DRAFT for Discussion

Presentation to Los Alamos County, Los Alamos National Lab, and Board of Public Utilities

Los Alamos County Integrated Resource Plan Interim Discussion

Key Objectives, Load Forecasts, Resource Options, and Portfolios Framework

FTI CONSULTING

November 1, 2021

Table of Contents

FTI and Team Introduction

FTI CONSULTING

FTI Consulting: Experts with Impact

FTI Consulting is an independent global business advisory firm dedicated to helping organizations manage change, mitigate risk and resolve disputes. Due to our unique mix of EXPERTISE, CULTURE, BREADTH OF SERVICES and INDUSTRY EXPERIENCE, we have a tangible impact on our clients' most complex opportunities and challenges.

Definitive Expertise

- **Who's Who Legal: Consulting Experts (Most Recognized),** *Law Business Research Ltd.* (2016 – 2020)
- Named **Global Turnaround Consulting Firm of the Year,** *Global M&A Turnaround Atlas* (2015-2019, 2021)
- **Recognized in 11 Categories in the Chambers Litigation Support guide,** *Chambers and Partners* (2021)
- **Achievement in Developing and Promoting Women**, *Stevie Awards* (2020)

A Culture That Delivers

- **Practical** in our communication and approach to outcomes
- **Judicious** in complex, multi-party situations
- **Collaborative** with clients and colleagues
- **Professional** in our commitment to work with the highest caliber

6,400+ Employees	**640+** SMDs	**$4.9B** Market Cap.[1]
86 Cities		**29** Countries
Advisor to **96** of the world's top **100** law firms	**55** of Fortune Global **100** corporations are clients	Advisor to **8** of the world's top **10** bank holding companies

Comprehensive Services

- Financial
- Legal
- Operational
- Political & Regulatory
- Reputational
- Transactional

Industry Experience

- Construction
- Energy Power & Products (EPP)
- Financial Institutions
- Healthcare & Life Sciences
- Insurance
- Mining
- Real Estate
- Retail & Consumer Products
- Telecom, Media & Technology

Note:
1) Market Cap is as of October 29, 2021.

FTI Consulting: Definitive Expertise to Make Tangible Impacts

America's Best Management Consulting Firms *Forbes* (2016 – 2020)	**Consulting Magazine's Best Firms to Work For List** *ALM Media Properties* (2018 – 2019)	**Who's Who Legal: Arbitration Consulting Firm of the Year** *Law Business Research* (2015 – 2019)	**#1 U.S. Restructuring Advisor of the Year** *The Deal* (2007 – 2019)
Corporate Counsel: Top Service Provider in the Legal Industry *ALM Media Properties* (2016 – 2019)	**Best M&A or Communications in Support of a Transaction** *PRCA City and Financial Awards* (2020)	**Consulting Firm of the Year** *Who's Who Legal* (2019)	**Named a Fortune 1000 Company** *Fortune* (2019)
Global Strategy Consulting Firm of the Year *Global M&A Network Atlas Awards* (2019)	**Gold Winner: Public Relations Agency of the Year** *PR World Awards* (2019)	**GAR: Expert Witness Firms' Power Index** *Law Business Research* (2019)	**#1 IT Consultant Services** *Corporate Counsel Best of 2018, American Lawyer* (2018)

FTI IRP Team Introduction

Ken Ditzel

Senior Managing Director

Ken advises clients in the oil and natural gas, coal, biofuels, electricity, and manufacturing sectors. Mr. Ditzel specializes in energy market supply, demand, and price forecasting, examining future scenarios under a range of technology, policy, and economic environments. He has used scenario analysis in portfolio analysis, asset acquisition / divestment, technology assessments, policy analysis, M&A due diligence, and corporate growth strategies.

Fengrong Li, CFA, CIRA

Managing Director

Fengrong has spent over 20 years in the energy sector and commodity trading. She specializes in market advisory, strategy development, resource planning, due diligence, asset modeling and valuation across the energy value chain. She has advised numerous LNG, gas, and power assets in Russia, Europe, Africa, Asia, North and South America. Prior to FTI, Ms. Li held senior positions at Siemens, and Mitsui & Co. Ltd.

Mitch DeRubis

Director

Mitch has advised oil and gas producers, biofuels manufacturers, refined product and natural gas midstream companies, industrial end-users, governments, and financial institutions on domestic and international energy market conditions and outlooks.

Prior to FTI, Mr. DeRubis was a senior energy analyst on the quantitative modeling team at S&P Global Platts/Bentek Energy.

Cameron Luther

Consultant

Cameron specializes in the analysis of power markets, with specific expertise in modeling MISO, SPP, and ERCOT. His work has been used in asset valuation, forensic price analysis, and state planning processes. Mr. Luther has experience in assessing renewables projects, evaluating energy market rules, and forecasting market trends. His areas of expertise include macroeconomic, regional, and energy modeling, with a focus on developing long-term forecasts.

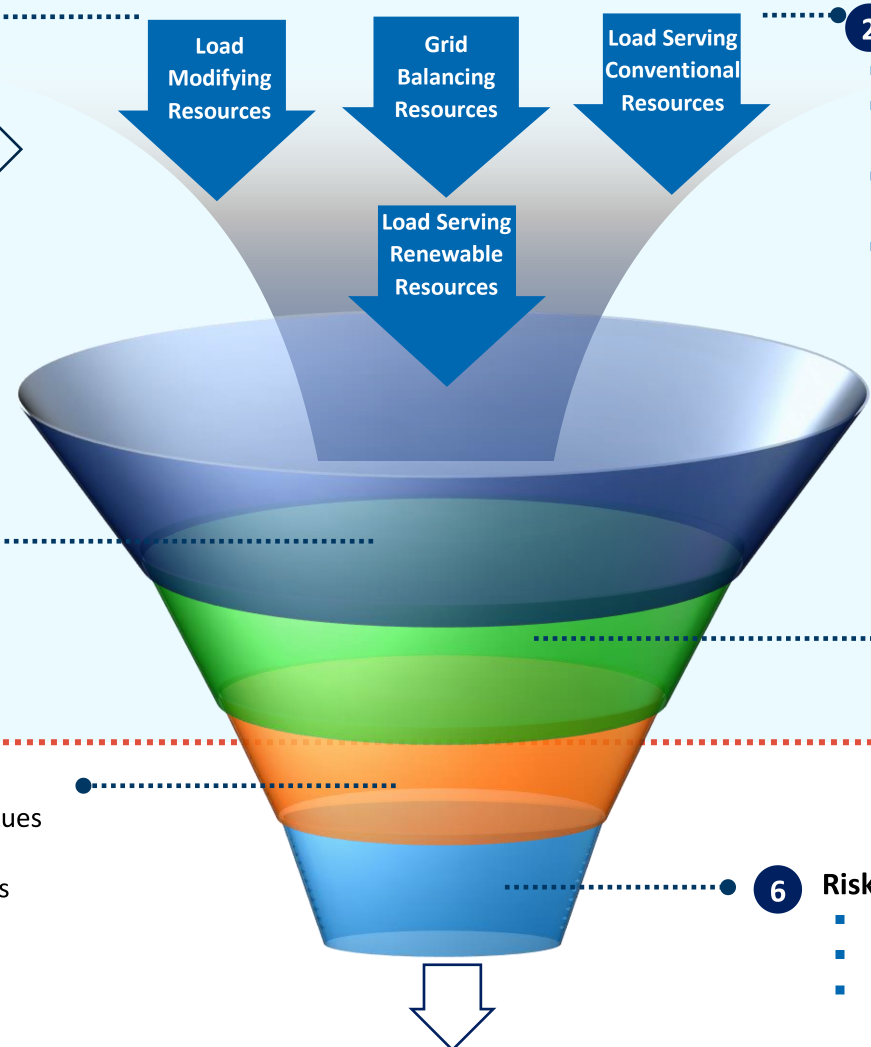
IRP Key Considerations, Objectives, Options, and Portfolios

FTI CONSULTING

Structured IRP Process to Address Key Issues and Objectives

1 Identify IRP Objectives
- Cost
- Risks
- Sustainability
- Operational Metrics
- Resiliency
- Diversification

2 Define Feasible Resource Options
- **Load modifying resources**: EE, DR, and DER
- **Grid balancing resources**: RICE, SCGT, pumped hydro, batteries, demand response
- **Load serving conventional resources**: natural gas fired CCGT, SCGT, RICE
- **Load serving emission free resources**: solar, wind, geothermal, Small Modular Nuclear Reactors (SMNR)



3 Modeling Inputs
- Load forecast
- Capital and operating costs
- Natural gas, coal, CO_2 prices
- Scenario definition

4 Screening Analysis
- Levelized cost of energy
- Operational benefits

5 Portfolios Construction
- Address key planning issues
- Represent different stakeholder perspectives

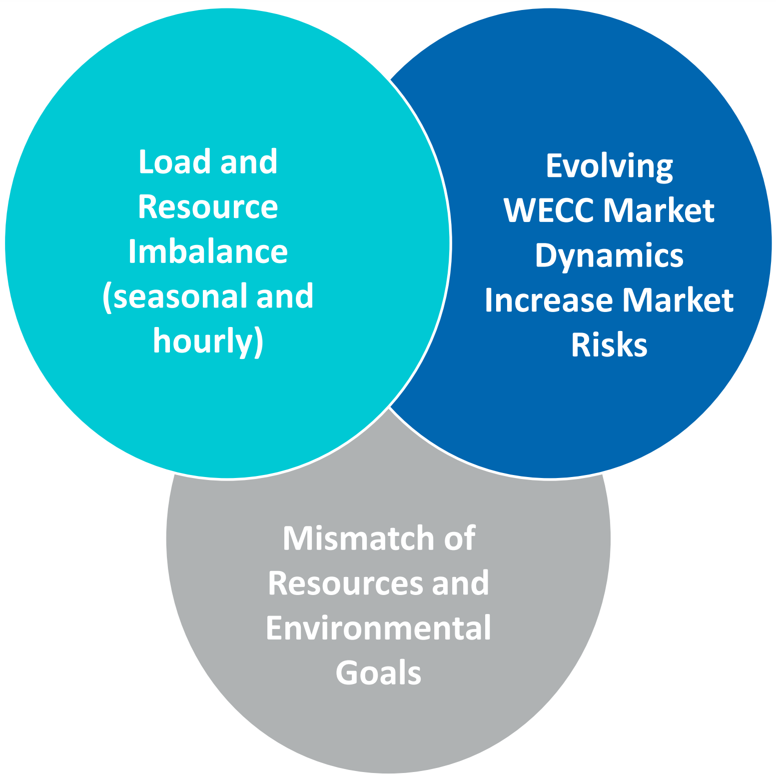
6 Risk Assessment
- Evaluate trade-offs
- Performance under market uncertainties
- Stochastic or scenario-based

7 Portfolios Recommendations:
Select best portfolio(s) based on balance of objectives and risk tolerance consistent with objectives

Notes:
1) EE: Energy Efficiency
2) DR: Demand Response
3) DER: Distributed Generation Resource
4) RICE: Reciprocating Internal Combustion Engine
5) SCGT: Simple Cycle Gas Turbine
6) SMNR: Small Modular Nuclear Reactor

Focus on LAC IRP Key Considerations and Challenges

Key Challenges



LAC IRP will consider how and when to replace fossil generation with combinations of renewables, storage, and demand side resources, factoring in rising market wide renewable penetration, EV adoption, heating and cooling electrification, viable utility scale storage options, transmission limits, resiliency, and grid stability issues.

LAC IRP Considerations

- **Carbon neutral goal (2035)**
- **Changing dynamics in PNM BA & EIM**
- **Manage long or short positions**
- **Manage risks (volatility and exposure)**
- **Small modular nuclear reactors**
- **Renewable resources**
- **Cost effective utility scale storage**
- **Demand side resources (DER, EE, DR)**

Notes:
1) BA: Balancing Authority
2) EIM: Energy Imbalance Market

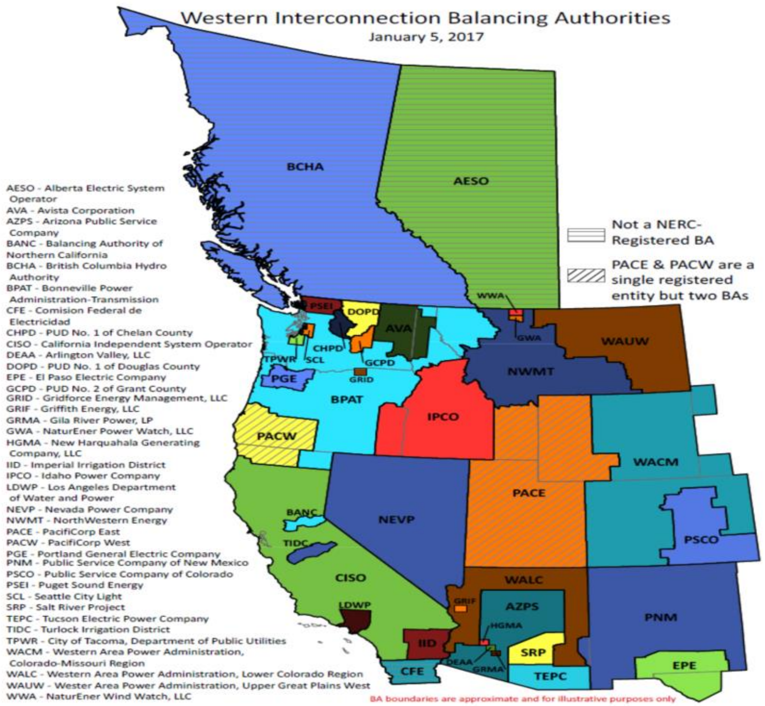
FTI Comprehensive Power Modeling Process for IRP

Utilize Plexos® model to simulate the WECC market.

Incorporate market conditions & regulations.

Dispatch the electric system in a way that minimizes costs and accounts for operational constraints of units & transmission interties.

Properly assess options of economic, environmentally responsible, and operationally viable plan to serve load and meet carbon neutral goal.



LAC IRP Modeling

- **Board of Public Utilities (BPU) policy**
- **Cost effectively meet the requirements for reliable and economic operations inside the PNM balancing area**
- **Evaluate a broad range of demand-side programs and supply-side resources**

Capacity Expansion and Hourly Dispatch

- **Security Constrained Economic Dispatch (SCED)**
- **Chronological Hourly Dispatch Optimization**

Market Rules

Market Conditions & Regulations

WECC Market

Plexos®

Notes:
1) WECC: Western Electricity Coordinating Council
2) SCED: Security Constrained Economic Dispatch

LAC IRP Key Objectives and Metrics

Objectives	Key Metrics
Cost	Portfolio Net Present Value (NPV) over the IRP horizon Ability to preserve competitive rates
Risks	Market exposure Development risk
Sustainability	LAC Net Carbon Zero Electricity by 2040 LANL 100 percent renewable by 2035[1] Portfolio CO_2 emissions
Operational	The largest contingency (transmission or generation) Weather dependence Practicality with transmission constraints
Reliability	Reserve margin Dispatchability for balancing Load shed minimization
Diversification	Location, generation types, fuel source Owned vs. contracted

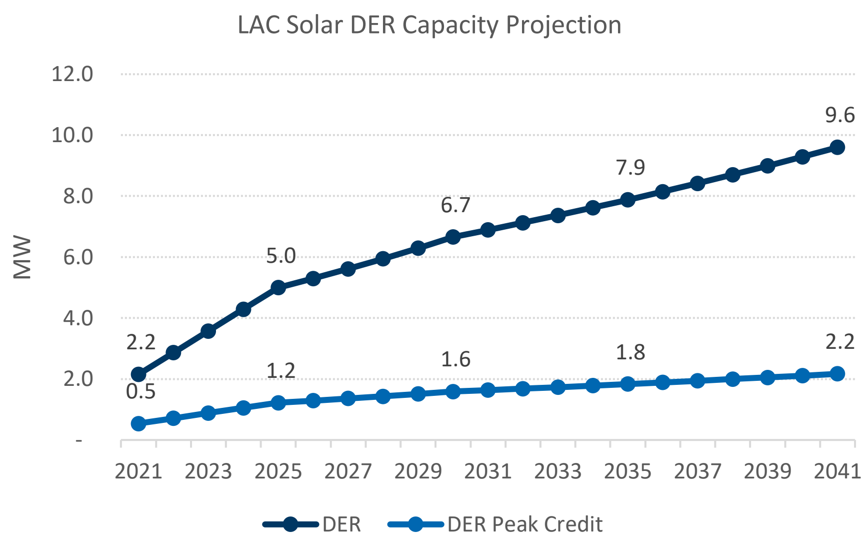
Note:
1) The 100 percent renewable power for LANL is a component of the Department of Energy 2021 Climate Adaptation and Resilience Plan, which includes comprehensive decarbonization goals across sectors

LAC IRP Demand Side Technology Options

Type	Resources	Considerations
Demand Side	Distributed Energy Resources (DER)	5 MW by 2025 and 10 MW by 2041
	Energy Efficiency (EE)	Load forecast is after EE impact
	Demand Response (DR)	No existing DR program

- LAC currently has 2.2 MW solar installed rooftop solar DER in the service territory.
- LAC projects the DER grow to 5 MW by 2025 and 10 MW by 2041.
- This IRP models the DER as an aggregate solar resource and applies a typical solar profile in New Mexico

- Energy efficiency educational program campaign through Pajarito Environmental Education Center (PEEC)
- Proposed Utah Associated Municipal Power Systems (UAMPS) rebate program
- Proposed advanced metering infrastructure (AMI) time of use rates for peak reduction



LAC IRP Supply Side Technology Options

Type			Resources	Considerations
Supply Side	Baseload	Thermal	Combined Cycle (CC)	Inconsistent with carbon neutral goal
			Laramie River Station (LRS)	Exit when economical by 2042 or life of plant[1]
		Nuclear	Carbon Free Power Project (CFPP)	Opportunity for LANL contract?
		Hybrid	ATC PPA with 28% Renewable[2]	Near term bridge PPA to replace San Juan Unit 4
		Firm Renewables	Solar + Wind	Uniper contract + more
			Solar + Battery	Weather dependent
			Geothermal	Opportunistic and geography dependent
			Fuel Cells	< 5 MW size, implemented in other national Labs
	Peaking	Thermal	Reciprocating Internal Combustion Engine (RICE)	Explore in IRP for dispatchability and balancing
			Simple Cycle Gas Turbine (SCGT)	Explore in IRP for dispatchability and balancing
		Storage	Pumped Hydro	Opportunistic and geography dependent
			Lithium-ion Battery	Duration considerations
			Vanadium Redox Flow Battery	High-cost; lack of actual projects development
	Intermittent	Renewables	Solar: on site new build or Power Purchase Agreement (PPA)	Weather dependent; site constraints
			Onshore Wind – PPA	Weather dependent; transmission constraints

Note:

1) As per Future Energy Resources (FER) recommendation, LAC can exit LRS by 2042 or life of plant when most economical.
2) ATC = around the clock

Balanced Score Card of Portfolios

	Portfolio Composition	PRM	Load	Cost	Risk	Sustainability	Operational	Reliability	Diversification	Overall
P1	SMR + solar + wind + storage	15%	Base + EV + Gas							
P2	SMR + solar + wind	15%	Base + EV + Gas							
P3	solar + wind + storage	15%	Base + EV + Gas							
P4	solar + wind	15%	Base + EV + Gas							
P5	SMR + solar + wind + SCGT	15%	Base + EV + Gas							
P6	SMR + solar + wind + RICE	15%	Base + EV + Gas							
P7	SMR + solar + wind + storage	-15%	Base + EV + Gas							
P8	SMR + solar + wind	-15%	Base + EV + Gas							
P9	solar + wind + storage	-15%	Base + EV + Gas							
P10	solar + wind	-15%	Base + EV + Gas							
P11	SMR + solar + wind + SCGT	-15%	Base + EV + Gas							
P12	SMR + solar + wind + RICE	-15%	Base + EV + Gas							

Notes:
1) RICE: Reciprocating Internal Combustion Engine
2) SCGT: Simple Cycle Gas Turbine
3) SMR: Small Modular Reactor
4) PRM: Planning Reserve Margin
5) Score rating will be based on quantitative or qualitative metrics.
6) The resources are in addition to existing LAPP resources.

Ratings

- Favorable
- Neutral
- Unfavorable

Load Forecast

FTI CONSULTING

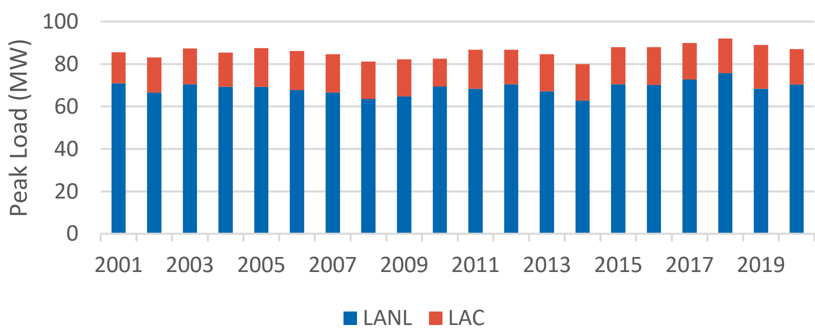
LAPP Hourly Energy Demand and Coincident Peak Load

- LAPP operates based on the ECA (Electric Coordination Agreement) between LAC and LANL.
- The LAPP coincident peak load was 85 MW, and energy consumption was 550 gigawatt hours (GWh) in 2020. The impacts of COVID-19 caused the load in 2020 to be the lowest of the time period.
- LANL's peak load represents approximately 80 percent of the coincidental LAPP peak load.
- LAC's annual energy use is approximately 120 GWh, serving approximately 8,500 customers.

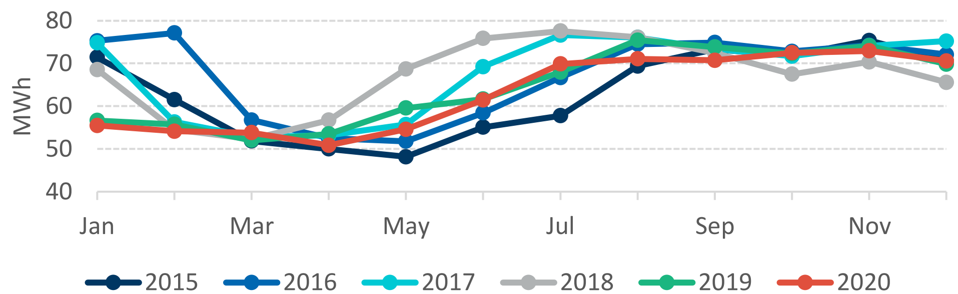
Hourly Load Shape Statistics

LAPP Demand	Unit	2015	2016	2017	2018	2019	2020
Hourly Maximum	MW	88	88	90	92	89	87
Hourly Minimum	MW	42	44	43	44	44	45
Hourly Average	MW	63	67	68	67	64	63

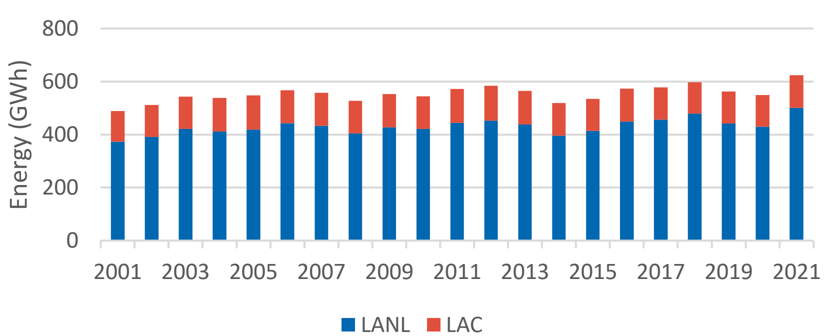
LAC and LANL Coincident Peak Load



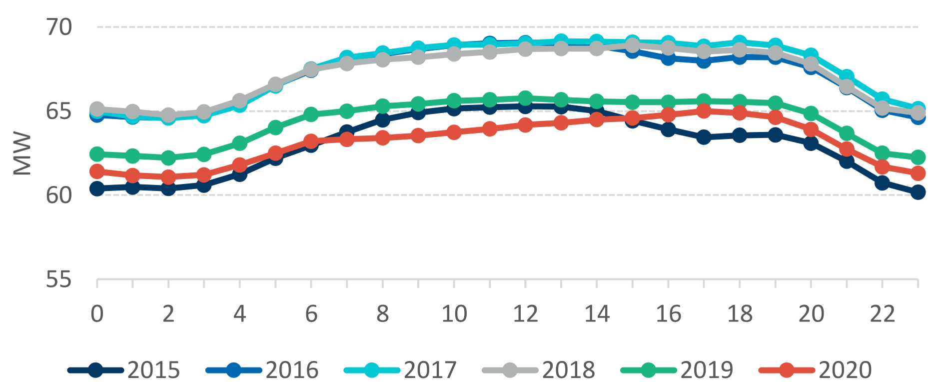
LAPP Monthly Energy Demand Shape



LAC and LANL Historical Energy Demand



LAPP Hourly Energy Demand Shape

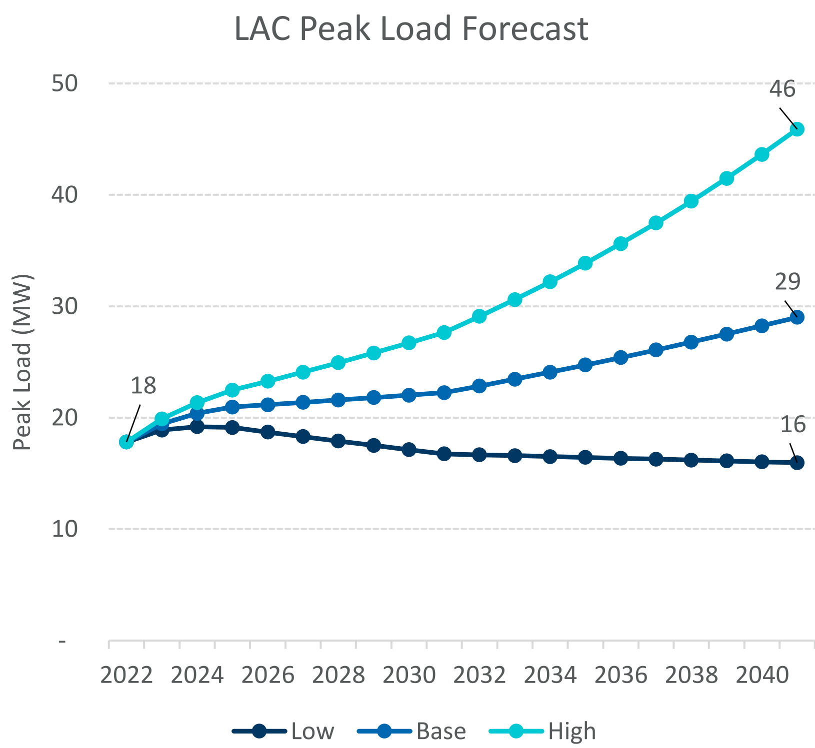


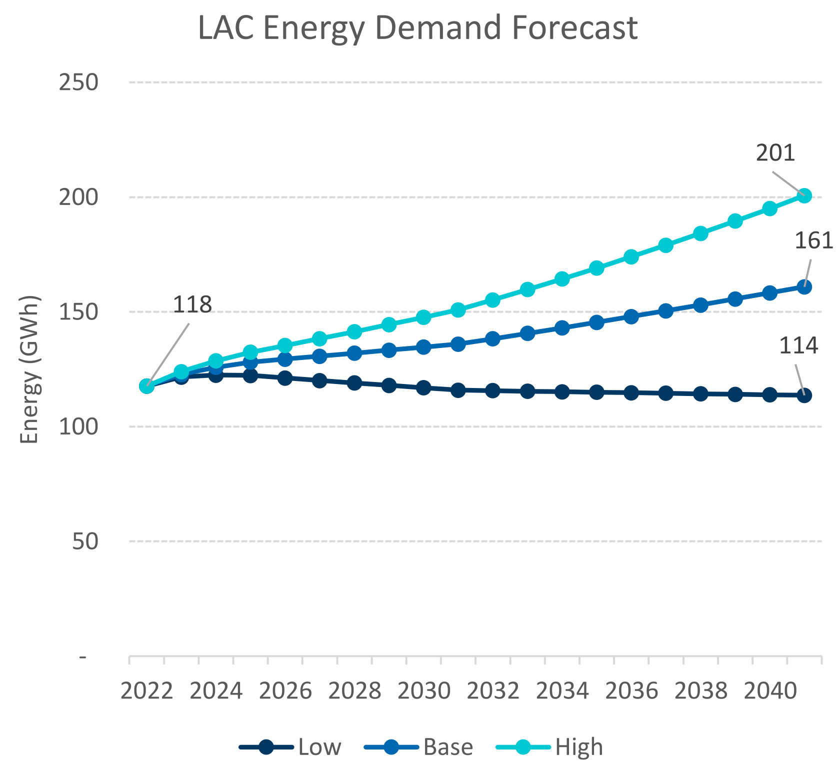
LAC Peak Load and Energy Demand Forecast

- LAC currently has peak load at ~18 MW. Load growth is driven by population growth and commercial activity.
- High and Low Case peak load and energy demand forecasts were generated using the differences between the average load compound annual growth rate (CAGR) and the maximum and minimum load growth CAGRs, respectively.
- LAC load (after considering energy efficiency) is forecasted to reach 46 MW in the high case, 29 MW in the base case, and 16 MW in the low case by 2041.
- LAC load peaks during the evening when residents return home from work

Case Assumptions

Difference from the Base Case	LAC Peak	LAC Energy
Low Case	-3.2%	-1.0%
High Case	2.5%	1.1%



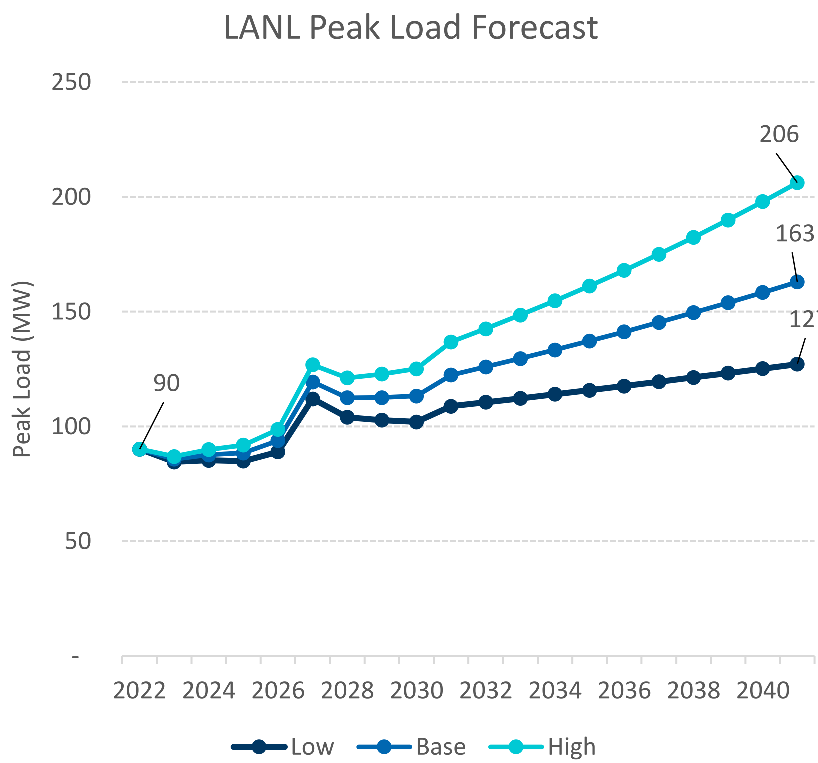


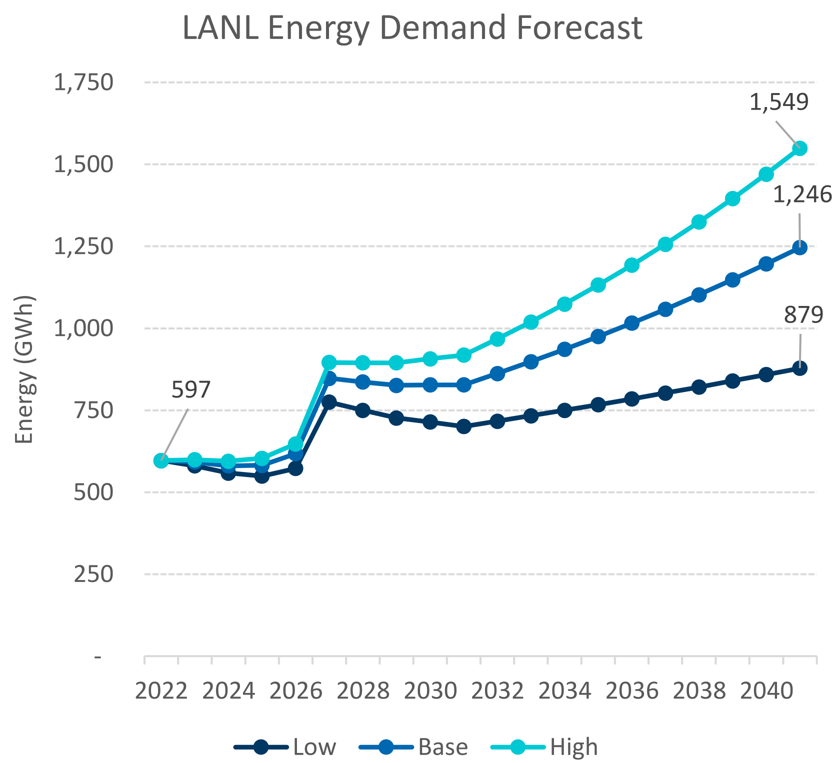
LANL Peak Load and Energy Demand Forecast

- LANL load growth is driven by mission change or operational tempo.
- The High Case and Low Case peak load and energy demand forecasts were generated using the differences between the average load growth CAGR and the maximum and minimum load growth CAGRs, respectively.
- LANL load is forecasted to reach 206 MW in the High Case, 163 MW in the Base Case, and 127 MW in the Low Case.
- LANL load peaks during the day when air conditioning and the laboratory equipment are in use.

Case Assumptions

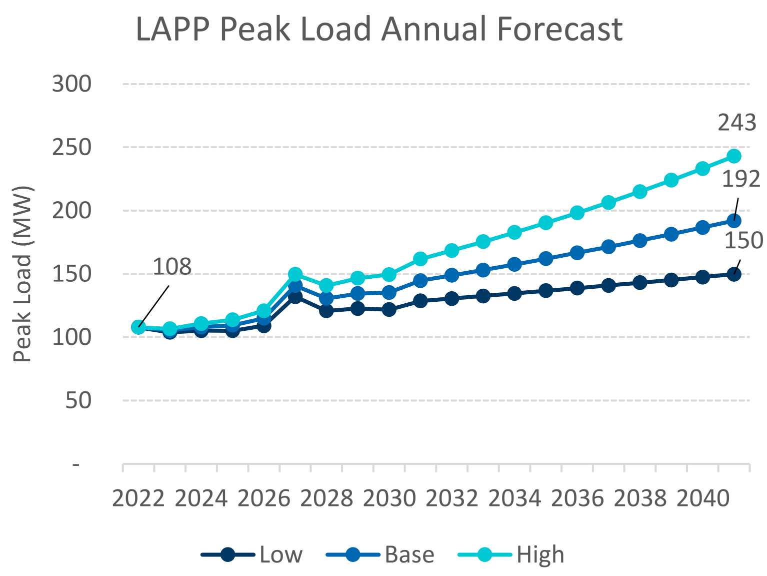
Difference from the Base Case	LANL Peak	LANL Energy
Low Case	-1.3%	-1.9%
High Case	1.3%	1.2%

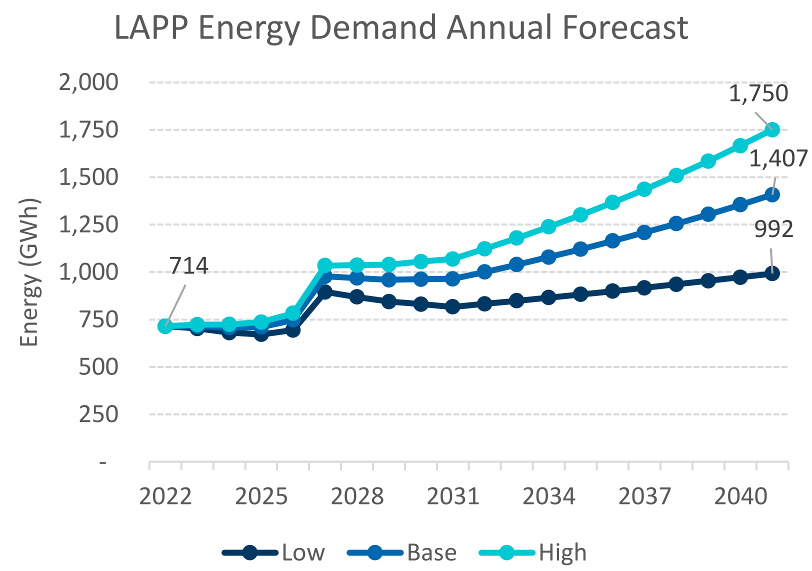


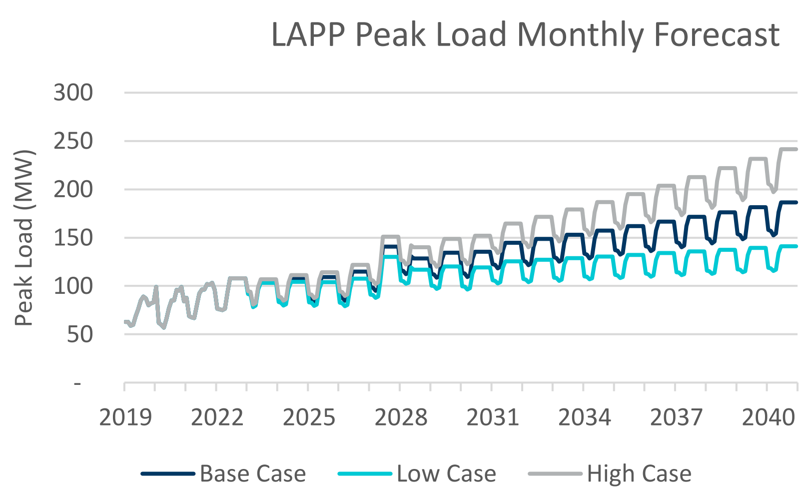


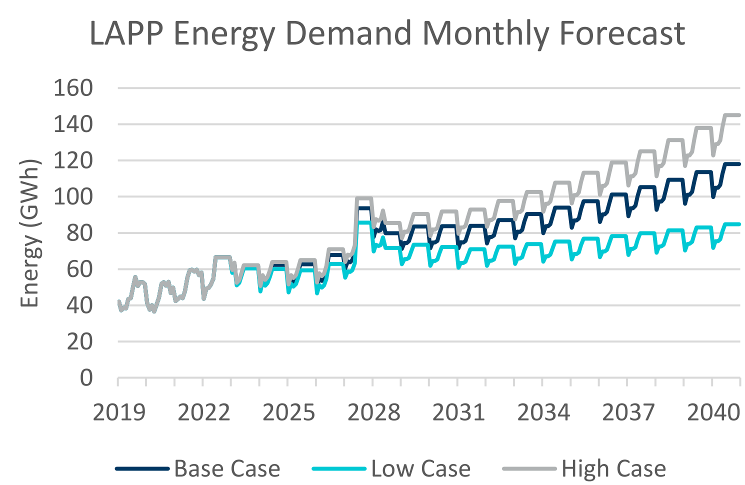
LAPP Peak Load and Energy Demand Forecast

- LAPP load (after considering energy efficiency) is forecasted to reach 243 MW in the high case, 192 MW in the base case, and 150 MW in the low case by 2041. LAPP benefits from the complimentary load shapes of LAC and LANL.







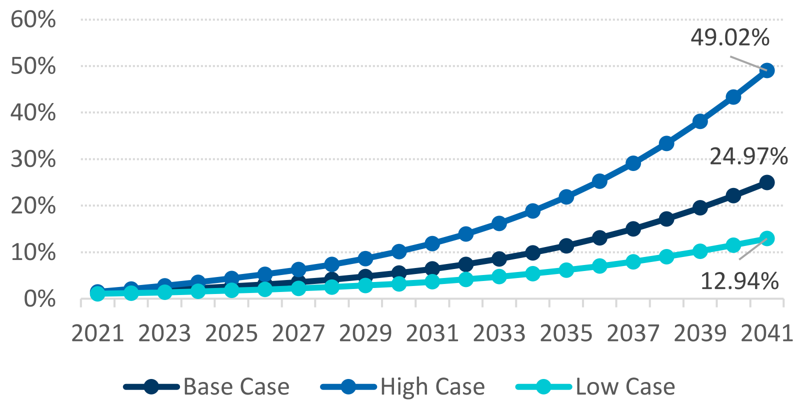


Electric Vehicle Forecast

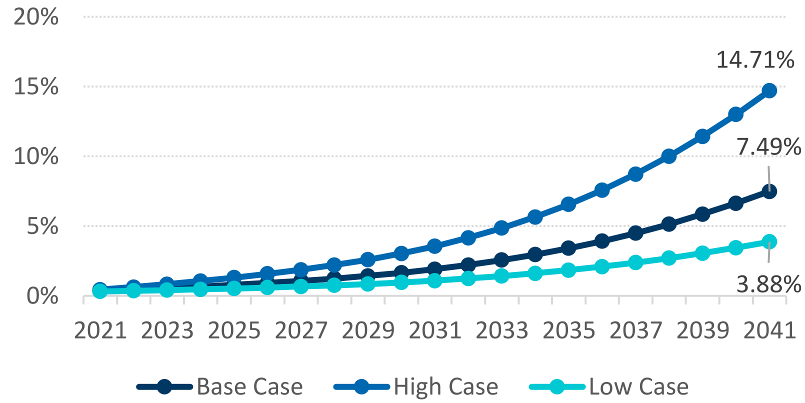
LAC Electric Vehicle Forecast

LAC county owned and personal owned EVs are expected to add 8 MW of peak load in the High Case, 5 MW of peak load in the Base Case, and 2 MW in the Low Case.

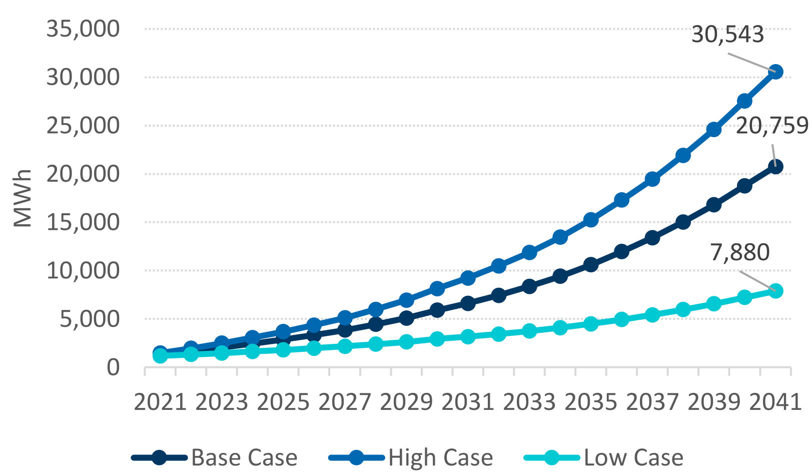
County Owned Light Duty Vehicle Penetration



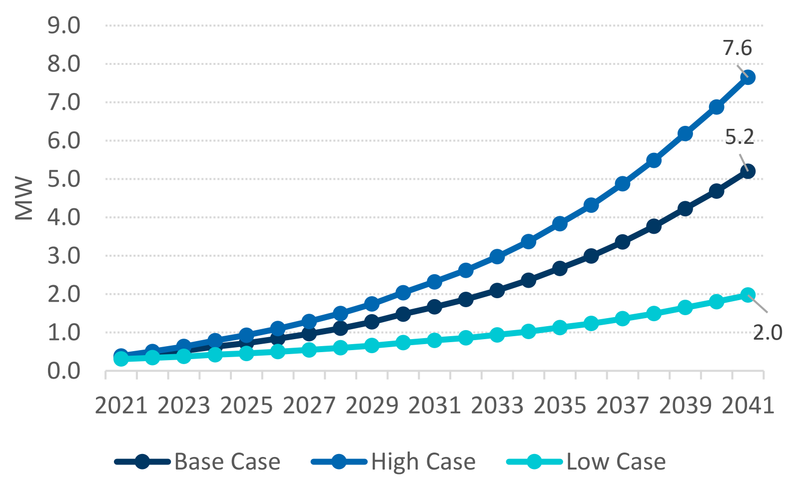
County Owned Medium and Heavy Duty Vehicle Penetration



LAC EV Electricity Demand

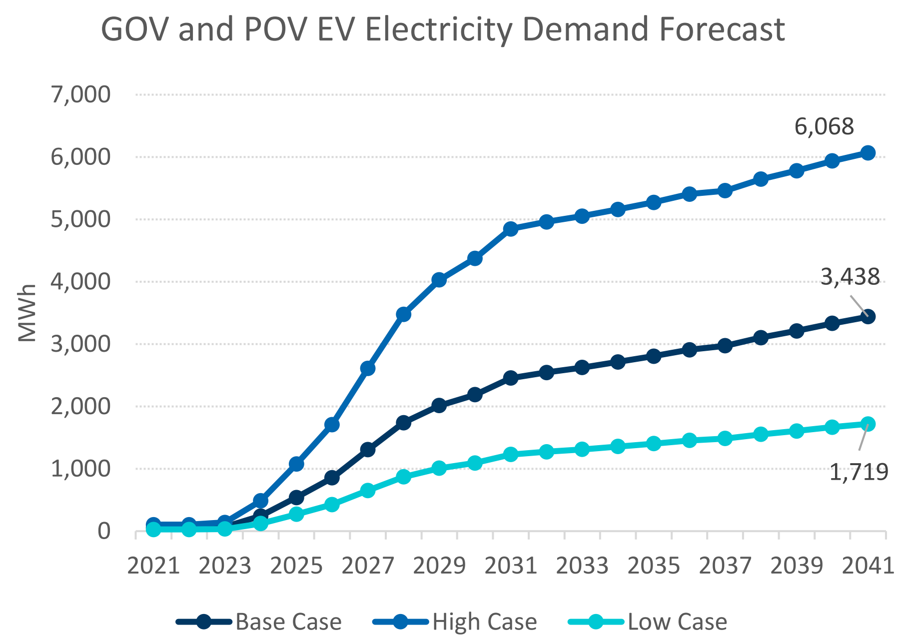


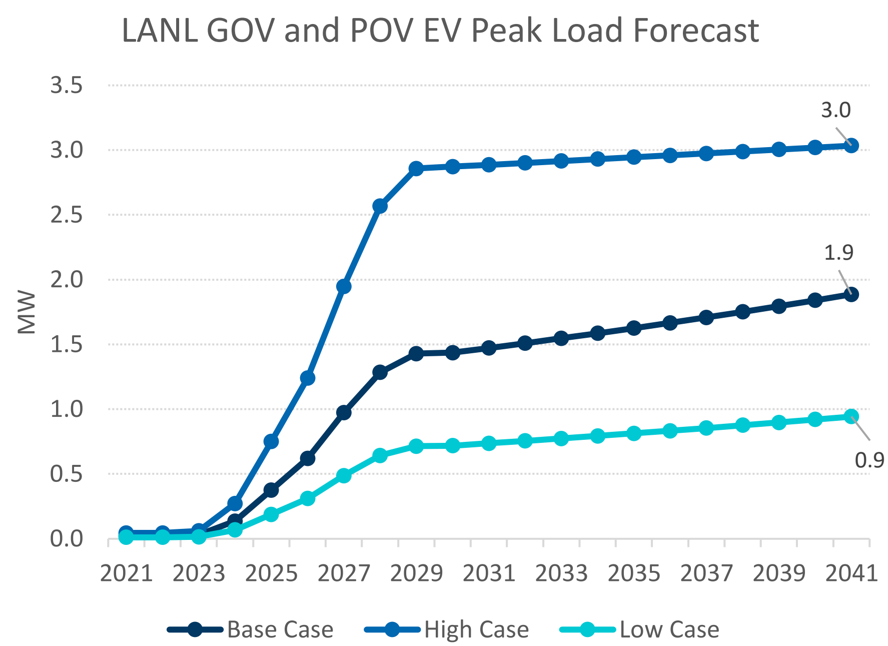
LAC EV Peak Load



LANL Electric Vehicle Forecast

LANL projects 100 percent EV adoption for light-duty vehicles in its government owned fleet by 2030 in the High Case, 50 percent in the Base Case, and 25 percent in the Low Case. In addition, the employee-owned vehicles will be charged on site subject to charging infrastructure availability.

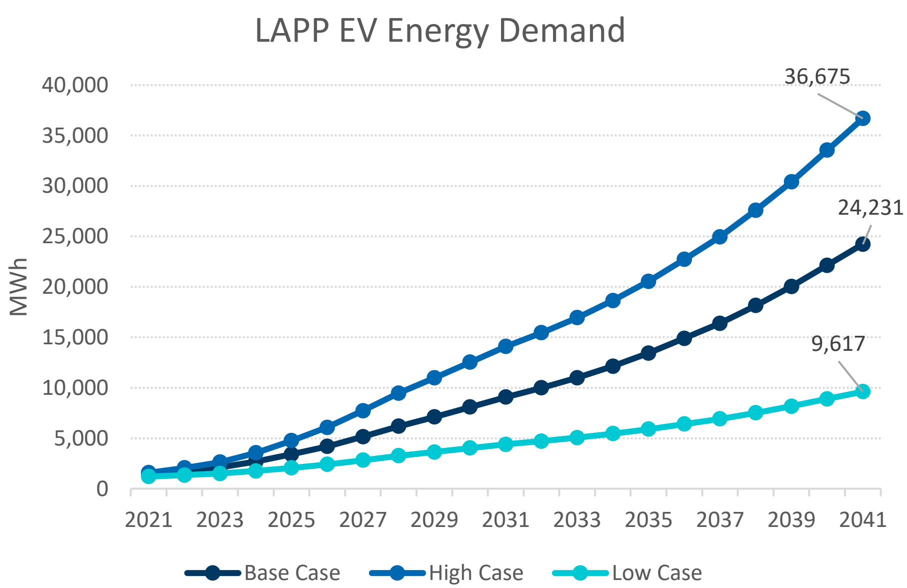


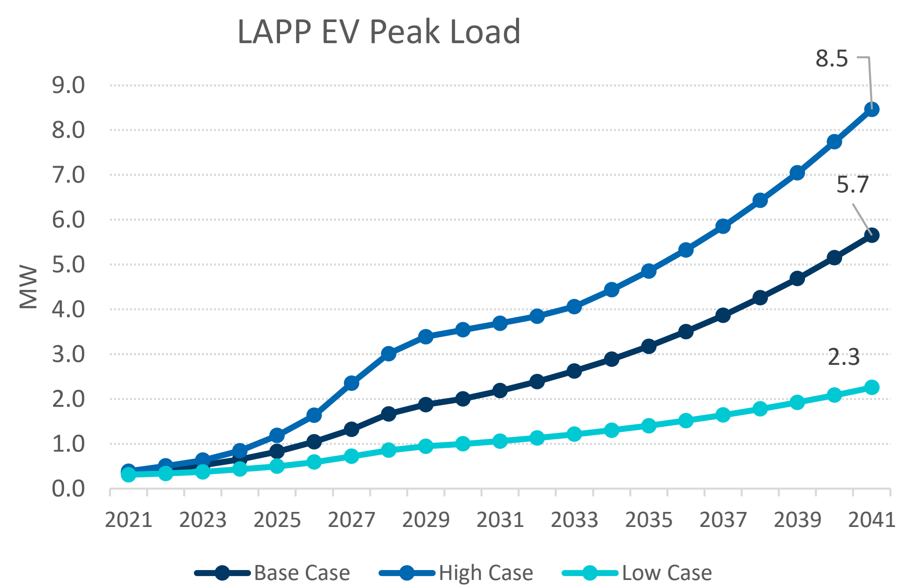


LAPP Electric Vehicle Forecast

LAPP forecasts total additional annual electricity demand from EVs to reach 24 GWh energy demand and a peak load of 6 MW by 2041.

- In the high case, the total additional annual electricity demand from EVs is forecasted to reach 37 GWh by 2041 with a peak load of 9 MW.
- In the low case, the total additional annual electricity demand from EVs is forecasted to reach 10 GWh by 2041 with a peak load of 2 MW.
- To put this into context, LANL's programmatic load is expected to grow by 7 MW, 12 MW, and 3 MW by 2026 from 2021 levels in the base case, high case, and low case, respectively.





Natural Gas Electrification Forecast

FTI CONSULTING

LAPP Natural Gas Electrification Forecast

IRP sets the constraints to have the incremental load from natural gas reduction to be served by 100 percent emission free resources.

LAC Considerations

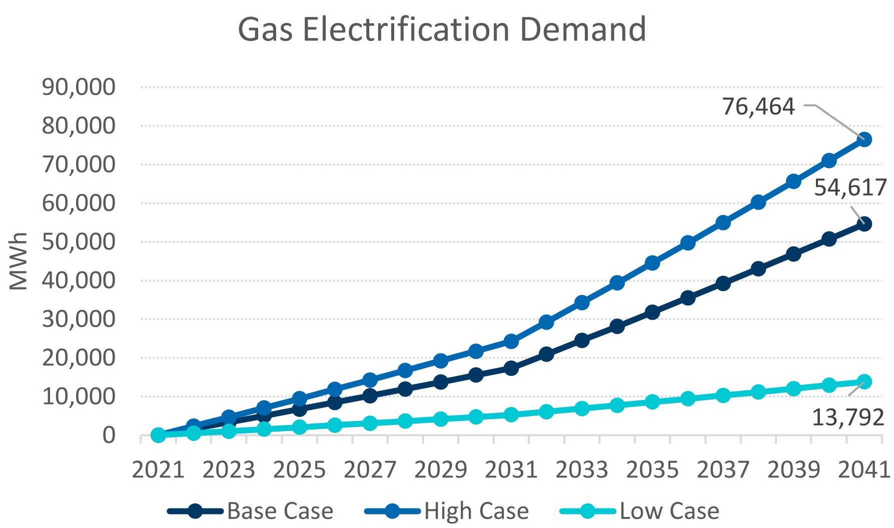
- "Los Alamos Resiliency, Energy and Sustainability (LARES) Task Force" has shared with the LAC some preliminary intent to reduce natural gas consumption, with detailed recommendations still under development while LAC develops its IRP.
- Residential, commercial, and industrial electrification is a pathway for reducing natural gas consumption and greenhouse gas (GHG) emissions.
- For LAC and LANL, this could be potentially achieved through an effective combination of strategy, policy, and incentives, with practical consideration of technology and infrastructure readiness, and benefit to cost economics.
- Electrification will only be meaningful if the incremental demand is served with emission-free generation resources, which include hydro, nuclear, wind, and solar.
- The conversion is assumed at an average of 48.8 percent, based on the key findings from the Energy Information Administration's (EIA) 2021 Annual Energy Outlook (AEO) for electrified heat pumps versus natural gas space heating solutions.

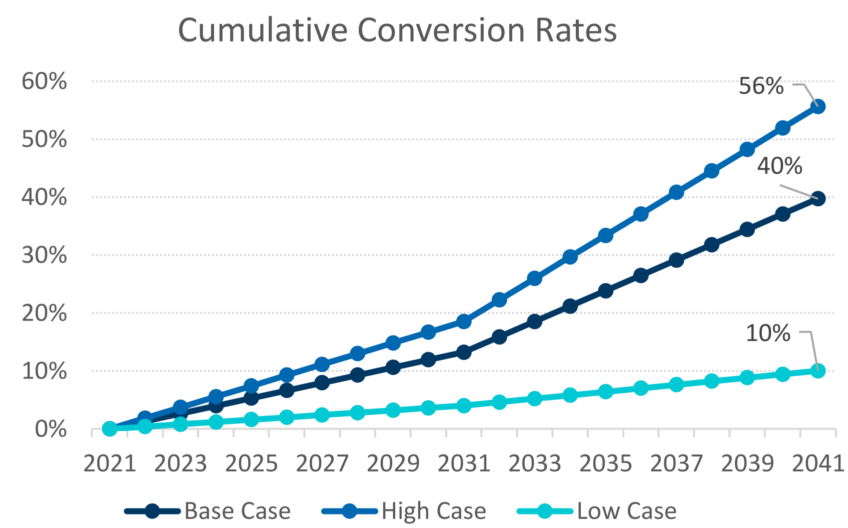
LANL Considerations

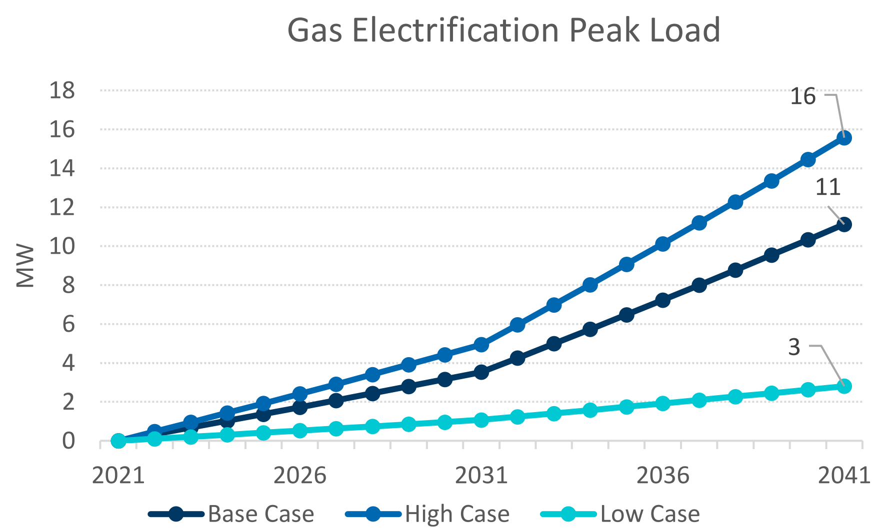
- Under the base case and low case, LANL has the same conversion targets as LAC, but it targets 90 percent conversion by 2041 in the high case, assuming this could be enabled through a combination of policy incentives and technological breakthroughs.
- The IRP models the high case electrification goal at 90 percent by 2041, assuming substitute sources like hydrogen can fill the remaining gap.
- LANL forecasts its gas demand growth at 17 percent over the next five years, then leveling out to near the U.S. average growth of long-term gas demand growth, estimated at 1 percent annually.
- The conversion for LANL is assumed at an average of 75 percent, based on the key findings from the EIA 2021 AEO for industrial appliances.

LAC Natural Gas Electrification Forecast

Building heating and cooling appliances replacement could result in electrification demands, with actual levels depending on technology readiness, cost, policies, and incentives.

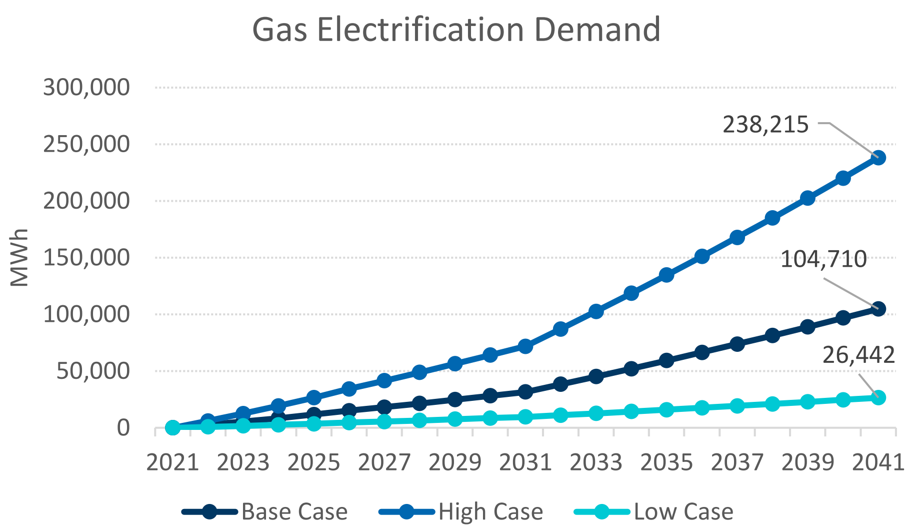


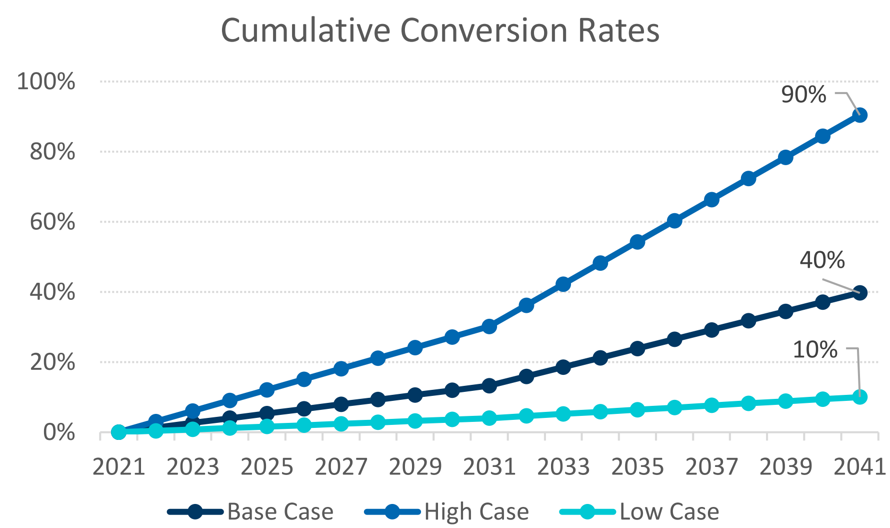


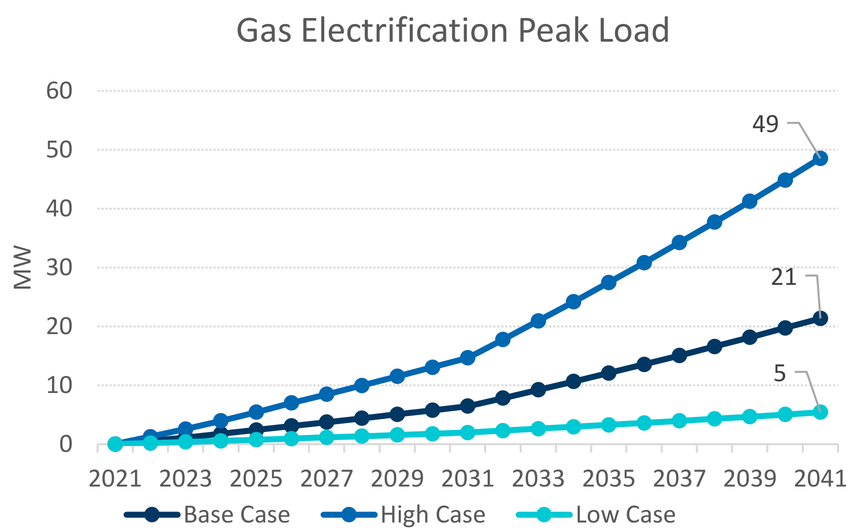


LANL Natural Gas Electrification Forecast

LANL's higher building electrification targets, along with a lower average conversion efficiency for industrial applications result in relatively higher additional electricity demand from gas electrification.



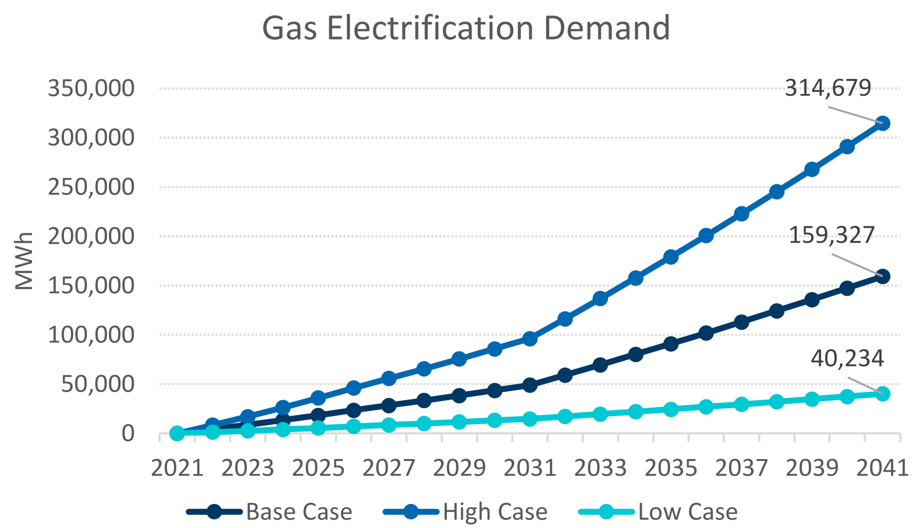


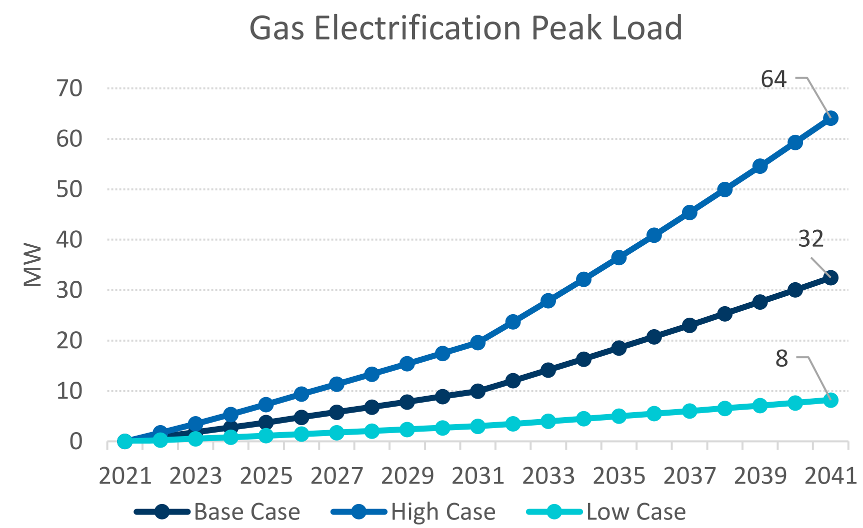


LAPP Natural Gas Electrification Forecast

LAPP forecasts total additional annual electricity demand from electrification to reach 159 GWh by 2041 with a peak load of 32 MW under the Base Case.

- Under the High Case, the total additional annual electricity demand from electrification is forecasted to reach 315 GWh by 2041 with a peak load of 64 MW.
- Under the Low Case, the total additional annual electricity demand from gas conversion is forecasted to reach 54 GWh by 2041 with a peak load of 11 MW.





Load and Resource Imbalances

FTI CONSULTING

LAPP Existing and Proposed Resources Summary

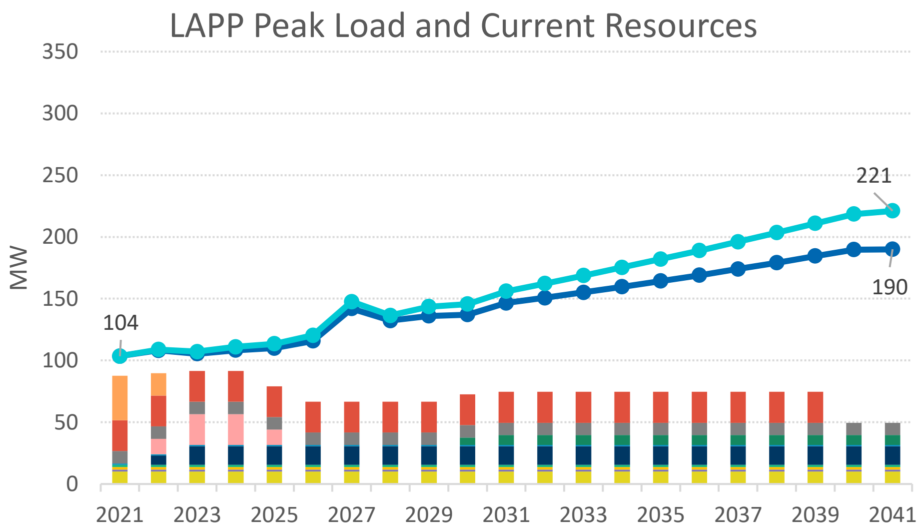
- LAC has a mix of generation assets, including coal, hydro, solar, firm renewable purchase power agreements (PPAs), and around the clock (ATC) PPA with expected 28 percent of renewables. LANL owns a gas-fired combustion turbine.
- Based on the existing and planned resources (solar and wind PPA, and SMR), LAPP has a total load serving capacity of 138 MW in summer and 127 MW in winter after accounting for reserves and losses. However, San Juan Generation Station Unit 4 will be retired in 2022, and SMR will only come online in 2030.
- IRP explicitly models the key performance characteristics of all generation resources including fuel costs, heat rate, variable operating and maintenance cost (VOM), and fixed operating and maintenance cost (FOM), hourly generation profiles based on the applicability to the specific resource types.

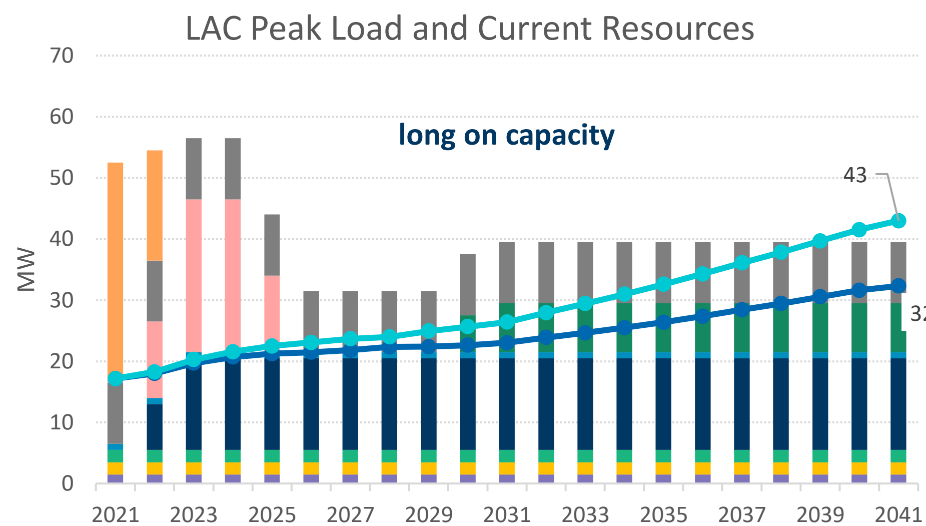
Resources		Status	Ownership	Summer Capacity MW	Winter Capacity MW
LANL	TA-3 Combustion Turbine	Retire in Q4 2039	Own	21.0	25.0
	Western	Operating	PPA	9.0	10.1
	LANL Resources Capacity			**30.0**	**35.1**
LAC	San Juan Generation Station Unit 4	Retire in June 2022	Own	36.0	36.0
	Laramie River Station	Operating	PPA	10.0	10.0
	Western	Operating	PPA	1.0	1.5
	El Vado	Operating	Own	9.0	2.0
	Abiquiu	Operating	Own	15.0	2.0
	Solar	Operating	Own	1.0	1.0
	Wind & Solar PPA	COD in Q1 2022	PPA	15.0	15.0
	Proposed ATC PPA	Q3 2022-Q2 2025	PPA	25.0	25.0
	Proposed SMR	COD in Q1 2030	PPA	8.0	8.0
	LAC Resources Capacity			**120.0**	**100.5**
LAPP	LAPP Resource Capability			150.0	135.6

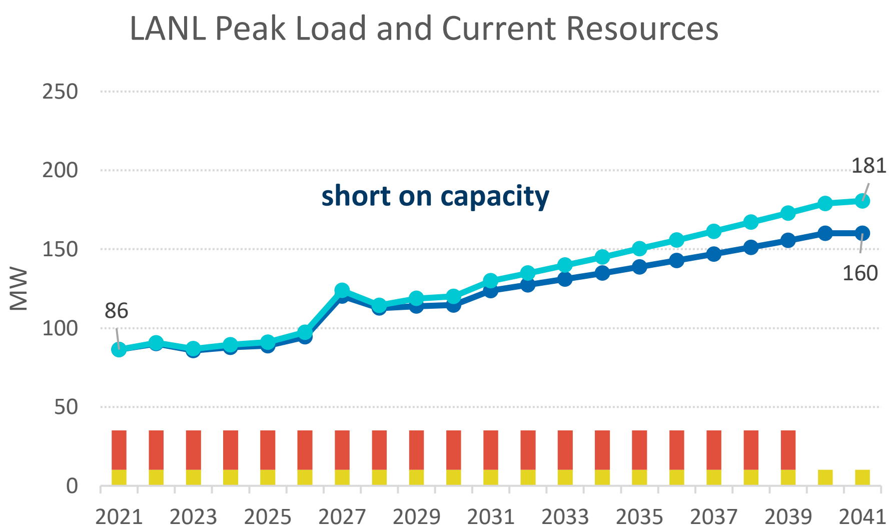
Notes:
1) ATC: around the clock

Load and Resources Imbalance: Base Case

LAPP base Load + EV is projected to grow from 104 MW in 2021 to 190 MW in 2041; with natural gas conversion, the total peak load is expected to reach 221 MW by 2041 under the Base Case.



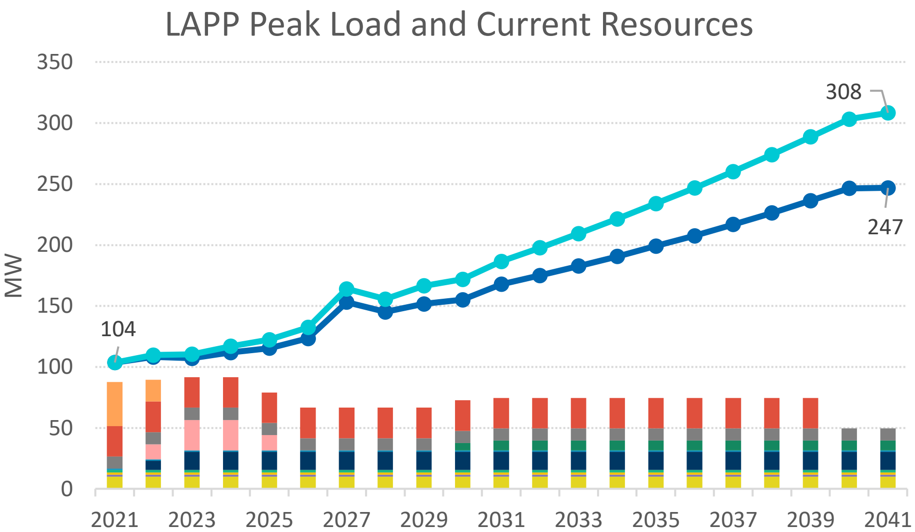


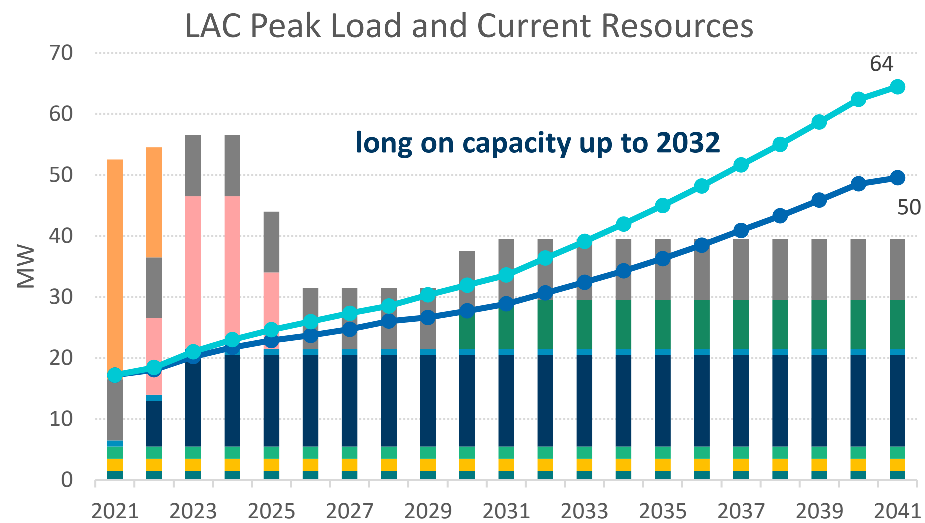


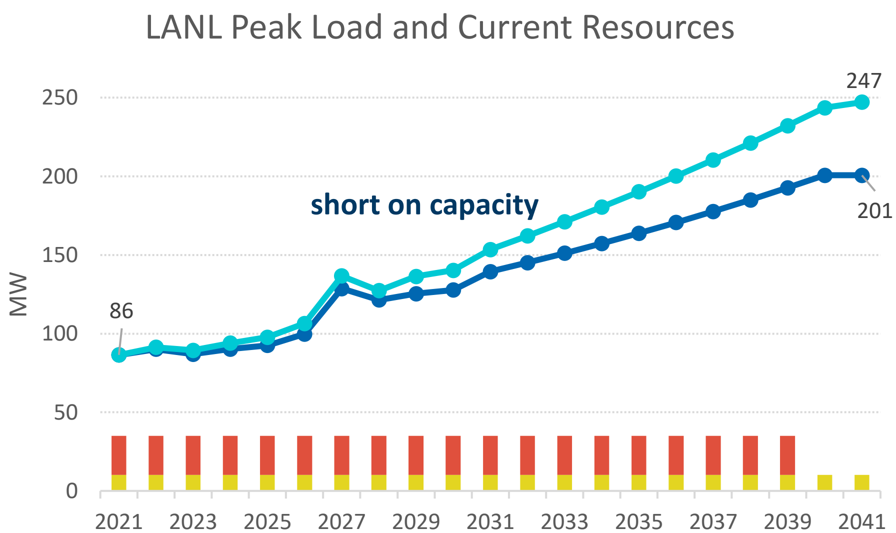
Note: The proposed ATC PPA is yet to be finalized.

Load And Resources Imbalance: High Case

LAPP base Load + EV is projected to grow from 104 MW in 2021 to 247 MW in 2041; with natural gas conversion, the total peak load is expected to reach 308 MW by 2041 under the High Case.



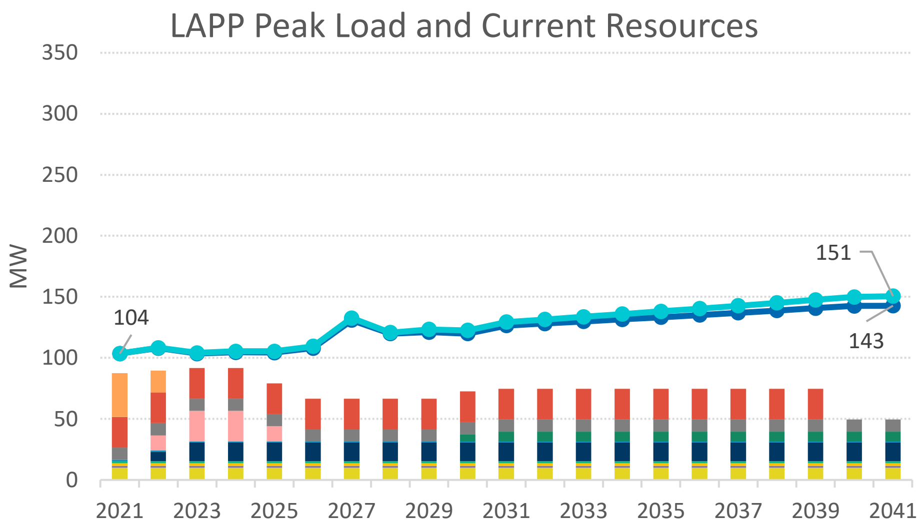


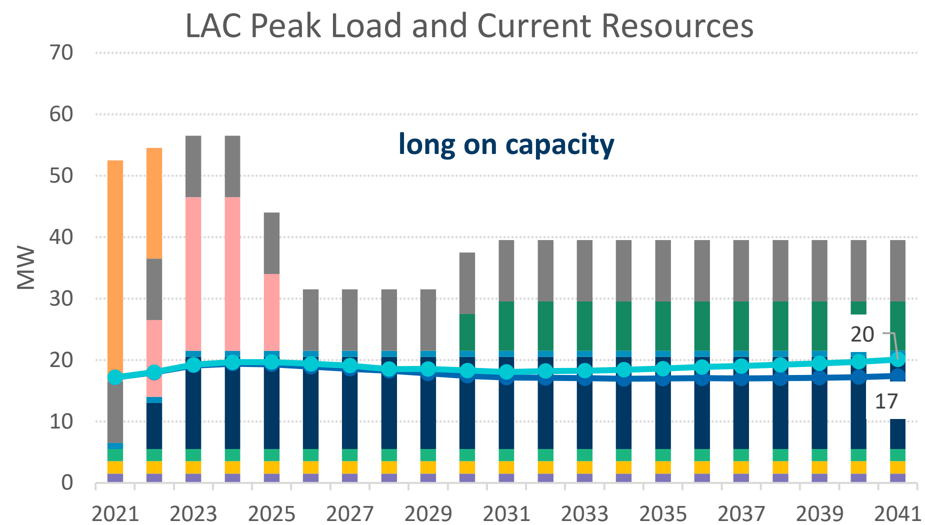


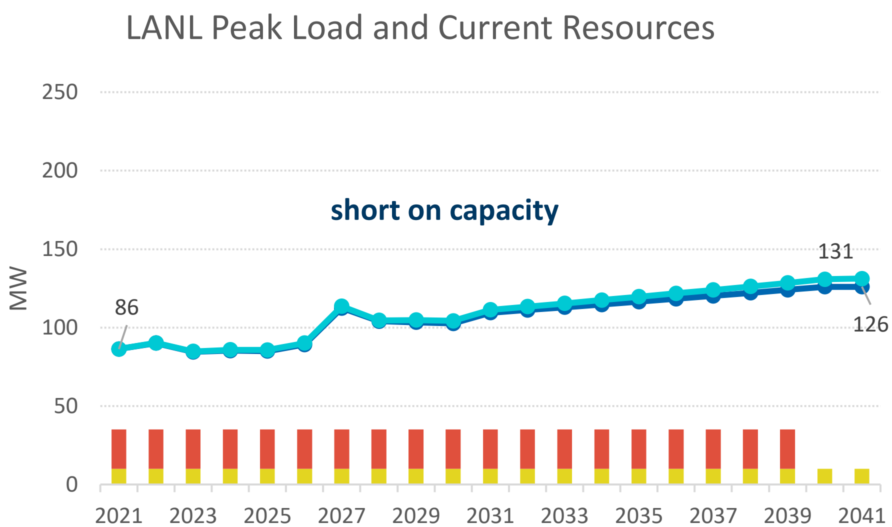
Note: The proposed ATC PPA is yet to be finalized.

Load And Resources Imbalance: Low Case

LAPP base Load + EV is projected to grow from 104 MW in 2021 to 143 MW in 2041; with natural gas conversion, the total peak load is expected to reach 151 MW by 2041 under the Low Case.







Note: The proposed ATC PPA is yet to be finalized.

Planning Scenarios: Fuel Prices, Carbon Prices, and Capital Costs

FTI CONSULTING

IRP Long Term Scenario Design

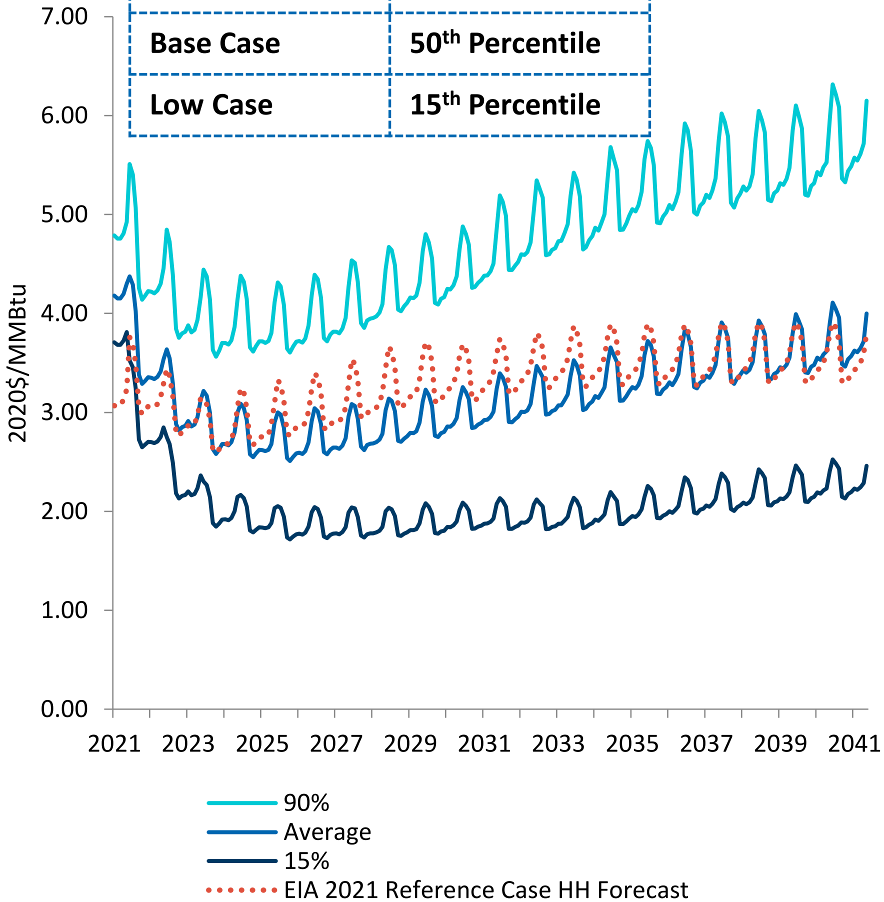
	FUEL	CARBON PRICES	RPS AND CES	LOAD	CAPITAL COSTS	ITC and PTC
BASE CASE	50th percentile - FTI stochastic simulation	▪ CA: "2019 IEPR Carbon Price Projections“ Mid Price Scenario by CEC ▪ No federal carbon program	▪ Renewables meet the state or regional RPS ▪ No national Clean Energy Standard (“CES”)	Moderate peak load and energy demand growth	NREL 2021 ATB Base Case costs	Current policy of Investment Tax Credits (“ITC”) and Production Tax Credits (“PTC”)
HIGH CASE	90th percentile - FTI stochastic simulation	▪ CA: "2019 IEPR Carbon Price Projections“ High Price Scenario by CEC ▪ No federal carbon program	▪ RPS targets are the same as Base Case ▪ Renewable demands are higher due to higher load ▪ No national CES	High peak load and energy demand growth	NREL 2021 ATB High Case costs	Current policy of ITC and PTC
LOW CASE	15th percentile - FTI stochastic simulation	▪ CA: "2019 IEPR Carbon Price Projections“ Low Price Scenario by CEC ▪ No federal carbon program	▪ RPS targets are the same as Base Case ▪ National CES	Low peak load and energy demand growth	NREL 2021 ATB Low Case costs	Extend the ITC and PTC by two years in consideration of Biden’s energy plan.

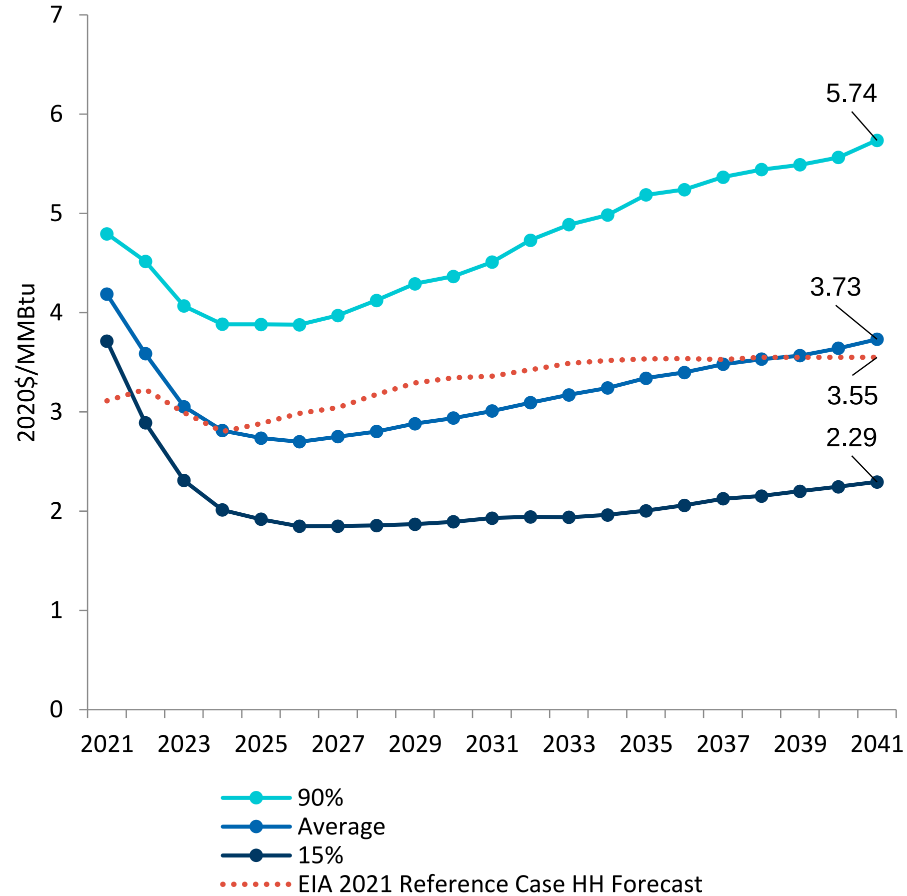
Notes:
1) NREL: the National Renewable Energy Laboratory
2) ATB: Annual Technology Benchmark
3) RPS: Renewable Portfolio Standards
4) CES: Clean Energy Standard
5) ITC: Investment Tax Credits
6) PTC: Production Tax Credits
7) IEPR: Integrated Energy Policy Report
8) CEC: California Energy Commission

Henry Hub Gas Monthly and Annual Price Forecasts

FTI uses a Monte Carlo approach to forecast Henry Hub prices. The 90th percentile of simulated values is used in the High Case, the Base Case uses the average, and the Low Case utilizes the 15th percentile.

High Case	**90th Percentile**
Base Case	**50th Percentile**
Low Case	**15th Percentile**

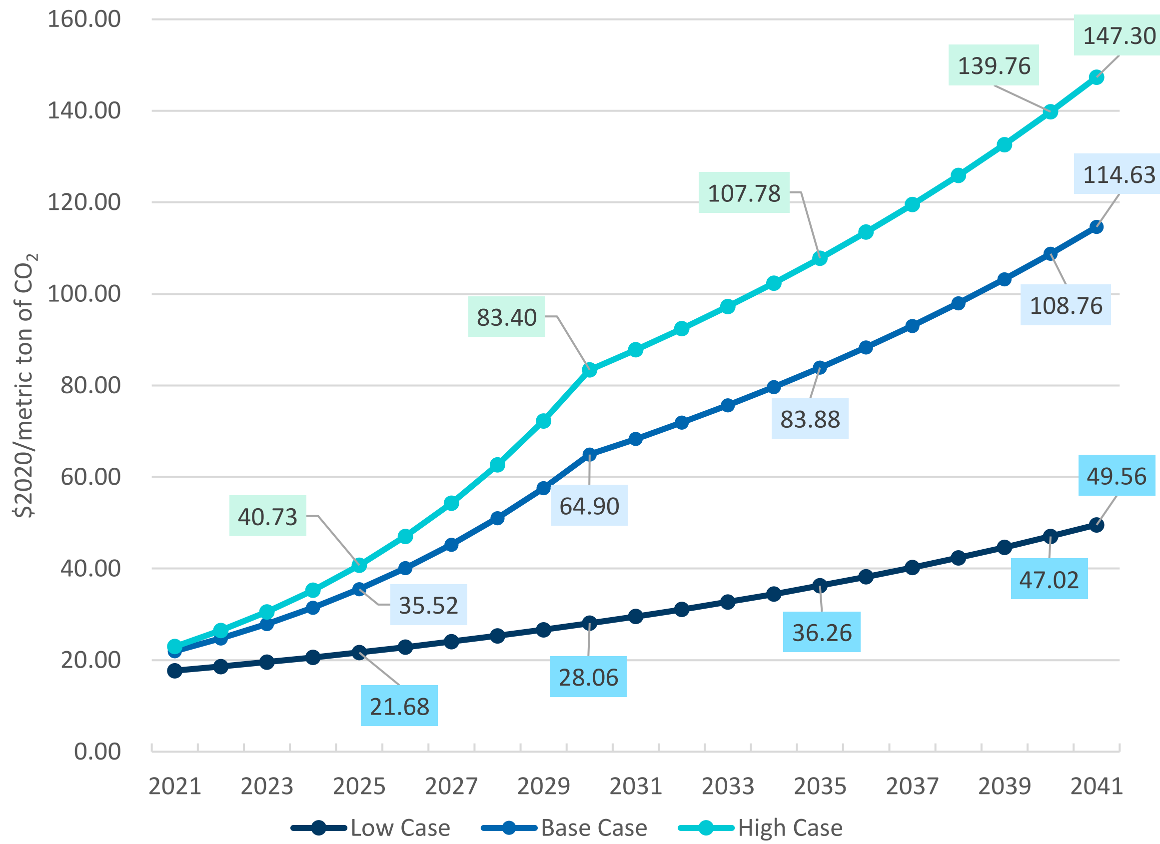




Carbon Price Assumptions

Carbon prices are based on the results of California's 2019 Integrated Energy Policy Report.

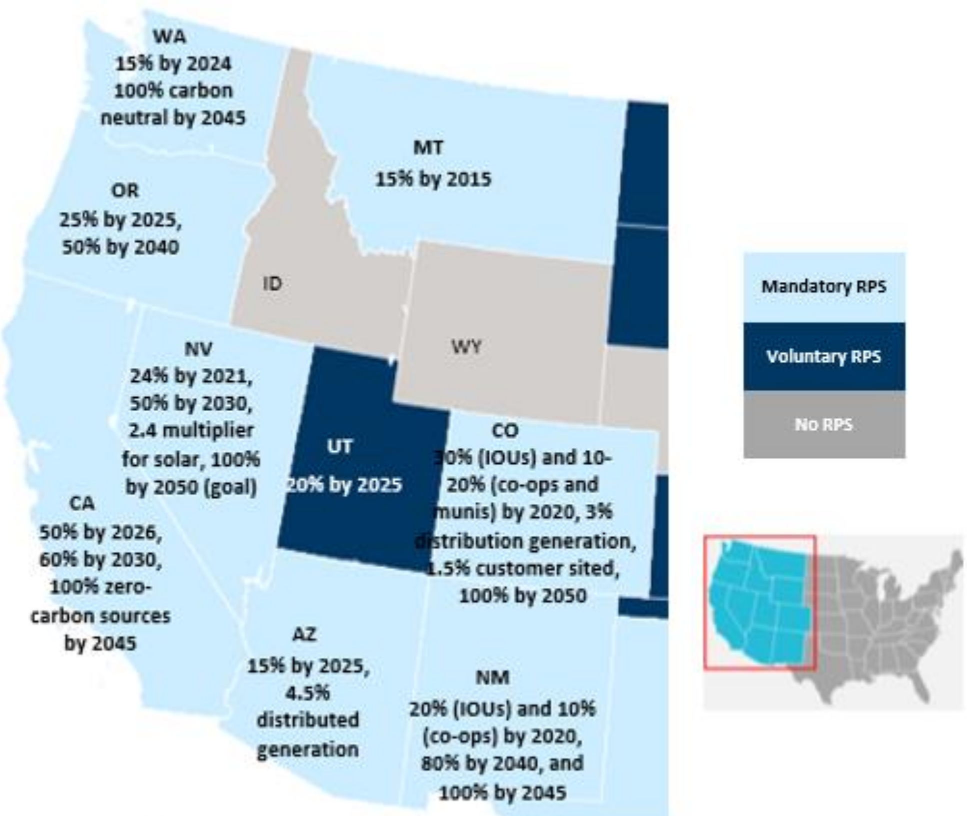
- The Low Case represents the price floor, the Base Case is the average of the auction reserve price and the price ceiling for all years, and the High Case is at the ¾ point of the auction reserve price and the price ceiling in all years.
- Carbon prices are applied to California resources and impacts overall market clearing prices in the WECC footprint.



Market Wide Renewable Standards Assumptions

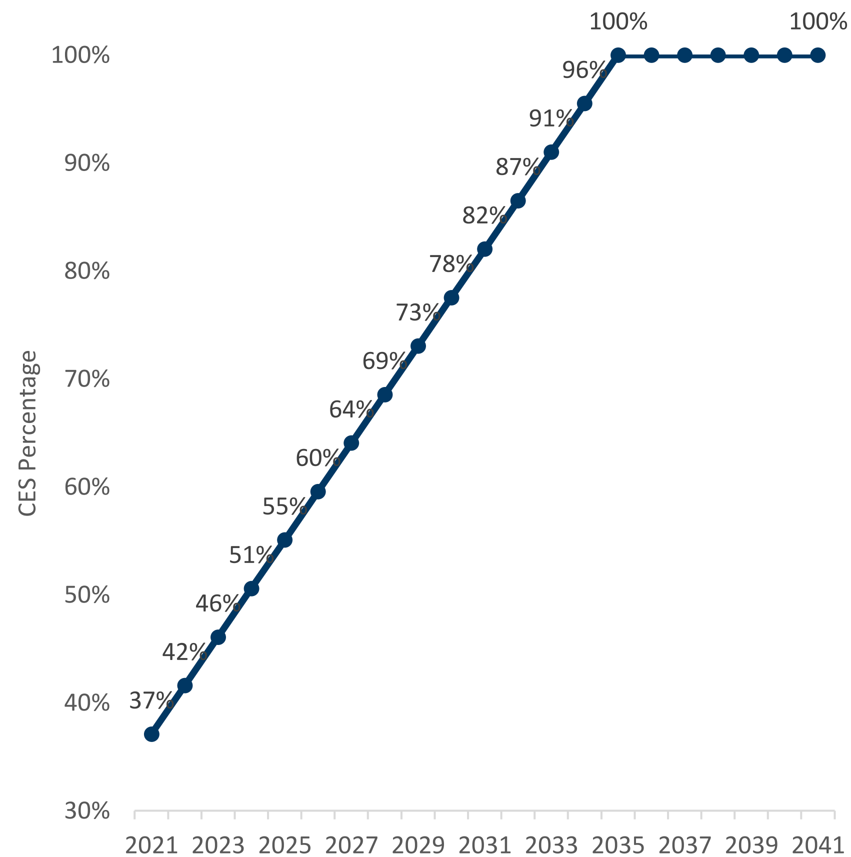
Renewable Portfolio Standards (RPS)

The WECC footprint contains diverse renewable portfolio standards. FTI utilizes the current renewable portfolio standard for each state for in all cases.



Clean Energy Standards (CES)

The Low Case assumes a national CES of 100 percent by 2035. The Base and High Cases assume no national CES.



New Resources Capital Costs and Performance Benchmark

National Renewable Energy Laboratory

National Renewable Energy Laboratory ("NREL") develops its annual ATB cost and performance benchmark for renewable resources through its proprietary bottom-up models and extensive analysis of published studies. The three scenarios explicitly assumes key drivers for cost decline such as innovation, R&D funding, and market adoptions.

- Onshore Wind
- Utility Scale Solar
- Geothermal
- Utility Scale Battery Storage

Pacific Northwest National Laboratory

Pacific Northwest National Laboratory, "2020 Grid Energy Storage Technology Cost and Performance Assessment", December 2020

- Pumped Storage Hydro

Technology Scenario Assumptions

High Case	Base Case	Low Case
Conservative Technology Innovation	**Moderate** Technology Innovation	**Advanced** Technology Innovation
• Today's technology with little innovation • Continued industrial learning • Decreased public and private R&D	• Widespread adoption of today's cutting edge • Expected level of innovation • Current levels of public and private R&D	• Market success of currently unproven innovation • New technology architectures • Increased public and private R&D

The actual project costs vary from region to region depending on the renewable resources, size, location, access to key infrastructure, and other localized development costs.

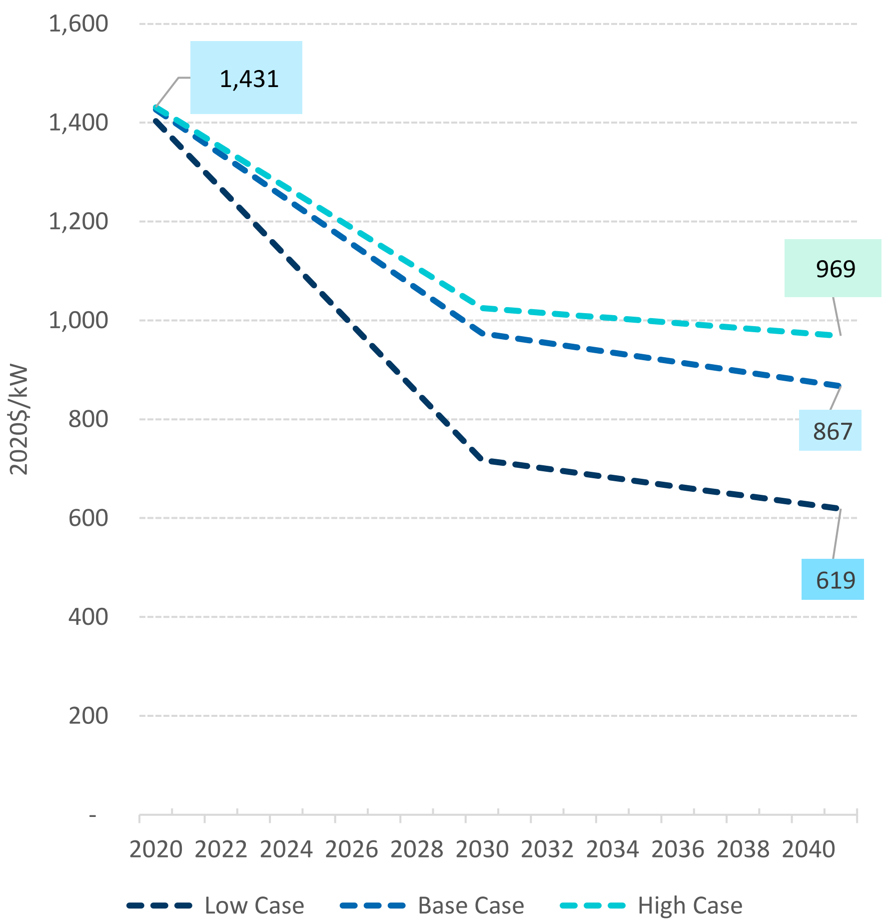
Recent project costs have been higher than benchmark because of the supply chain disruptions and COVID impacts.

Source:
NREL (National Renewable Energy Laboratory). 2021. "2021 Annual Technology Baseline."
Pacific Northwest National Laboratory, "2020 Grid Energy Storage Technology Cost and Performance Assessment", December 2020

Onshore Wind CAPEX and LCOE Projections

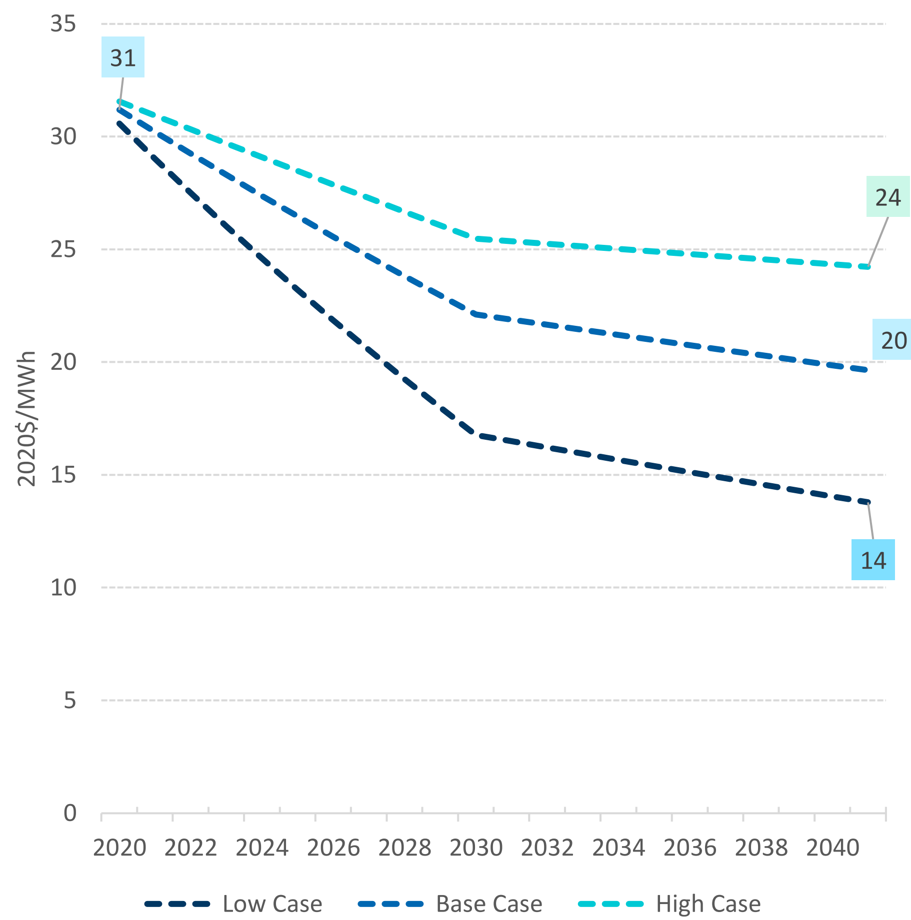
Onshore Wind CAPEX Projections

Onshore wind capital expenditures are projected to decline from $1,431 per kW in 2020 to $619 per kW by 2041 in the Low Case, to $867 per kW in the Base Case, and to $969 per kW in the High Case.



Onshore Wind LCOE Projections

Onshore wind LCOE values are projected to decline from $31 per MWh in 2020 to $14 per MWh by 2041 in the Low Case, to $20 per MWh in the Base Case, and to $24 per MWh in the High Case.

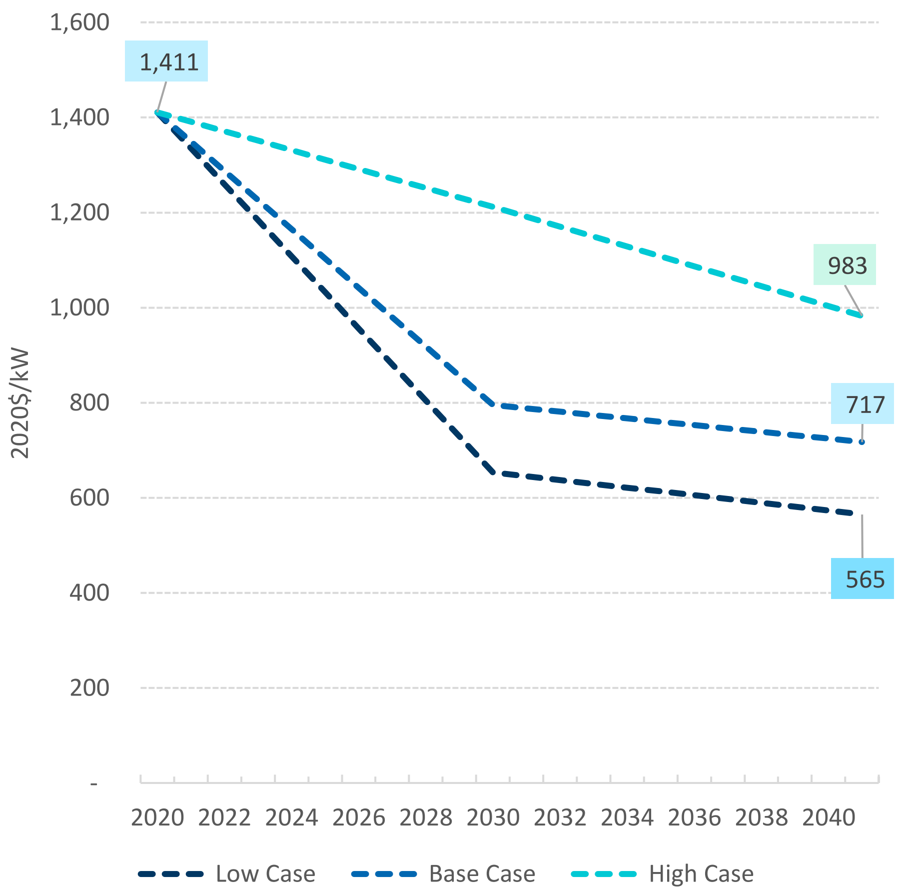


Data source: NREL (National Renewable Energy Laboratory). 2021. "2021 Annual Technology Baseline."

Utility Scale Solar CAPEX and LCOE Projections

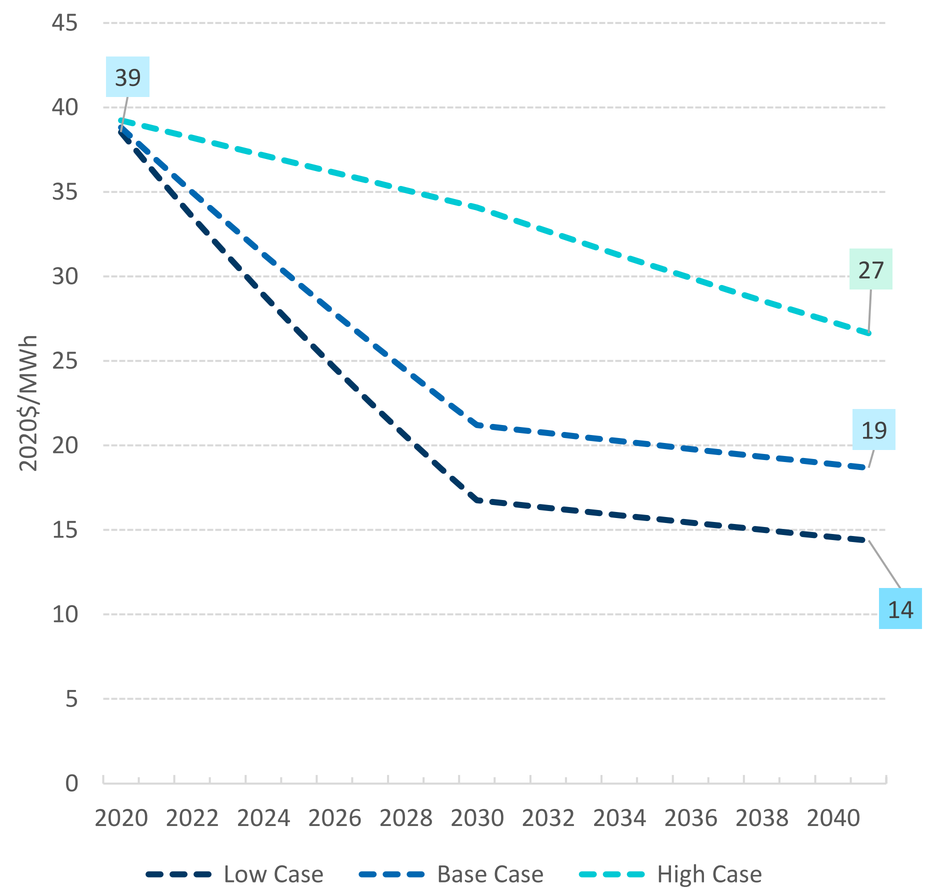
Utility-scale Solar CAPEX Projections

Utility-scale solar CAPEX values are projected to decline from $1,411 per kW in 2020 to $565 per kW by 2041 in the Low Case, to $717 per kW in the Base Case, and to $983 per kW in the High Case.



Utility-scale Solar LCOE Projections

Utility-scale solar LCOE values are projected to decline from $39 per MWh in 2020 to $14 per MWh by 2041 in the Low Case, to $19 per MWh in the Base Case, and to $27 per MWh in the High Case.

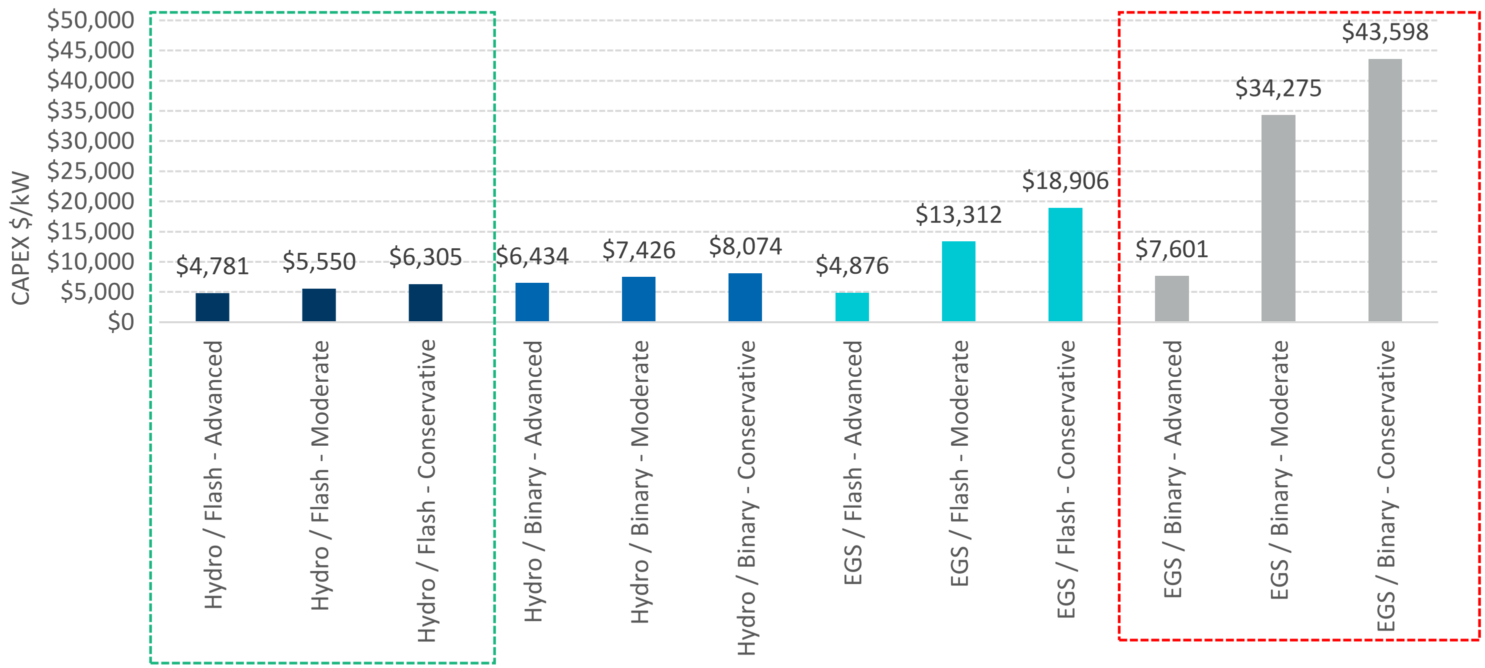


Data source: NREL (National Renewable Energy Laboratory). 2021. "2021 Annual Technology Baseline."

Geothermal Capital Costs Projection in 2030

Geothermal costs are highly dependent on geography, turbine type, and configurations.

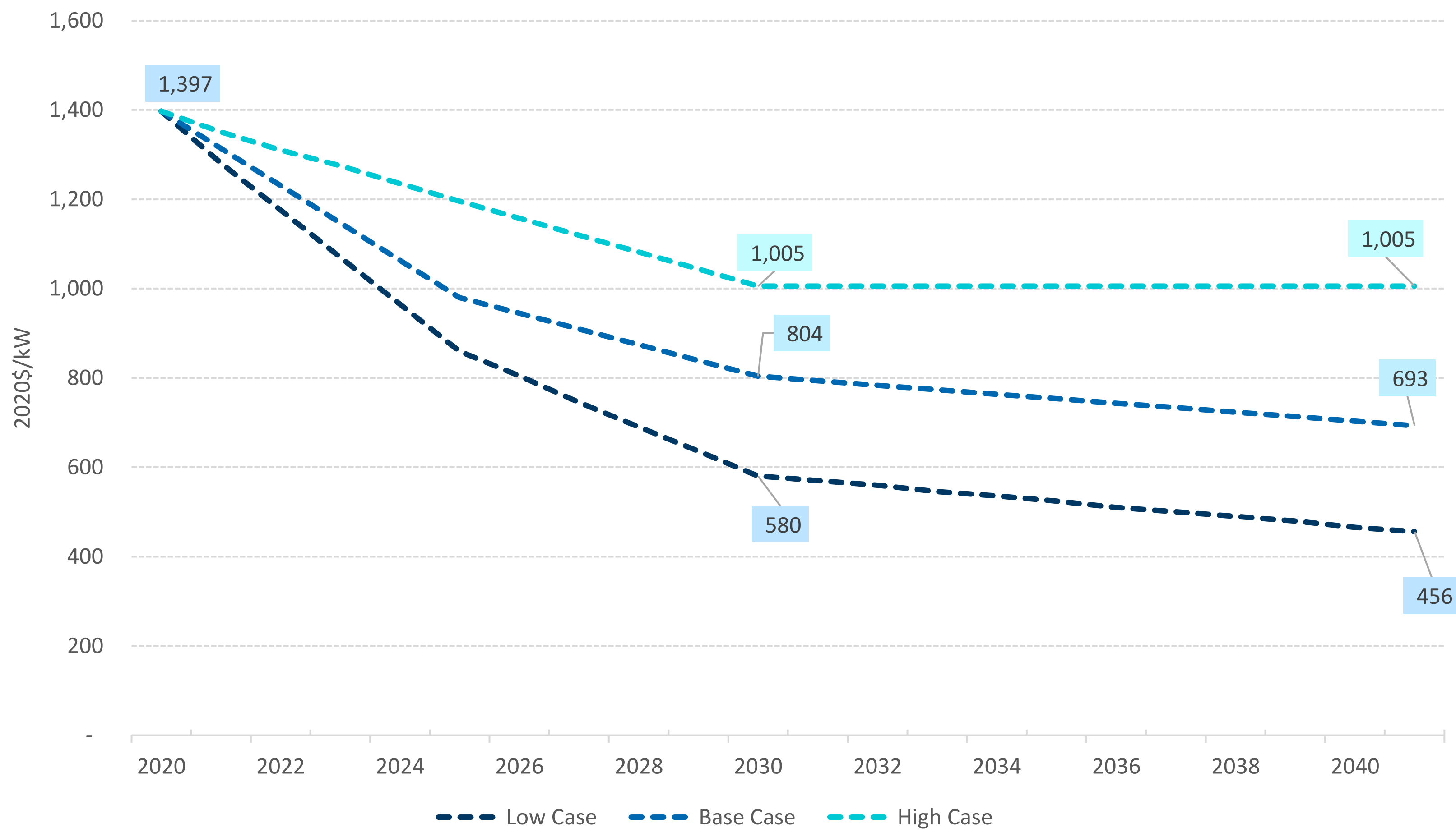
		Hydrothermal Naturally occurring zones of Earth-heated circulating fluid that can be exploited for electricity generation	**Enhanced Geothermal Systems (EGS)** Naturally occurring zones of heat but lack sufficient fluid flow and require engineering to enhance permeability.
Binary	Use a heat exchanger and secondary working fluid. This technology generally applies to lower-temperature systems (<200°C) due to the current maximum operating temperature of pumping technology.	**2nd Tier**	**Highest Cost** **4th Tier**
Flash	Flash plants generate steam through a pressure change of the thermal fluid that directly drives a turbine. This technology generally applies to higher-temperature systems.	**Lowest Cost** **1st Tier**	**3rd Tier**



Data source: NREL (National Renewable Energy Laboratory). 2021. "2021 Annual Technology Baseline."

Utility Scale 4-hour Lithium-ion Battery Storage CAPEX Projections

Based on the latest National Renewable Energy Laboratory 2021 Annual Technology Baseline, utility-scale battery capital expenditures are projected to decline from $1397 per kW in 2020 to $456 per kW by 2041 in the Low Case, to $693 per kW in the Base Case, and to $1,005 per kW in the High Case.

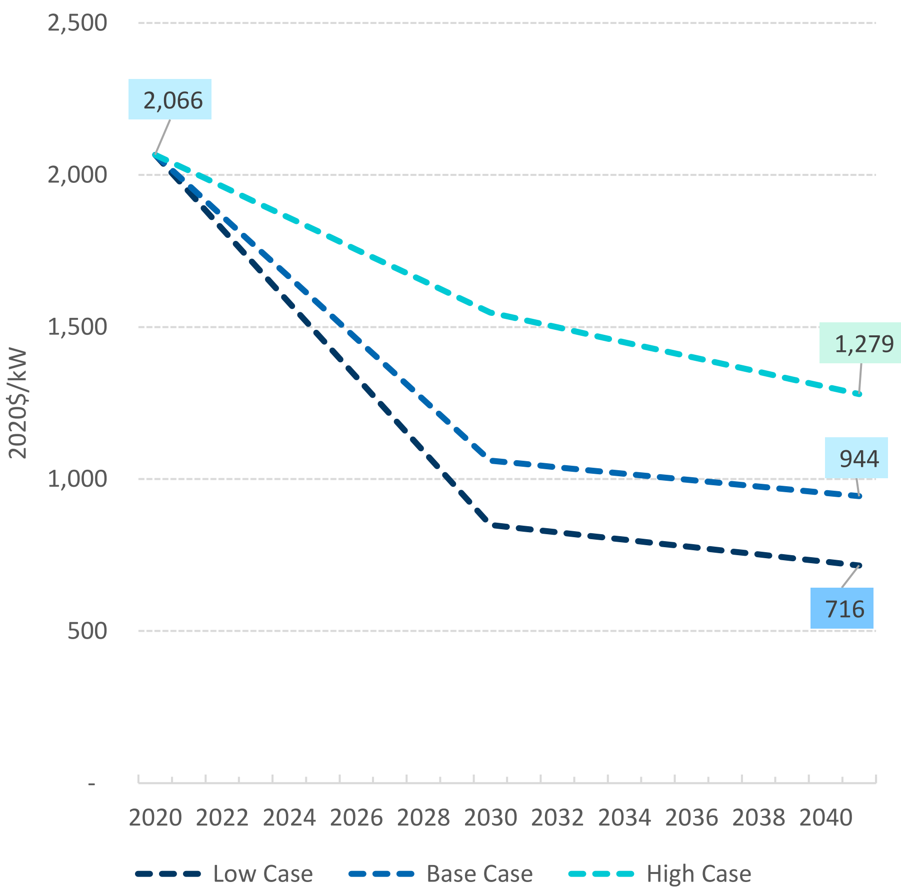


Data source: NREL (National Renewable Energy Laboratory). 2021. "2021 Annual Technology Baseline."

Utility Scale PV-plus-Battery CAPEX and LCOE Projections

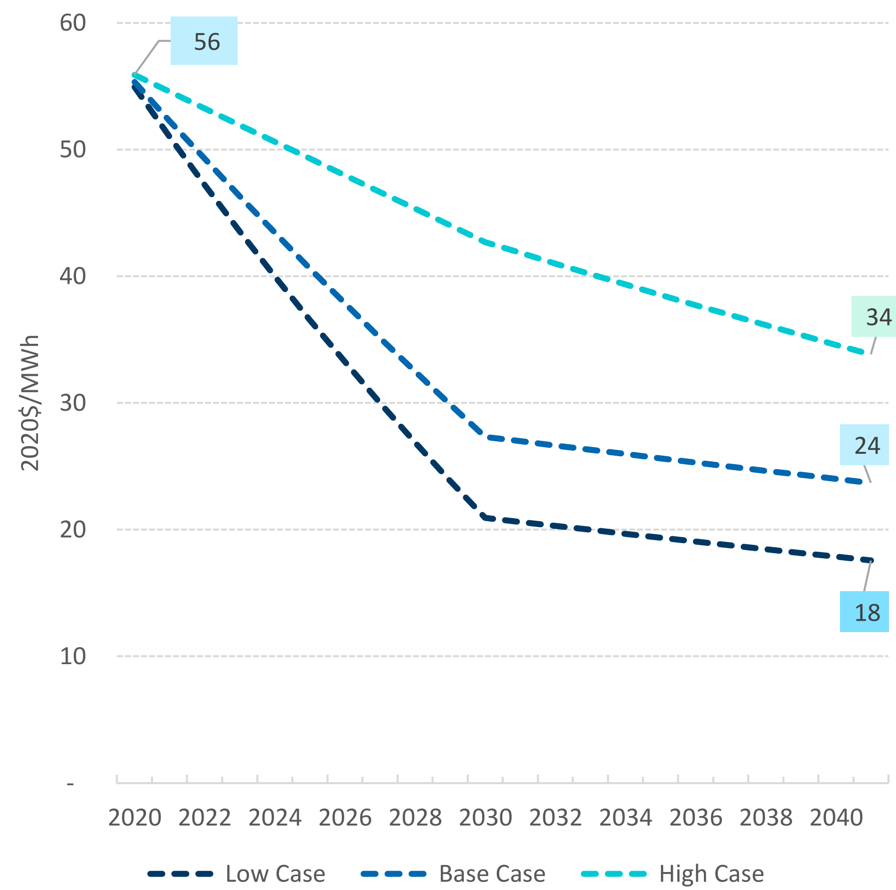
Utility-scale PV-plus-Battery CAPEX Projections

Utility-scale PV-plus battery CAPEX values are projected to decline from $2,066 per kW in 2020 to $716 per kW by 2041 in the Low Case, to $944 per kW in the Base Case, and to $1,279 per kW in the High Case.



Utility-scale PV-plus-Battery LCOE Projections

Utility-scale PV-plus-battery LCOE values are projected to decline from $56 per MWh in 2020 to $18 per MWh by 2041 in the Low Case, to $24 per MWh in the Base Case, and to $34 per MWh in the High Case.



Data source: NREL (National Renewable Energy Laboratory). 2021. "2021 Annual Technology Baseline."

Pumped Storage Hydro Installed Costs Projection in 2030

PSH costs are highly dependent on geography, turbine type, and reservoir configurations.

- Pumped storage hydro (PSH) pumps water from a lower reservoir to a higher one where it is stored until needed. When released, the water from the upper reservoir flows back down through a turbine and generates electricity.
- PSH exhibits wide ranges of costs, depending on the geography and technology. Configurations may include open-loop and closed loop, and turbine technologies offer different features and capabilities, including fixed speed, advanced speed, and ternary.

Installed Energy Storage System Cost

Year	Technology	Low	Base	High
		$/kWh	*$/kWh*	*$/kWh*
2020	Lithium ion LFP	326	385	438
	Lithium ion NMC	330	395	457
	Redox Flow	466	517	569
	PSH	325	512	563

Installed Energy Storage System Cost

Year	Technology	Low	Base	High
		$/kW	*$/kW*	*$/kW*
2020	Lithium ion LFP	1,302	1,541	1,752
	Lithium ion NMC	1,320	1,581	1,827
	Redox Flow	1,863	2,070	2,277
	PSH	1,301	2,046	2,250

Year	Technology	Low	Base	High
		$/kWh	*$/kWh*	*$/kWh*
2030	Lithium ion LFP	236	270	312
	Lithium ion NMC	241	282	320
	Redox Flow	347	414	466
	PSH	325	512	563

Year	Technology	Low	Base	High
		$/kW	*$/kW*	*$/kW*
2030	Lithium ion LFP	944	1,081	1,249
	Lithium ion NMC	965	1,128	1,279
	Redox Flow	1,388	1,655	1,864
	PSH	1,301	2,046	2,250

Note:
1) LFP = lithium-ion iron phosphate
2) NMC = nickel manganese cobalt
3) Redox Flow: A flow battery, or redox flow battery (after reduction–oxidation), is a type of electrochemical cell where chemical energy is provided by two chemical components dissolved in liquids that are pumped through the system on separate sides of a membrane.
3) PSH = pumped storage hydro

Data source: Pacific Northwest National Laboratory, "2020 Grid Energy Storage Technology Cost and Performance Assessment“, December 2020

Costs and Performances of Gas Peaking Units and Fuel Cells

Capital costs for internal combustion turbines and aeroderivative combustion turbines are stable, while the capital costs for fuel cells are currently high, with future cost reductions possible.

Technology	Size	Heat Rate	Overnight Cost	VOM	FOM
	MW	(Btu/kWh)	(2020 $/kW)	(2020 $/MWh)	(2020 $/kW-yr)
RICE	21	8,295	1,813	5.72	35.34
Aero SCCT	105	9,124	1,169	4.72	16.38
Fuel cells	10	6,469	6,866	0.59	30.94

Notes:

1) Overnight cost is the cost of a construction project if no interest was incurred during construction, as if the project was completed "overnight." This concept is used for providing a simplistic cost comparison between power plant projects or technologies.
2) VOM: variable operating and maintenance costs
3) FOM: fixed operating and maintenance costs

Data Source: U.S. Energy Information Administration, Cost and Performance Characteristics of New Generating Technologies, Annual Energy Outlook 2021

Glossary

Glossary (1/4)

1. **AEO:** Annual Energy Outlook is a comprehensive assessment of U.S, energy outlook produced by the U.S. Energy Information Administration.
2. **AMI:** Advanced Metering Infrastructure is a two-way communication system to collect detailed metering information throughout a utility's service industry.
3. **ATB:** Annual Technology Benchmark is a cost and performance benchmark study produced by the National Renewable Energy Laboratory.
4. **ATC:** Around the clock energy supply overcomes the limitations of intermittent renewable energy sources that are not dispatchable, such as wind and solar.
5. **BA (balancing authority) area**: A BA area is the collection of generation, transmission, and loads within the metered boundaries of the balancing authority.
6. **BPU (Board of Public Utilities):** The Los Alamos Department of Public Utilities (DPU) operates the county-owned electric, gas, water & wastewater systems under the jurisdiction and control of the BPU. The BPU consists of five voting members appointed by County Council.
7. **CAGR:** Compound annual growth rate is the rate of return that would be required for an investment to grow from its beginning balance to its ending balance.
8. **CC (Combined Cycle)**: CC is a form of power generation that captures exhaust heat often from a CT (or multiple CTs) to create additional electric power beyond that created by the simple CT and enhance the overall efficiency of the unit by producing more output for the same level of input.
9. **CCS (carbon capture and storage):** CCS is the process of capturing carbon dioxide (CO_2) formed during power generation and industrial processes and storing it so that it is not emitted into the atmosphere.
10. **CEC:** California Energy Commission is the primary energy policy and planning agency for California.
11. **CES (Clean Energy Standard)**: A clean energy standard requires a percentage of retail electricity sales to come from low- and zero-carbon sources.
12. **CFPP (Carbon Free Power Project):** CFPP is a nuclear power plant, which would be comprised of up to a dozen 50-MW pressurized light water reactor modules at the Idaho National Engineering Laboratory in Idaho Falls. The project is proposed by the Utah Associated Municipal Power Systems (UAMPS).
13. **COD:** Commercial online date is the date that a project achieves commercial operation.
14. **CT (Combustion Turbine):** CT is a form of power generation that forces air into a chamber heated through the combustion of a type of fuel (often diesel or natural gas) which causes the heated air to expand and power the circulation of a turbine that spins an electric generator to produce electricity.
15. **DER:** Distributed energy resources are electrical generation and storage performed by a variety of small, grid-connected or distribution system-connected devices.
16. **DOE:** Department of Energy
17. **DR: D**emand response is a change in the power consumption of an electric utility customer to better match the demand for power with the supply.
18. **ECA (Electric Coordination Agreement):** The ECA is an agreement between Los Alamos County (LAC) and the Department of Energy (DOE) that commenced the Los Alamos Power Pool (LAPP) in July 1985. The agreement established a resource sharing and cost allocating accounting pool, whereby the two parties committed their resources to serve the combined power requirements of LAC and the Los Alamos National Laboratory (LANL).

FTI CONSULTING

Glossary (2/4)

19. **EE (Energy Efficiency):** EE refers to any number of technologies deployed to reduce energy consumption. Examples include more efficient lighting, refrigeration, and heating, etc.
20. **EIA**: Energy Information Administration
21. **EIM:** Energy Imbalance Market is a voluntary market that provides a sub-hourly economic dispatch of participating resources for balancing supply and demand.
22. **FER (Future Energy Resources):** The Los Alamos Future Energy Resources committee is an ad hoc citizens committee formed by Board of Public Utilities.
23. **FOM (Fixed Operations and Maintenance Expenses):** FOM is fixed expenses incurred as a result of operations and maintenance that do not vary with operations.
24. **Fossil fuel:** Fossil fuel is typically derived from the decomposition of plant and animal matter under the ground. Typically, coal, oil, and natural gas fall under the definition of fossil fuels.
25. **Heat rate:** Heat rate is the efficiency at which a generator converts input fuel to electric output, typically measured in Btu/kWh.
26. **IEPR:** Integrated Energy Policy Report is issued by the California Energy Commission, in collaboration with a range of stakeholders, to develop and implement energy plans and policies.
27. **IRP (Integrated Resource Plan):** IRP is a comprehensive planning process for a utility to establish a road map to provide reliable and cost competitive service to its customers in the near, mid and long-term.
28. **ITC (investment tax credit):** Solar ITC, known as the federal solar tax credit, allows solar developers to deduct certain percent of the cost of installing a solar energy system from the federal taxes.
29. **KW (Kilowatt):** One thousand watts.
30. **kWh (Kilowatt-hour):** One thousand watts produced for one hour.
31. **LAC:** Los Alamos County
32. **LANL:** Los Alamos National Lab
33. **LAPP (Los Alamos Power Pool):** Based on the Energy Coordination Agreement (ECA) in place since 1985, Incorporated County of Los Alamos (LAC) and Los Alamos National Laboratory (LANL) pool their generation resources together and operate in the Los Alamos Power Pool.
34. **LFP:** Lithium-ion iron phosphate energy storage system is a type of lithium-ion battery using lithium iron phosphate as the cathode material, and a graphitic carbon electrode with a metallic backing as the anode.
35. **Long position:** In this IRP, long position means that total capacity of peak serving resources is more than the peak load.

Glossary (3/4)

36. **LRS (Laramie River Station):** The Laramie River Station, located east of Wheatland, WY, is one of the largest consumer-operated, regional, joint power supply ventures in the U.S. Laramie River Station has three coal-based units: Unit 1: 570 net megawatts began operating in 1980; Unit 2: 570 net megawatts began operating in 1981; Unit 3: 570 net megawatts began operating in 1982.
37. **MW (Megawatt):** One million watts or 1,000 kilowatts.
38. **MWh (Megawatt-hour):** One million watts (or 1,000 kilowatts) produced for one hour.
39. **NMC:** Nickel manganese cobalt energy storage system is one of the two commonly used lithium-ion chemistries: Nickel Manganese Cobalt (NMC) and Lithium Iron Phosphate (LFP).
40. **NPV (Net Present Value):** A method of calculating the current value of a series of cash flows, which considers the time value of money, and discounts future cash flows based on a determined discount rate or cost of capital.
41. **NREL (the National Renewable Energy Laboratory):** NREL is a national laboratory of the U.S. Department of Energy.
42. **Operating reserve:** Operating reserve is a portion of generating capacity available to the operator of a power system that may be increased or decreased in order to match short-term fluctuations in energy demand on the system.
43. **Overnight cost:** Overnight cost is the cost of a construction project if no interest was incurred during construction, as if the project was completed "overnight." This concept is used for providing a simplistic cost comparison between power plant projects or technologies.
44. **PEEC:** Pajarito Environmental Education Center
45. **Planning Reserve Margin:** A measure of available capacity over and above the capacity needed to meet normal peak demand levels.
46. **PNM:** Public Service Company of New Mexico
47. **PPA (Power Purchase Agreement**): A contract by which energy is bought and sold at prices and over time periods specified by the contractual terms.
48. **PSH:** Pumped storage hydro is a type of hydroelectric energy storage with a configuration of two reservoirs at different elevations that can generate power as water moves down from one to the other (discharge), passing through a turbine.
49. **PTC (production tax credit):** The renewable PTC is a per kilowatt-hour (kWh) federal tax credit included under Section 45 of the U.S. tax code for electricity generated by qualified renewable energy resources.
50. **PV (Photovoltaics):** Solar PV converts solar energy into direct current electricity using semiconducting materials that exhibit the photovoltaic effect, a phenomenon commonly studied in physics, photochemistry and electrochemistry**.**
51. **Redox Flow:** A flow battery, or redox flow battery (after reduction–oxidation), is a type of electrochemical cell where chemical energy is provided by two chemical components dissolved in liquids that are pumped through the system on separate sides of a membrane.

Glossary (4/4)

52. **Renewable generation:** Electric generation produced by a renewable source, including power generated by the wind, the sun (through photovoltaic processes or solar thermal processes), water (hydroelectric generation), and biomass, etc.
53. **RICE (Reciprocating Internal Combustion Engine)**: A generating unit type that utilizes the movement of pistons to convert pressure into a rotating motion, which can be used to turn an electric generator and produce electricity.
54. **RPS (Renewable Portfolio Standard):** Renewable portfolio standards (RPS) are policies designed to increase the use of renewable energy sources for electricity generation. These policies require or encourage electricity suppliers to provide their customers with a stated minimum share of electricity from eligible renewable resources.
55. **SCGT:** Simple cycle combustion turbine a type of gas turbine frequently used in the power generation, The simple-cycle combustion turbine follows the Brayton Cycle and differs from a combined cycle operation in that it has only one power cycle (i.e., no provision for waste heat recovery).
56. **SCED (Security Constrained Economic Dispatch):** SCED models the most economic generation dispatch while considering key system operation constraints, such as power balance constraint, reserve requirement constraints, transmission security constraints, as well as generation limitations, such as ramp rates, minimum and maximum output levels.
57. **Short position:** In this IRP, short position means that total capacity of peak serving resources is less than the peak load.
58. **SJGS (San Juan Generation Station):** The SJGS is operated by Public Service Company of New Mexico (PNM) and owned by nine companies. The plant has a net capacity of 1,683 megawatts: Unit 1 340 MW, Unit 2 340 MW, Unit 3 496 MW and Unit 4 507 MW. The oldest unit (Unit 2) went online in 1973, and the newest unit (Unit 4) went online in 1982.
59. **SMR (Small Modular Reactors) or SMNRs (Small Modular Nuclear Reactors):** SMRs or SMNRs are nuclear power plants that are small in size (300 MWe or less) than current generation base load plants (1,000 MWe or higher). These smaller, compact designs are factory-fabricated reactors that can be transported by truck or rail to a nuclear power site.
60. **Thermal generation:** Power generation created through the creation of heat, as contrasted against many renewable generation technologies (biomass and biogas excepted), which do not rely on heat to produce electricity.
61. **Transmission system:** The series of towers and wires that transmit electricity from generation sources to the distribution system at higher voltages than the distribution system to minimize technical losses of transmitted electricity.
62. **UAMPS (Utah Associated Municipal Power Systems):** UAMPS is a political subdivision of the State of Utah that provides comprehensive wholesale electric-energy, transmission, and other energy services, on a nonprofit basis, to community-owned power systems throughout the Intermountain West.
63. **VOM (Variable Operations and Maintenance Expenses):** Operations and maintenance expenses that vary as a function of the amount of energy that is being produced.
64. **WECC:** The Western Electricity Coordinating Council promotes Bulk Electric System reliability for the entire Western Interconnection system. WECC is the Regional Entity responsible for compliance monitoring and enforcement. In addition, WECC provides an environment for the development of Reliability Standards and the coordination of the operating and planning activities of its members as set forth in the WECC Bylaws.

Experts with Impact™

FTI™ CONSULTING