City of Columbia Pre-Council Meeting

Monday, May 16, 2022

Christian Johanningmeier, PE
Power Production Superintendent

Eric Worts, PE
Engineering Supervisor

city of Columbia

IER&MP Task Force

- Eleven voting members
  - Five from W&L Advisory Board
  - Six from Community
- Four Ad-Hoc members
- Citizen led task force with open public meetings
- Task Force met 50 times with first in July 2018
  - 2018 – 4 meeting
  - 2019 – 15 meetings
  - 2020 – 12 meetings
  - 2021 – 19 meetings

IER&MP Task Force

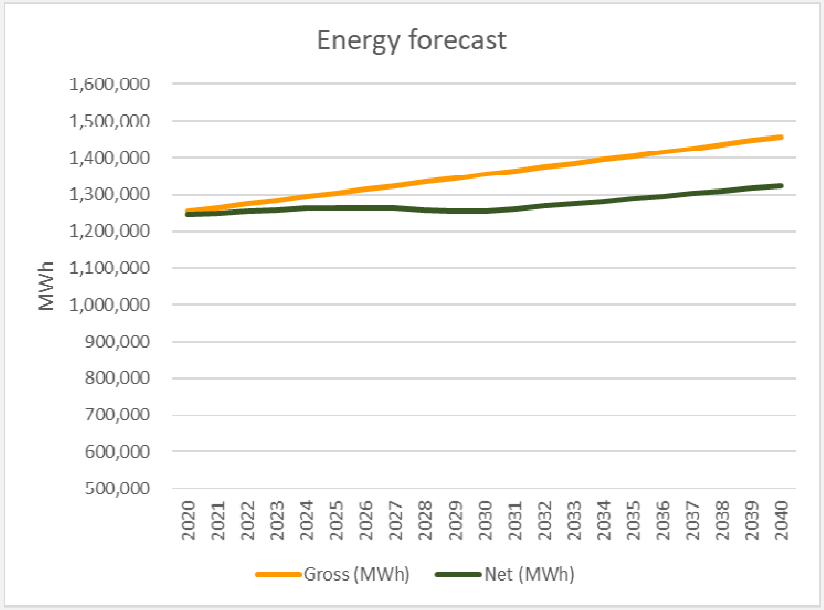
Activities

- Establish Scope of Work for the project
- Three Part Scope
- Solicit Requests for Proposals
- Review Proposals, Interview and Select Consultants
- Consultant Contracts Approved by Council – September 2019
  - - Siemens - $831,741 (Parts 1 & 2)
  - - Horizons Energy - $68,000 (Part 3)

Integrated Resource Plan

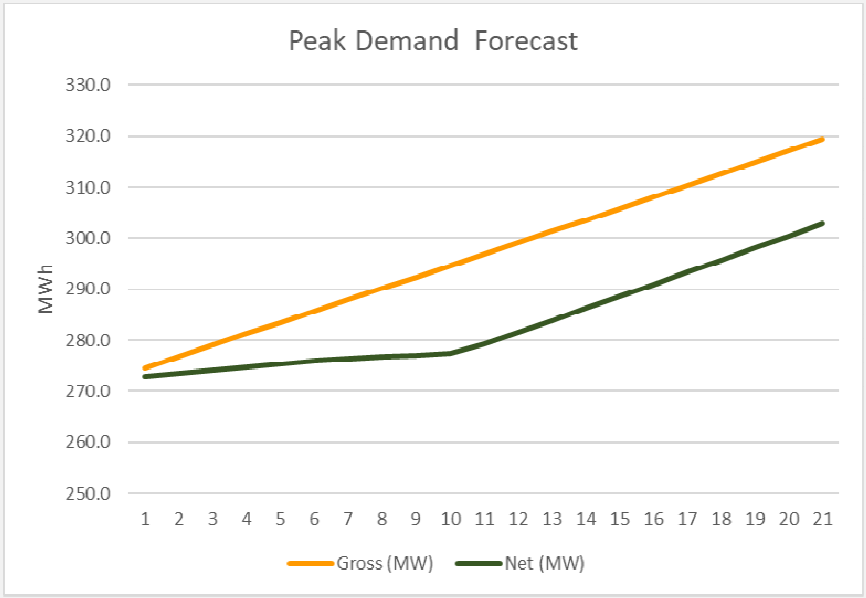
- The Integrated Resource Plan (IRP) scope of work included:
- 10 Year Load Forecast
- Evaluation of Current Contracts and Generation Assets
- Resource Portfolio and Utilization Plan
- Sensitivity Analysis
- Demand Side Management and Distributed Energy Resources
- SPP vs. MISO
- Value of Solar

Load Forecast – Energy



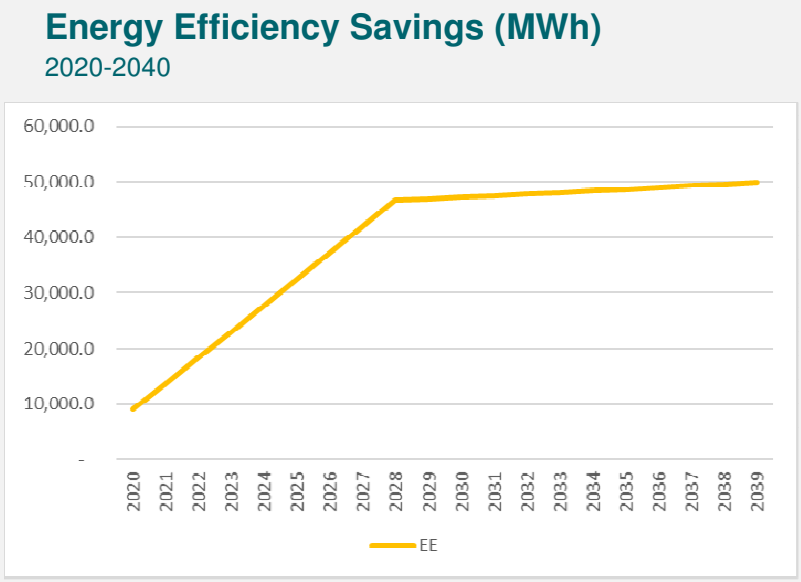
- Forecast for Energy (MWh)
- Siemens leveraged W&L forecast methodology
- Base energy consumption expected to grow
- Load modifiers applied to base forecast

Load Forecast – Demand



- W&L will remain a summer peaking utility.
- Both gross and net system peak load expected to grow

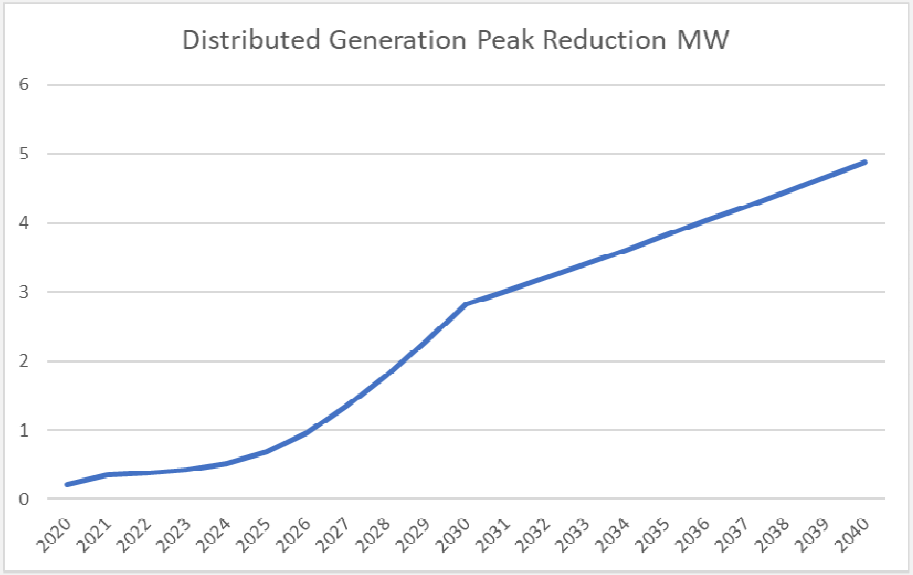
Energy Efficiency



- New energy savings expected to grow to 47,000 MWH and 17 MW of peak load reduction by 2029.

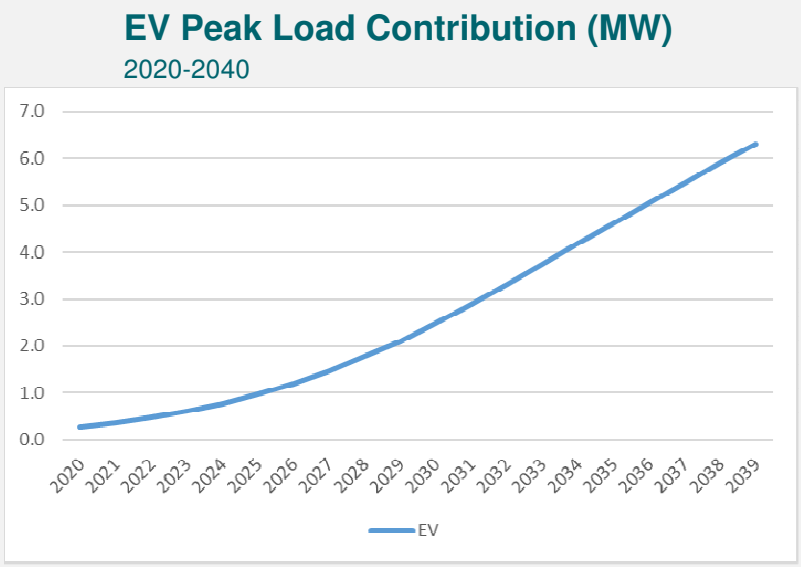
Distributed Solar

Distributed Solar Peak Reduction (MW)



- New DS to generate over 107 GWh by 2040 (7.4% of gross energy)
- Installed capacity to increase from 3.5 MW to 78 MW
- DS expected to reduce peak load by 2.0% at peak hour.

Electric Vehicles



- EV adoption in Missouri expected to lag other states
- EV Charging by 2040
  - Energy – 1.7% of load
  - Demand – 2.0% of load

Base Resource Plan

- Optimal Resource Plan Development
  - Expected Load
  - Existing Resources
  - Future Resources
- Complex model of North American market
- Numerous inputs applied and varied

Unit	Description	Fuel	Online Date	(MW)
Turbine 6	Westinghouse W171 Gas Turbine	Natural Gas	1963	12.5
Boiler 7 - Turbine 7	Westinghouse Steam Turbine	Biomass/Wood	1965	22.0
Boiler 8 - Turbine 8	General Electric Steam Turbine	Natural Gas	1970	35.0
CEC-1	GE Frame 6B Combustion Turbine	Natural Gas	2001	36.0
CEC-2	GE Frame 6B Combustion Turbine	Natural Gas	2001	36.0
CEC-3	GE Frame 6B Combustion Turbine	Natural Gas	2001	36.0
CEC-4	GE Frame 6B Combustion Turbine	Natural Gas	2001	36.0
LFG-1	GE-Jenbacher model J320GS	Landfill Gas	2008	1.1
LFG-2	GE-Jenbacher model J320GS	Landfill Gas	2008	1.1
LFG-3	GE-Jenbacher model J320GS	Landfill Gas	2013	1.1

CWL Assets Modeled

Columbia Energy Center

4 GE Frame 6B Combustion Turbines

144 MW total

W&L Assets

Steam Turbine #8 – 35 MW

Landfill Gas Plant Engine – 1 MW

Unit	Term	Fuel	PPA Begin Date	PPA End Date	(MW)	PPA Var Costs ($/MWh)	Average Capacity Factor (%)
Sikeston	Life of Plant	Coal	October 1983	12/31/2030	66	$23.82	88%
Iatan	Life of Plant	Coal	January 2011	Life of Plant	20	$14.90	50%
Prairie State	Life of Plant	Coal	2012	Life of Plant	50	$11.48	75%
Ameresco	20-yr PPA	Landfill	4/1/2009	4/1/2029	3.2	$52.50	77%
Bluegrass Ridge (AECI)	20-yr PPA	Wind	6/1/2007	6/1/2027	6.3	$58.25	22%
Crystal Lake III (1st PPA)	20-yr (Under renewal extension & retrofit)	Wind	2/11/2012	12/31/2040	21.0	$45.01	36%
Crystal Lake III (2nd PPA)	20-yr (Under renewal extension)	Wind	1/1/2017	12/31/2040	27.0	$20.41	36%
Capacity Contract (Dynegy)	10-yr	N/A	2017/2018 Planning Year	2026/2027 Planning Year	5 - 45	$2.50 - $4.60/kW-month	N/A
Total					231.5		

Existing PPAs Modeled

Unit	Term	Fuel	PPA Begin Date	PPA End Date	(MW)	PPA Var Costs ($/MWh)	Expected Capacity Factor
Truman Solar	20-yr PPA	Solar	12/31/2020	12/31/2040	10.0	$44.8	25%
Boone-Stephens	20-yr PPA	Solar	12/31/2023	12/31/2053	64.0	$31.7	26%
Iron Star	20-yr PPA	Wind	1/1/2024	1/1/2044	35.0	$21.0	40%
Total					**109.0**		

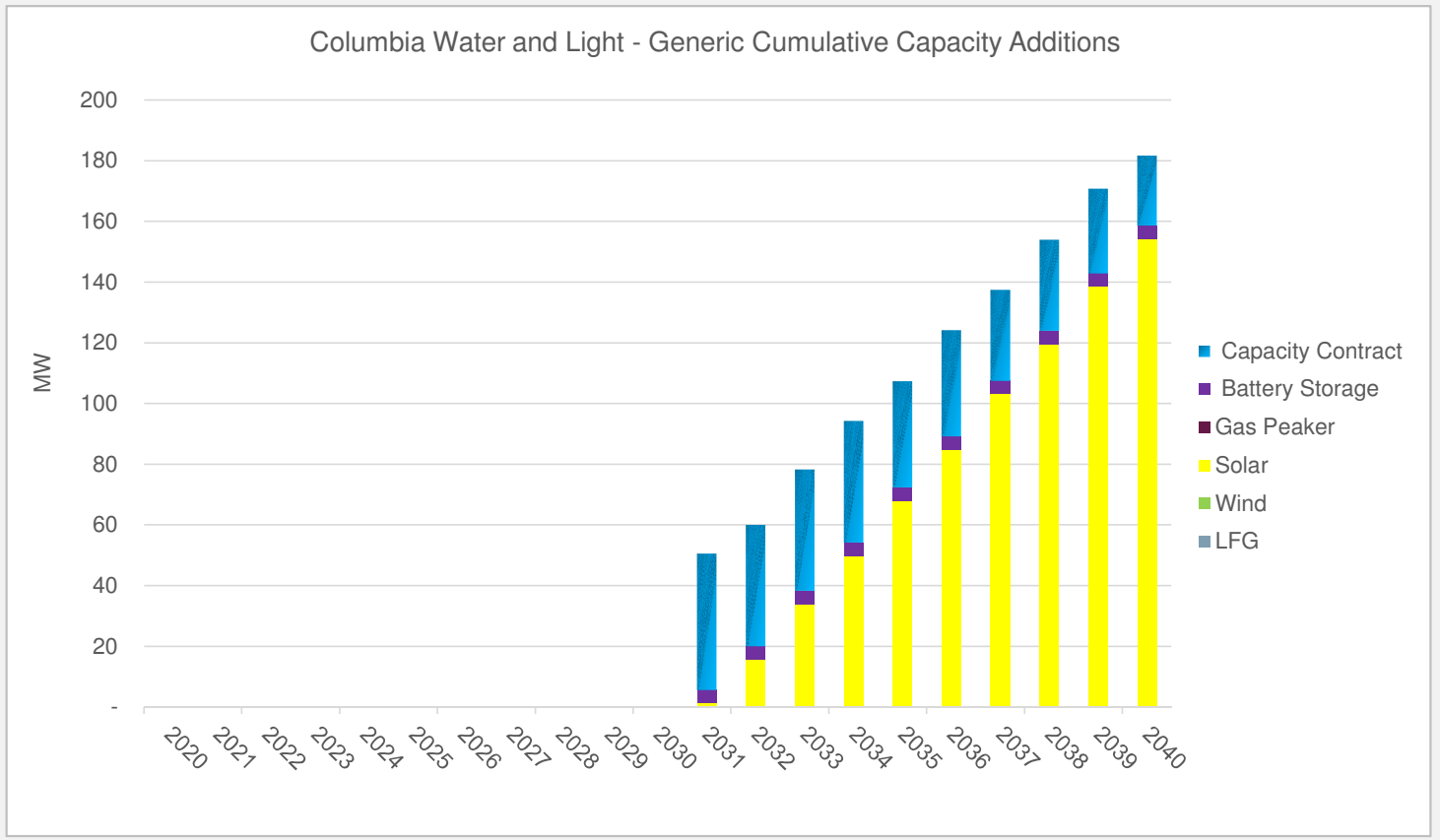
New Renewable PPAs Modeled

Truman Solar

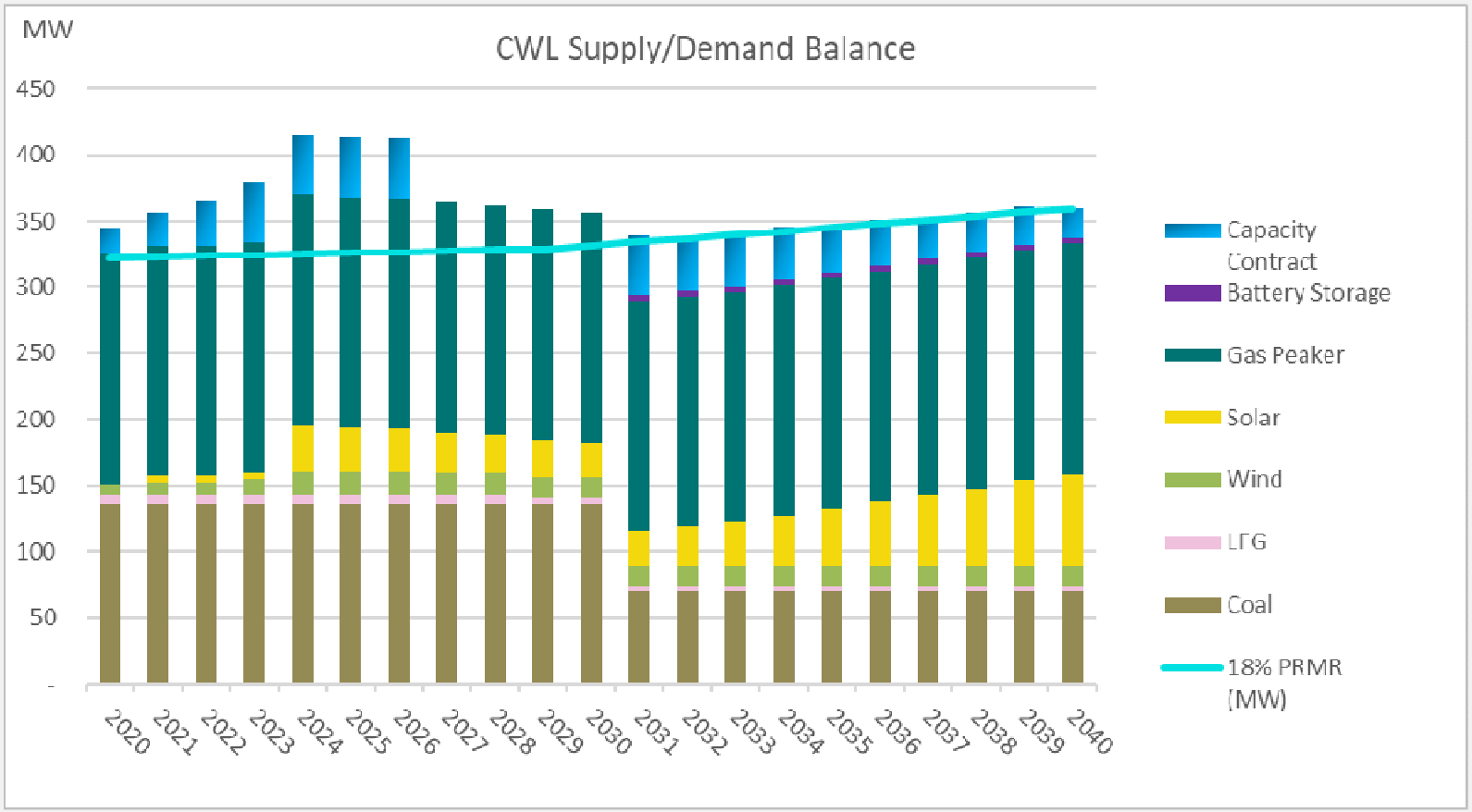
10 MW project located east of Columbia

New Plant Parameters (2019$/kW)								
Technology	Fossil			Renewables				
	Small Aero Simple Cycle	Small Aero Simple Cycle	RICE	Utility Solar PV - Single Tracking	Onshore Wind	Biomass	Landfill Gas	Lithium Ion Batteries
Definition	1x0, LM6000	LM2500	2x0 Wartsila 18V50SG	Single Axis Tracking	Onshore Wind	Biomass	4x9.1 MW RICE, power only	4 hour battery
Fuel	Natural Gas	Natural Gas	Natural Gas	Sun	Wind	Woodchips	Landfill Gas	N/A
Construction Time, Yrs	2	2	2	2	3	3	1.5	<1
Size (MW)	47	30	36	25	25	25	35.6	20 MWh
Baseload Heat Rate, Btu/kWh, ISO, HHV	9,204	9367	8,290			13,300	8,513	N/A
Average Heat Rate, Btu/kWh, ISO, HHV	9,779	9508	8,927					N/A
VOM, 2019$/MWh	5.70	3.18	4.80	na	na	6.03	6.2	0
FOM, 2019$/kW-yr	24.62	63.51	11.33	19.54	37.57	116.64	20.10	20.80
Operating Life, yrs	30	30	30	30	25	40	30	
Capacity Factor *	10%	10%	10%	25%	41%	85%	85%	14%

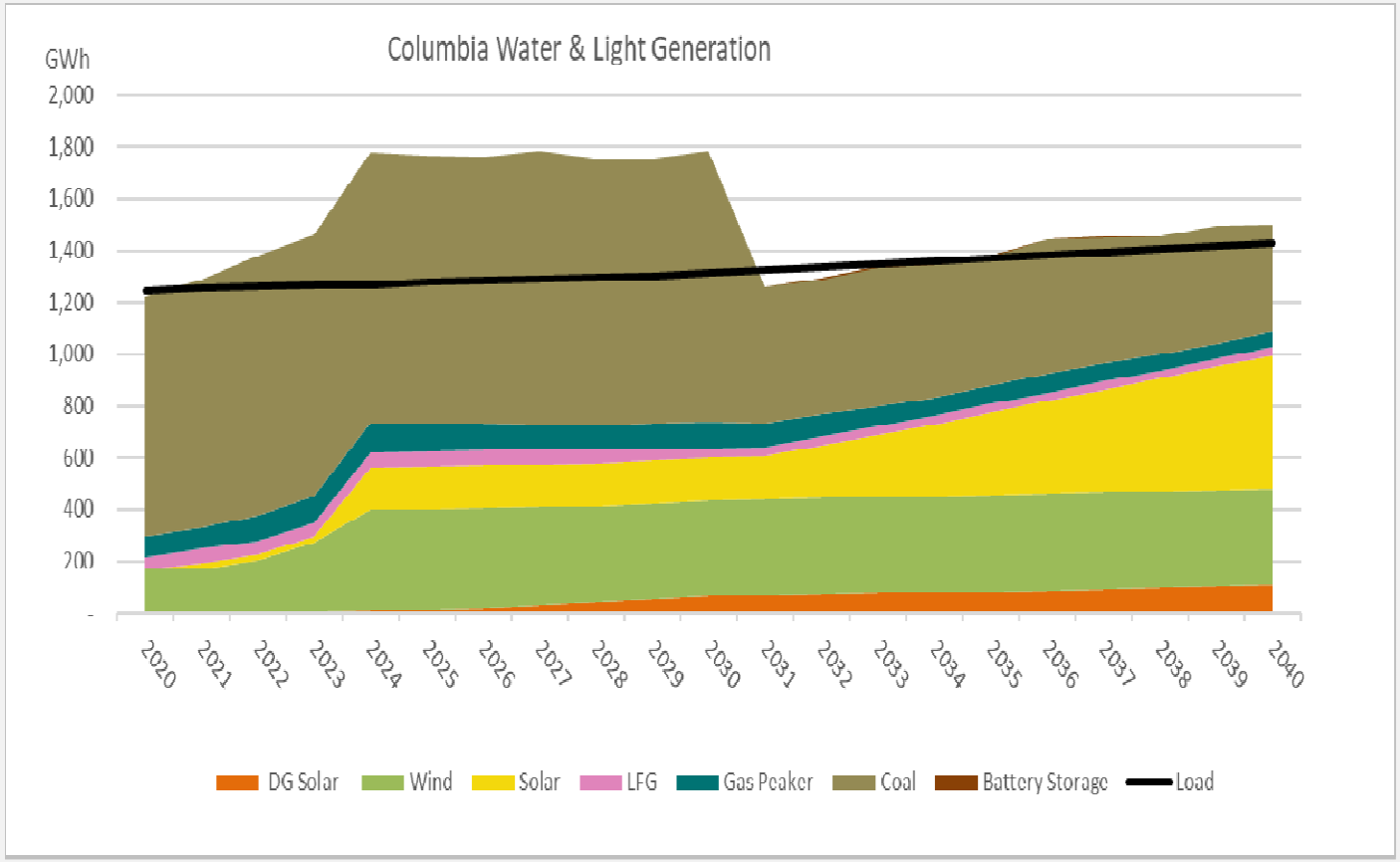
New Technologies Considered for Expansion Plan



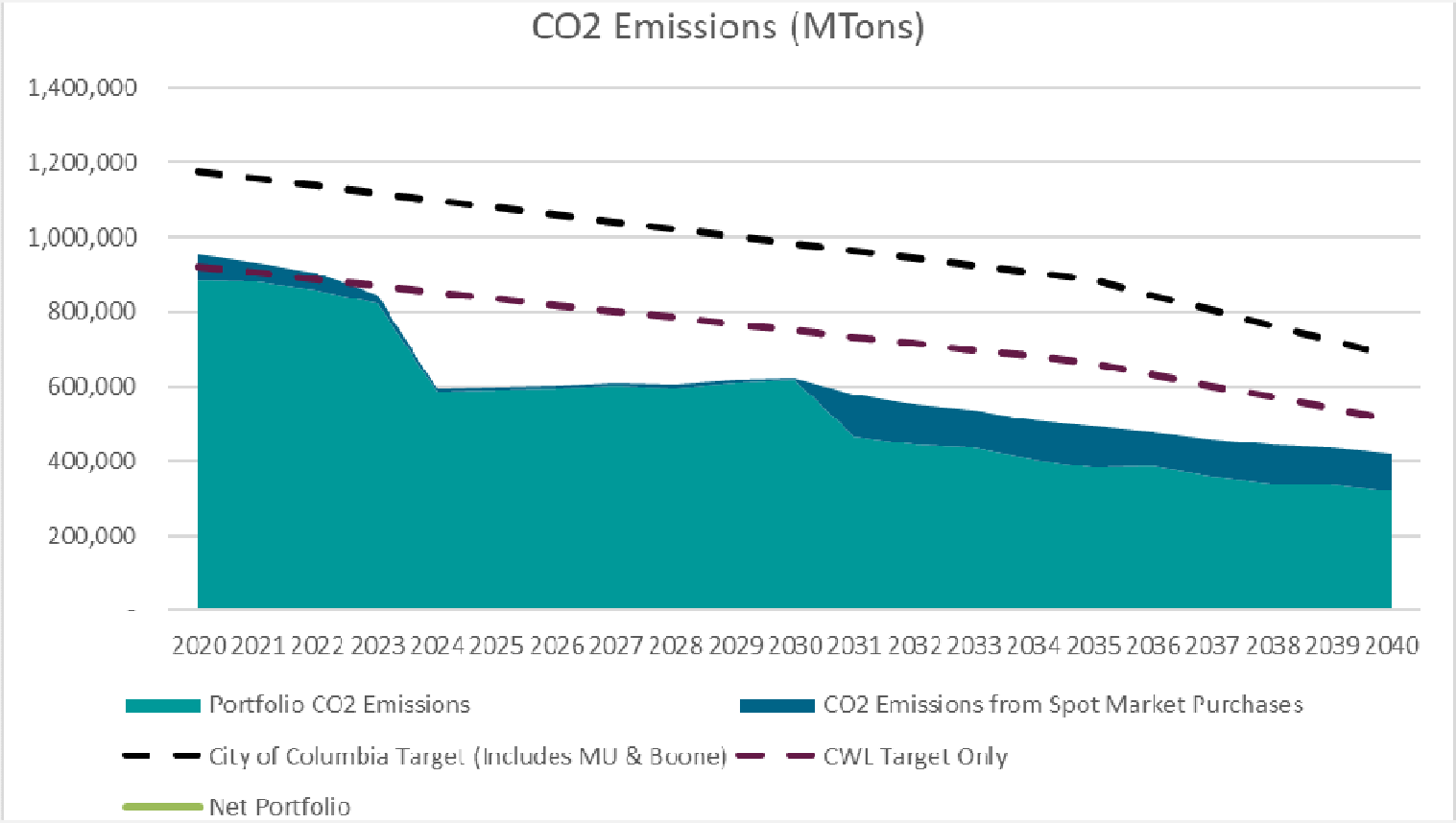
Future Capacity Additions



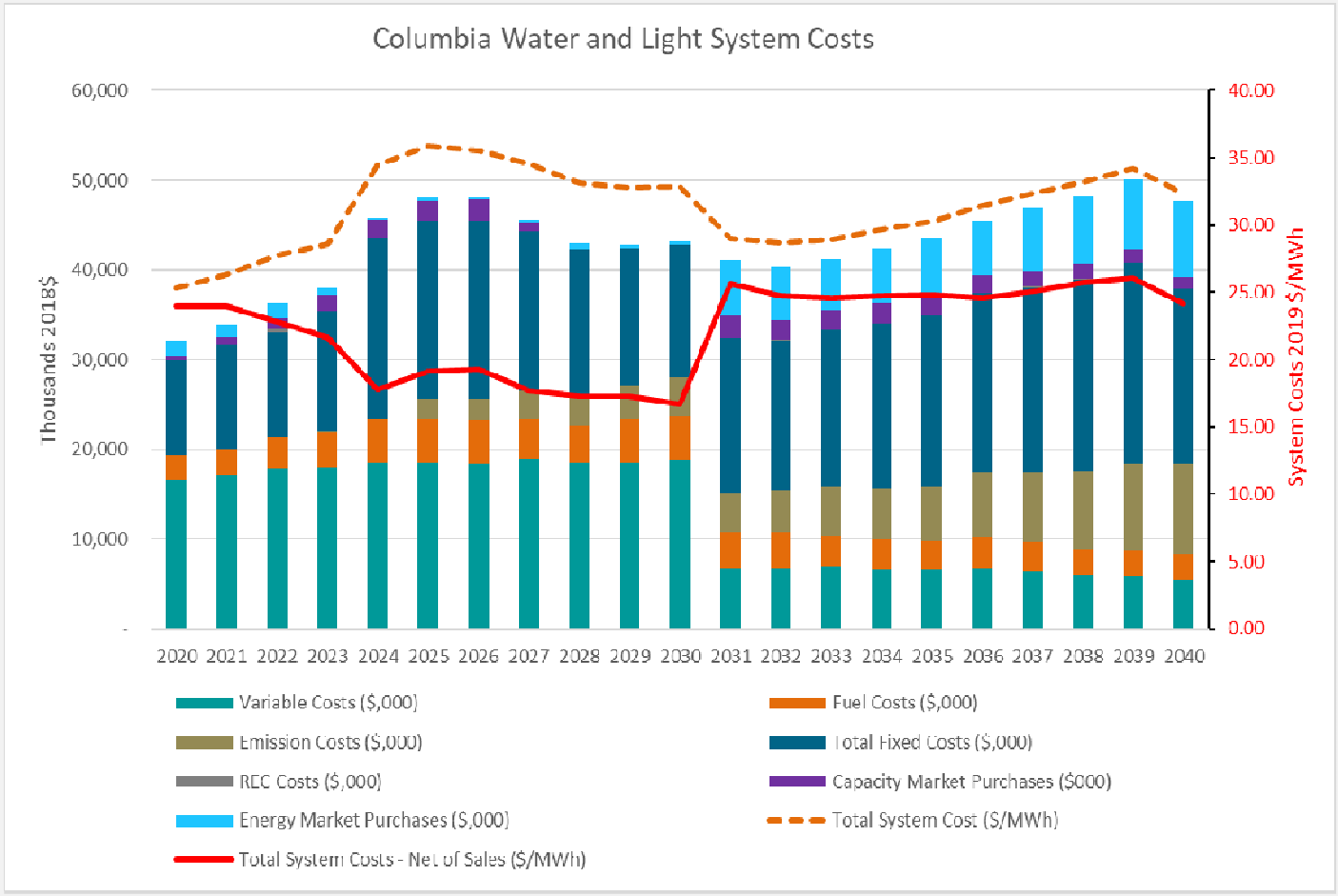
Future Capacity Mix (MW)



Future Generation Mix (MWh)



Declining CO2 Emissions



Forecast System Costs

Base Plan Observations

- Base plan developed to be in compliance with existing RPS and CAAP goals on net energy basis.
- Uncertainty related to Sikeston retirement is very important.
- Current market conditions are significantly different than at time Siemens did their analysis.
- All W&L resources projected to remain in service, and must do so pending significant transmission investment.

Base Plan Observations

- Future changes to MISO capacity requirements and markets may impact how CWL choses to meet it obligations.
- Capacity markets are becoming increasingly constrained as major assets are retired.
- Further evaluation of existing long-term coal PPAs is appropriate.

Sensitivity Analysis

- Scenario analysis used to test base case sensitivities.
- Scenarios were developed by the Task Force.
- Optimal solutions developed for each scenario based upon changes in model inputs.
- Solutions included suggested portfolios and estimated costs.
- Seven scenarios were analyzed.

Scenario Element	Reference Case	High Technology case	High Regulatory case	High economic growth	Mid Term Utility Renewable	Early Utility Renewable (regardless of what the rest of country does, probably not a climate crisis scenario)	High Seasonal Load (hotter summers, and increased loads from electrification and colder winters)	Recession Economy (what happens if we enter long recession that slows investment in new EV and furnaces, etc.)
City Goal of 80% Carbon Reduction **	2050	2050	2050	2050	Prior to 2040	Prior to 2030	2050	2050
City Goal of 100% Carbon Reduction **	2060	2060	2060	2060	2040	2030	2060	2060
Electric Utility at 100% Renewable	2050	2050	2050	2050	2040	2030	2050	2050
Economic Growth	Base	High	Low	High	Base	Base	Base	Low
Regional load	Base	Base	Low	High	Base	Base	High	Low
Transmission Permitting hurdle	Base	Base	Base	Base	Base	Base	Base	Base
Thermal Capital costs	Base	Base	Base	Base	Base	Base	Base	Base
Renewables and Battery Storage Capital costs	Base	Low	Base	Base	Base	Base	Base	Base
DSM, EE, DR Penetration	Base	High	Low	Base	High	High	Base	Base
Delivered coal prices	Base	Base	High	Base	Base	Base	Base	Low
Delivered natural gas prices	Base	Low	High	Base	Base	Base	Base	Low
CO2 Emission Prices *	Base	Low	High	Base	Base	Base	Base	Low
Electric Vehicle Penetration	Base	High	Base	High	High	High	High	Low
Electrification for Heating	Base	High	Base	High	High	High	High	Low
DER (Solar, CHP)	Base	High	High	High	High	High	Base	Base
Fracking and Methane regulations	Status Quo	Status Quo	Stringent	Status Quo	Status Quo	Status Quo	Status Quo	Status Quo
Coal Emissions and Waste Regulations	Status Quo	Status Quo	Stringent	Status Quo	Status Quo	Status Quo	Status Quo	Status Quo

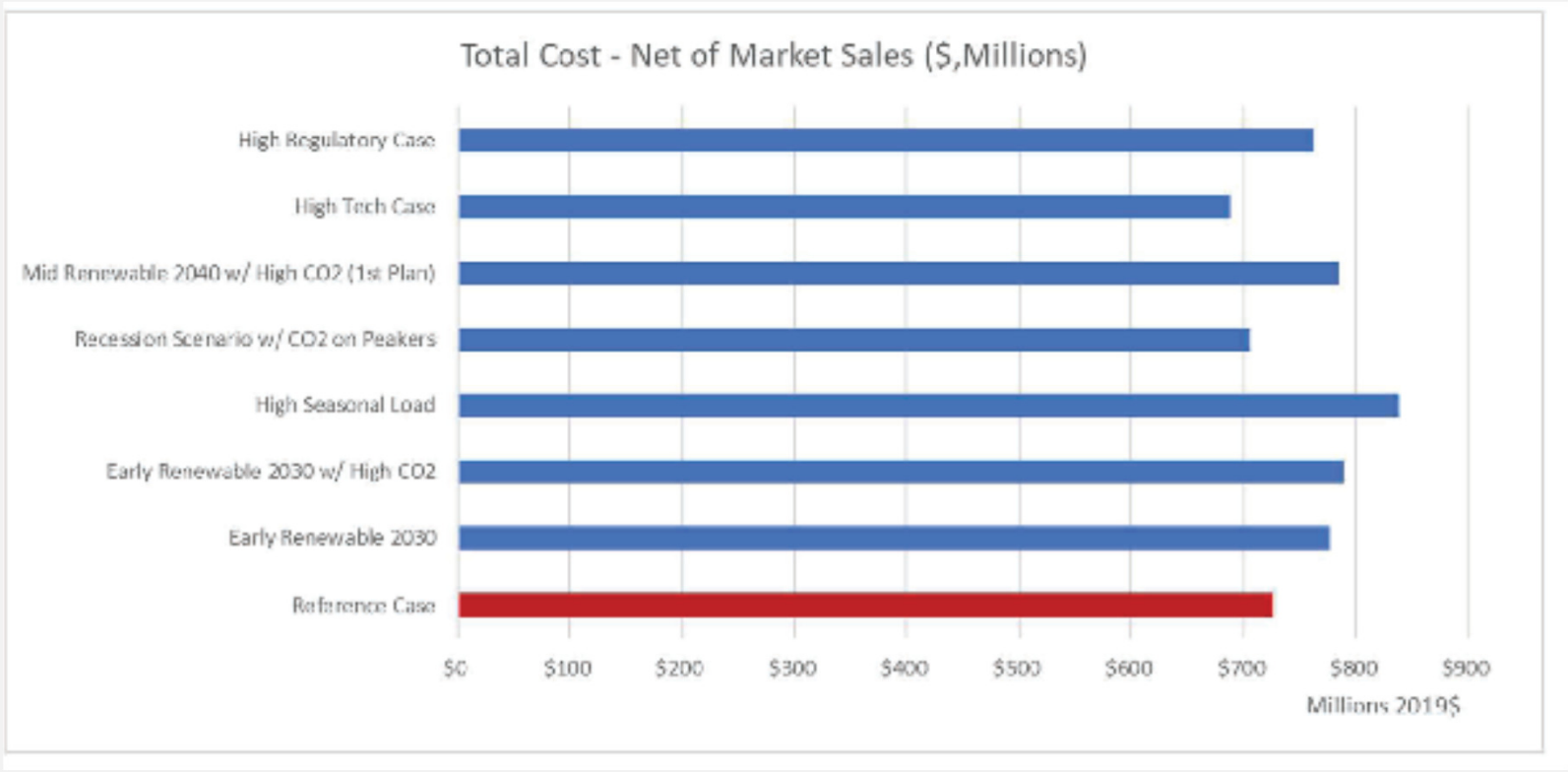
* Base assumes Siemens Reference Case Carbon pricing starting in the mid 2020s. Low stands for near zero pricing.

** Assumes a Net Zero Carbon Goal

Scenario Analysis Matrix

Technology	Reference Case	Early Renewable 2030	High Seasonal Load	Recession Scenario	Early Renewable 2030 w/ High CO2	Mid Renewable 2040 w/ CO2 (1st Plan)	Mid Renewable 2040 w/ CO2 (2nd Plan)	High Tech Case	High Regulation Case
LFG	0	0	0	0	0	0	0	0	0
Wind	0	68	20	22	38	84	90	54	8
Solar	154	175	159	81	213	129	94	0	46
Gas Peaker	0	0	18	0	0	0	18	54	18
Battery Storage	4	2	1	0	0	1	10	0	0
Max. Capacity Purchased Single Year	45	5	48	20	0	15	5	50	20
Biomass	0	0	0	0	0	0	0	0	0
Total Installed Capacity Excluding Capacity Market Purchases (MW)	**159**	**246**	**198**	**102**	**251**	**214**	**212**	**108**	**71**
Total Renewable + Storage	**159**	**246**	**180**	**102**	**251**	**214**	**194**	**54**	**53**

Expansion Plans Across Scenarios



NPV of Cost Across Scenarios

Scenario Analysis Observations

- An optimal portfolio was not calculated.
- Scenarios are not possible choices that can be picked.
- The scenarios are snapshots of the view of the future when the analysis was done.
- Current market conditions are significantly different than at the time the analysis was completed.
- Use Levelized Cost Of Energy (LCOE) with caution.

Renewable Observations

- Moving forward, what does 100% renewable mean?
  - Net-zero vs. absolute zero?
  - Energy only?
  - What reconciliation period?
    - Yearly, monthly, weekly, daily, hourly or 5-minute.
  - What about capacity?
  - What about RECs?

- Current CWL practice and the Siemens study is based on net-zero energy only basis with an annual reconciliation period.

Demand Side Management

- Siemens initially looked at DSM at a high level and estimated impact on load.
- Siemens delivered a supplement report.
- W&L has a long history with DSM programs.
  - Energy Star Partner - Sustained Excellency Award (3rd time)
  - 2021 savings was 129% of projected saving from 2012 IRP
  - $7.5 million spent in local economy of upgrades in 2021
- Staff will bring further recommendation in future.

MISO vs. SPP

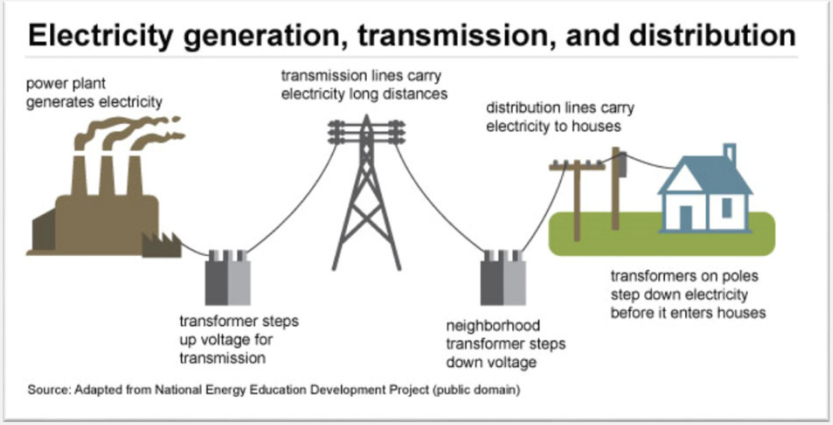
- Siemens analysis looked at the availability of potential future resources in each market, particularly renewable.
- Operational impacts were not considered.
- Staff agrees with Siemens recommendation to remain in MISO.

Value of Solar

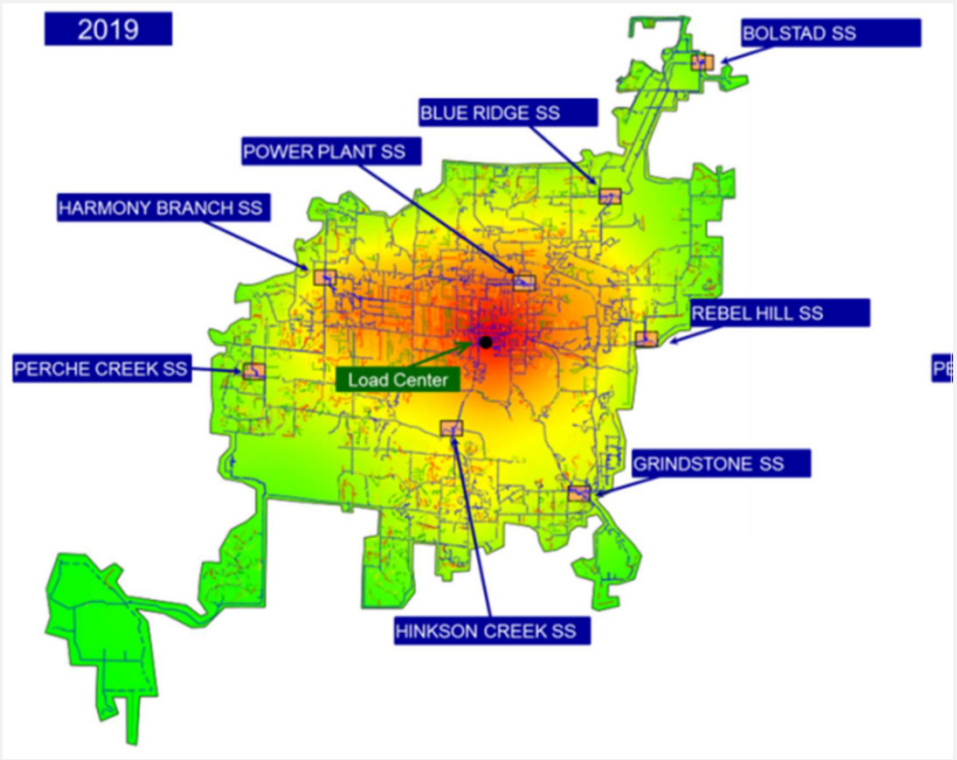
- Requested by Task Force.
- Staff finds the methodology used to be sound and accurately calculates the savings and/or avoided costs accruing to CWL from customer owned solar.
- Analysis of limited use at this time.
- Reference frames are important

Master Plan

- The Master Plan is a Study of the Transmission and Distribution Infrastructure In Columbia
- Spatial Load Forecast
- Substation Expansion
- Distribution System Assessment
- Transmission System Assessment
- Smart Grid Initiatives and AMI
- Capital Projects Review

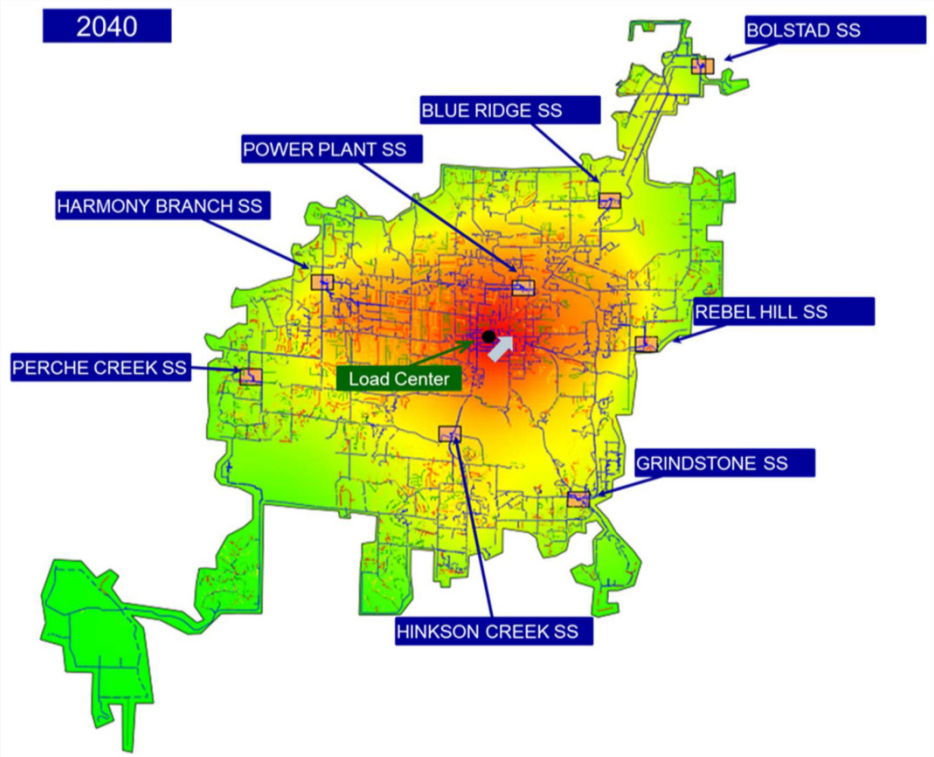


Spatial Load Forecast



- Economic and Population Data
- Zoning Data
- Load Forecast and Modifiers from IRP
- Assign to Green Field Areas Likely to Develop

Spatial Load Forecast



- Created as a Tool to Facilitate the Master Plan
- Growth is Hard to Predict
- No Redevelopment
- No Electrification
- No Temperature Variance

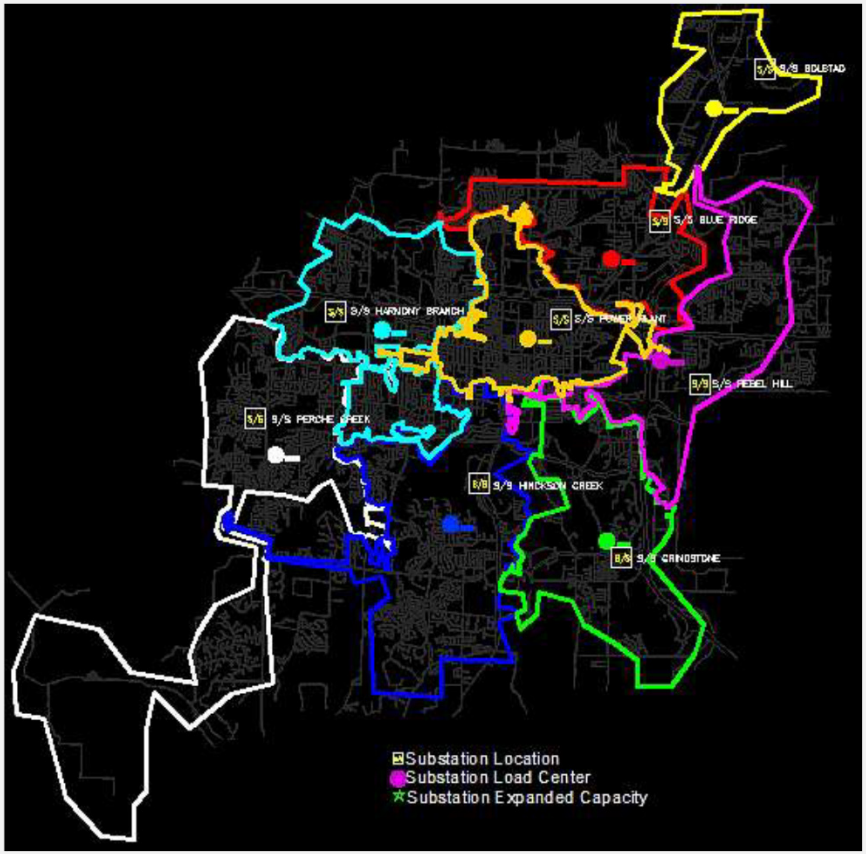
Substation Expansion

Substation	2020 Peak	% Load (N-1)
Bolstad	24.2 (MVA)	108%
Blue Ridge	23.4	106%
Harmony Branch	40.5	91%
Power Plant	51.3	115%
Rebel Hill	31.7	113%
Perche Creek	36.1	161%
Hinkson Creek	45.2	101%
Grindstone	41.7	93%

- 8 Substations
- Plan for Loss of a Transformer
- Report Calls for 4 new Transformers
- Perche Creek in Critical Need

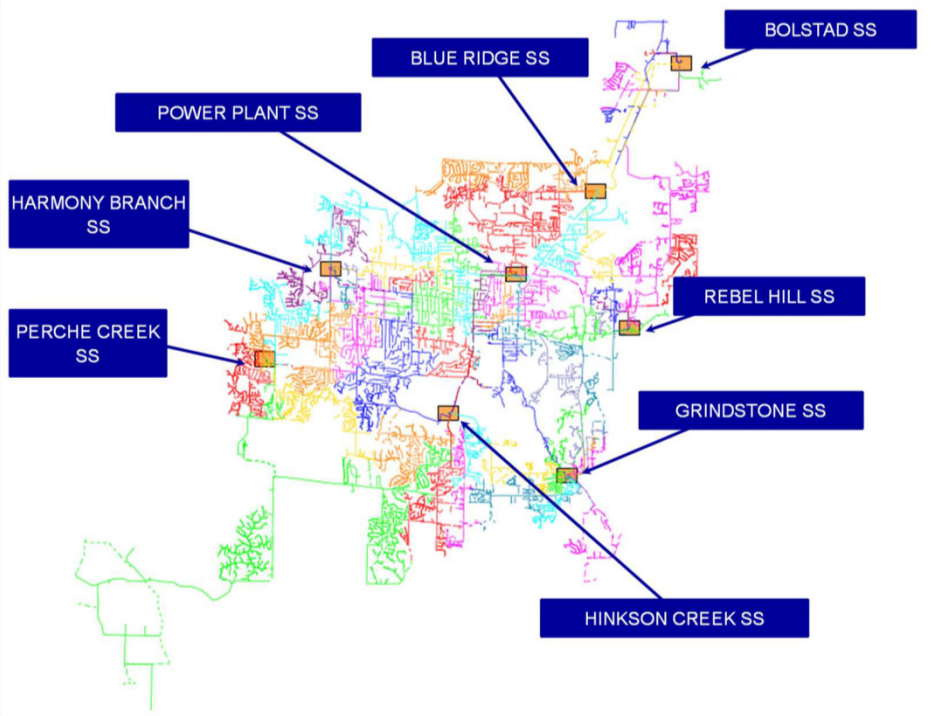
Perche Creek Substation

Substation Coverage



- Proactive vs Reactive Expansion Plan
  - Try to have spare capacity at every substation
- New Substation vs. Expanding Existing
  - Some substations difficult to expand
  - New substation closer to load center

Distribution System



- 60 Feeders
- Over 52,000 Customers
- Commercial, Residential and Industrial Have Different Needs

Distribution Elements

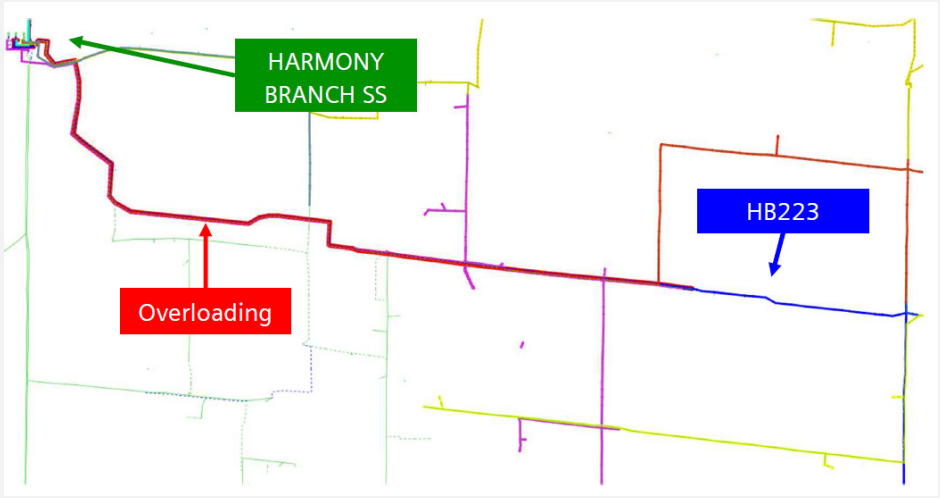
Pole Mount Transformers

Pad Mount Transformer

Typical Elements

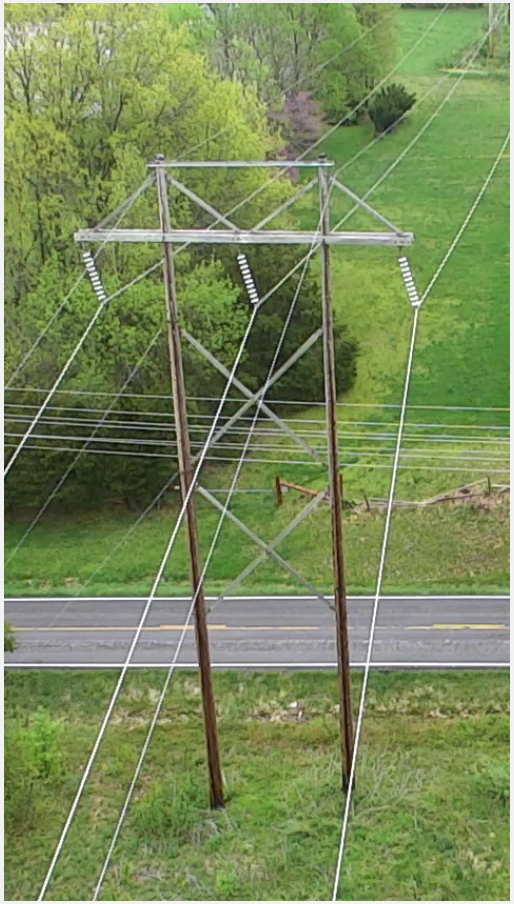
- Poles
- Conduits
- Cables
- Switches
- Fuses
- Capacitors
- Transformers

Distribution System Assessment

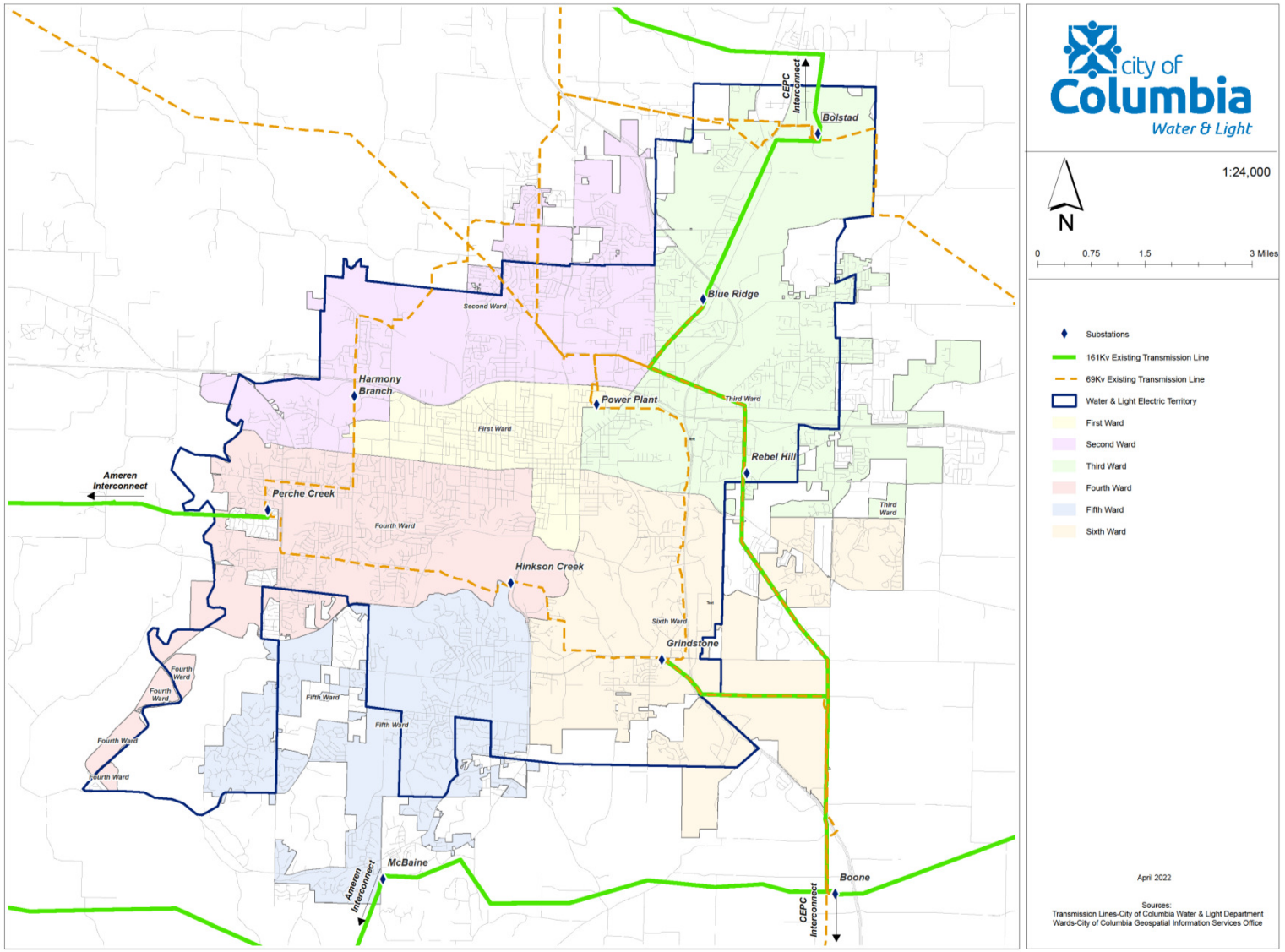


- Recommended Plan Based on Spatial Load Forecast
- Distribution Expansion is a Natural Consequence of Growth
- Water and Light has a Good Reliability Record

Transmission System



- 161kV Transmission Lines for Importing Power Regionally
  - Ameren and Associated Electric (AECI)
- 69kV Sub-Transmission Lines for Local Power Delivery
  - Fulton, University, and Central Electric Power Cooperative
- 4 Gas Turbine Generators at Columbia Energy Center (144 MW)
- 1 Gas Boiler-Steam Turbine and 1 Gas Turbine at Municipal Power Plant (47.5 MW)



city of Columbia
Water & Light

1:24,000

N

0 0.75 1.5 3 Miles

- Substations
- 161Kv Existing Transmission Line
- 69Kv Existing Transmission Line
- Water & Light Electric Territory
- First Ward
- Second Ward
- Third Ward
- Fourth Ward
- Fifth Ward
- Sixth Ward

April 2022

Sources:
Transmission Lines-City of Columbia Water & Light Department
Wards-City of Columbia Geospatial Information Services Office

Transmission System Challenges

- Columbia is Located “At the Seams” Between MISO and Other Entities (AECI, TVA, SPP)
- Columbia Relies Heavily on 69kV Sub-Transmission
- Large Addition of Wind and Solar Makes the Regional Transmission Grid Harder to Model in Spring and Fall
  - High Wind Generation Coupled with Maintenance Season
- Provide Necessary Transmission Services to University
- Transmission Provides Path to Import Renewable Energy

Transmission System Assessment

- Specific Transmission Scenarios Require a Close Session
- Transmission System Performs within NERC Standards
- Able to Shed Load to Protect Transmission in N-1-1 Scenarios
- Transmission Expansion Recommended to Maintain a Robust Transmission Network
- Internal Natural Gas Generation Essential to Maintain Reliability and NERC Compliance
- Non-Wires Solution Requires More Study

AMI and Smartgrid

- AMI is the First Step to Benefits Offered by a Smart Grid
- Enables More Advanced Rate Structures
- Better Track of Distributed PV
- Need to do an In Depth Study
- Water Utility Benefits

Capital Projects

- Rough Equivalence in Cost Between Recommended Capital Project Plan and Current Plan
- Recommended Timeline is Very Accelerated
- Biggest Discrepancy is in AMI

Hinkson Creek Substation

Transformer installation project

Fall 2021

Capital Projects

Siemens Capital Projects

Project Description	FY 22	FY 23	FY 24	FY 25	FY 26	FY 27	FY 28	FY 29	FY 30
Siemens Distribution Reconfiguration	5,513,600	5,513,600	5,513,600	5,513,600	-	-	-	-	-
Siemens Distribution Transformers	3,614,200	3,614,200	3,614,200	3,614,200	578,600	578,600	578,600	578,600	578,600
Siemens Capacitor Banks	89,600	89,600	89,600	89,600	8,100	8,100	8,100	8,100	8,100
Siemens Substation Expansion	1,152,500	1,152,500	1,152,500	1,152,500	-	-	-	-	-
Implement AMI System	8,049,600	8,049,600	8,049,600	-	-	-	-	-	-
Hinkson Creek 161 kV conversion	7,508,300	7,508,300	7,508,300	7,508,300	-	-	-	-	-
Totals	**25,927,800**	**25,927,800**	**25,927,800**	**17,878,200**	**586,700**	**586,700**	**586,700**	**586,700**	**586,700**

Grand Total **98,595,100**

Capital Projects

Current Electric CIP

Project Description	FY 22	FY 23	FY 24	FY 25	FY 26	FY 27	FY 28	FY 29	FY 30
Core Distribution System Projects	2,230,000	5,600,000	5,250,000	4,450,000	4,700,000	4,700,000	3,550,000	-	-
Specific Distribution System Projects	300,000	100,000	2,450,000	2,150,000	2,200,000	-	-	-	-
Core Transmission & Sub-Station Projects	100,000	1,550,000	2,000,000	1,150,000	1,050,000	1,050,000	950,000	700,000	700,000
Specific Transmission and Substation Projects	950,000	-	-	-	-	-	-	-	-
Power Supply & Balancing	1,800,000	1,200,000	300,000	-	-	-	-	-	-
Maintenance - O&M	-	250,000	-	-	-	-	-	-	-
AMI Projects	-	8,000,000	-	-	-	-	-	-	-
Option A - Mill Creek Substation Related Projects	-	8,000,000	14,200,000	5,000,000	-	12,500,000	-	-	-
Miscellaneous Projects	-	-	900,000	4,400,000	-	-	-	-	-
Totals	5,380,000	24,700,000	25,100,000	17,150,000	7,950,000	18,250,000	4,500,000	700,000	700,000

Grand Total **104,430,000**