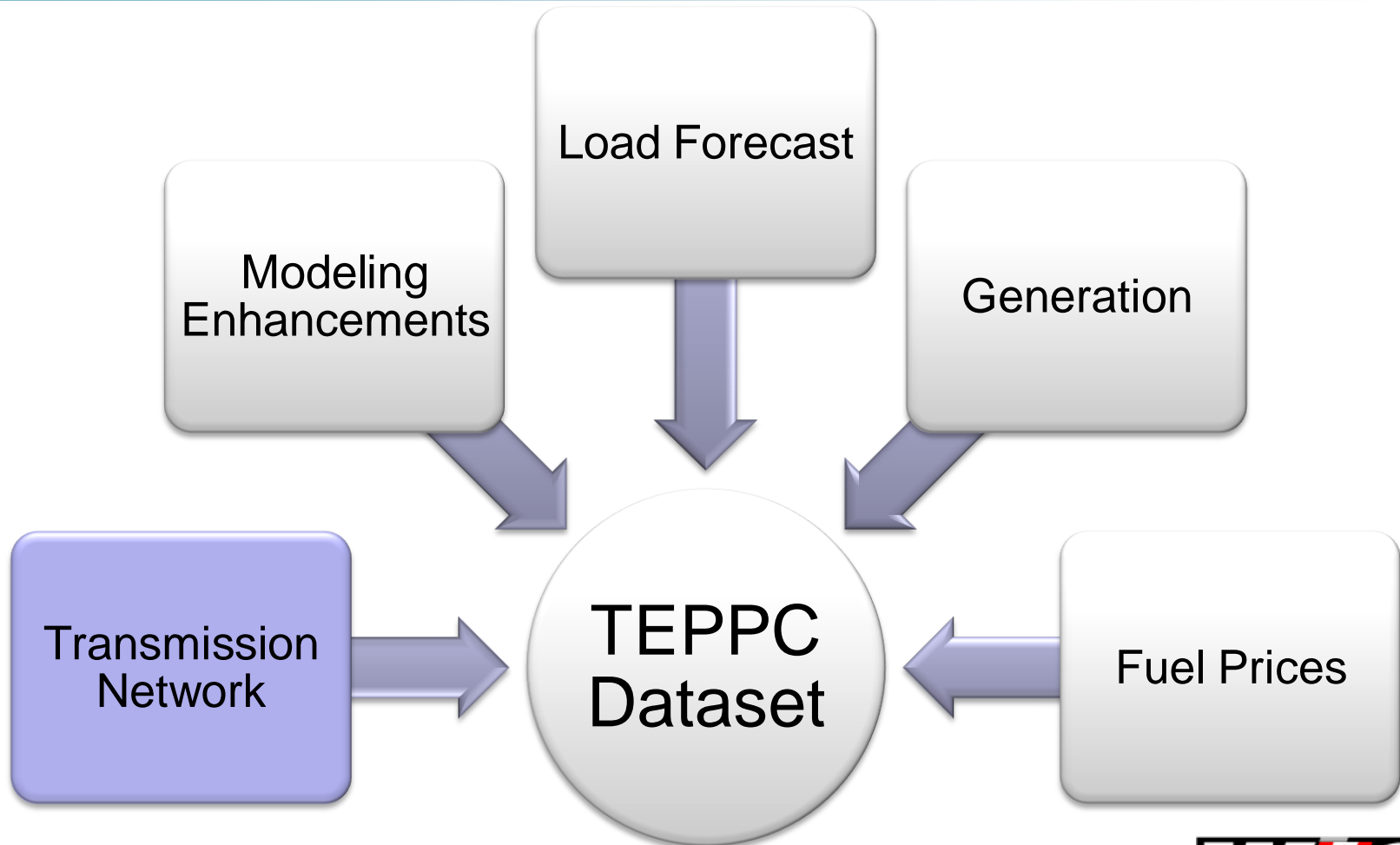


TEPPC

Generation Update - Schedule

Generation Update Process	June	July	August	September	October
1. Implement LRS Data changes	■	■			
2. Determine RPS Energy Targets		■	■		
3. Collect & Process IRP Plans (LBL + RG)		■	■	■	
4. Add RPS Generation to reach targets				■	
5. Balance Load/Gen/Imports to Planning Margin				■	
6. Develop Planned Maintenance Schedule				■	
7. Preliminary Promod Runs				■	■
8. Validation				■	■
9. Start 2020 Study Runs					■

Transmission Network Update



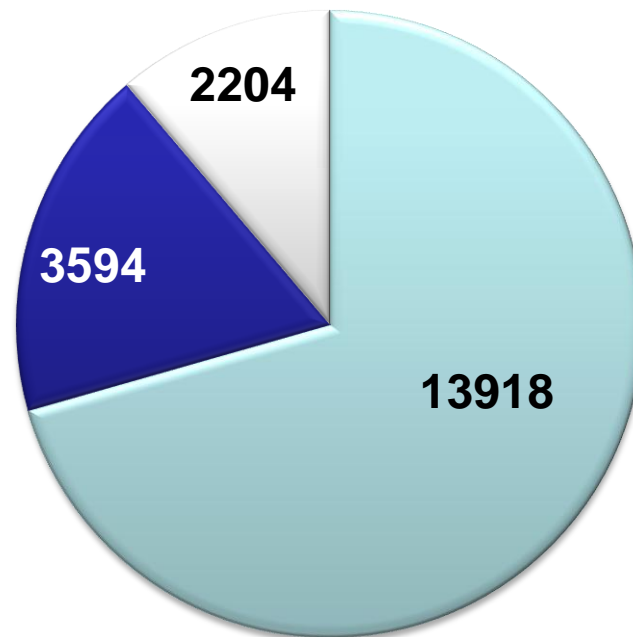
Transmission Network Update

- Process

- Replace old power flow case in 2019 dataset (2012 HS2) and remove cases that added transmission to create the 2019 dataset
- Map load and generation to new buses and new buses to areas
- Update case to include generation +/-
- Update branches with new buses

Differences Between Powerflows

Buses in 2019 & 2020 Datasets



■ In 2019 & 2020

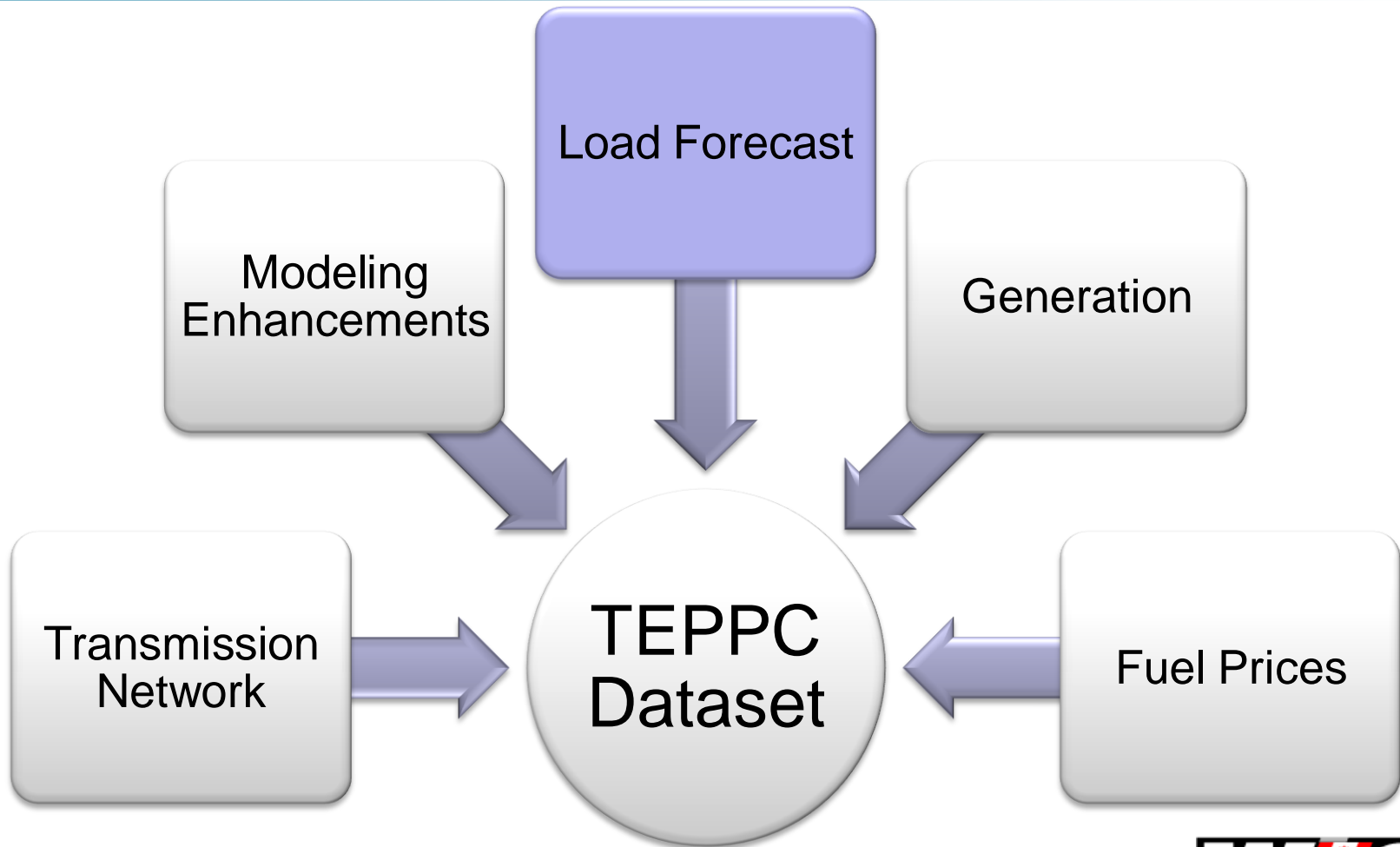
■ In 2020 & Not in 2019

■ Not in 2020 & In 2019

Transmission Network Reconciliation

- 2020 HS1 against the SCG list of foundational transmission projects
- Paths in TEPPC case vs. 2010 WECC Path Rating Catalog

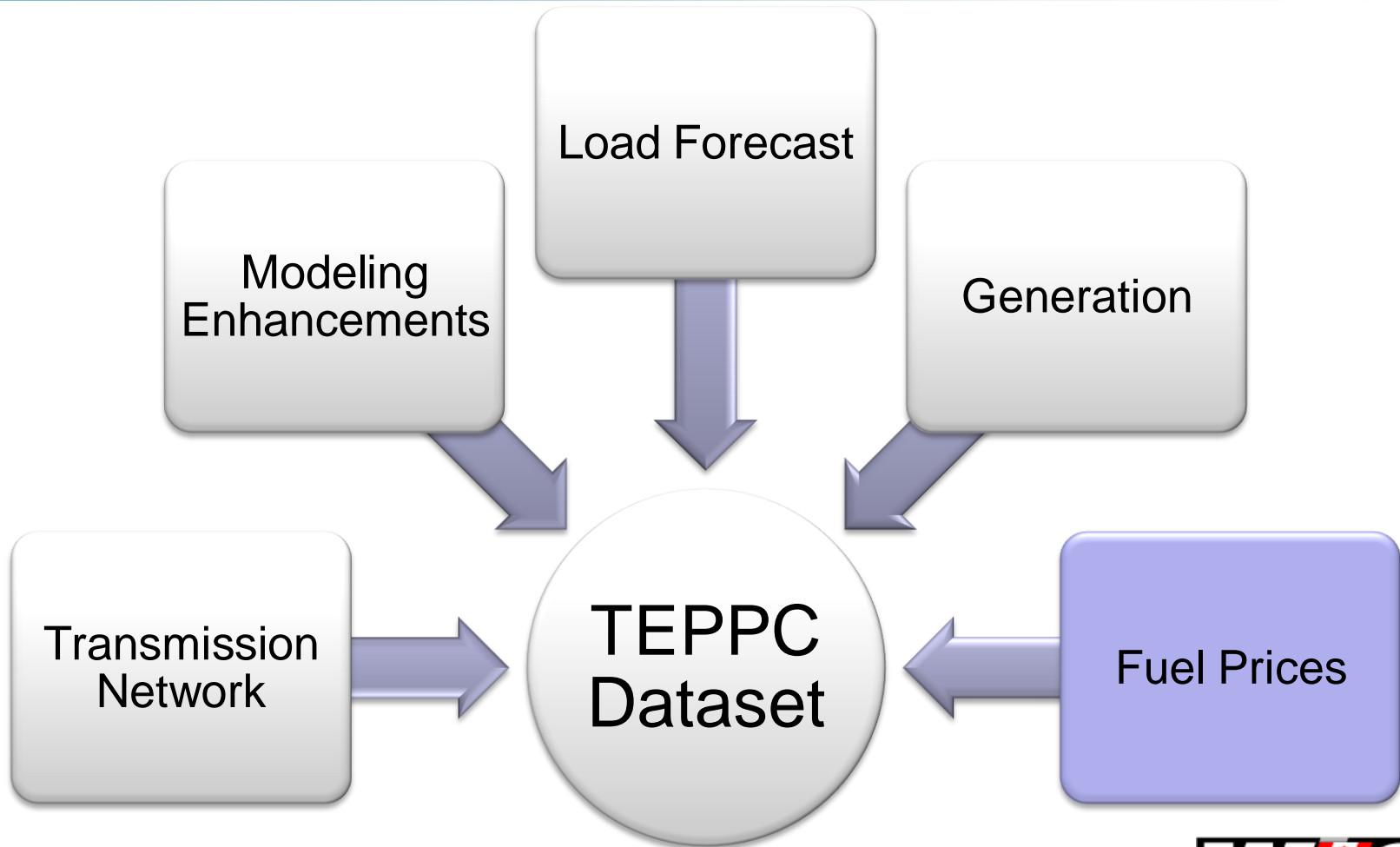
Load Forecast Update



Load Forecast Update

- Data Work Group
 - Updated loads in the TEPPC base case
 - Used 2006 historic load shapes
 - Used 2009 LRS forecast
- The Demand Side Modeling Task Force
 - With the help of Galen Barbose of LBNL¹ has developed the State-Adjusted load forecast for the SPSC Reference Case
 - Working on modeling non firm load

Fuel Price Update

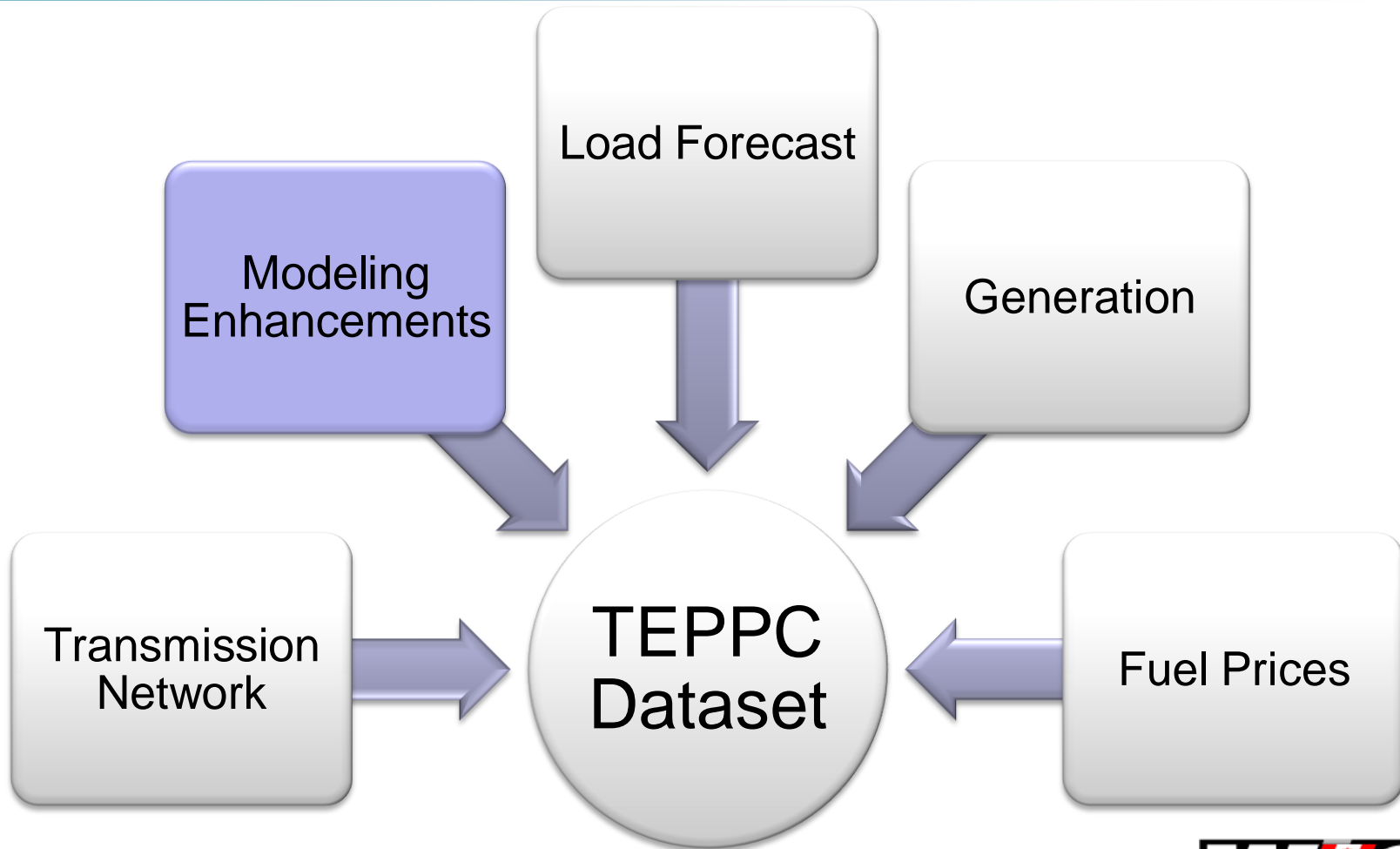


Fuel Price Update

- Data Work Group

- Updated the natural gas prices in the 2020 dataset
 - The natural gas prices and transportation costs were updated using the NPCC 6th Power Plan Methodology
 - Henry Hub Price = \$7.28 in 2010 dollars
- All other fuel prices unchanged from the 2019 dataset

Modeling Enhancements



Modeling Enhancements

- Modeling Work Group
 - Tres-Amigas Project
 - SCE Import Nomogram
 - SCIT Nomogram
 - Region to Region Dynamic Scheduling
 - Quantifying/Reporting over-generation
 - Estimating the cost of cycling large base load units Coal/CC
 - Working in conjunction with Data Work Group
- The Hydro Modeling Task Force
 - Updated hydro data to be coincident with 2006 load shapes

Questions?
