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2015 IRP DRAFT Findings

Glendale Water and Power Commission

May 4, 2015

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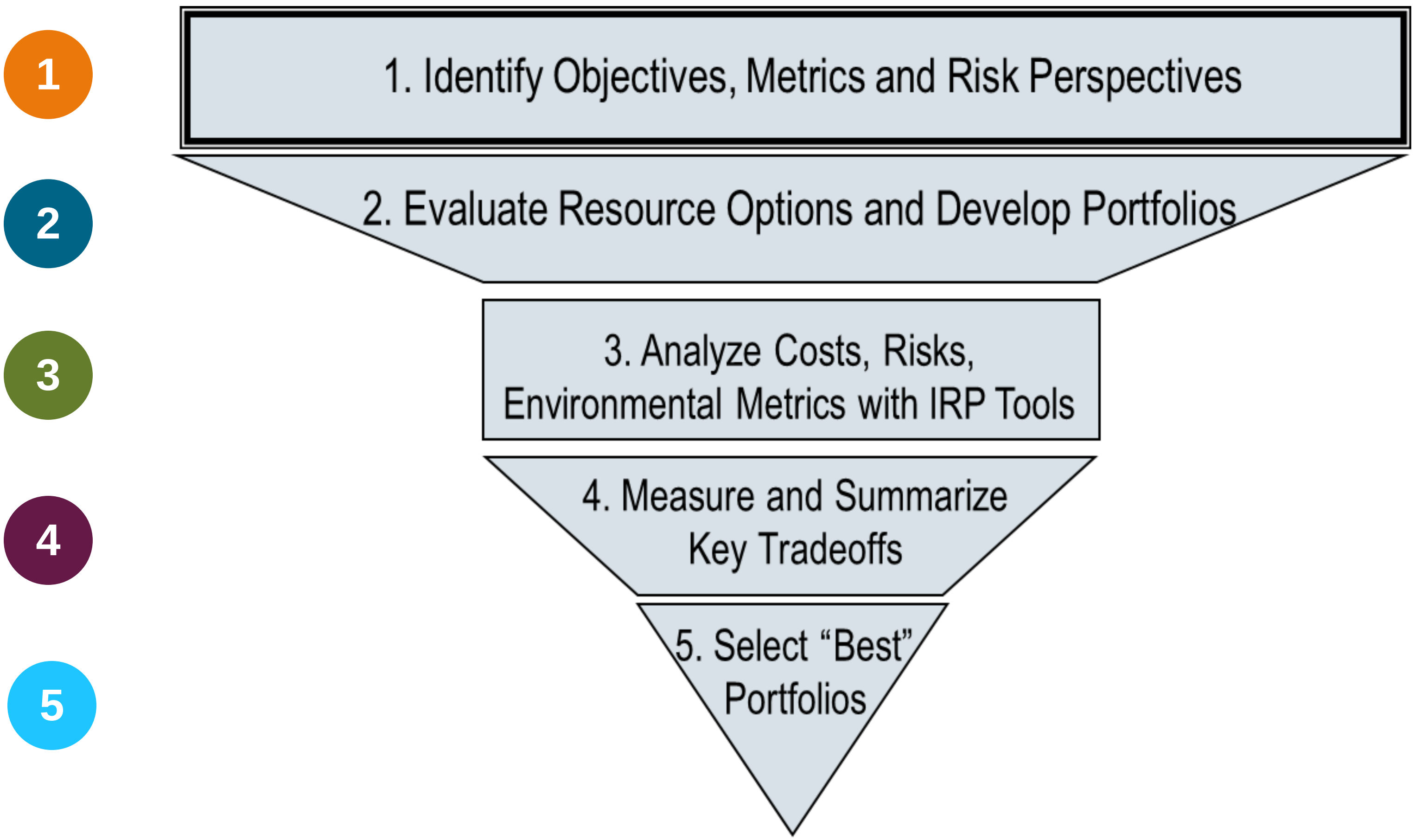
Answers for infrastructure and cities.

Motivation for the IRP Project

- Grayson: aging local power plant, increasing forced outages, increasing cost to maintain, inefficient combustion of landfill gas (LFG)
- RPS compliance: additional renewables necessary by late 2020s under current law
- GHG compliance: need to prepare for end of free allowances
- Contract expirations or resource shut-downs: San Juan, renewables, IPP
- Renewable integration: renewables require complementary generation
- Operations in LA's Balancing Area: expected to become more costly, and self-supply needs to be evaluated
- Storage options: needed for integrating renewables and self-supply of capacity required for operation in LA's Balancing Area
- Rate design issues: using the new Smart Meters

Overview of IRP Process



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Objectives and Metrics

Objective	Metric
Minimize Cost	Levelized NPV ($/MWh) generation portfolio costs
Improve Rate Stability/ Manage Risks to Ratepayers	Range of $/MWh levelized costs across scenarios
	Reliance on market transactions (% of total costs)
Improve Reliability	Frequency and total MWh of loss of load events
Enhance Environmental Stewardship	CO_2 emissions; Renewable %
Support Financial Stability	Total invested capital

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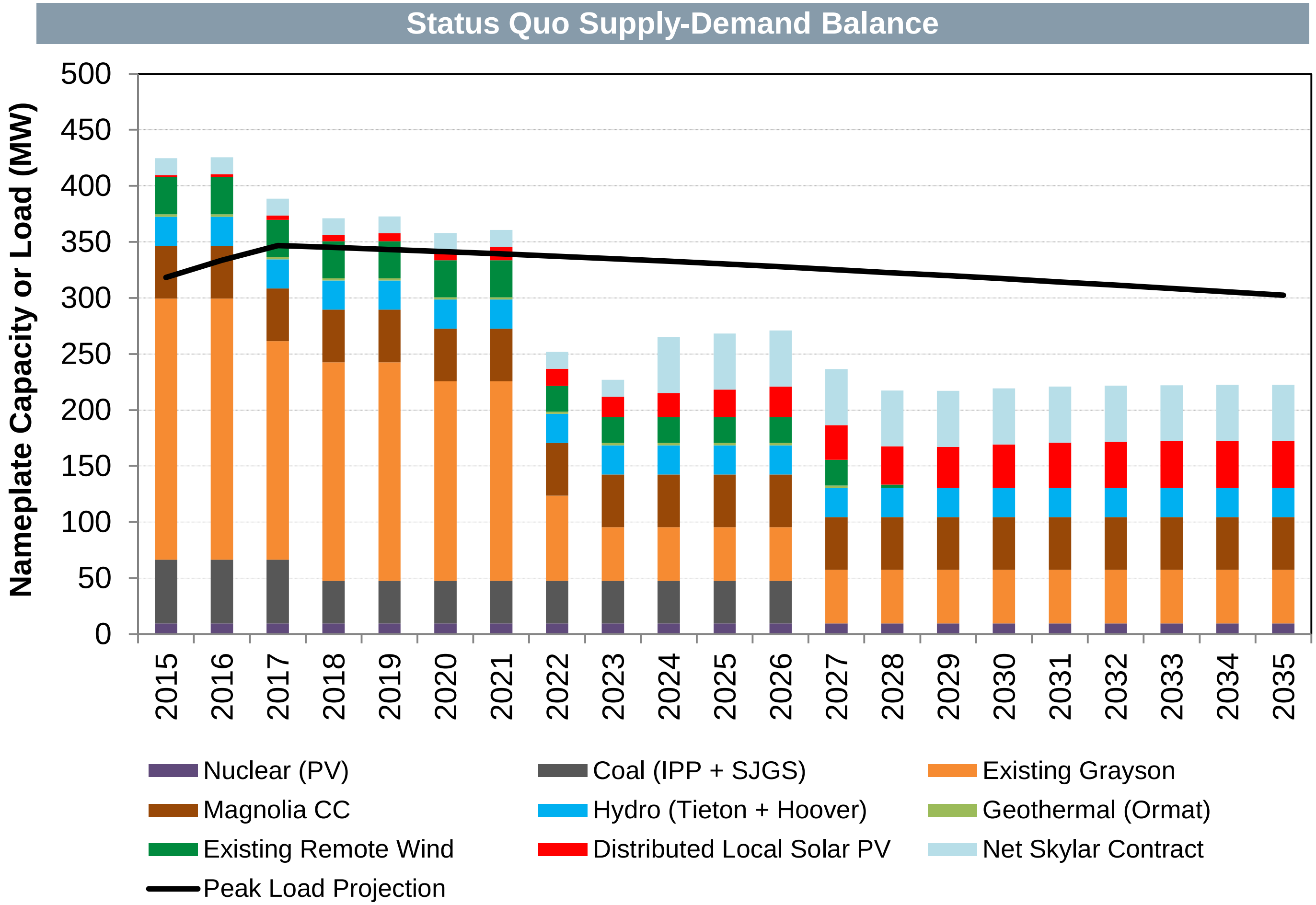
Major Elements of IRP for GWP

Resource Planning Issues	Approach
Grayson Re-Powering	Quantitative Screening of Options for Portfolios
RPS Compliance – Current and Potential Future Laws	
Shift from Coal Power – San Juan and IPP	
Energy Storage	
LFG (Scholl Canyon)	
Energy Efficiency and Load Reductions (TOU Rates)	Load Forecast w/ Study of Time-of-Use (TOU) Rates
Carbon and GHG Legislation	Portfolio Modeling
Transmission Options	
Energy Market Structure and Ancillary Services	
Distributed Generation and Solar Technology Advances	Customized Study

2

Existing Portfolio is Likely to Develop Capacity Shortage Soon



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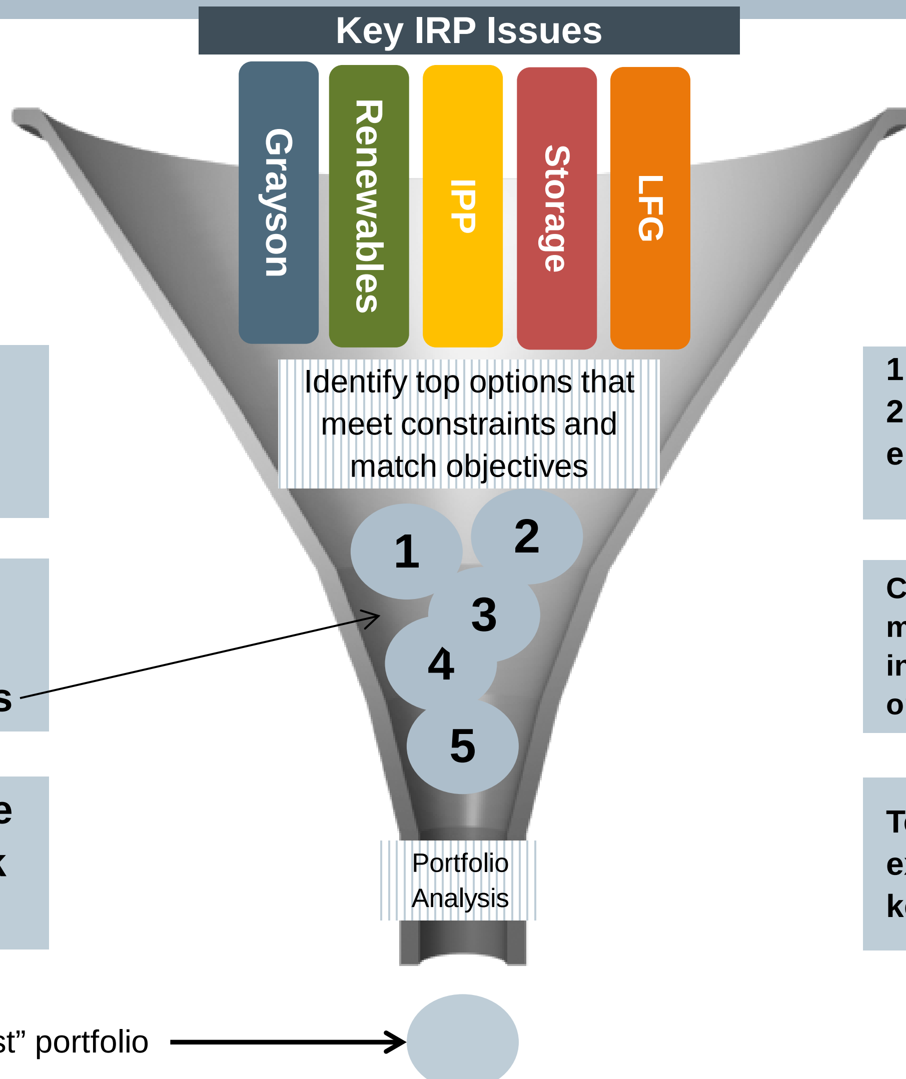
Screening for Each Major IRP Issue

Task

Screen feasible options for each "issue category"

Combine individual options into integrated portfolios

Perform quantitative scenario-based risk analysis



Select "best" portfolio

Approach

1. Meet planning constraints;
2. Rank by cost and environmental performance (Excel and Aurora)

Construct portfolio options that meet constraints and incorporate various strategy options

Test each portfolio against external market risks and all key metrics

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Screening Performed for Major Issue Categories

Grayson	Developed 9 configurations; narrowed to 4 leading options; Unit 9 kept in all analyses
Renewables	Evaluated costs of remote renewable options; narrowed options to combinations of intermittent wind & solar, and baseload geothermal
IPP	Tested new combined cycle combustion turbine (CC) and peaker options at IPP compared with walking away; narrowed to CC
Storage	Screened out grid-scale and behind-the-meter storage; *local option for regulation services <u>still under study</u>*
LFG	Developed separate from Grayson; Identified three distinct turbine and engine options at Scholl Canyon Landfill

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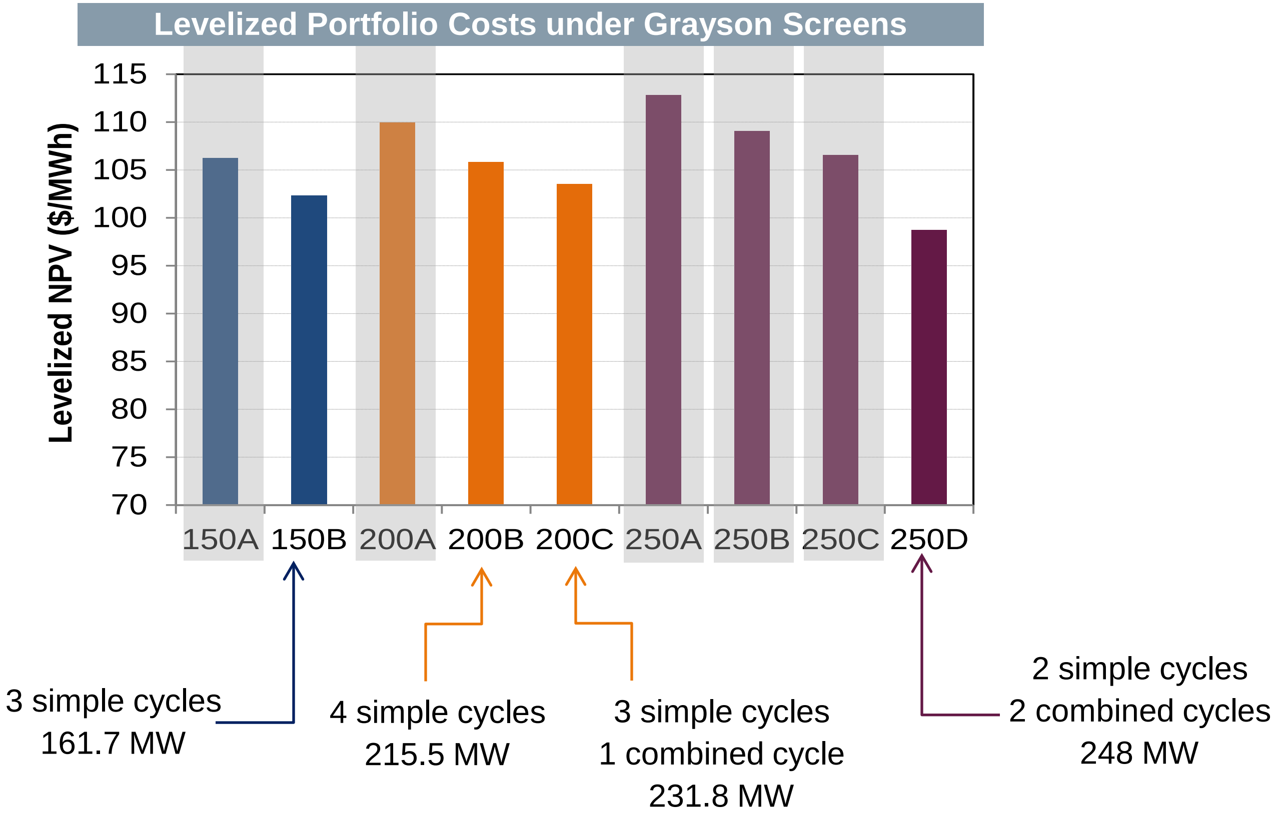
Grayson Screening

- Initial technology screen performed by Stantec
- Wartsila options costly due to inflexibility, so eliminated
- Narrowed to four options with combinations of LM6000 simple cycles and combined cycles



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Grayson Screening – Incremental Transmission

- The Grayson screening analysis included additional transmission capacity for reliability purposes: 150 MW Portfolios - 100 MW new transmission
  200 MW Portfolios - 50 MW new transmission
  250 MW Portfolios - None

Option	Source	Annual Cost for 150 Portfolio
Rent	LADWP*	$5.2 million
Build/Own	New connection to CAISO/SCE^	$3.4 million

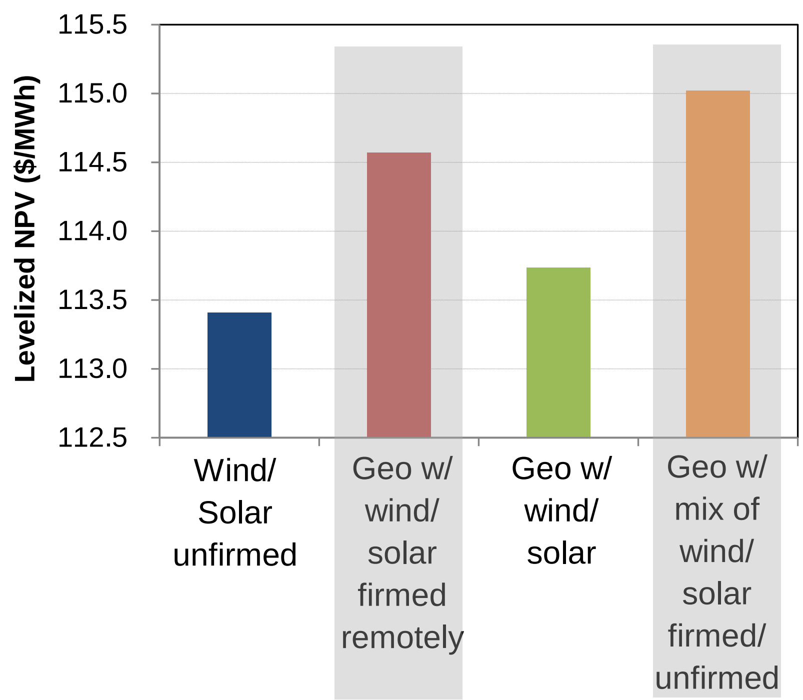
- Building and owning appears less expensive, but it carries risks:
  - Cost uncertainties around development and transmission system impacts (yet to be studied)
  - Reliability of new connection to CAISO is uncertain
  - An increase in GWP's single largest contingency changes would increase other costs
- As a result of the risks, portfolios have been developed with **rent** option, with further study on full implications pending

** From Schedules 1, 2, 3, and 7 of LADWP's Open Access Transmission Tariff*
^ Stantec report on new transmission option from GWP Kellogg Substation to SCE Eagle Rock Substation estimated $66 million in upfront costs, plus ongoing O&M

Renewable Screening

- Identified top renewable options: wind from the Northwest, solar PV from the Southwest, and geothermal
- Concluded that firming intermittent resources with Grayson is preferable to firming by a third party

Levelized Portfolio Costs under Renewable Screens



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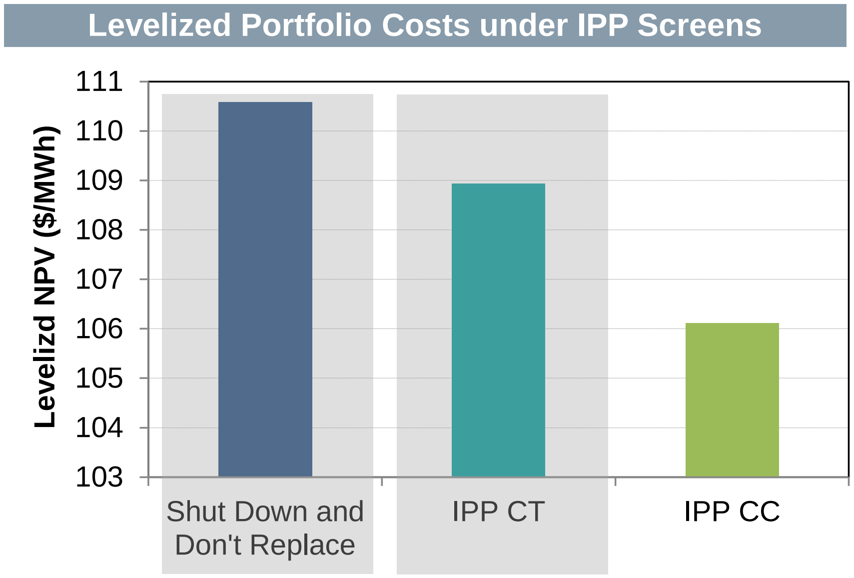
IPP Screening

Most cost-effective option: potential to join a consortium of existing plant owners to develop a new, large natural gas-fired combined cycle ("CC") plant on the site and contract for 50 MW of that new plant



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Storage Options Screening

- **<u>Grid-Scale</u>**: Even with declining cost expectations, battery additions at the grid-scale are not cost-effective at this time
- **<u>Behind-the-Meter-Scale</u>**: Unless customers help pay for a thermal energy storage solution, behind-the-meter storage is not cost-effective
- **<u>Substation-Scale</u>**: Intra-hour regulation and avoided costs are *currently being studied separately* to evaluate storage at the substation level.

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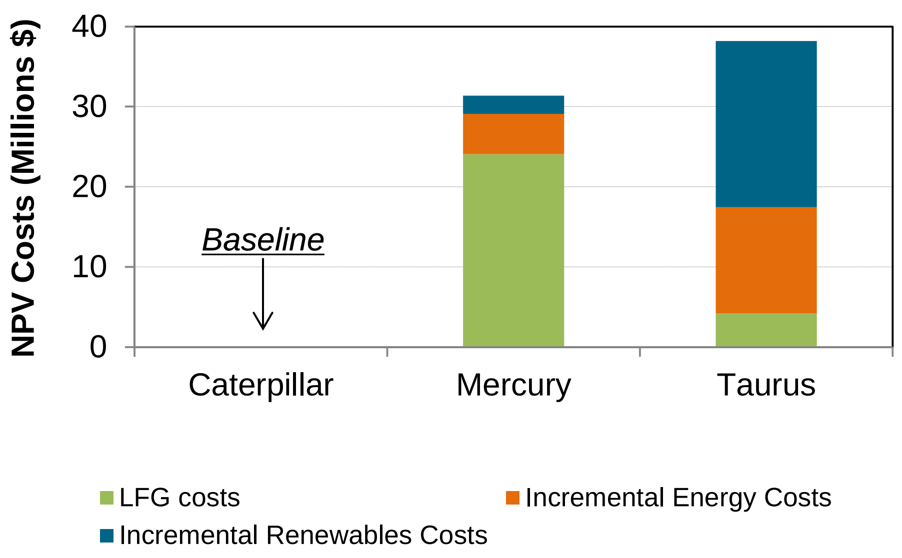
LFG Screening

- Caterpillar option at the Scholl Canyon landfill has lower fixed costs and produces more energy when compared to alternatives

NPV Impact of Portfolio Costs – Caterpillar as Baseline



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Based on Screening, Defined Integrated Portfolio Options

	Candidate Portfolio	Grayson	LFG	IPP	Renew-ables
1.	Run to Fail	No new investments beyond limited capital extension	No new investment	CC	Wind/ Solar/ Geothermal
2.	150B/ wind/ solar	3 simple cycles	Caterpillar	CC	Wind/ Solar
3.	150B/ wind/ solar/ geo	3 simple cycles	Caterpillar	CC	Wind/ Solar/ Geothermal
4.	200B/ wind/ solar	4 simple cycles	Caterpillar	CC	Wind/ Solar
5.	200B/ wind/ solar/ geo	4 simple cycles	Caterpillar	CC	Wind/ Solar/ Geothermal
6.	200C/ wind/ solar	3 simple cycles 1 combined cycle	Caterpillar	CC	Wind/ Solar
7.	200C/ wind/ solar/ geo	3 simple cycles 1 combined cycle	Caterpillar	CC	Wind/ Solar/ Geothermal
8.	250D/ wind/ solar	2 simple cycles 2 combined cycles	Caterpillar	CC	Wind/ Solar
9.	250D/ wind/ solar/ geo	2 simple cycles 2 combined cycles	Caterpillar	CC	Wind/ Solar/ Geothermal

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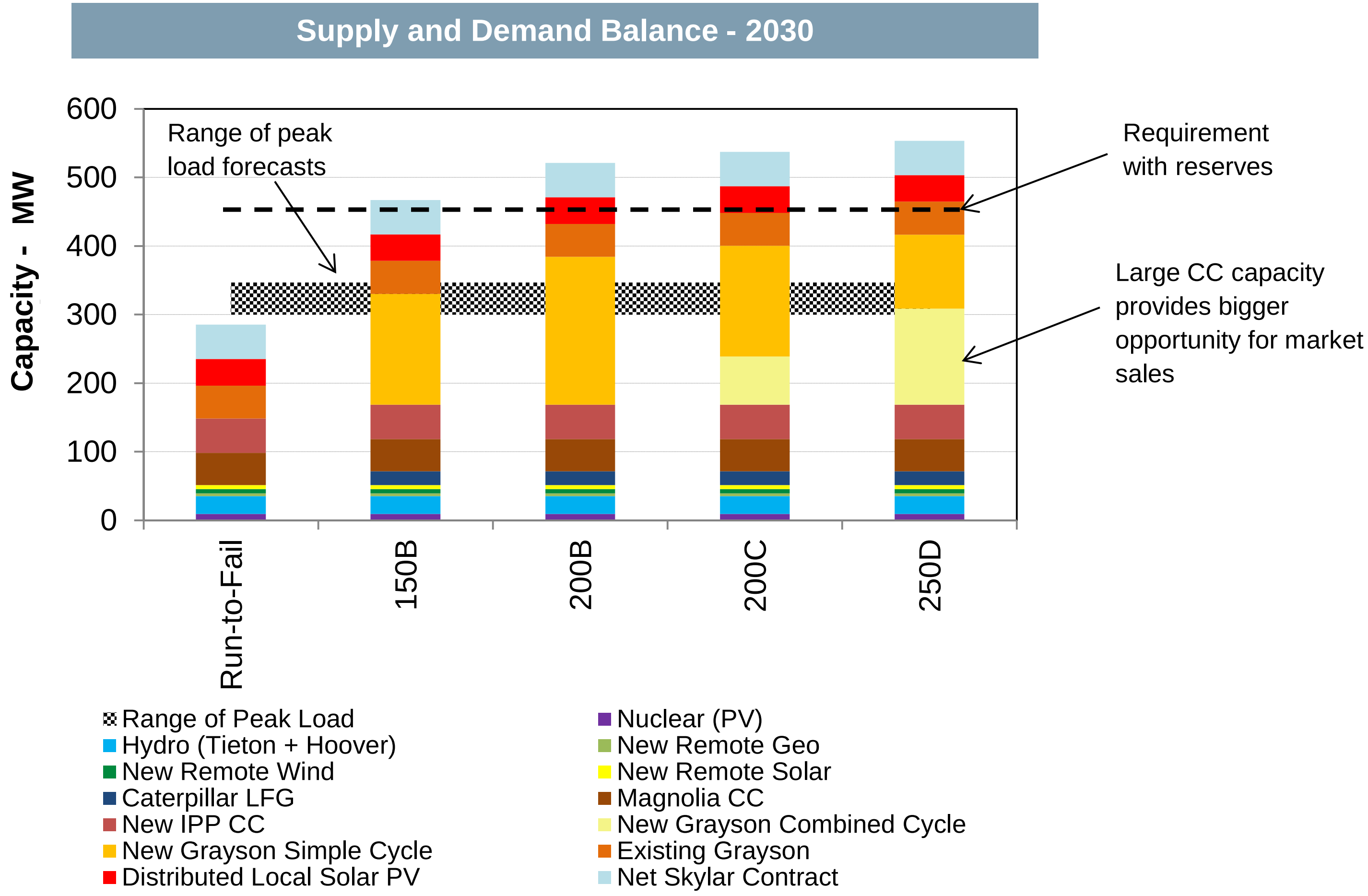
Capacity for Grayson Options



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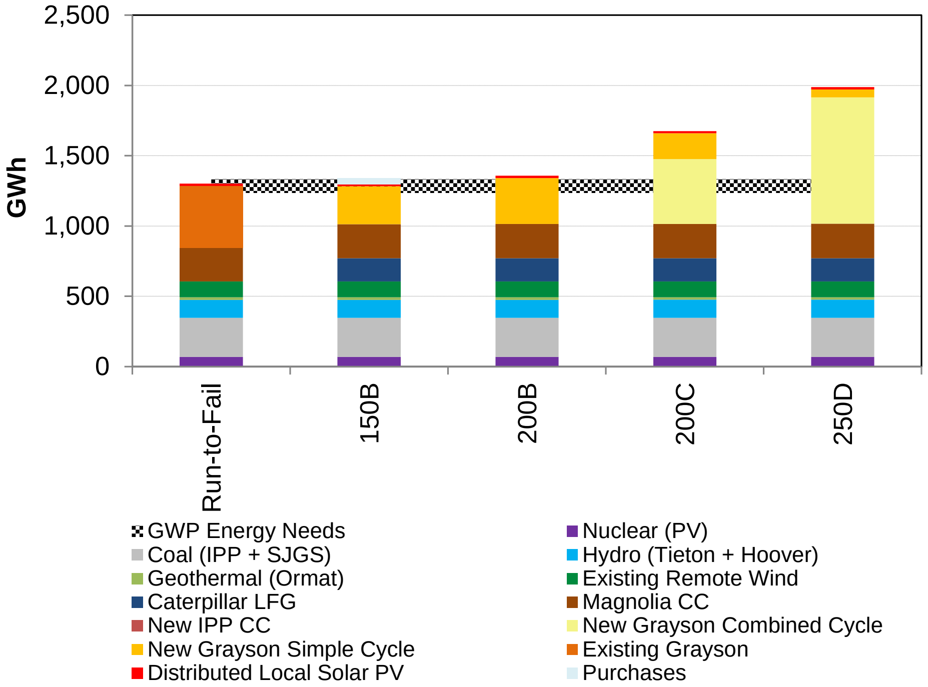
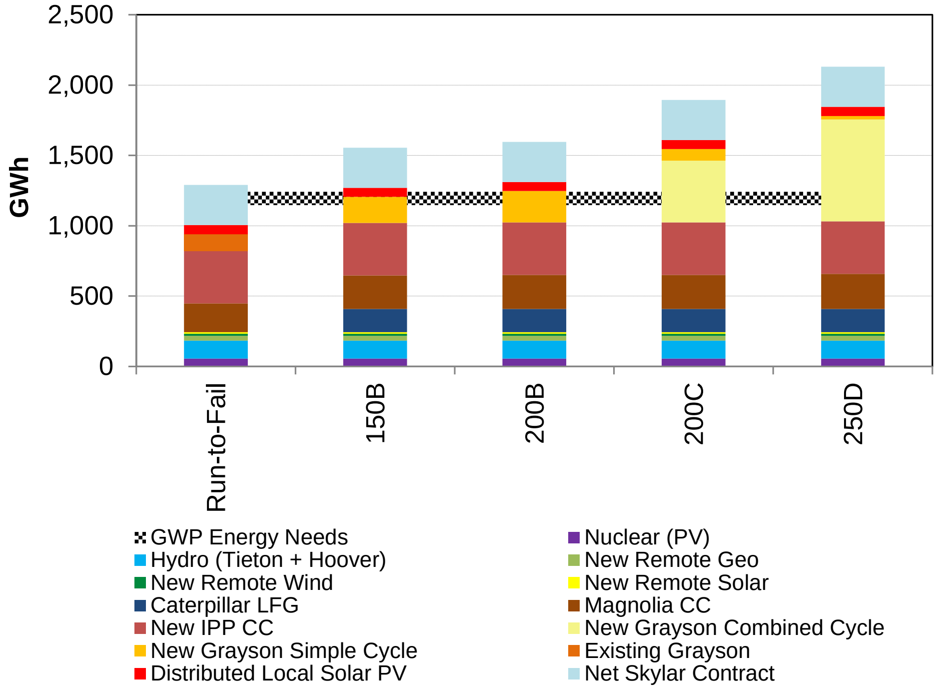
Energy for Grayson Options

Energy Needs and Resources - 2020



Energy Needs and Resources - 2030



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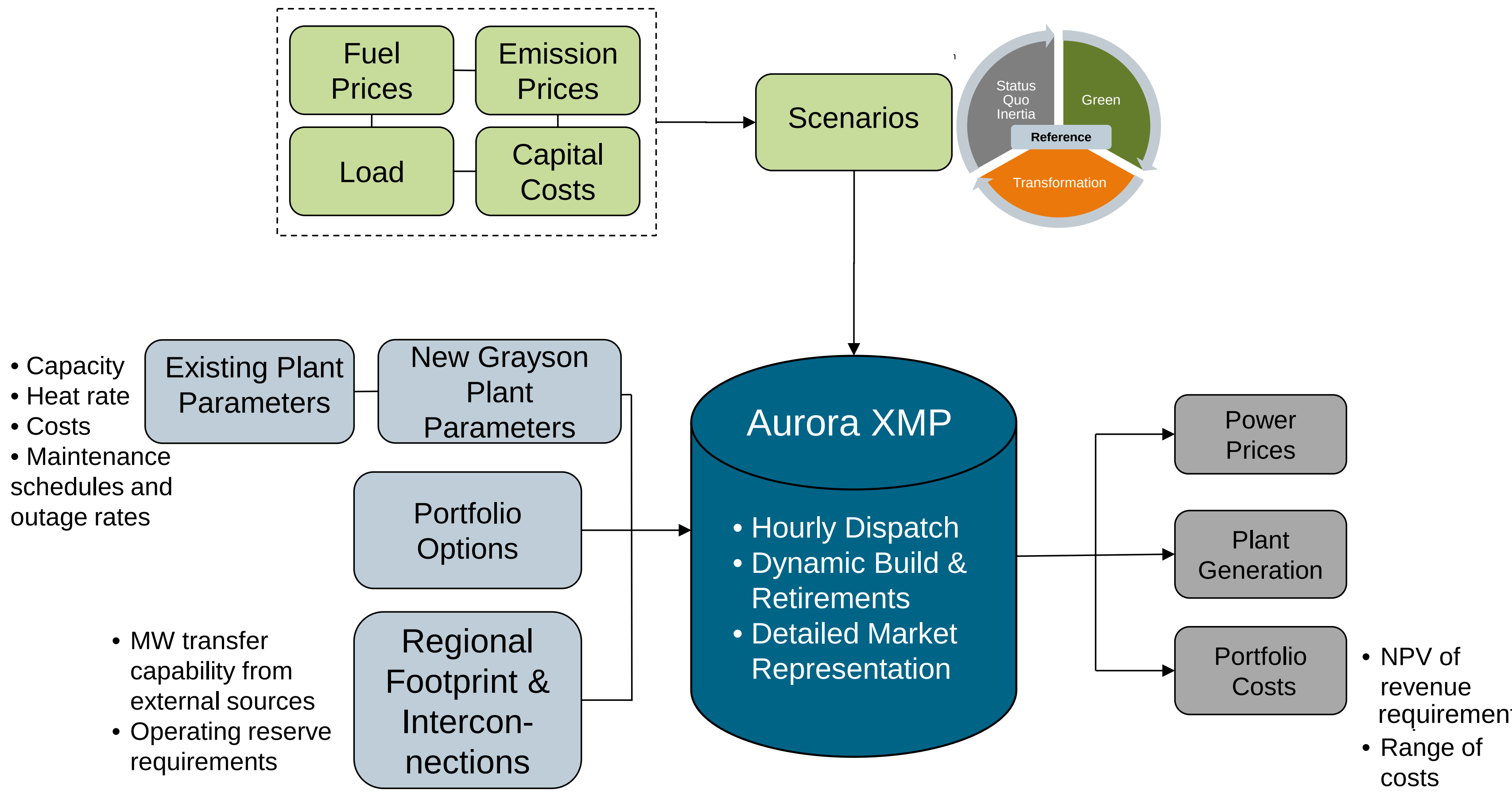
Framework for Portfolio Evaluation



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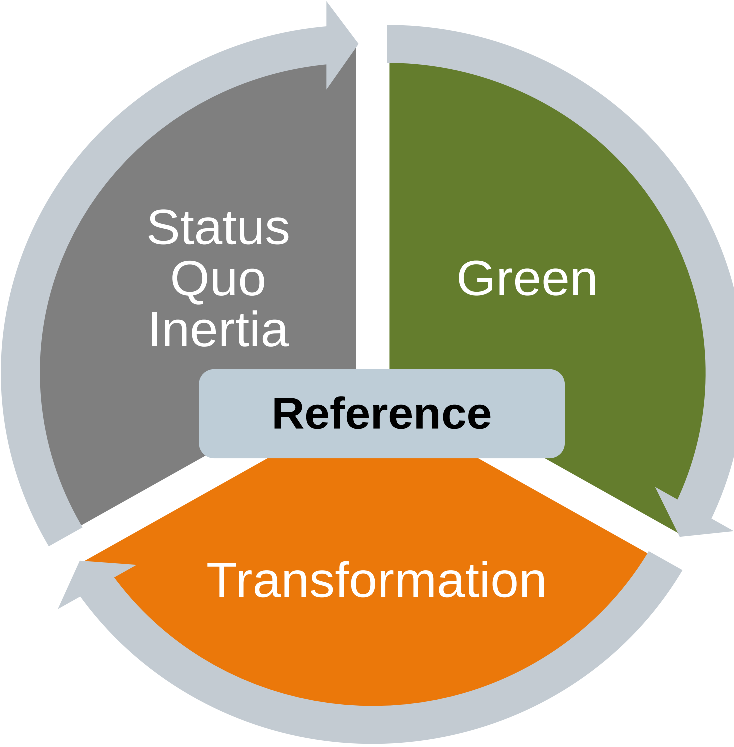
Scenarios to Stress-Test Portfolios

- Gas prices stay low
- Carbon/ RPS regulation at status quo
- Solar PV penetration less than reference
- Customer count grows faster



- CO_2 regs strengthen and allowance prices increase
- Gas demand rises, fracking restrictions implemented, and prices are higher
- CA RPS rises to 50%

- High solar PV and electric vehicle penetration due to declining capital costs of solar and batteries
- TOU rate deployment alters load shape

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Variables in Each Scenario

Variable	Status Quo Inertia	Green	Transformation
Natural Gas Price	↓ Lower production costs and prices	↑ Higher demand for gas and fracking ban	— Same as reference
Carbon Price	↓ Status quo policies remain in place	↑ Stricter regulations and higher compliance costs	— Same as reference
Solar PV Penetration	↓ Lower retail rates and longer payback economics	— Same as reference	↑ Lower technology costs and shorter payback economics
GWP Load Growth	↑ Customer count growth increases	— Same as reference	↓ Peak load declines due to TOU rates; ↑ Sales increase from PHEVs

Summary of Portfolio Results

Portfolios	Cost	Risk/ Rate Stability		Reliability		Environmental Stewardship	Flexibility/ Financial Stability
Study Period: 2016-35 All portfolios meet 33% RPS	Reference Case Levelized NPV* ($/MWh)	Worst Case Cost across Scenarios ($/MWh)	Reliance on market (Net Sales as a % of Total Portfolio Costs- 2020)	Total MWh of Lost Load over 10-year Period	Range Value of Lost Load (millions of 2013$)	Total CO_2 Emissions for owned resources plus purchases 2019-2035 average (000s tons)	Total Capital Investment at Grayson and LFG (millions of $)
Run to Fail	103.9	115.5	-7%	2019: 569 2027: 5,962	2019: 0.75-2.6 2027: 7.9-27.0	338.9	8.5
150B/ wind/ solar	95.4	105.6	0%	2019: 186 2027: 55	2019: 0.25-0.84 2027: 0.07-0.25	408.3	201.4
150B/ wind/ solar/ geo	95.3	104.8	0%	2019: 186 2027: 55	2019: 0.25-0.84 2027: 0.07-0.25	407.8	201.4
200B/ wind/ solar	95.8	106.3	1%	2019: 55	2019: 0.07-0.25	428.3	263.1
200B/ wind/ solar/ geo	95.7	105.4	1%	2019: 55	2019: 0.07-0.25	428.8	263.1
200C/ wind/ solar	95.2	103.3	14%	2019: 45	2019: 0.05-0.20	514.1	300.1
200C/ wind/ solar/ geo	95.1	102.5	14%	2019: 45	2019: 0.05-0.20	514.6	300.1
250D/ wind/ solar	94.1	101.1	27%	2019: 28	2019: 0.04-0.13	601.7	337.1
250D/ wind/ solar/ geo	94.0	100.2	27%	2019: 28	2019: 0.04-0.13	603.0	337.1

Key Findings: Grayson Repower and Renewables

- The Run-to-Fail option is not feasible: high cost and unacceptable risk to local reliability
- The 150 MW option has relatively low capital investment, but some reliability risk
- The 250 MW option has the highest capital investment but lowest range of costs; it has highest reliance on off-system sales in order to keep costs down.
- The 200 MW option performs relatively well across all metrics, but doesn't “win” in any.
- Portfolios with diverse remote renewables (wind, solar, and geothermal) are slightly lower cost and have greater technological diversity than portfolios that just have wind and solar

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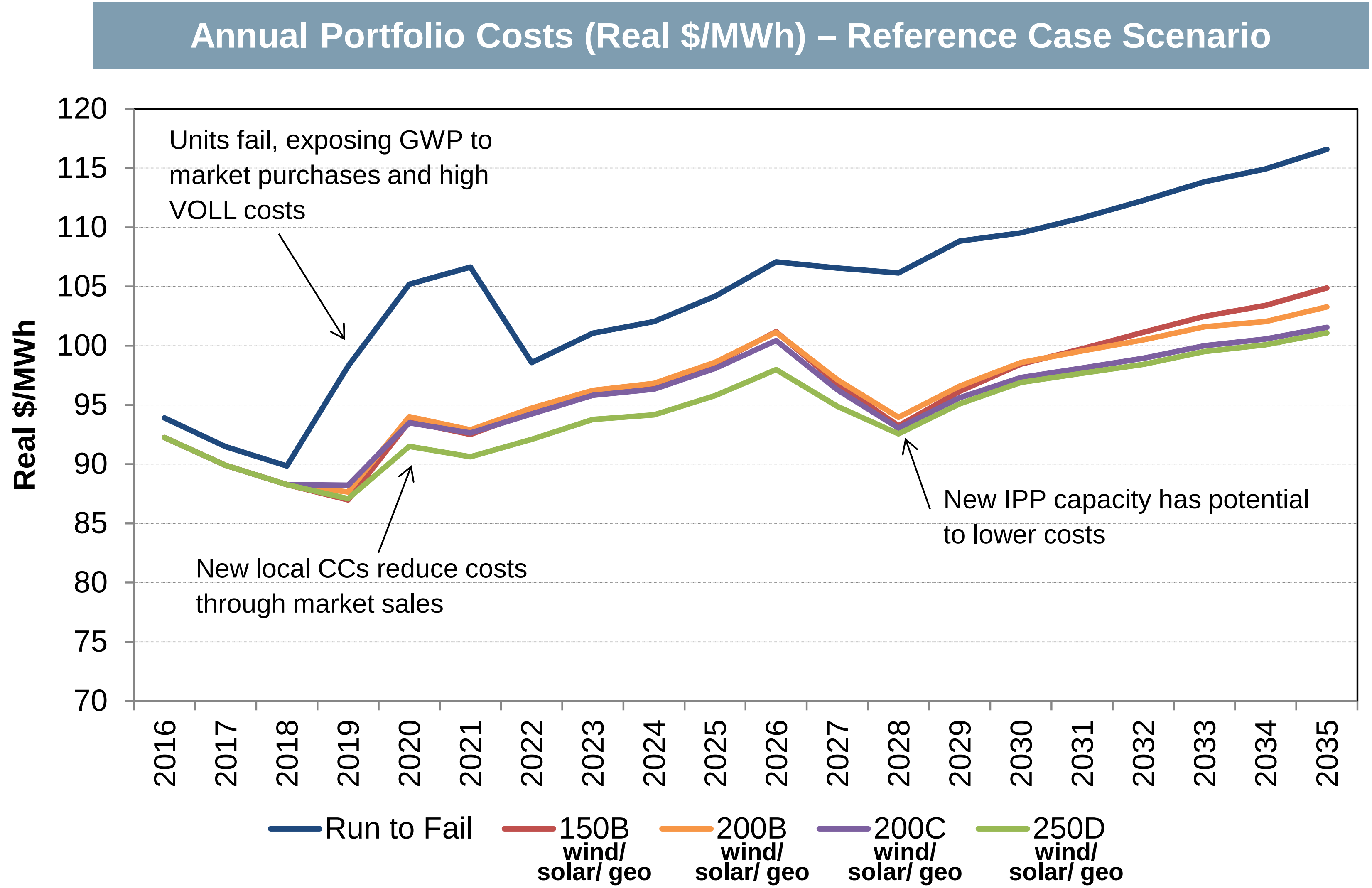
Costs of Major Grayson Options



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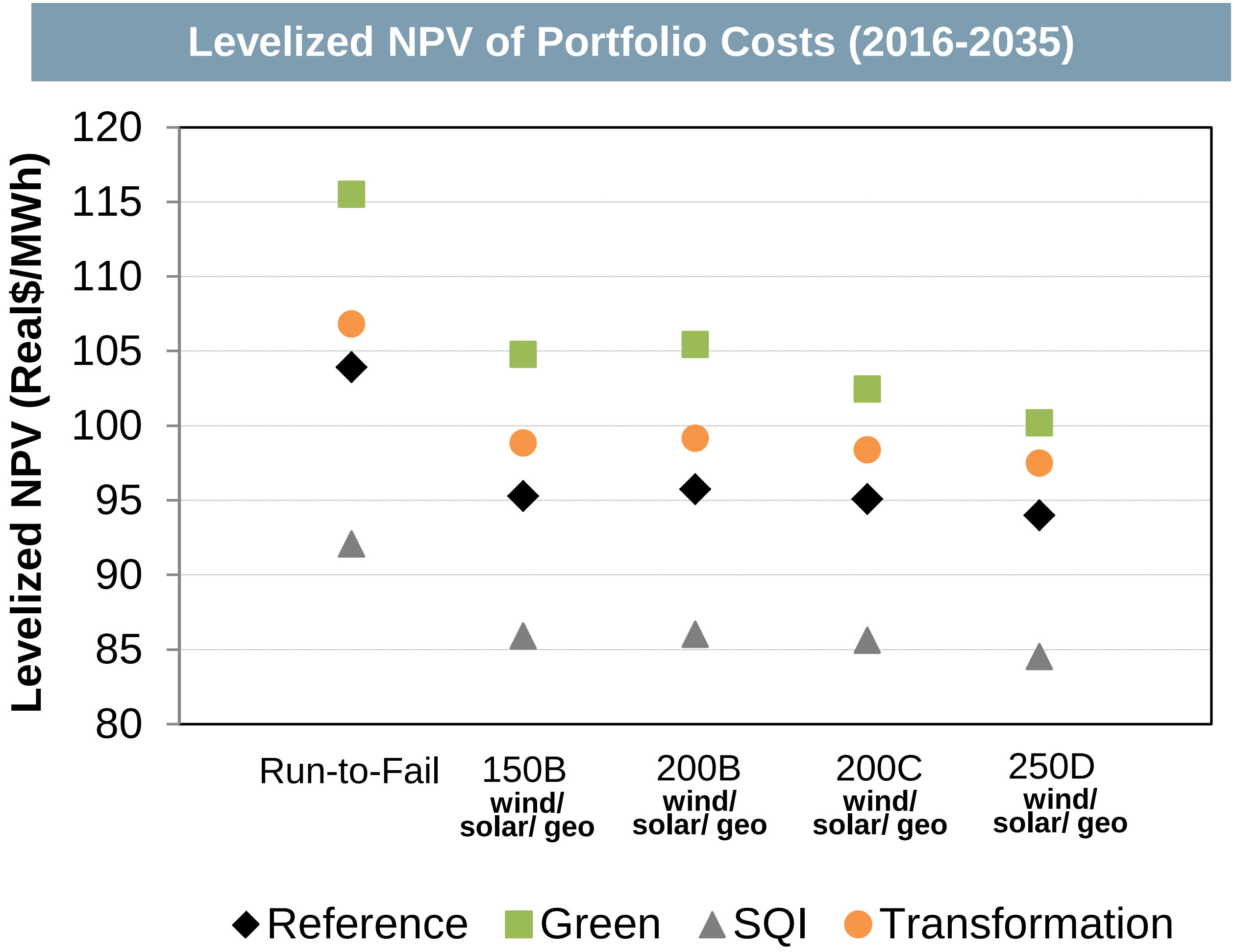
Grayson 250D Portfolio: Lowest Cost and Lowest Range of Costs



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Key Findings by Metric for Grayson

Cost

- Run-to-fail portfolio is highest cost; 250D portfolio is lowest cost

Risk

- 250D portfolio offers hedge against high market prices; more local generation provides insurance against catastrophes, such as earthquakes
- By 2020, 250D portfolio relies heavily on market sales; partner recommended

Reliability

- Run-to-fail portfolio violates reliability standards by 2019 and later; 150B portfolio faces moderate reliability risks; larger portfolios meet reliability guidelines

Environmental Stewardship

- Portfolios with more local generation have highest CO_2 emission footprint

Financial Flexibility

- 250D portfolio requires the highest capital expenditures and thus new debt; partner recommended

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Key Findings: LFG Combustion

- Existing combustion at Grayson is inefficient and more expensive than new combustion equipment would be
- Pipeline transporting LFG from Scholl Canyon to Grayson is subject to increasing regulatory risks and maintenance costs
- Separating LFG combustion from Grayson and moving it to Scholl Canyon avoids tens of millions of dollars in air emissions permit costs
- Installing new, efficient combustion at Scholl could double the renewable energy produced by Glendale's LFG
- Avoided costs may be close to incremental costs, minimizing any rate impact
- Recommendation: move LFG combustion to Scholl Canyon

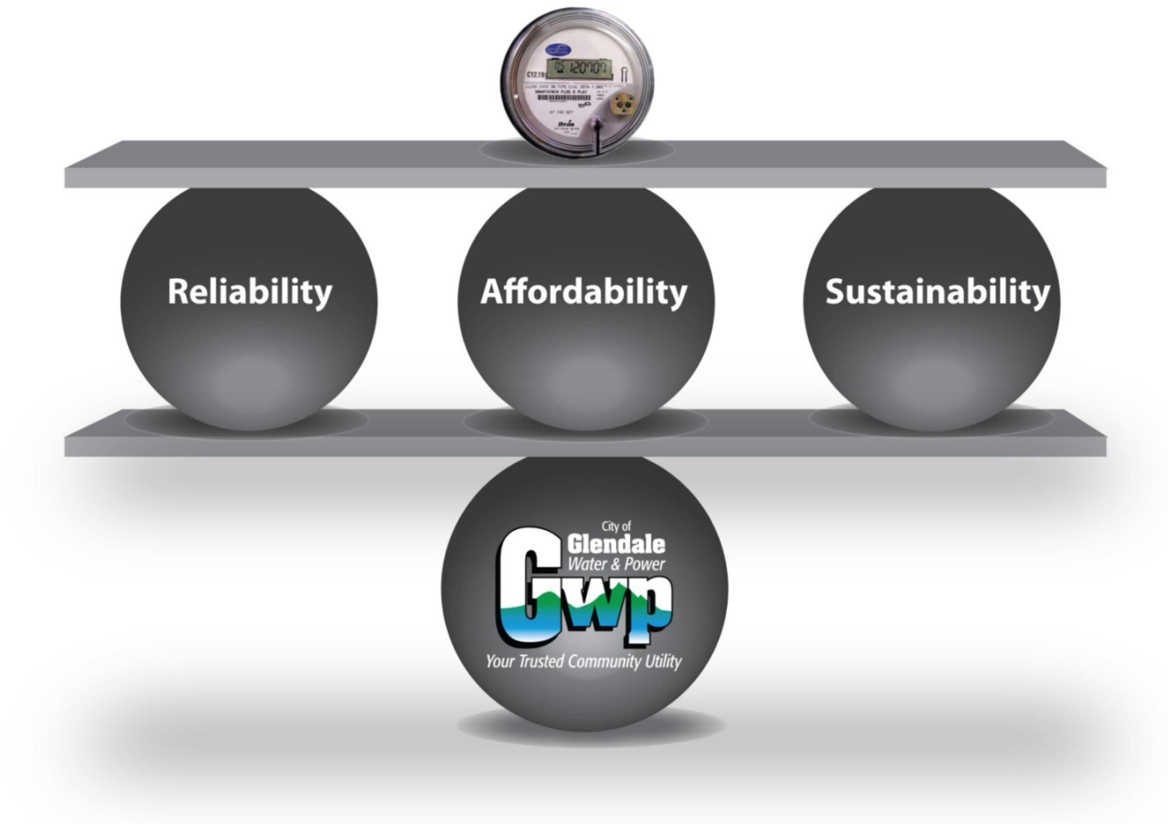
Recommended Actions

- Grayson Repower
  - Proceed with repower
  - Find long-term municipal partner for share of 250 MW option
- LFG Combustion
  - Proceed with new generation at Scholl Canyon
- RPS Compliance
  - Retire Grayson boilers; increase energy from LFG; prepare to integrate new renewables with repowered Grayson
- Energy Storage
  - Complete intra-hour analysis and develop recommendations
- Transmission Capacity
  - Continue study of new transmission connection, but plan to buy from LADWP unless risks can be controlled

Recommended Actions

- Coal Replacement
  - Replace San Juan with generic market energy and renewables
  - Develop options for IPP renewal
- GHG Compliance
  - Build inventory of free allowances between now and 2020
- Distributed Generation (Solar PV)
  - Monitor build-out and prepare for system impacts
- Retail Rates
  - Develop plan for changes in rate design post-2018; investigate TOU rates
- Community Outreach
  - Develop message strategy, esp. for CEQA compliance

Discussion and Questions



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Appendix I

Screening Analysis Details

City of Glendale Water & Power
GWP
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Answers for infrastructure and cities.

Initial Step Required Identification of Feasible Options at Grayson Site

- Stantec identified nine distinct configurations using combinations of Wartsila engines and LM6000 simple cycle and combined cycle additions in three general capacity sizes: 150 MW, 200 MW, and 250 MW.

Configuration Name	Wartsila 18V50SG		LM6000PG Sprint Simple Cycle		LM6000PG Sprint 1x1 Combined Cycle	
	Number of Units	Capacity (MW)	Number of Units	Capacity (MW)	Number of Units	Capacity (MW)
150A	3	55.0 MW	2	107.8 MW		
150B			3	161.7 MW		
200A	3	55.0 MW	3	161.7 MW		
200B			4	215.5 MW		
200C			3	161.7 MW	1	70.1 MW
250A	3	55.0 MW	4	215.5 MW		
250B			5	269.4 MW		
250C			4	215.5 MW	1	70.1 MW
250D			2	107.8 MW	2	140.2 MW

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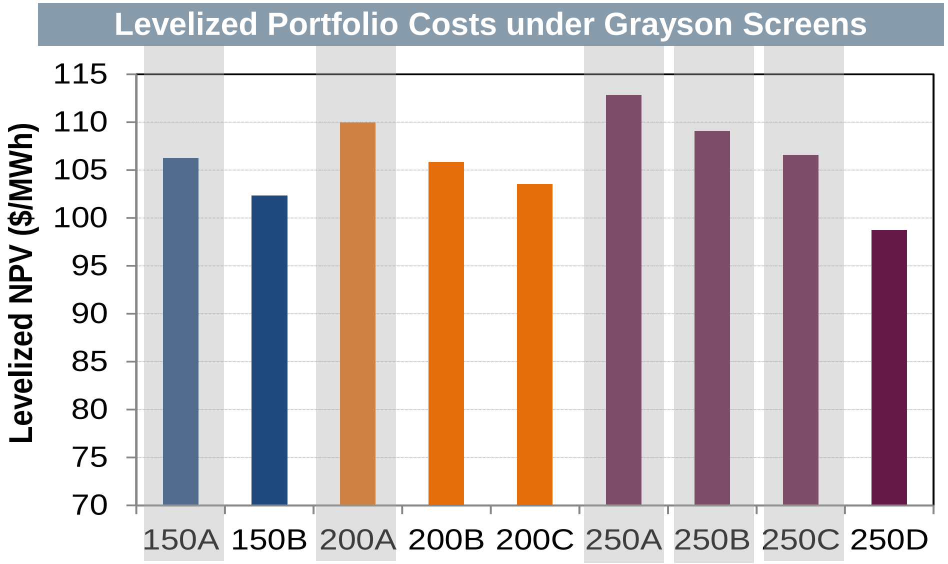
Screening Analysis Eliminated Wartsila Option and Reduced the Candidate List to Four

- The Wartsila "A" family (150A) is higher cost than the other LM6000 options within each capacity grouping, as a result of the very high minimum capacity level required for Wartsila operations.
- The 250D portfolio achieves the lowest cost as a result of significant market sales opportunities that develop with 140 MW of efficient combined cycle capacity.
  - 250A and 250B build only simple cycles and cannot expect to recover costs through market sales
- Even with additional transmission cost requirements, the 150B portfolio is the second lowest cost, but has reliability issues
- The 200B and 200C portfolios are within the top four options, although both are slightly higher than the best-performing 150 and 250 portfolios at the screening phase.



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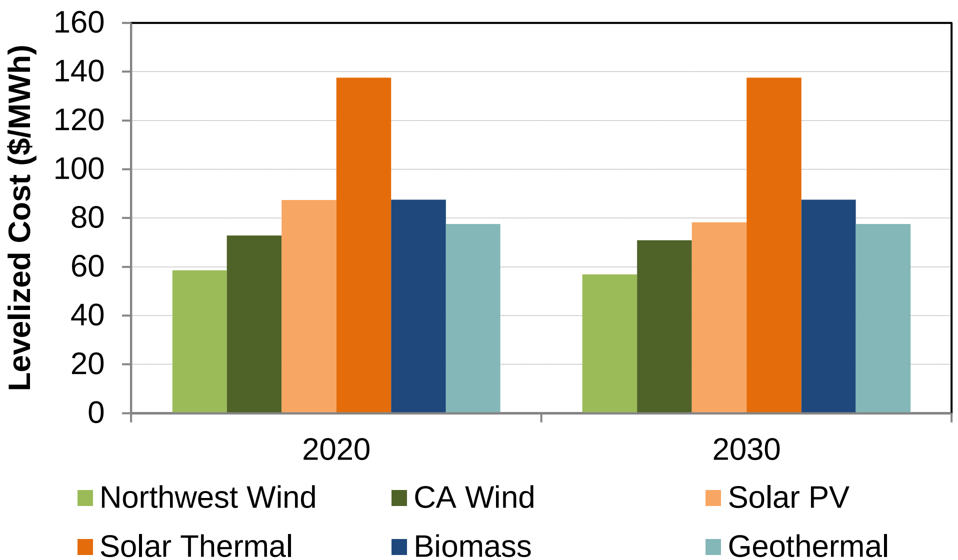
Remote Capacity Additions

- Remote renewable options were assessed as if developed by an independent power producer, selling under contract to GWP
- Screening analysis first narrowed options to Northwest wind, solar PV, and geothermal

Levelized Cost of Electricity for Remote Renewable Options



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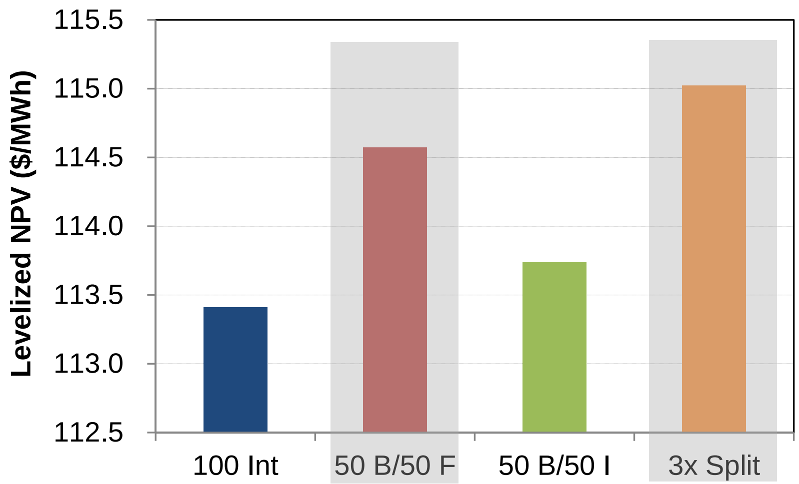
Renewable Portfolios Were Constructed around Different "Themes" for Further Screening

- 100% intermittent supplies (50% from NW Wind, 50% from SW solar PV);
- 50% baseload geothermal and 50% *firmed* intermittent supplies (50% from NW Wind, 50% from SW solar PV with a gas CT to firm supply during lower production hours);
- 50% baseload geothermal and 50% intermittent supplies (50% from NW Wind, 50% from SW solar PV) with no explicit firming costs beyond local generation resources;
- An even split between baseload geothermal, *firmed* intermittent, and intermittent supplies.

Levelized Portfolio Costs under Renewable Screens



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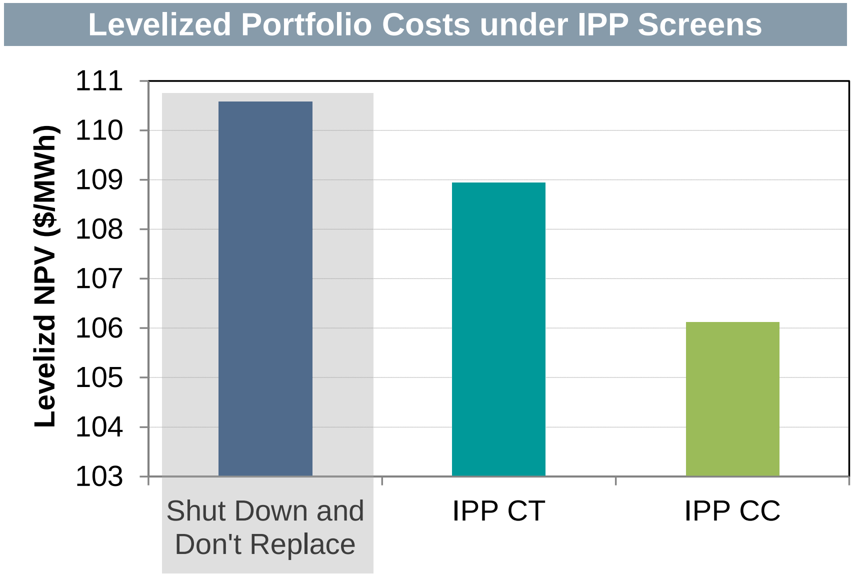
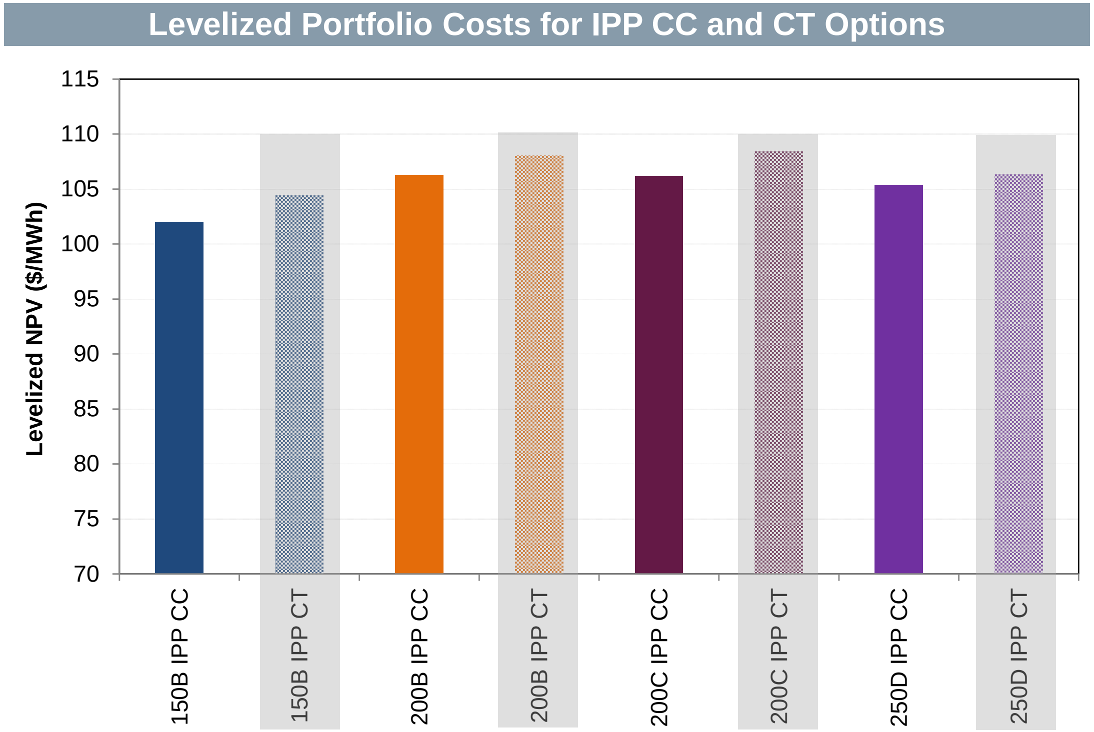
Replacement Options for Coal at IPP

- Join a consortium of existing plant owners to develop a new, large natural gas-fired combined cycle (“CC”) plant on the site and contract for 50 MW of that new plant;
- Work with another entity to develop a smaller LMS100 gas-fired combustion turbine (100 MW “CT”) on the site and split that capacity 50/50; or
- Let IPP shut down without replacement with new generating capacity, lose all existing transmission rights, and acquire new transmission through lease from LADWP.



Combined Cycle vs. Peaker Options

- CC and CT options were evaluated against each of the four leading Grayson options
- The CC replacement remained lowest cost across the board



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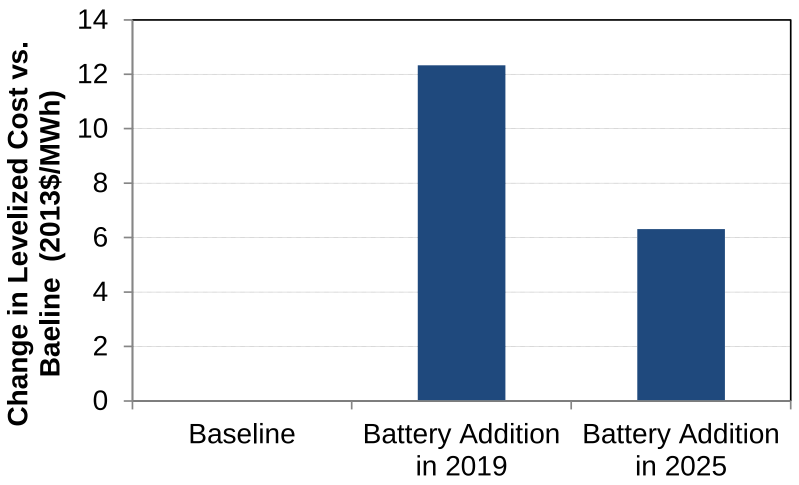
Storage

Grid-Scale Storage Options Were Evaluated over Time

- Battery additions to provide firming resource at the grid-scale were evaluated over time
- Even with declining cost expectations, the battery additions are not cost-effective
- **Note: this ignores intra-hour avoided costs, which will be studied separately**

Category	Characteristic
Storage Duration	4 Hours
Round Trip Efficiency	85-90%
Battery Life	11-15 Years
FOM (2013$/kW-yr)	101
2015 Cost (2013$/kW)	4,681
2019 Cost (2013$/kW)	1,500
2025 Cost (2013$/kW)	1,000

Levelized Portfolio Cost Differences for Battery Screens



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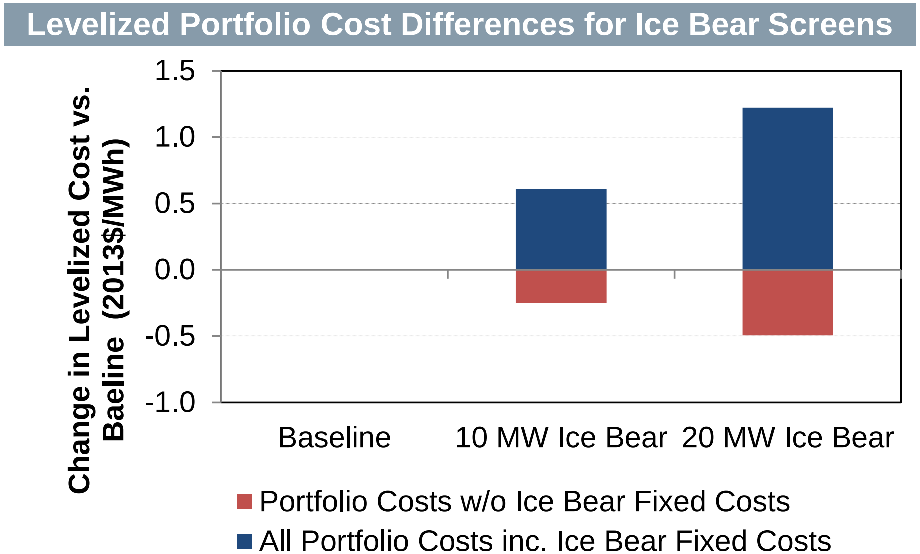
Behind-the-Meter Storage Option

- Load shifting contributes to a savings on the order of 0.1% to 0.2% for 10 MW and 20 MW additions, respectively.
- The capital costs plus incremental operating costs, however, overwhelm this savings under the assumption that GWP pays all costs of installation and operation.



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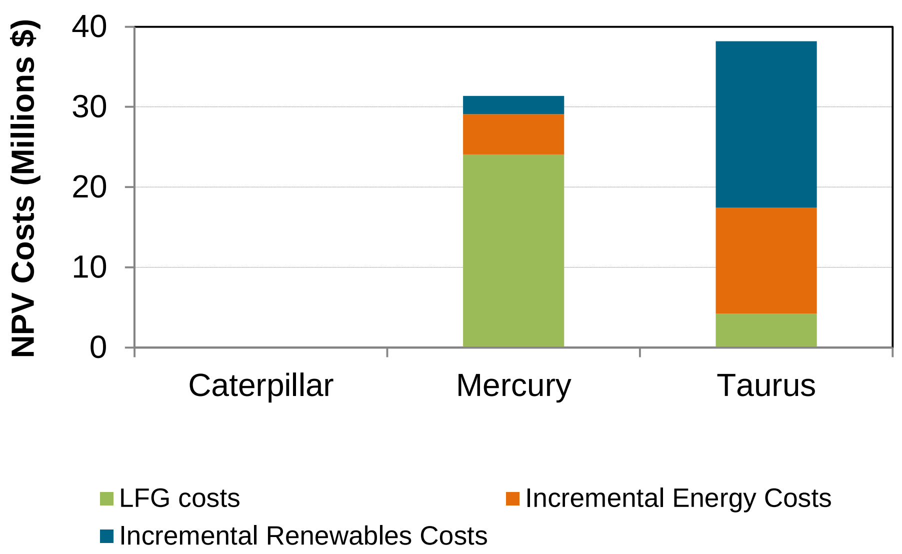
LFG

Caterpillar Option Performs Better than Solar Mercury or Solar Taurus Options

	Annual Renewable Generation (MWh)	Equipment cost (Millions $)	O&M Cost (Millions $)	Annual Equipment Cost Payment (Millions $)	Annual Fixed Costs (Millions $)
Mercury	153,300	22.1	2.8	1.1	3.8
Taurus	131,400	17.2	1.7	0.8	2.5
Caterpillar	165,564	16.3	1.8	0.8	2.6

NPV Impact of Portfolio Costs – Caterpillar as Baseline



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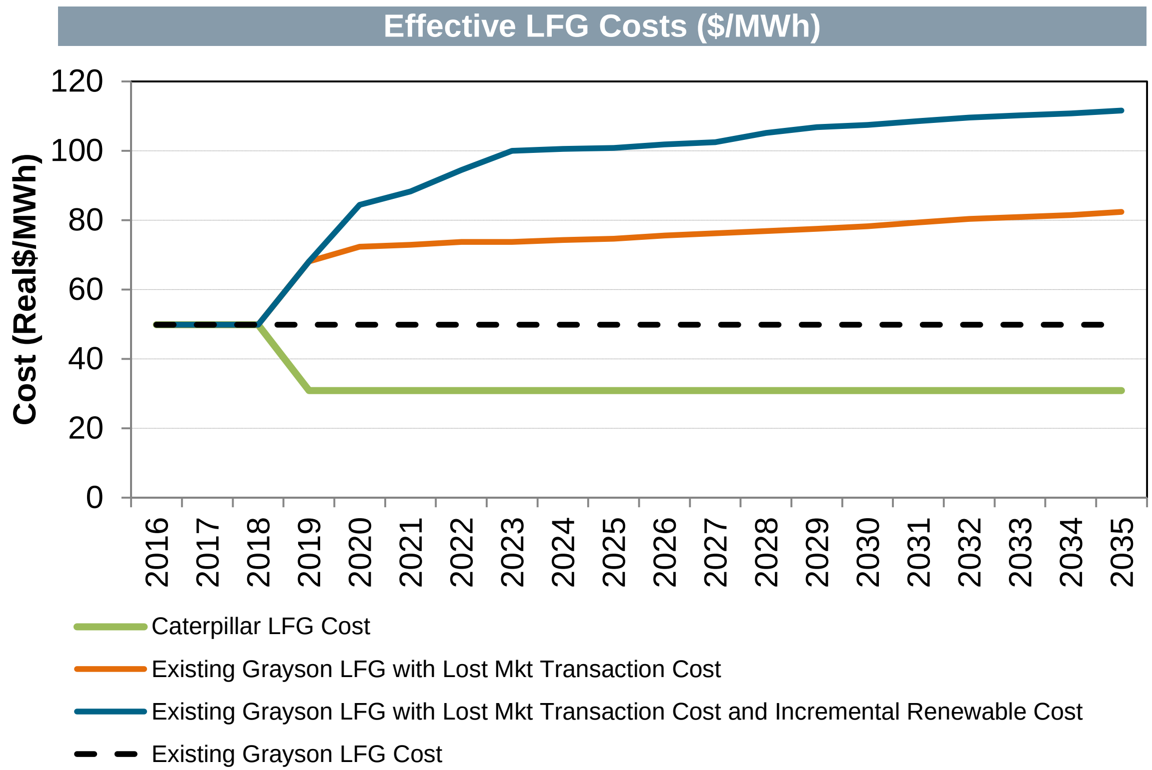
LFG

Caterpillar Option Provides Significant Savings against Status Quo

- The Caterpillar LFG option reduces costs significantly vs. current operations, especially after taking into account avoided energy and renewable benefits



**Note that costs include a payment to the City for the landfill gas of $2.5 million per year.*

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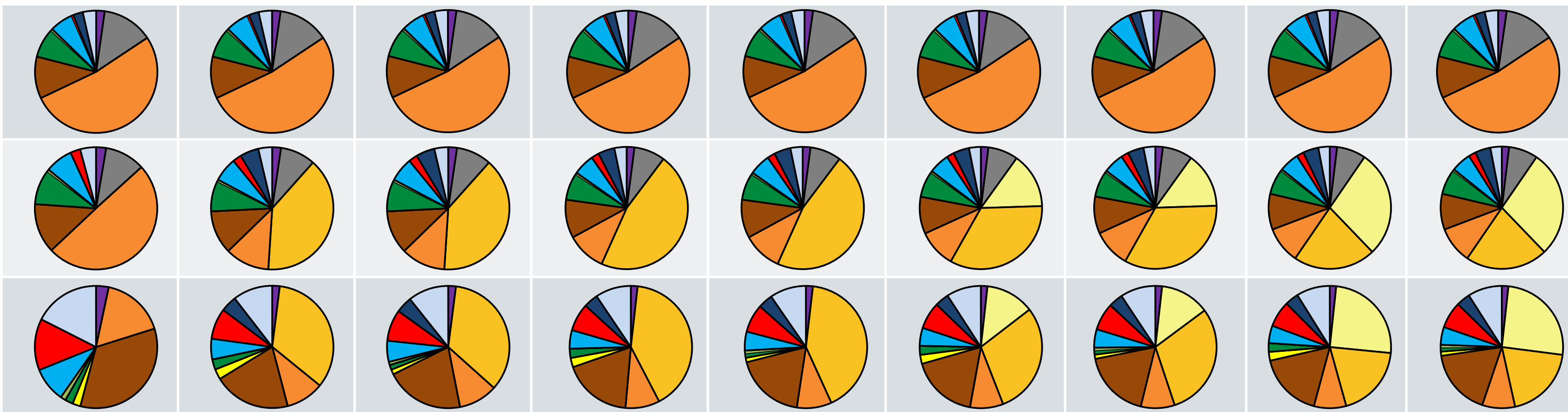
Overview of All Portfolios after Screening

All capacity represented by installed MW

	Run to Fail	150B/ wind/ solar	150B/ wind/ solar/ geo	200B/ wind/ solar	200B/ wind/ solar/ geo	200C/ wind/ solar	200C/ wind/ solar/ geo	250D/ wind/ solar	250D/ wind/ solar/ geo
Capacity Mix: 2015									
Capacity Mix: 2020									
Capacity Mix: 2030									



Total Capacity Additions / Losses (MW) by 2030

	Run to Fail		150B/ wind/ solar		150B/ wind/ solar/ geo		200B/ wind/ solar		200B/ wind/ solar/ geo		200C/ wind/ solar		200C/ wind/ solar/ geo		250D/ wind/ solar		250D/ wind/ solar/ geo	
Nuclear																		
Coal		-57		-57		-57		-57		-57		-57		-57		-57		-57
Local Gas – LM6000 CC											+70.1		+70.1		+140.2		+140.2	
Local Gas – LM6000 CT			+161.7		+161.7		+215.5		+215.5		+161.7		+161.7		+107.8		+107.8	
Local Gas – Existing CT/ST		-174		-174		-174		-174		-174		-174		-174		-174		-174
Remote Gas – CC (Mag/IPP)	+50		+50		+50		+50		+50		+50		+50		+50		+50	
Remote Solar	+6		+13		+6		+13		+6		+13		+6		+13		+6	
Remote Wind	+6	-33	+13	-33	+6	-33	+13	-33	+6	-33	+13	-33	+6	-33	+13	-33	+6	-33
Remote Geo	+4	-2.1		-2.1	+4	-2.1		-2.1	+4	-2.1		-2.1	+4	-2.1		-2.1	+4	-2.1
Remote Hydro																		
Local DER - Solar	+36.8		+36.8		+36.8		+36.8		+36.8		+36.8		+36.8		+36.8		+36.8	
LFG		-11	+20.2	-11	+20.2	-11	+20.2	-11	+20.2	-11	+20.2	-11	+20.2	-11	+20.2	-11	+20.2	-11
Net Skylar	+35		+35		+35		+35		+35		+35		+35		+35		+35	

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Appendix II

Scenario Details

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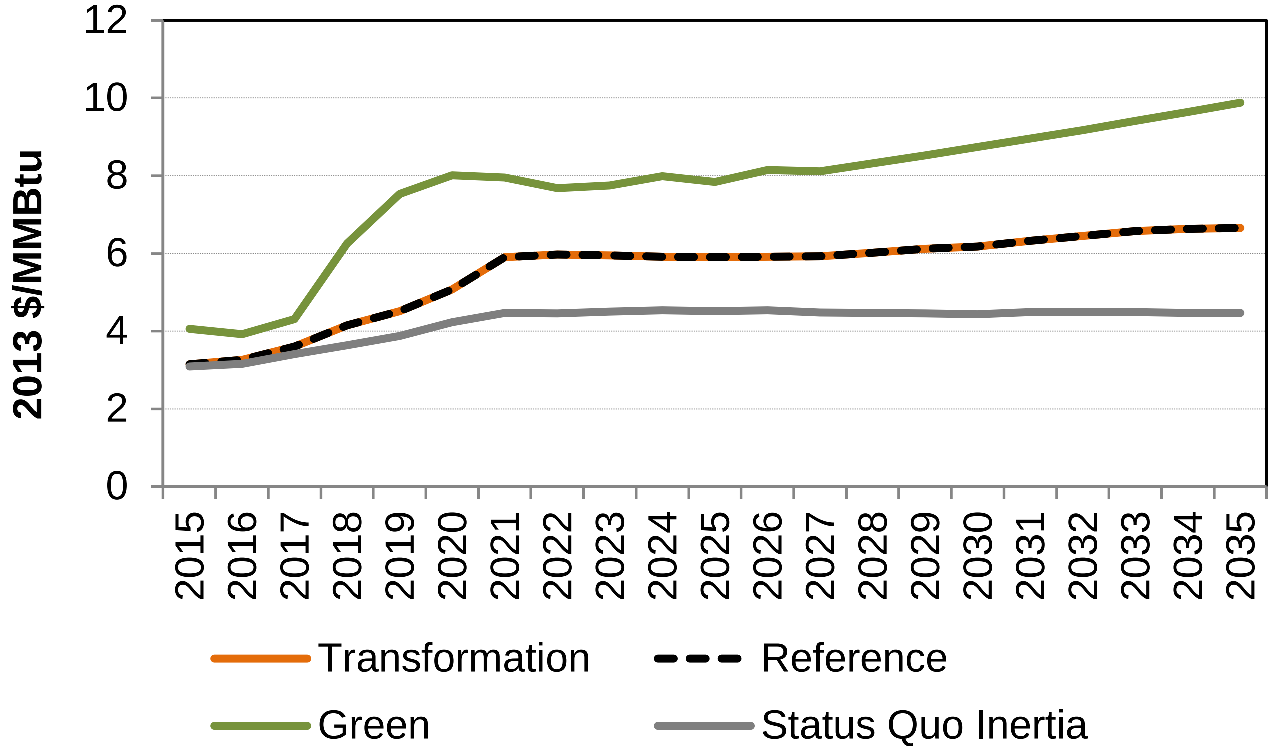
Answers for infrastructure and cities.

Natural Gas Prices across Scenarios

SQI: abundant supply with production costs low

Green: high demand for gas and fracking restrictions

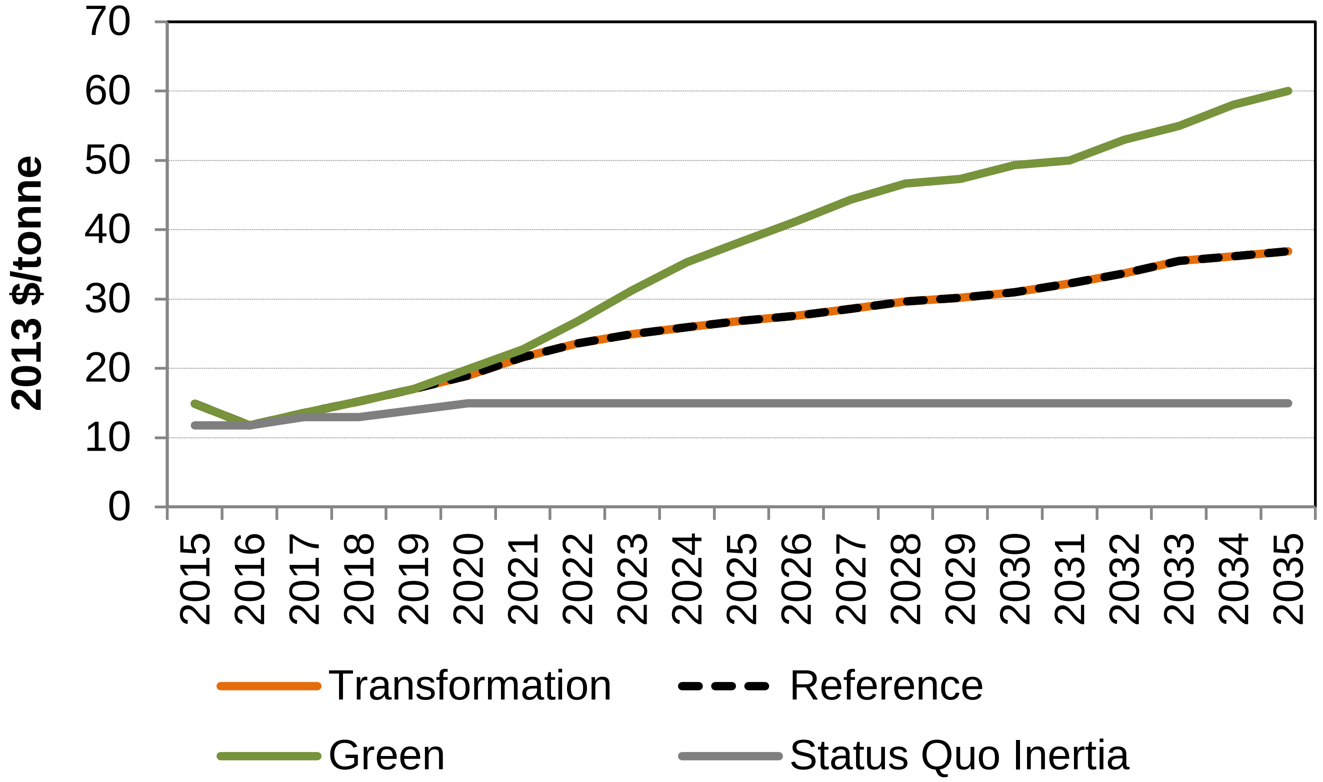


**Note that the Transformation scenario uses the Reference Case gas price projections.*

Carbon Prices across Scenarios

SQI: cost-effective reductions and efficient changes in other sectors

Green: more stringent caps and higher gas prices drive higher carbon costs



**Note that the Transformation scenario uses the Reference Case carbon price projections.*

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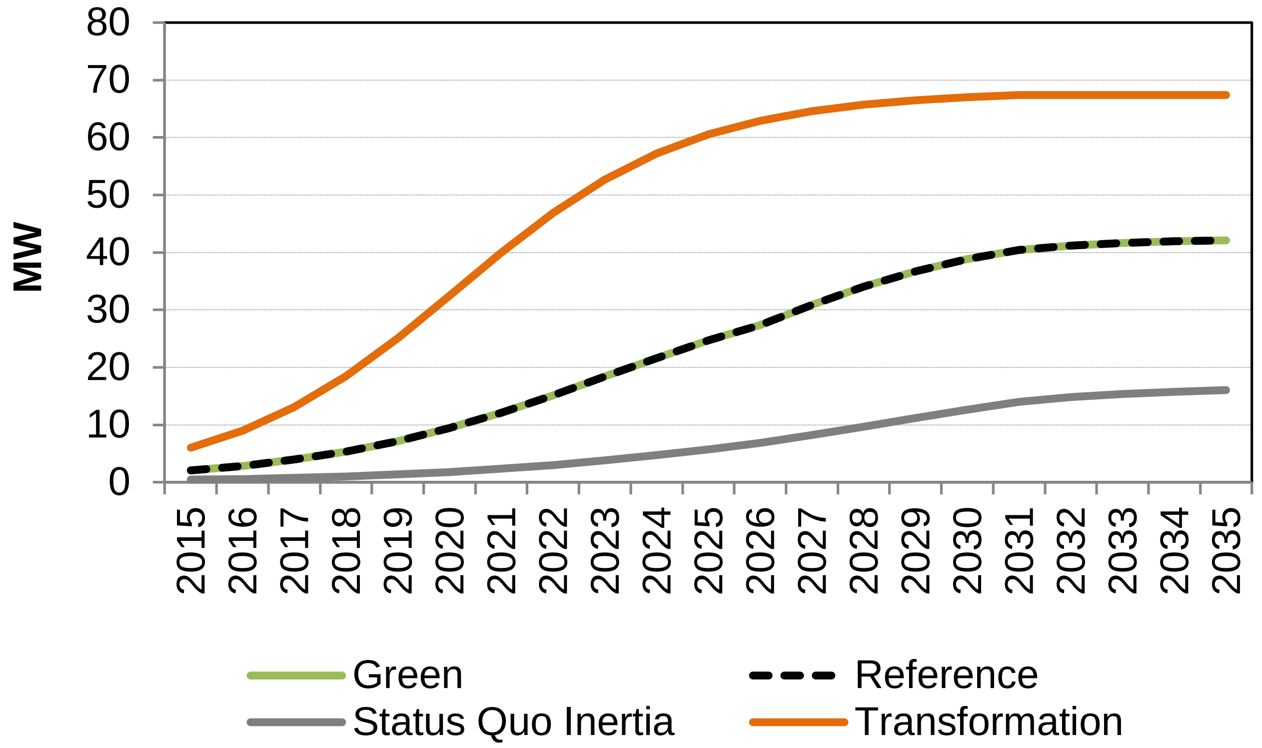
Solar PV Penetration across Scenarios

SQI: costs of electricity lower; payback period higher

Transformation: solar PV and battery costs decline; other technology and information enables adoption



**Note that the Green scenario uses the Reference Case solar PV penetration levels.*

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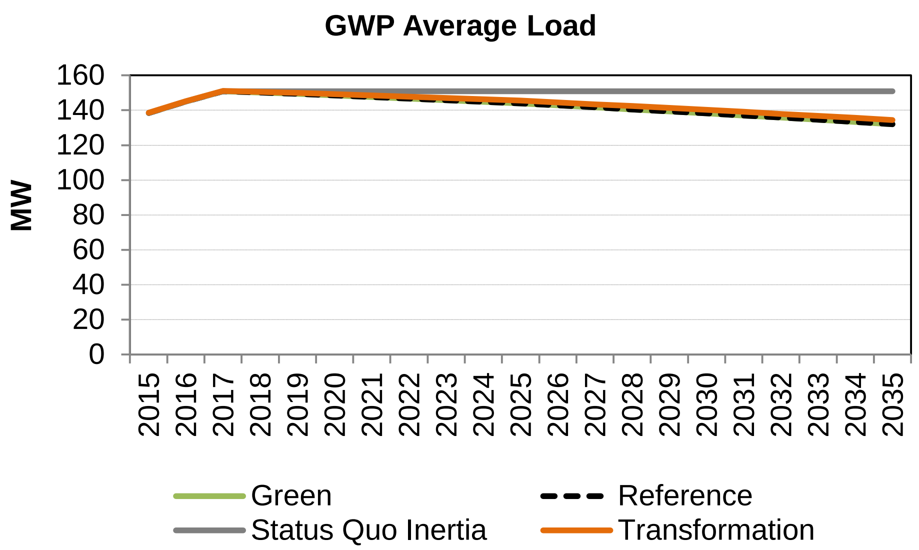
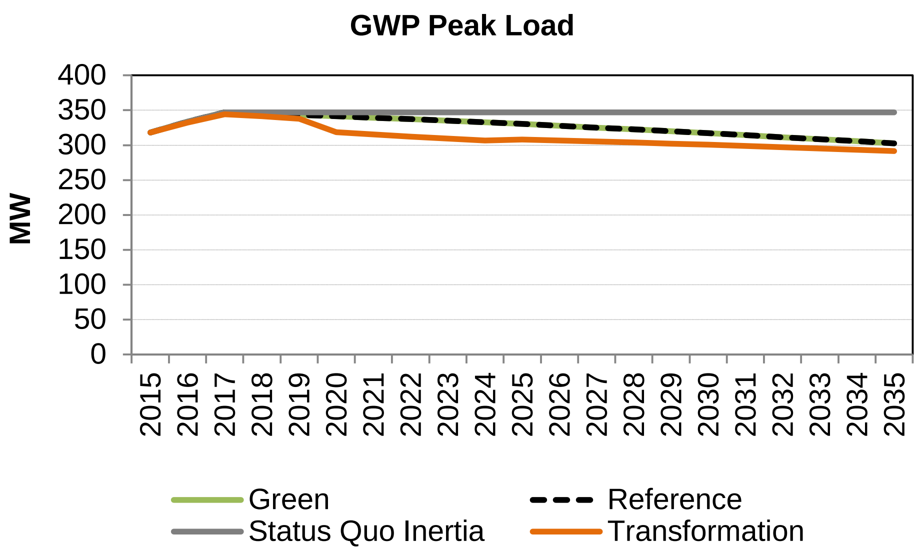
Load Growth across Scenarios

SQI: customer count increases continue as a result of re-development and increased population density

Transformation: TOU rate adoption, but electric vehicle penetration is higher as a result of batter cost declines





**Note that the Green scenario uses the Reference Case load growth levels.*

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Appendix III

Portfolio Analysis Details

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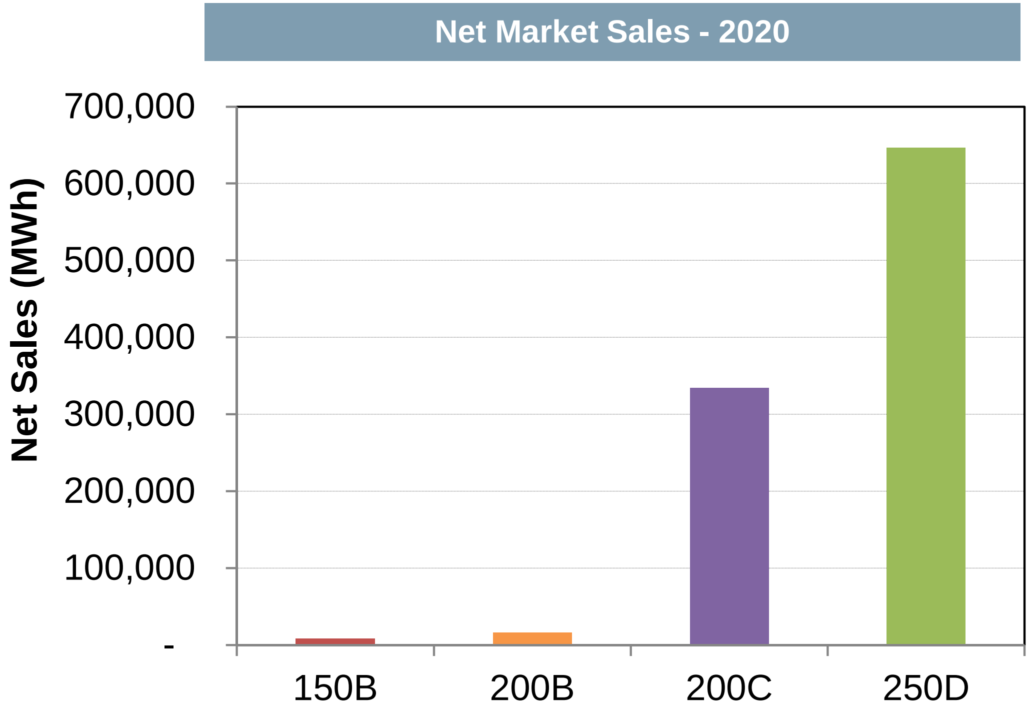
Portfolios with Local Combined Cycles Produce Significant Off-System Sales

- In 2020, while 150B and 200B (portfolios with only simple cycle LM6000s) have limited net transactions with the outside market, the CC portfolios generate significant revenues to offset larger capital costs



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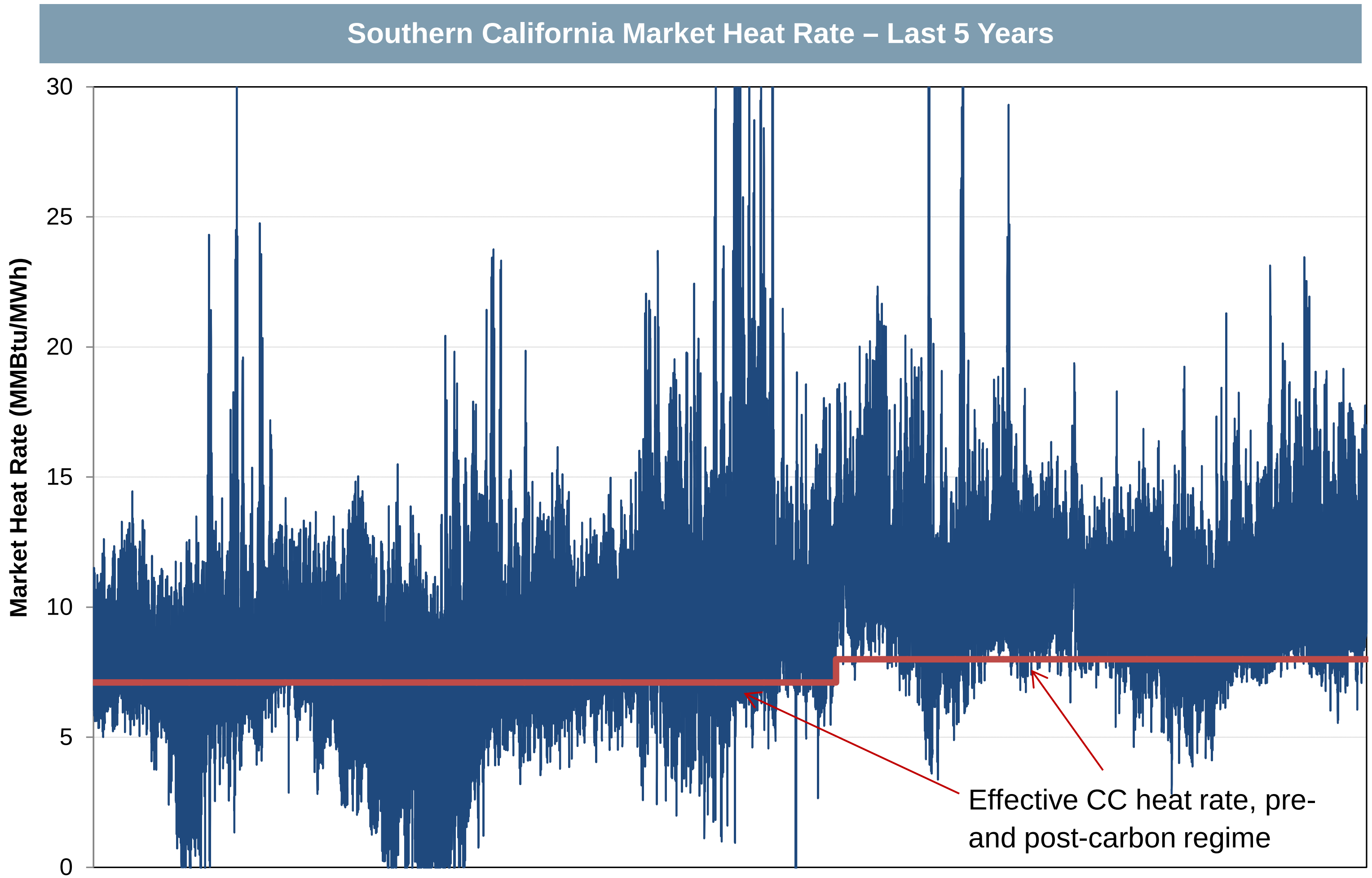
Market Volatility Can Pose Dispatch and Sales Risks for CC Portfolios



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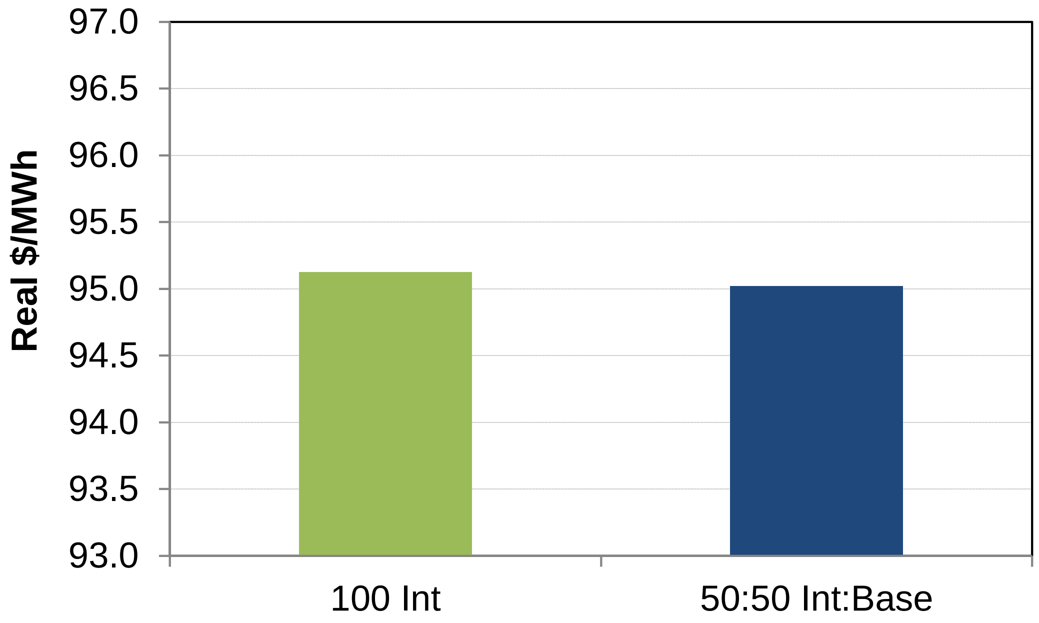
Diverse Remote Renewables are Slightly Lower Costs

- Across all scenarios, the portfolio options that obtain renewables from wind, solar, and geo are slightly lower cost than the pure wind/solar mix

Portfolio Cost Average for Renewable Strategies – Reference Case



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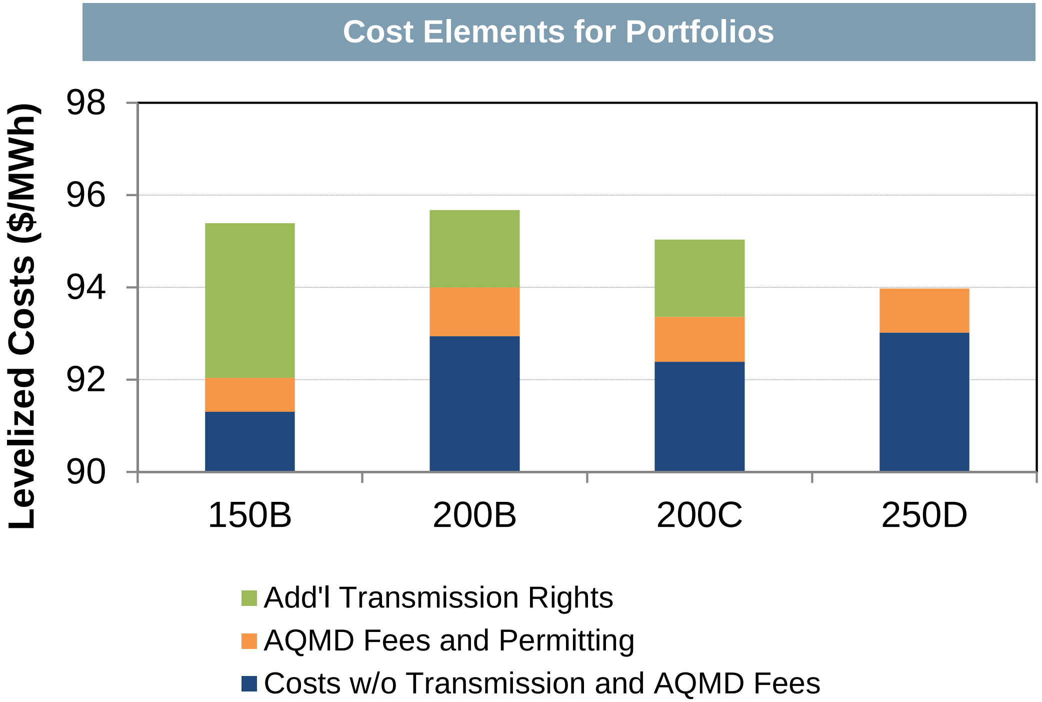
Extra Transmission Costs Impact the 150 and 200 Families

- If the 150B portfolio did not face additional charges associated with paying for additional transmission rights to access external energy, its overall portfolio costs would be much closer to the other options



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Appendix IV

LOLE Study

City of Glendale Water & Power
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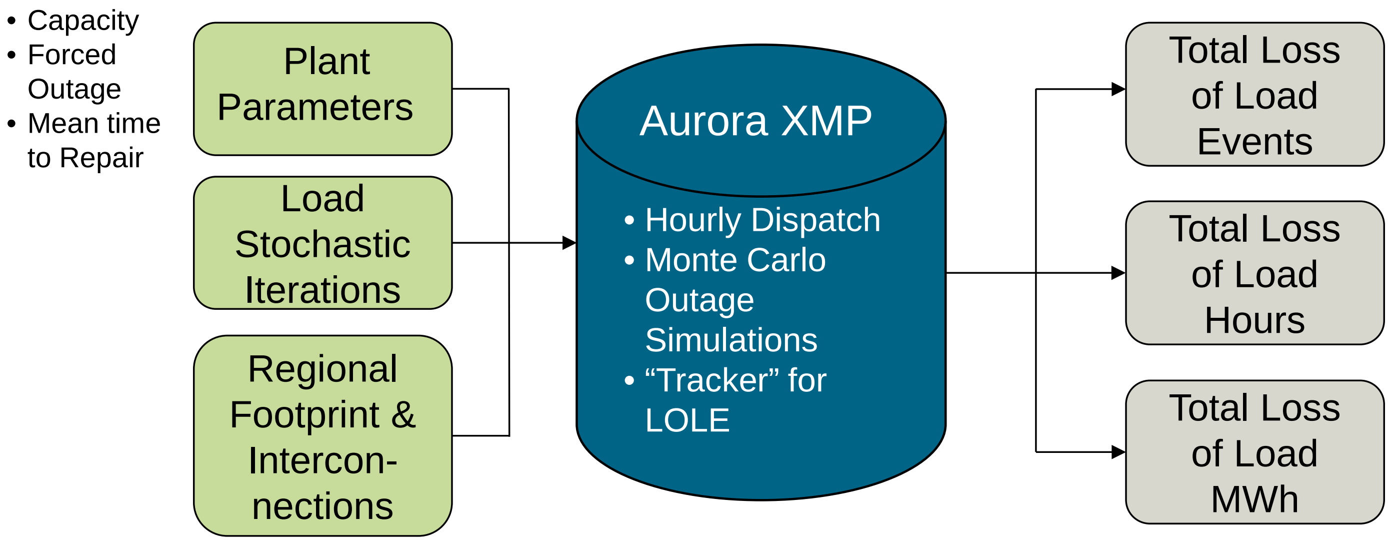
Answers for infrastructure and cities.

Loss of Load Study Assesses System Reliability

- Tests the likelihood that GWP's generation and transmission system will be unable to meet load for any period of time.
  - Monte Carlo-based simulations for outages in the generation and transmission system, as well as uncertainty in hourly loads for GWP's system.
- The industry standard for loss of load events ("LOLE") is one event in ten years ("1-in-10 Standard").



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Key Input Drivers Include Supply Availability and Load Uncertainty

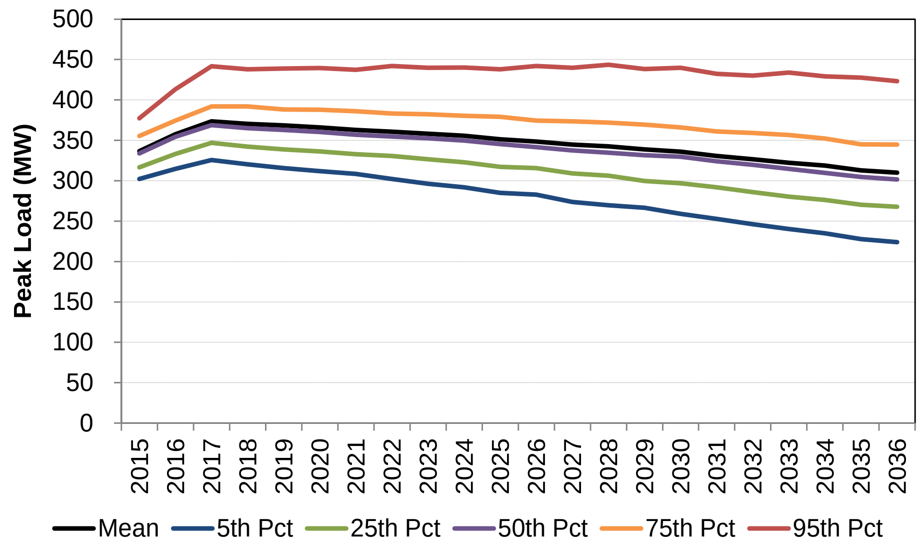
- Simulation evaluates possibility of generation or transmission system outage against a range of potential future load outcomes, driven by uncertainty in weather, economic growth, customer additions and energy efficiency penetration

Supply

System Element	Forced Outage Rate (%)	Mean Time to Repair (hours)
Grayson Unit 3	20%*	720
Grayson Unit 4	10%**	720
Grayson Unit 5	10%^	720
Grayson Unit 8A	10%^^	720
Grayson Unit 8B	10%^^	720
Grayson Unit 9	2.5%	88
LM6000 Simple Cycle	1.9%	88
LM6000 Combined Cycle	2.7%	120
Victorville – LA Import Path	0.35%	72
NOB – Sylmar Import Path	0.35%	72
Magnolia Import Path	0.35%	72

*Initial rate is 20%. This increases by 5% per year until planned retirement in 2020.
**Initial rate is 10%. This increases linearly up to 20% until planned retirement in 2023.
^Note that this unit retires in 2017.
^^Initial rate is 10%. This increases linearly up to 20% until retirement in 2022.

Demand



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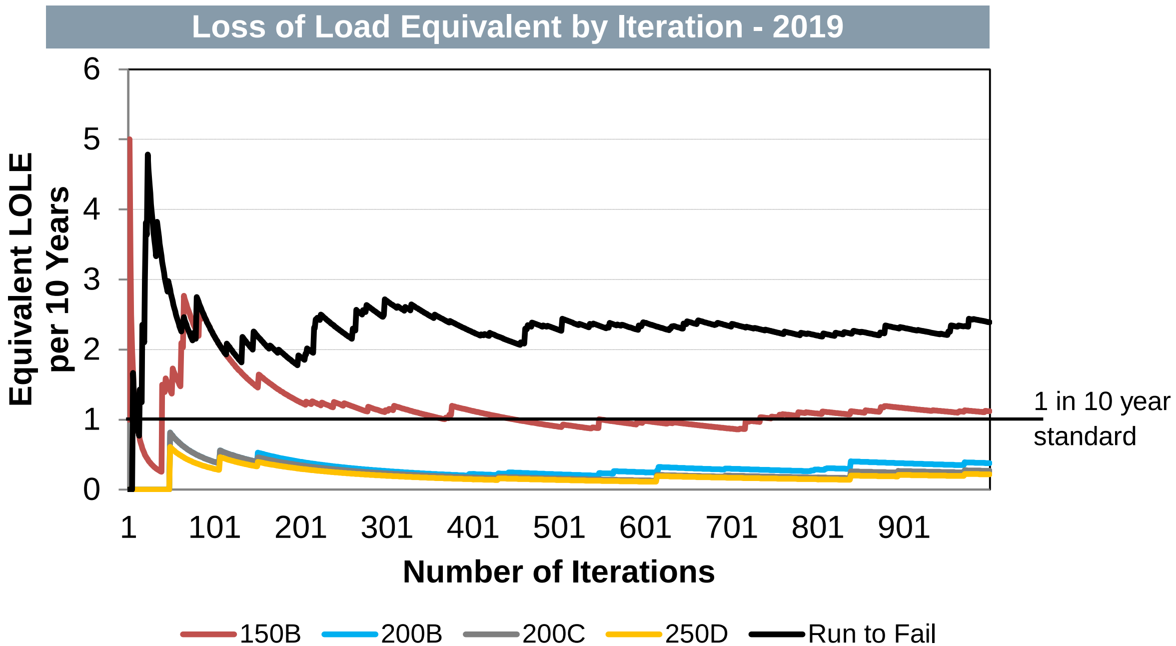
Run-to-Fail Portfolio Faces Significant Reliability Risk

- Under a 2019 test year, the run-to-fail and 150B options violate the standard
- By 2027, the run-to-fail portfolio faces significant risk of loss of load events, while the 150B portfolio moves back within acceptable standards as a result of declining load expectations



Portfolio/ Year	Loss of load Events per 10 years	Loss of Load Hours per 10 year period	Loss of MWh per 10 year period
150B/ 2019	1.1	5.3	186
200B/ 2019	0.4	1.5	55
200C/ 2019	0.3	1.2	45
250D/ 2019	0.2	0.9	28
Run to Fail/ 2019	2.4	14.3	569
150B/ 2027	0.5	2.0	55
Run to Fail/ 2027	22.3	149.8	5,962

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Cost Impacts of Loss of Load Events Can be Significant

- The estimated value of lost load ("VOLL") climbs well into the millions of dollars per year range for the run-to-fail portfolio

Portfolio/ Year	Residential VOLL (2013$)	Industrial and Commercial VOLL (2013$)	VOLL (Total 2013$)
150B/ 2019	$6,075	$239,617-$835,982	$245,692-$842,057
200B/ 2019	$1,796	$70,854-$247,199	$72,650-$248,995
200C/ 2019	$1,470	$57,972-$202,254	$59,442-$203,724
250D/ 2019	$914	$36,071-$125,847	$36,985-$126,761
Run to Fail/ 2019	$18,583	$733,022-$2,557,385	$751,605-$2,575,968
150B/ 2027	$1,796	$70,854-$24,7199	$72,650-$248,995
Run to Fail/ 2027	$194,714	$7,680,626-$26,796,358	$7,875,340-$26,991,072

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Appendix V

Distributed Solar PV Penetration

City of Glendale Water & Power
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Answers for infrastructure and cities.

Impact of Distributed Solar PV on GWP Portfolio Costs

Objective: Assess the likely future penetration rates of solar PV at the distributed (residential and commercial customers) level

Approach: Estimate market share and adoption rate as a function of economic payback period

- Retail rate projections for GWP customer classes
- California-specific capital cost estimates for solar PV
- Three discrete periods (early, mid, late) over which to evaluate payback economics

Outputs: Expected penetration over time, including:

- PV meter count
- Installed PV (MW)
- Reduction in total expected load (MWh) served by GWP

Key Input Assumption Drivers

- **Module Size**: 3 kW for residential customers; 8 kW for commercial customers. The module size was based on peak consumption per customer as observed historically. The solar module capacity factor was assumed to be 15%, consistent with average fixed tilt rooftop systems in California.
- **Technology Capital Costs**: Solar PV costs declining from $3,300/kW range to $2,600/kW by the end of the decade and $2,300/kW by 2030.
- **Retail Rate Projections**: The retail rates projection was based on current rates, incremental changes in revenue requirements over time as a function of changes in operating costs (fuel and operating costs) on the supply side, investments in generation such as Grayson, and investments in transmission and distribution expenses over time.

All values in real 2015$

Year	Retail Rate ($/KWh)	Capital Cost ($/KW)
2015	0.155	3,300
2016	0.165	3,169
2017	0.165	3,036
2018	0.163	2,905
2019	0.169	2,772
2020	0.176	2,641
2021	0.175	2,607
2022	0.177	2,574
2023	0.178	2,541
2024	0.178	2,508
2025	0.178	2,475
2026	0.178	2,443
2027	0.173	2,410
2028	0.170	2,376
2029	0.170	2,343
2030	0.170	2,310
2031	0.171	2,275
2032	0.172	2,238
2033	0.172	2,200
2034	0.172	2,160
2035	0.173	2,119

Solar Penetration Curves Vary across Different Economic Payback Periods

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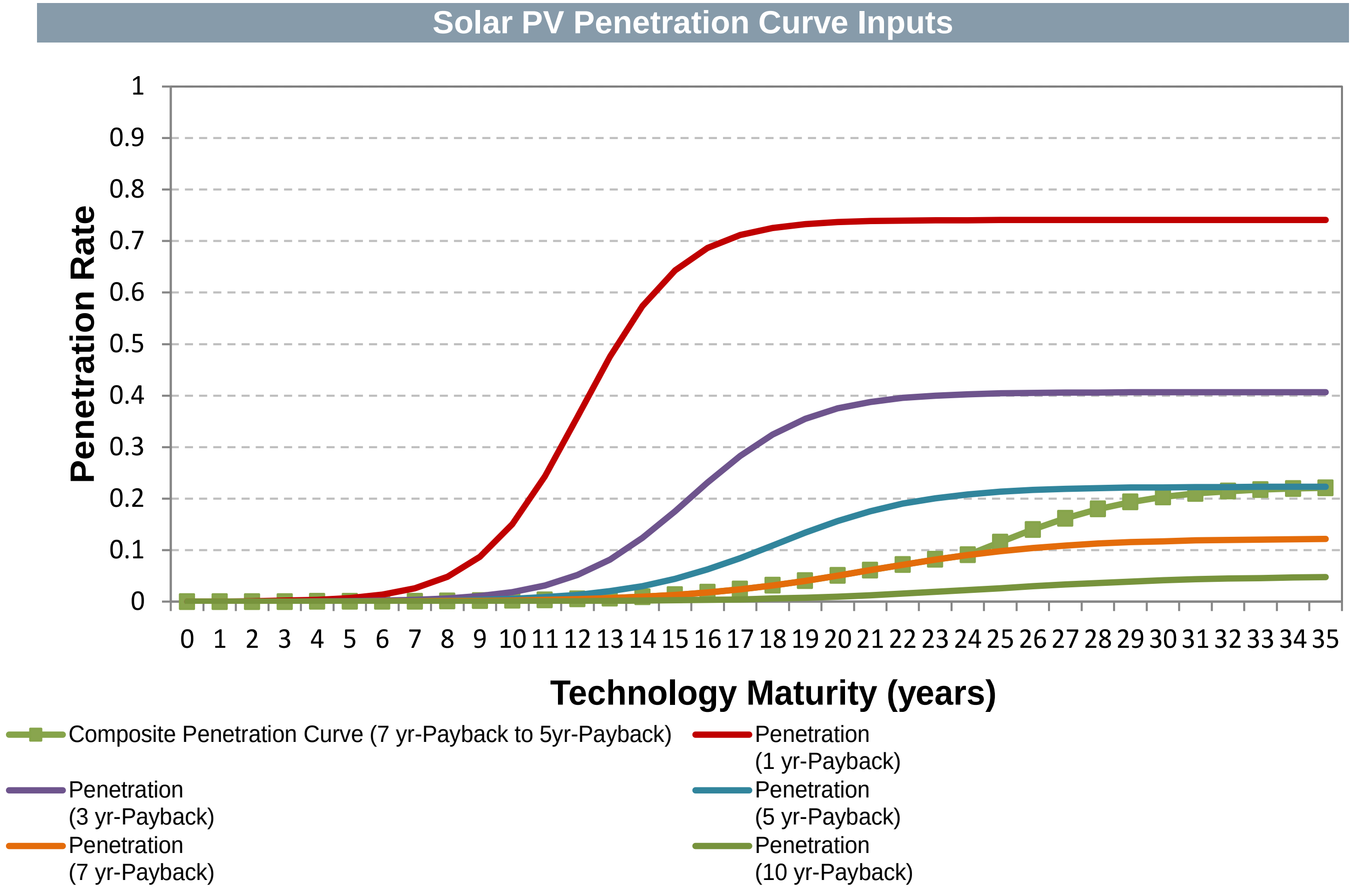

Source: NREL

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Total Load Reductions Could be as High as Five Percent by the 2030s

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- Reference case projections indicate potential sales declines on the order of five percent by 2030, with over 10,000 PV meters across GWP's service territory

Commercial Class Impacts

Commercial	Reduction In Load (MWh)	Total Load (MWh)	Load Reduction (%)	Installed PV (kW)	PV Meter Count
2015	611	412,369	0.1%	465	58
2016	849	439,043	0.2%	646	81
2017	1,168	462,520	0.3%	889	111
2018	1,589	460,321	0.3%	1209	151
2019	2,128	458,048	0.5%	1619	202
2020	2,794	455,541	0.6%	2127	266
2021	3,585	452,889	0.8%	2728	341
2022	4,476	450,175	1.0%	3406	426
2023	5,426	447,405	1.2%	4129	516
2024	6,379	444,577	1.4%	4855	607
2025	7,283	441,672	1.6%	5542	693
2026	8,092	438,715	1.8%	6158	770
2027	10,331	435,708	2.4%	7862	983
2028	12,546	432,639	2.9%	9548	1193
2029	14,536	429,498	3.4%	11062	1383
2030	16,175	426,284	3.8%	12310	1539
2031	17,441	423,028	4.1%	13273	1659

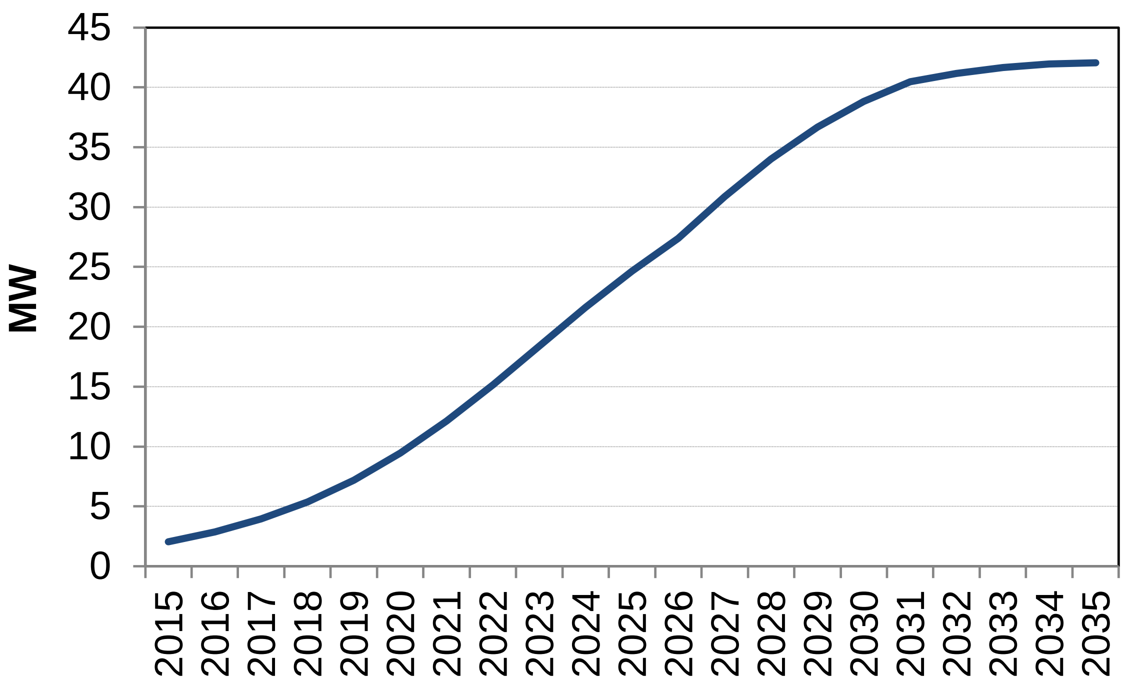
Residential Class Impacts

Residential	Reduction In Load (MWh)	Total Load (MWh)	Load Reduction (%)	Installed PV (kW)	PV Meter Count
2015	2,094	475,241	0.4%	1593	531
2016	2,910	493,548	0.6%	2215	738
2017	4,009	509,686	0.8%	3051	1017
2018	5,458	508,733	1.1%	4154	1385
2019	7,315	507,752	1.4%	5567	1856
2020	9,616	506,591	1.9%	7318	2439
2021	12,347	505,341	2.4%	9396	3132
2022	15,430	504,091	3.1%	11743	3914
2023	18,721	502,848	3.7%	14247	4749
2024	22,013	501,190	4.4%	16752	5584
2025	25,127	499,481	5.0%	19123	6374
2026	27,888	496,869	5.6%	21224	7075
2027	30,228	494,163	6.1%	23004	7668
2028	32,155	491,759	6.5%	24471	8157
2029	33,673	489,250	6.9%	25627	8542
2030	34,839	486,632	7.2%	26514	8838
2031	35,717	483,951	7.4%	27182	9061

Total Distributed Solar PV Could Exceed 40 MW

- Reference case projections indicate close to 10 MW by the early 2020s and around 40 MW by the early 2030s
- All portfolio analysis includes this capacity

Total Solar PV Installed MW over Time



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Appendix VI

Load Forecast

City of Glendale Water & Power
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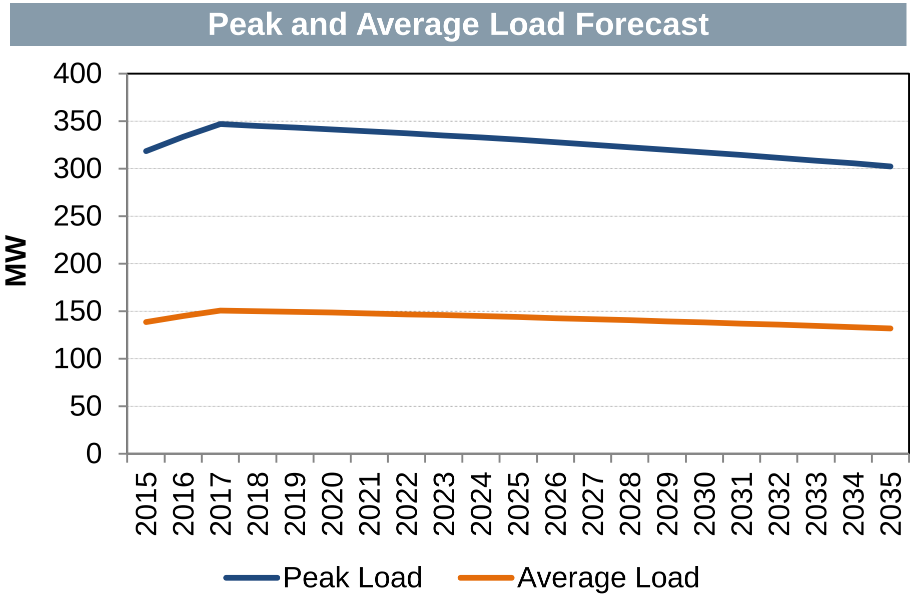
Answers for infrastructure and cities.

Load Forecast Overview

- Performed an historical econometric analysis of key weather and economic drivers;
- Developed the base load forecast driven by normal weather, projections for economic variables, and known customer additions;
- Made adjustments for energy efficiency, demand side management ("DSM"), and plug-in electric vehicle penetration.



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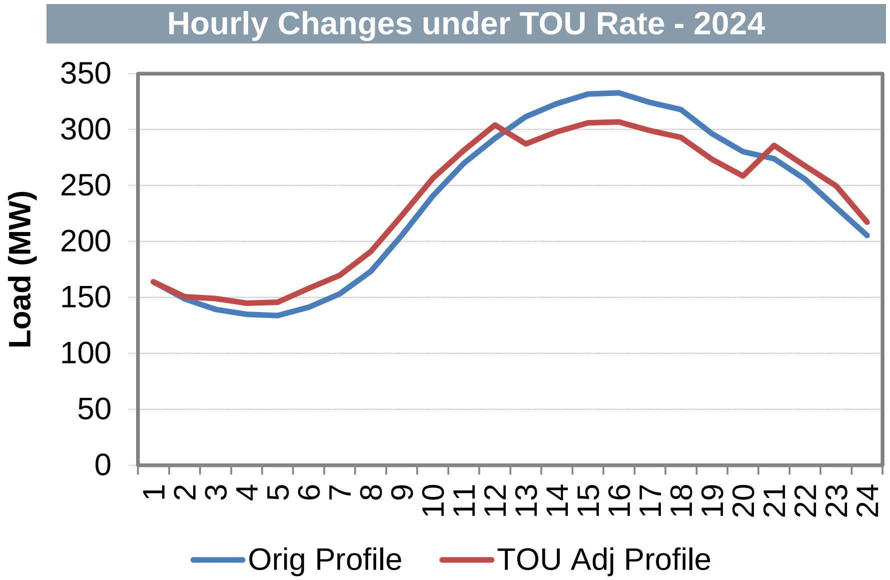
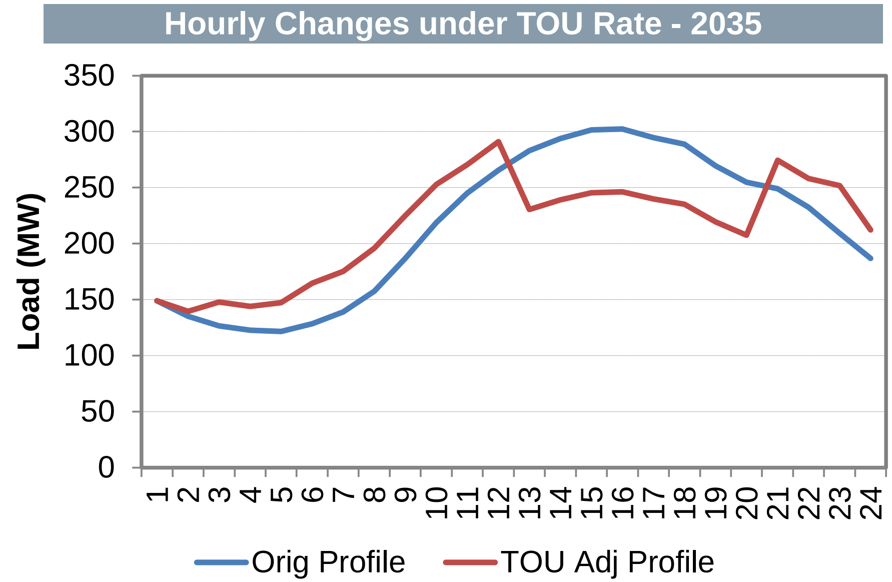
Time of Use Rates Can Drive Load Shifting

- As time passes and as more participants enter a TOU rate structure, load shifts are expected in GWP





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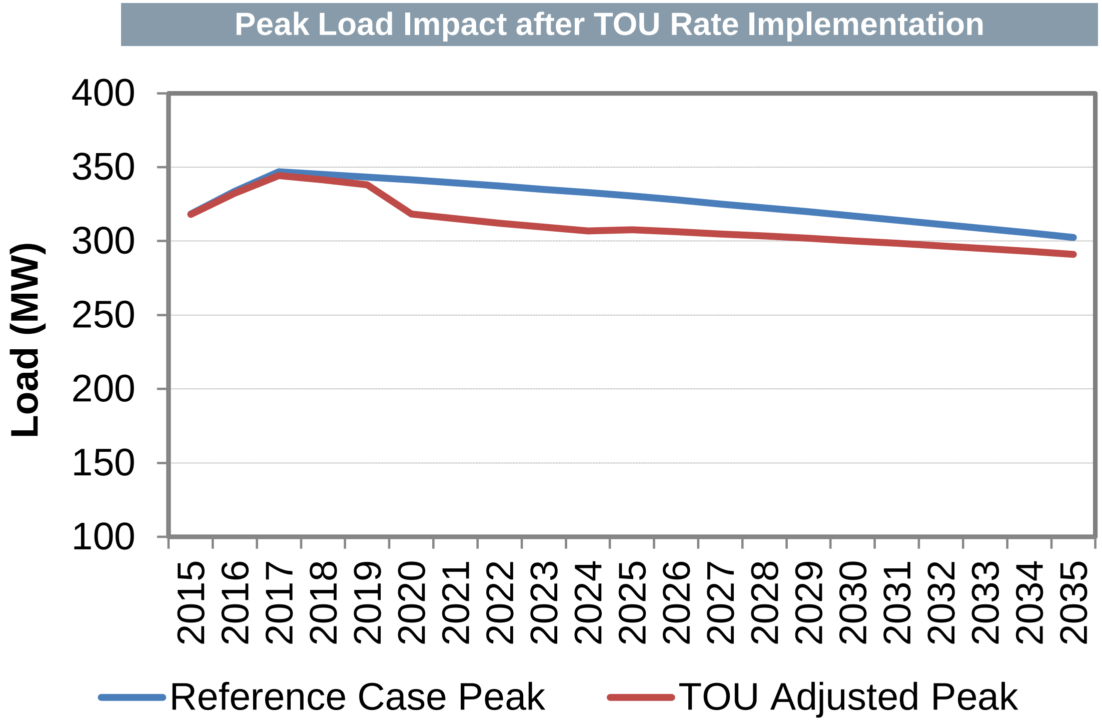
Time of Use Rates Can Lower Peak Load Expectations

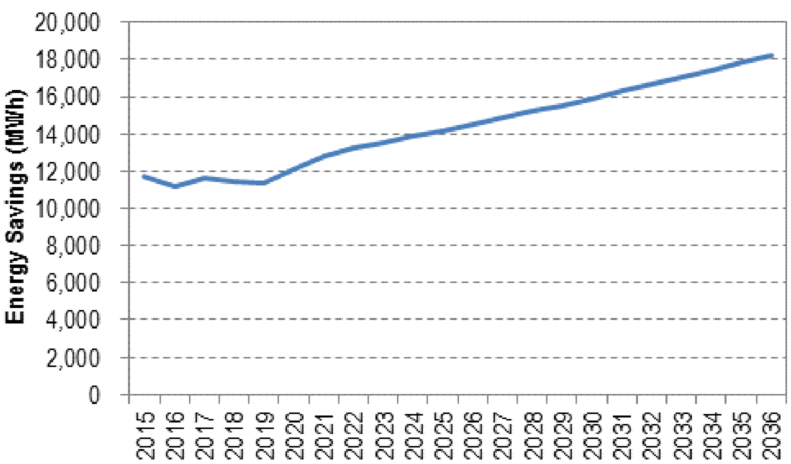
- The implementation of a time of use rate program could shift significant load from the peak hours to other parts of the day if participation levels are high



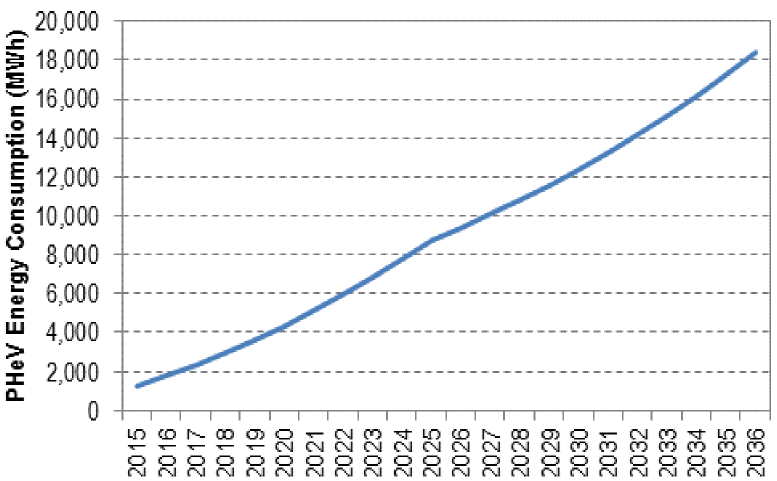
Load Forecast Assessed Energy Savings and Future Electric Vehicle Loads

- Load forecast analysis assessed energy efficiency penetration over time in line with GWP's current goals
- Load forecast included expectations for electric vehicle load growth in line with current state-level goals

Cumulative Energy Efficiency Penetration



Cumulative Electric Vehicle Load



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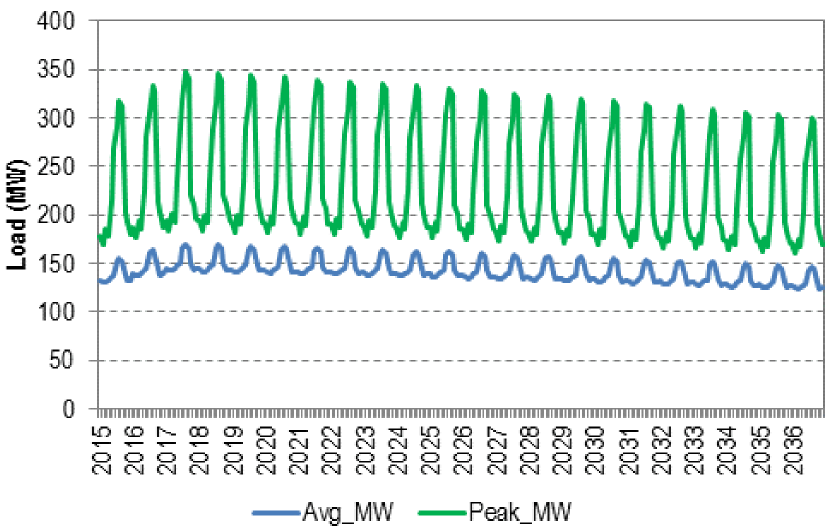
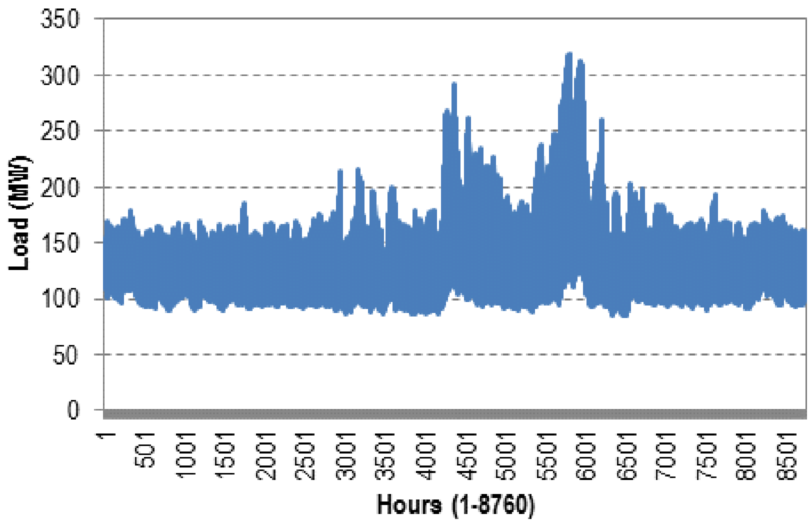
Detailed Hourly Portfolio Analysis Included Granular Projections

Monthly Load Forecast



Hourly Load Forecast Shape



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