Renewables for California

October 7th 2020

Pathto100.org

Path to 100%

Presenters

Gary Ackerman
President
Foothill Services, Inc
Moderator

Scott Miller
Executive Director,
Western Power Trading Forum
Speaker

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Ph.D, CEO & Co-Founder
Ascend Analytics
Speaker

Jussi Heikkinen
Director, Growth & Development, Americas
Wärtsilä
Speaker

Path to 100%

Decarbonizing Electricity in California by 2045

Content

1. **California decarbonization scenarios**
2. Managing heat waves
3. Summary

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California decarbonization scenarios

Situation & Plan

- Firm decarbonization targets
- Dependency of imports
- Rapid growth of solar power
- Closures of firm capacity (Nuclear, gas / OTC´s)
- Very limited repowering of gas plants

Challenges

- Increasing issues with solar curtailment, evening ramps, generation costs and security of supply
- How to integrate renewables to ensure security of supply, sustainability and affordability

Path to 100 approach

- Search for the optimal decarbonization plan for California using leading software & supercomputers
- White Paper & webinar in March, added hydrogen and carbon neutral methane scenarios in May
- **Major heat wave** in western USA in August 2020. Hourly load data did not contain such heat waves → Insert →

New, modified Optimal Path scenario ensuring security of supply during extreme heat waves

Scenarios

New scenario

Current Plan*	Current Plan Without any thermal	Optimal Path+ (PtM)	Optimal Path (PtM)	Optimal Path (PtH)
• Follows the 2019 state IRP (46 MMT Alternate Scenario) until 2030, and mirrors the IRP (High Electrification Scenario) until 2045 • OTC retirement delayed to 2026+ • Limited repowering with thermal • 100% of retail sales carbon-neutral by 2045 • ~ 8% of generation can still be fossil-thermal to cover grid losses	• OTC retirement delayed to 2026+ • NO repowering with thermal • Only solar, wind & traditional storage capacity additions allowed • 100 % carbon-neutral by 2045	• **OTC retirement 2023** • OTC's repowered with optimal capacity mix • RPS commitments met by 2040 (5 years early) • 100 % carbon-neutral by 2045 • Requires allowance of Power-to-Methane (PtM) • **Ensured security of supply during extreme heat waves**	• **OTC retirement 2023** • OTC's repowered with optimal capacity mix • RPS commitments met by 2040 (5 years early) • 100 % carbon-neutral by 2045 • Requires allowance of Power-to-Methane (PtM)	• **OTC retirement 2023** • OTC's repowered with optimal capacity mix • RPS commitments met by 2040 (5 years early) • 100 % carbon-neutral by 2045 • Requires allowance of Power-to-Hydrogen (PtH)

* Current Plan emulates the current California state plan

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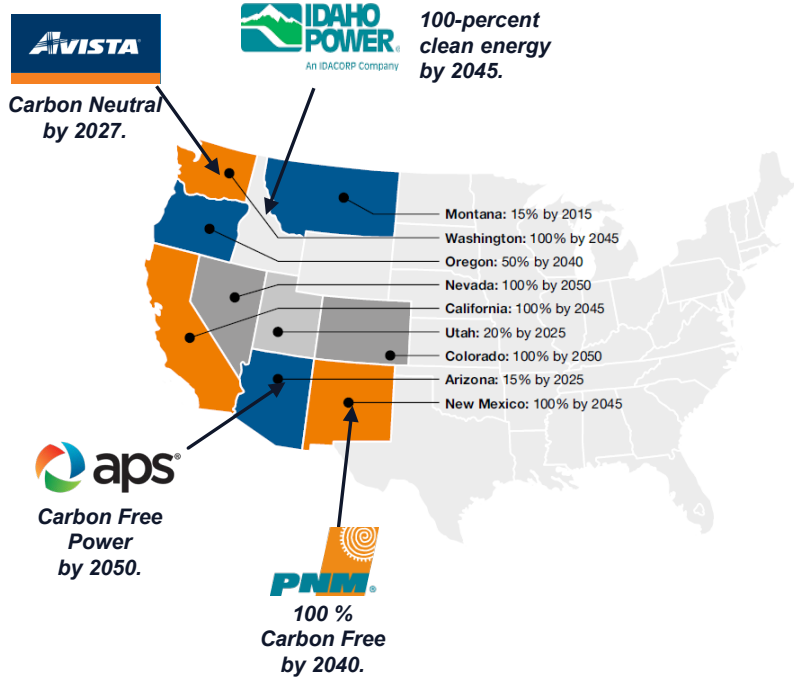
Common Assumptions to all Scenarios

Neighboring states decarbonize their power generation by 2045

- Fossil balancing power will not be available from the neighbors in 2045

Modelling approach

- Plexos can add all technologies to the power system (including pump storage etc.) if it makes economic sense & enables reaching the carbon targets
- Capex & Opex costs to produce adequate carbon neutral fuels (hydrogen or methane) for power generation locally in California are included in some scenarios (except hydrogen network and storage infra costs which are not known)
- Bloomberg price learning curves for solar, wind & battery storage



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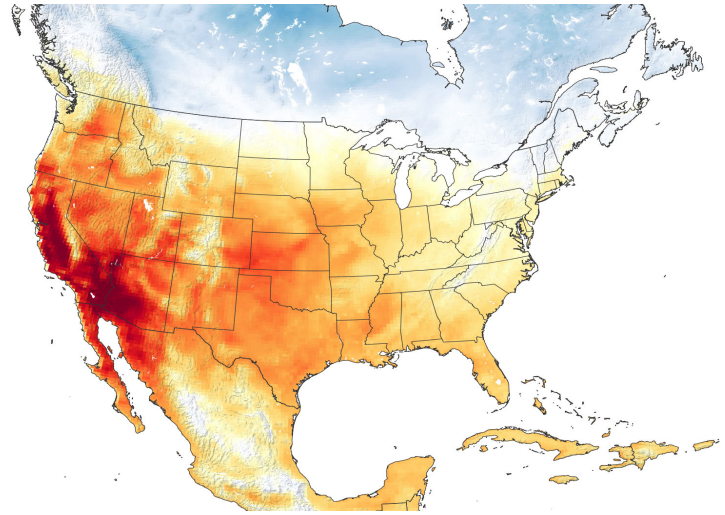

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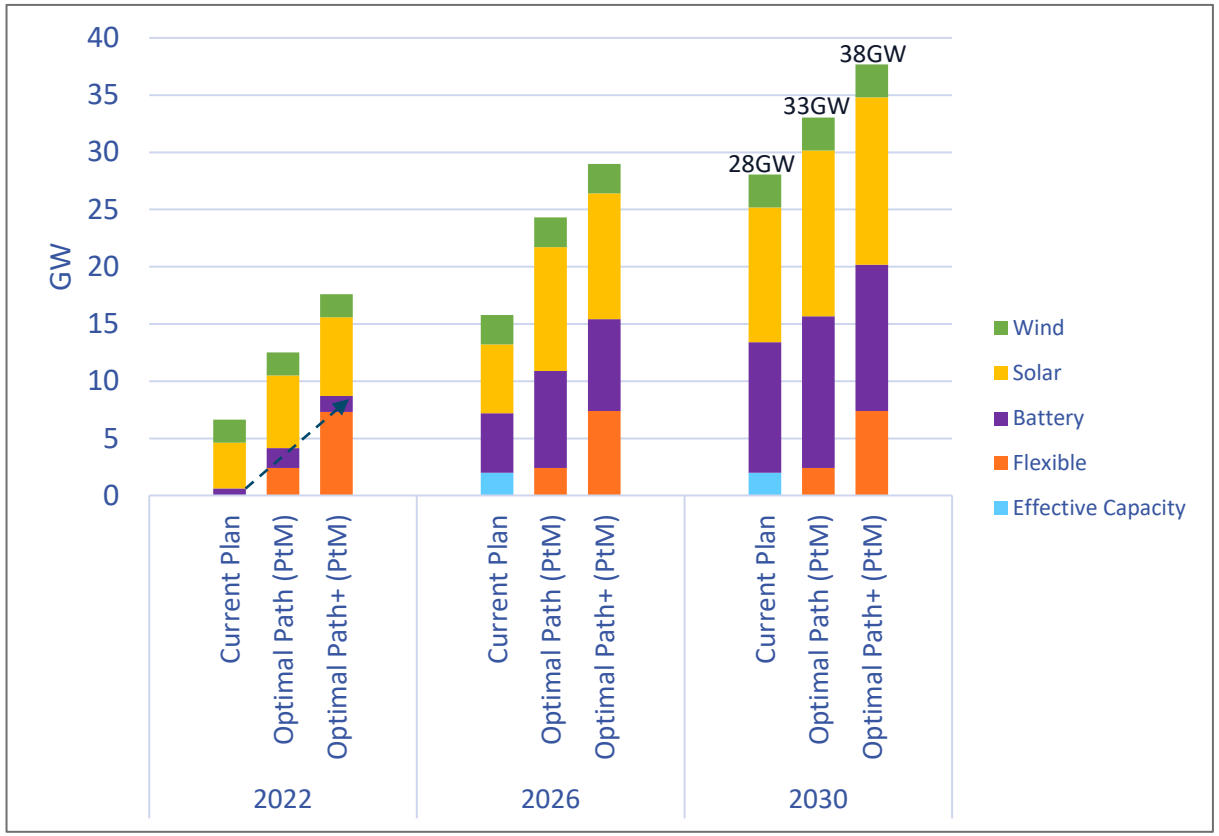
Managing heat waves!

Cumulative capacity additions until 2030



* Current Plan emulates the current state IRP

Current Plan (IRP)

- OTC retirements delayed until 2026
- ”Generic Effective Capacity” as a “perfectly dispatchable peaker with zero emissions” replaces OTC´s 2026

Optimal Path

- Faster addition of solar and battery storage
- OTC retirements in 2023. Flexible gas generation, additional storage and solar replace OTC’s and ensure system reliability

Optimal Path+

- Compared to Optimal Path
  - Fast immediate addition of 7.4 GW firm gas capacity
  - Similar solar & wind additions, sligtly slower addition of storage
- System reliability ensured even during heat waves

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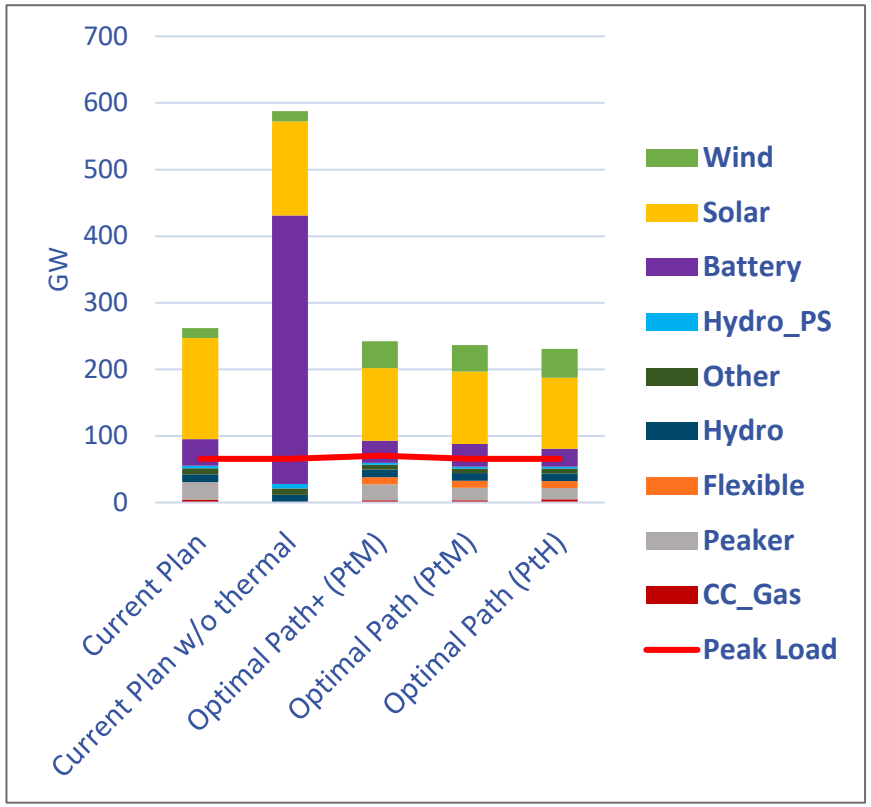
Scenario comparison

	Current Plan (IRP)	Current Plan w/o thermal	Optimal Path+ (PtM)	Optimal Path (PtM)	Optimal Path (PtH)
Power **system capacity** 2045, **GW**	**263**	**588**	**242**	**237**	**231**
Battery + Pump Storage, GWh	**515**	**1957**	**438**	**443**	**393**
Fuel Storage, GWh	**-**	**-**	**9265**	**7650**	**13617**
Cumulative **Carbon** until 2045, Mton	**948**	**935**	**828**	**824**	**820**
Carbon in 2045, Mton	4	0	0	0	0
Generation **costs** in 2045, **$/MWh**	**51**	**128**	**51**	**50**	**54**

Optimal Path(s)

- System capacity ~ 10 % lower than IRP
- Enable OTC retirements by 2023
- Reach RPS target 5 years early in 2040, with full decarbonization by 2045

System capacity in 2045



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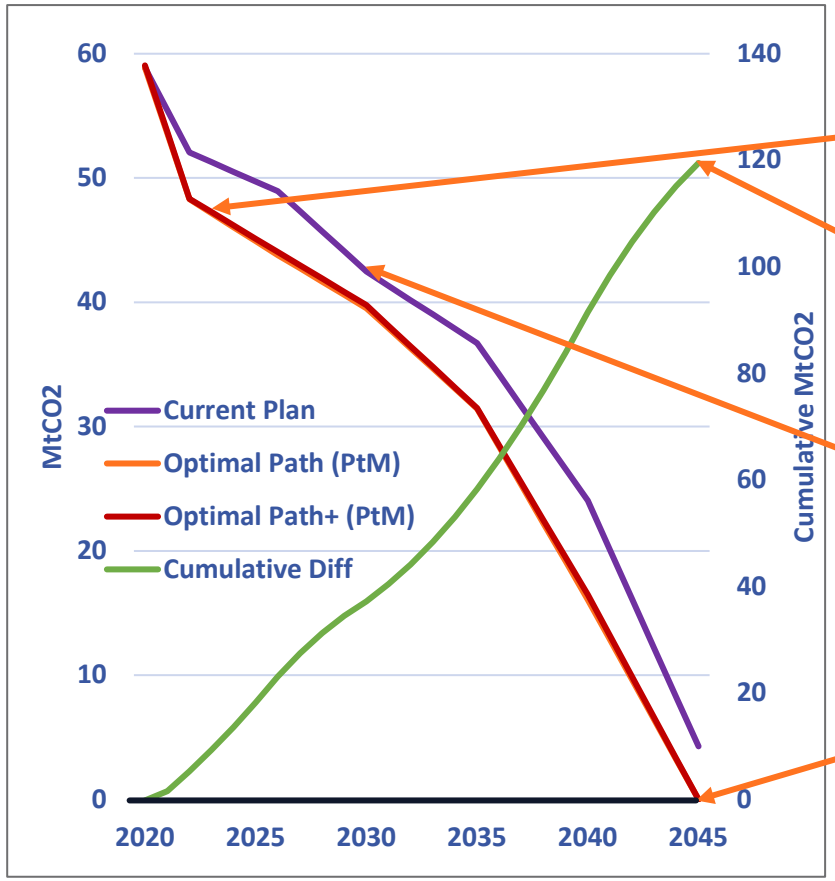
Carbon Emissions during the Path



Optimal Path allows faster growth of renewables, without OTC extensions

Optimal Path avoids 124 $MtCO_2$ of Carbon compared to Current Path

Current Plan meets 60% RPS target at 2030, but Optimal Path exceeds it

Optimal Path is at 100% net-zero by 2045 while Current Path is not

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Future fuel´s production process

Air

Direct Air Carbon Capture

Excess Renewable Electricity

CO_2

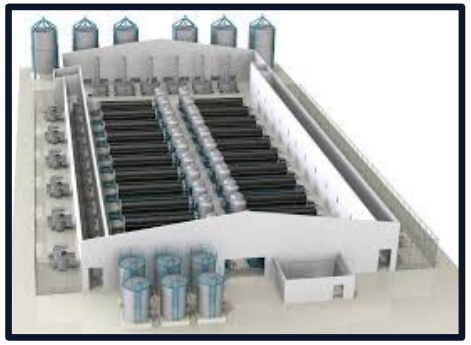
Methanizer

CH_4

Carbon Neutral Methane to natural gas network, or to LNG

Water

Electrolyzer



H_2

Hydrogen for flexible power plants

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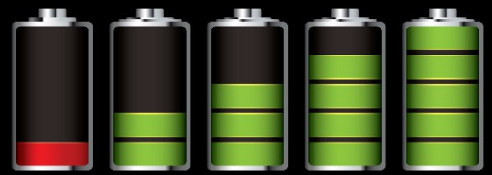
New Approach to Electricity Storage

Excess Renewable Electricity

Short Term Storage
158 GWh (PtM) / 108 GWh (PtH)



Long Term Storage
7650 GWh (PtM) / 13617 GWh (PtH)

Conversion Inverter

Conversion Gas Power Plant

- Ancillary services
- Minute-to-hour-to-daily balancing
- Daily shifting of solar

Balancing Power for the Grid

- Unusual weather management
- Seasonal system balancing

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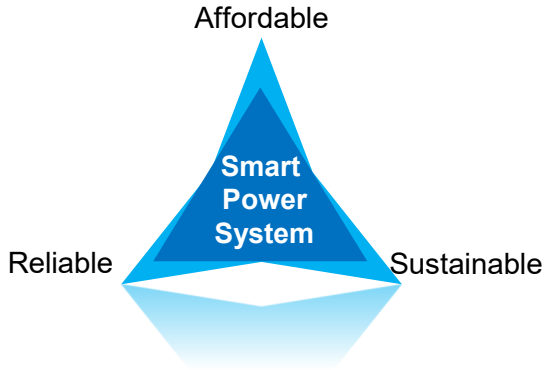
Key takeaways



1. ***Optimal Path*+ outlined in the study offers a practical path to 100 % for California**
   - Faster & complete decarbonization with lower costs for ratepayers
   - Maximized security of supply ensured even during extreme heat waves
2. **Power to Gas** (Methane or Hydrogen) **is a key ingredient of the optimal, decarbonized power system**
3. **Policy recommendations for California,** to enter the *Optimal Path*+ to 100 %:
   - Recognition of Renewable Fuels (including renewably sourced Methane and Hydrogen) as ”renewable” for RPS compliance purposes
   - Maintain OTC 2023 retirement dates
     - Add 7.4 GW of flexible gas generation to the power system
     - Ensure the new flexible capacity can later be converted to carbon neutral fuels
   - Add optimal proportions of Renewables, Storage and Flexible Thermal, to enable the transition to 100% clean energy

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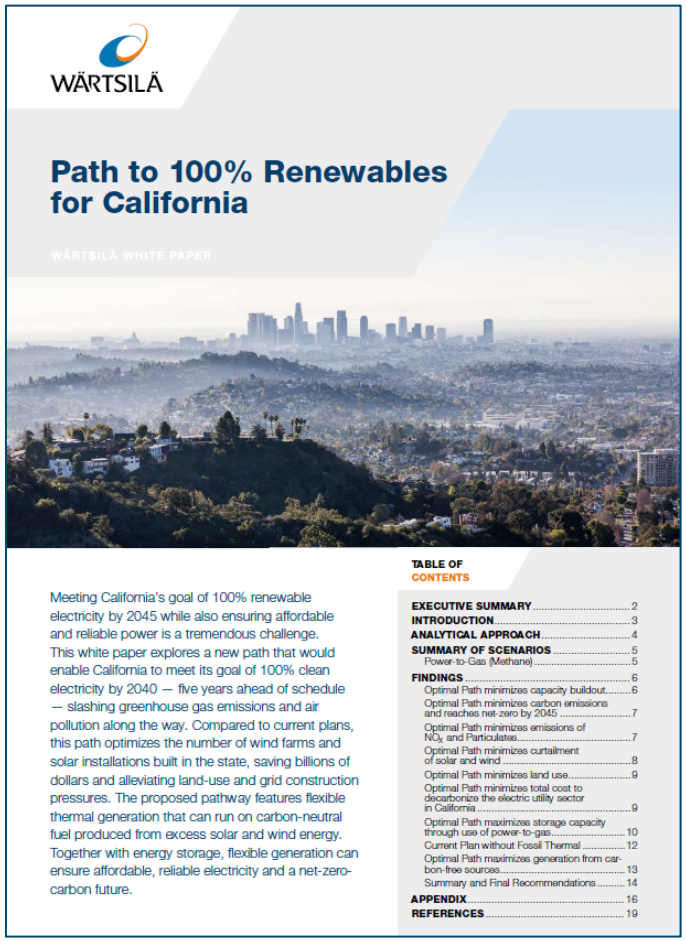
White Paper available at PATHTO100.ORG



WÄRTSILÄ

Path to 100% Renewables for California

WÄRTSILÄ WHITE PAPER

Meeting California's goal of 100% renewable electricity by 2045 while also ensuring affordable and reliable power is a tremendous challenge. This white paper explores a new path that would enable California to meet its goal of 100% clean electricity by 2040 — five years ahead of schedule — slashing greenhouse gas emissions and air pollution along the way. Compared to current plans, this path optimizes the number of wind farms and solar installations built in the state, saving billions of dollars and alleviating land-use and grid construction pressures. The proposed pathway features flexible thermal generation that can run on carbon-neutral fuel produced from excess solar and wind energy. Together with energy storage, flexible generation can ensure affordable, reliable electricity and a net-zero-carbon future.

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Ascend Analytics
Better models. Better decisions.

Case Study: Resource Selection for the Environment and Reliability

Using Analytics to Build Consensus and Find Win-Wins for Future Resource Portfolios

Dr. Gary Dorris, CEO, Ascend Analytics

Wartsila
September 23, 2020

About Ascend Analytics

- Founded in 2002 with 50 employees in Boulder, Oakland and Bozeman
- Seven integrated software products for operations, portfolio analytics, and planning
- Consulting and custom analytical solutions

Proven and Broadly Adopted

TERRA-GEN

NEXTera ENERGY

DUKE ENERGY

New York Power Authority

nrg

AUSTIN ENERGY

AES the power of being global

SILICON VALLEY CLEAN ENERGY

NorthWestern Energy

LA DWP Los Angeles Department of Water & Power

Enhanced Decision Analysis Across Time

PowerSimm OPS
OPERATIONAL STRATEGY

- Optimal short-term dispatch
- Determine operating strategies from position and financial exposure
- Track realized customer revenue and costs to settled day ahead and real time price
- Optimize financial exposure between day ahead and real time prices

PowerSimm Portfolio Manager
PORTFOLIO MANAGEMENT

- Portfolio management
- Generation asset management
- Hydro and renewable asset modeling
- Retail management & pricing
- Energy purchases and sales
- CFaR, GMaR, EaR

PowerSimm Planner
VALUATION & PLANNING

- Asset valuation
- Resource Planning
- Capacity Expansion Planning
- Reliability Analysis
- Renewable Integration
- Long-term Price Forecasting

BatterySimm Operations
STORAGE OPTIMIZATION

- Optimal offers to ISO
- Continuous adjust ISO offers
- Forecast probabilities of price spikes
- Renewables plus storage

BatterySimm Valuation
STORAGE VALUATION

- Optimal siting and sizing
- Captures realistic revenues given imperfect foresight
- Battery cycle analysis

CurveDeveloper

- Complete set of forward curves and forecast curves for 30 years
- ISO settlement data
- Incorporate broker projections

Clean Energy Resources for Grayson Replacement

- Natural gas steam unit, built in 1940s. Provides critical local generation in a transmission constrained area
- Pathway to 100% renewable

Peak load = 350 MW

Located 9 miles from downtown LA

"The resource portfolio recommended in this Integrated Resource Plan (IRP) will firmly establish Glendale Water and Power (GWP) as a national clean energy leader. The future envisioned herein represents a complete transformation of the way GWP provides reliable, affordable, and clean energy resources to the citizens of Glendale."

- 2019 Integrated Resources Plan, Page 1.

28 MW of energy efficiency and demand response

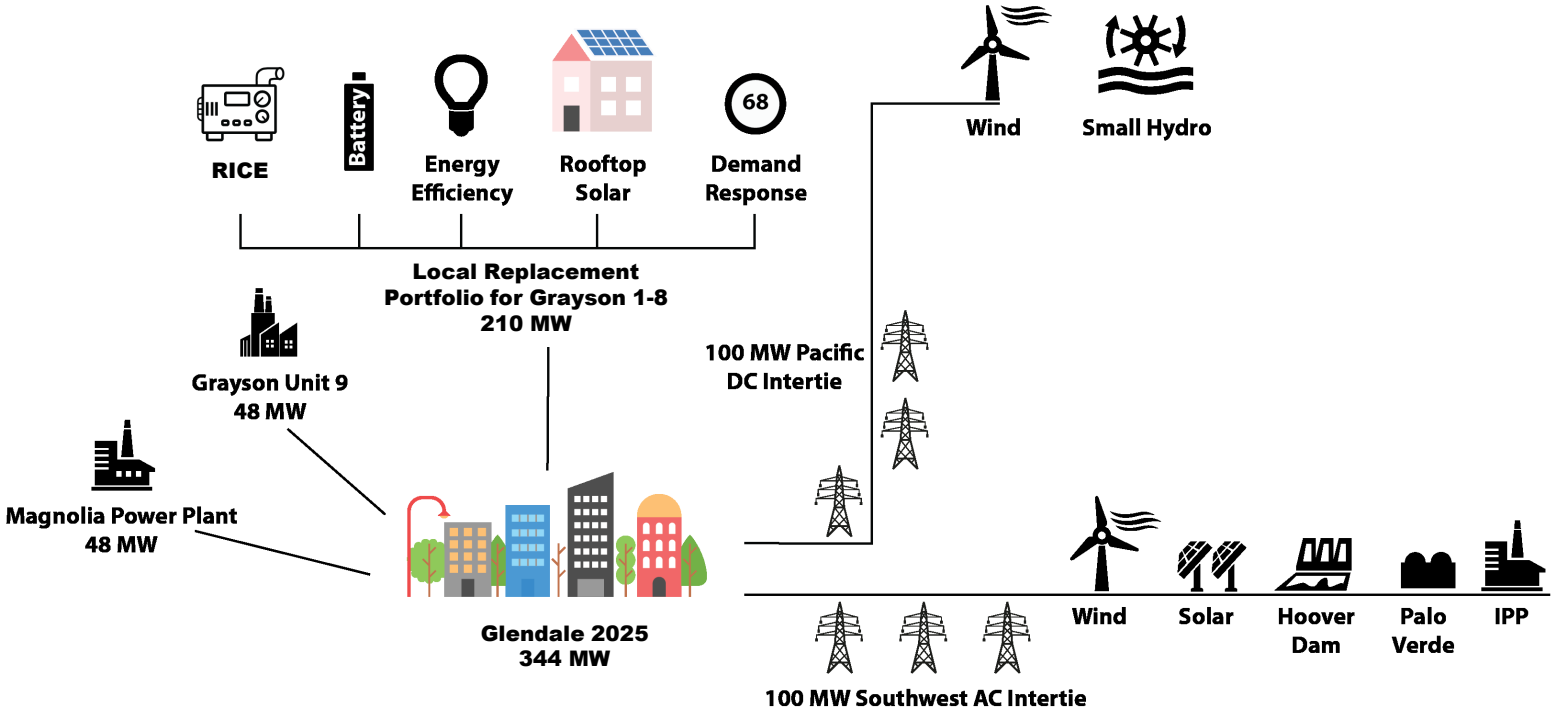
23 MW of rooftop solar and storage

75 MW of large-scale battery storage

93 MW of critical back-up power

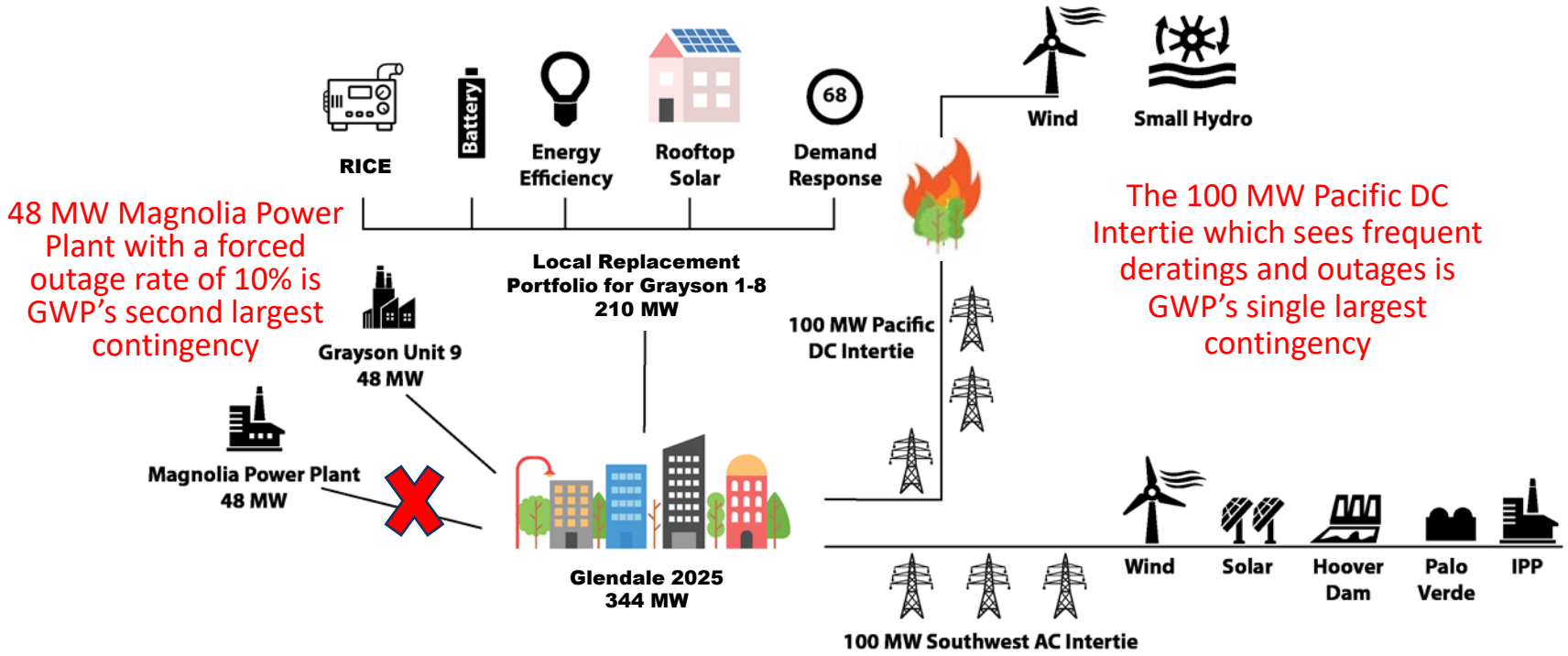
Glendale Water and Power (GWP)

Glendale's load significantly exceeds the available local supply, therefore transmission is critical for reliability



Reliability Requirements: N-1-1

NERC standards require GWP to maintain contingency reserves up to an N-1-1 contingency situation in which the second largest resource fails while the first largest resource is unavailable



(MW)	2019	2020	2021	2022	2023	2025	2030	2035	2038
Mean Peak	340	341	339	339	341	344	359	371	377
N-1-1 Reserve Requirement	148	148	148	148	148	148	148	148	148
Total Capacity Requirement (at peak)	488	489	487	487	489	492	507	519	525

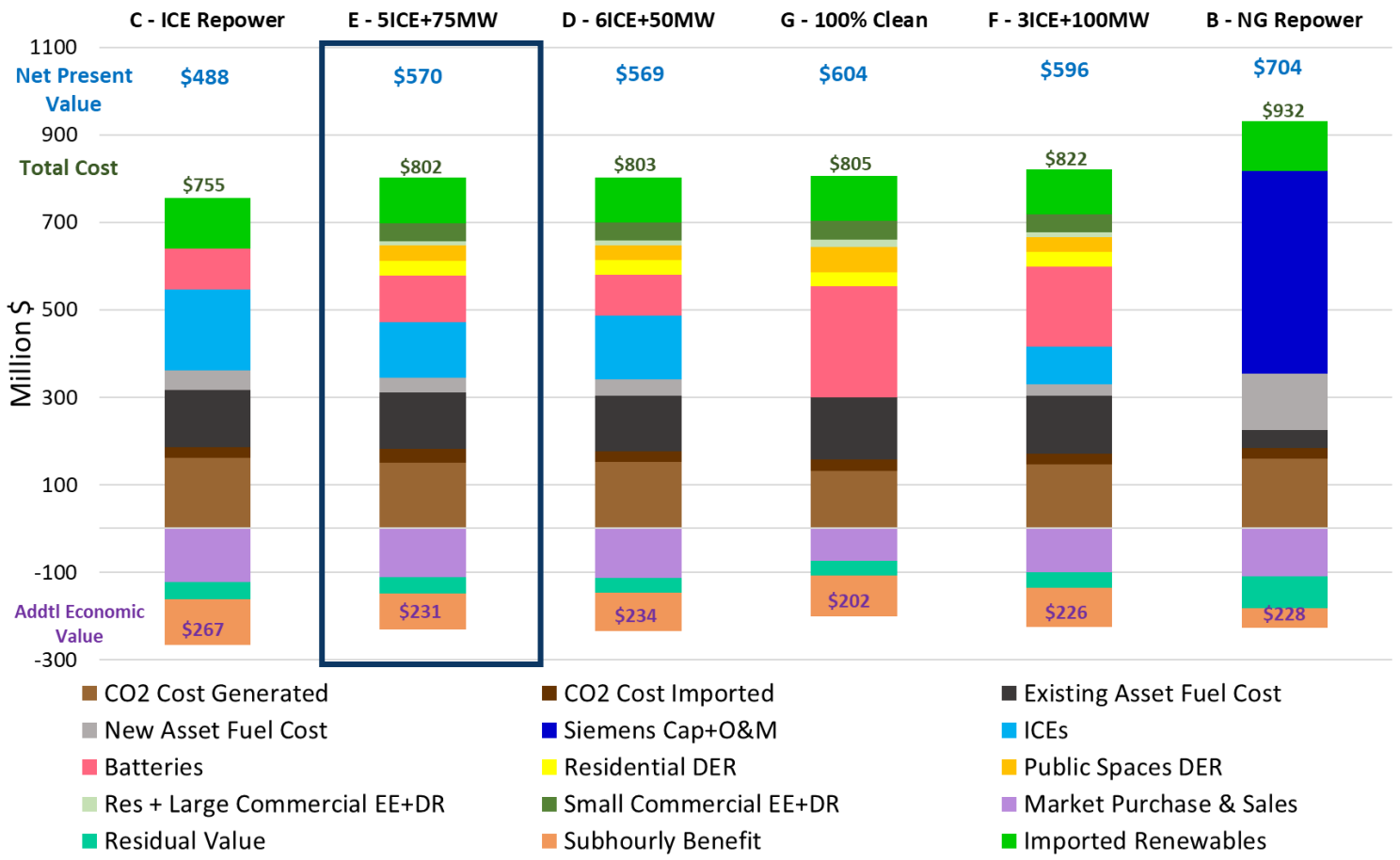
Alternatives Considered

winner

Portfolio		B – NG Repower	C – ICE Repower	D – 50 MW Batt + 6xICE	E – 75 MW Batt + 5xICE	F – 100 MW Batt + 3xICE	G – 100% Clean
Candidate Resource		Nameplate Capacity (MW)					
Clean Energy + Load Reduction	Residential DER			13	13	13	13
	Public Spaces DER			10	10	10	20
	Residential and Large Commercial EE+DR			7.5	7.5	7.5	20.5
	Small Commercial EE+DR			20.4	20.4	20.4	20.4
Imported Renewable Resources	Solar	140	140	130	130	130	130
	Wind	140	140	130	130	130	130
Storage	Utility Battery	50	50	50	75	100	150
Conventional Generation	CC	71					
	CT	120					
	ICE		149	112	93	56	

Present Value Cost Comparison

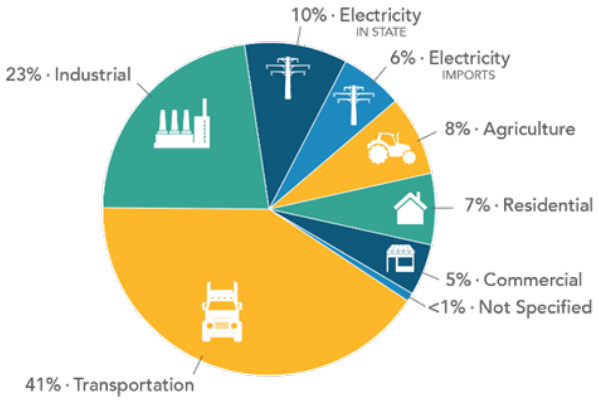
Portfolio E is the least-cost portfolio that incorporates clean energy and load reduction resources identified through the Clean Energy RFP.

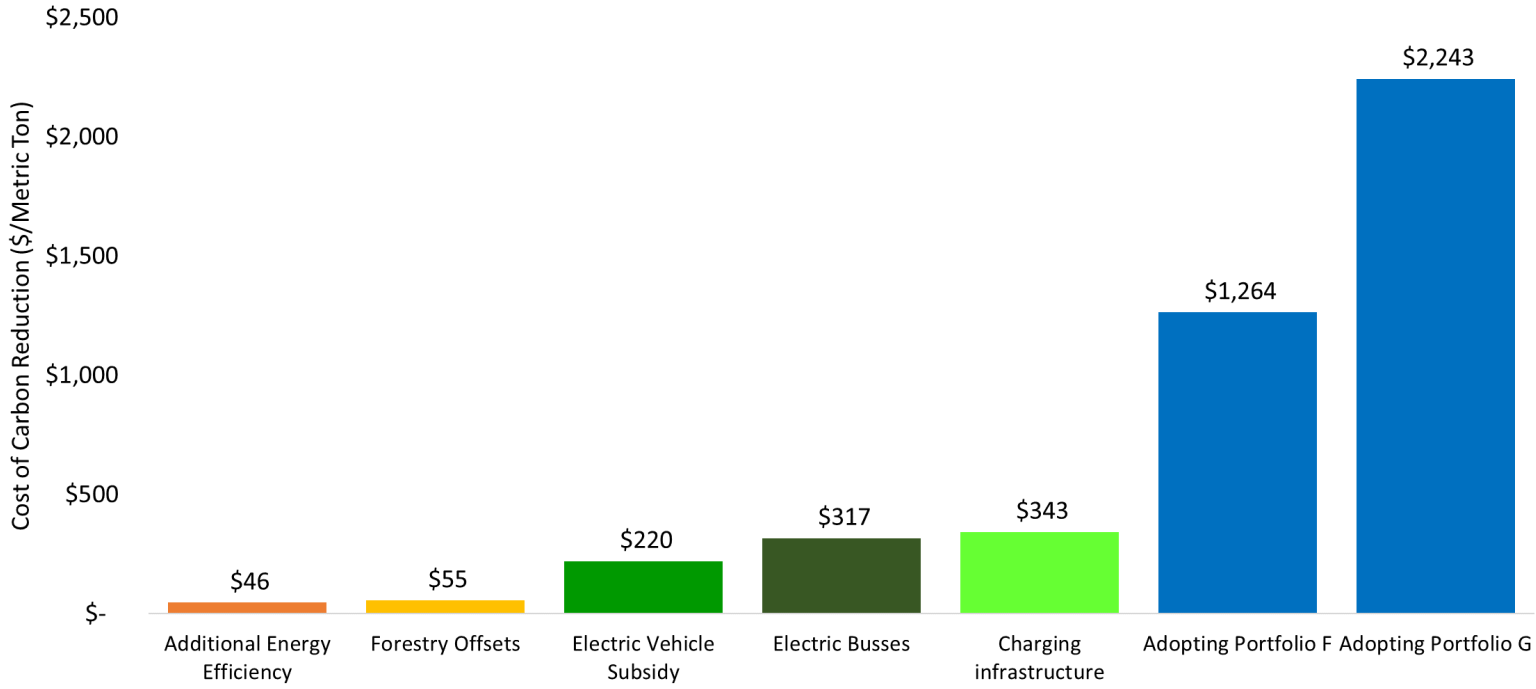


Marginal Abatement Cost of Carbon

- The cost of each marginal metric ton of carbon saved in moving from Portfolio E to Portfolio F is $1,264/tonnes, the cost of moving to Portfolio G is $2,243/tonnes
- Alternative carbon abatement strategies exist that are more cost-effective

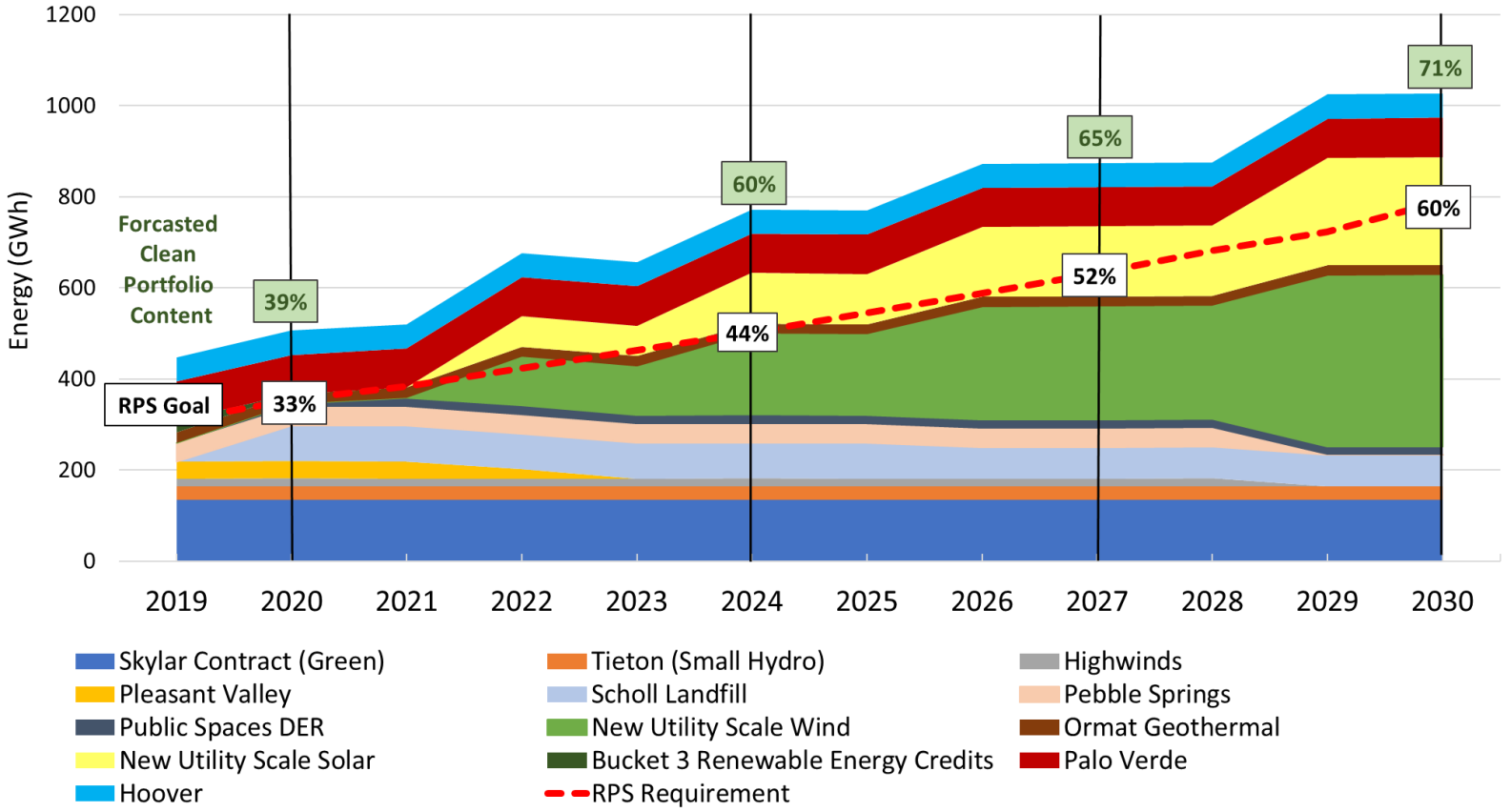
41% of CA emissions from transportation, only 10% from electricity





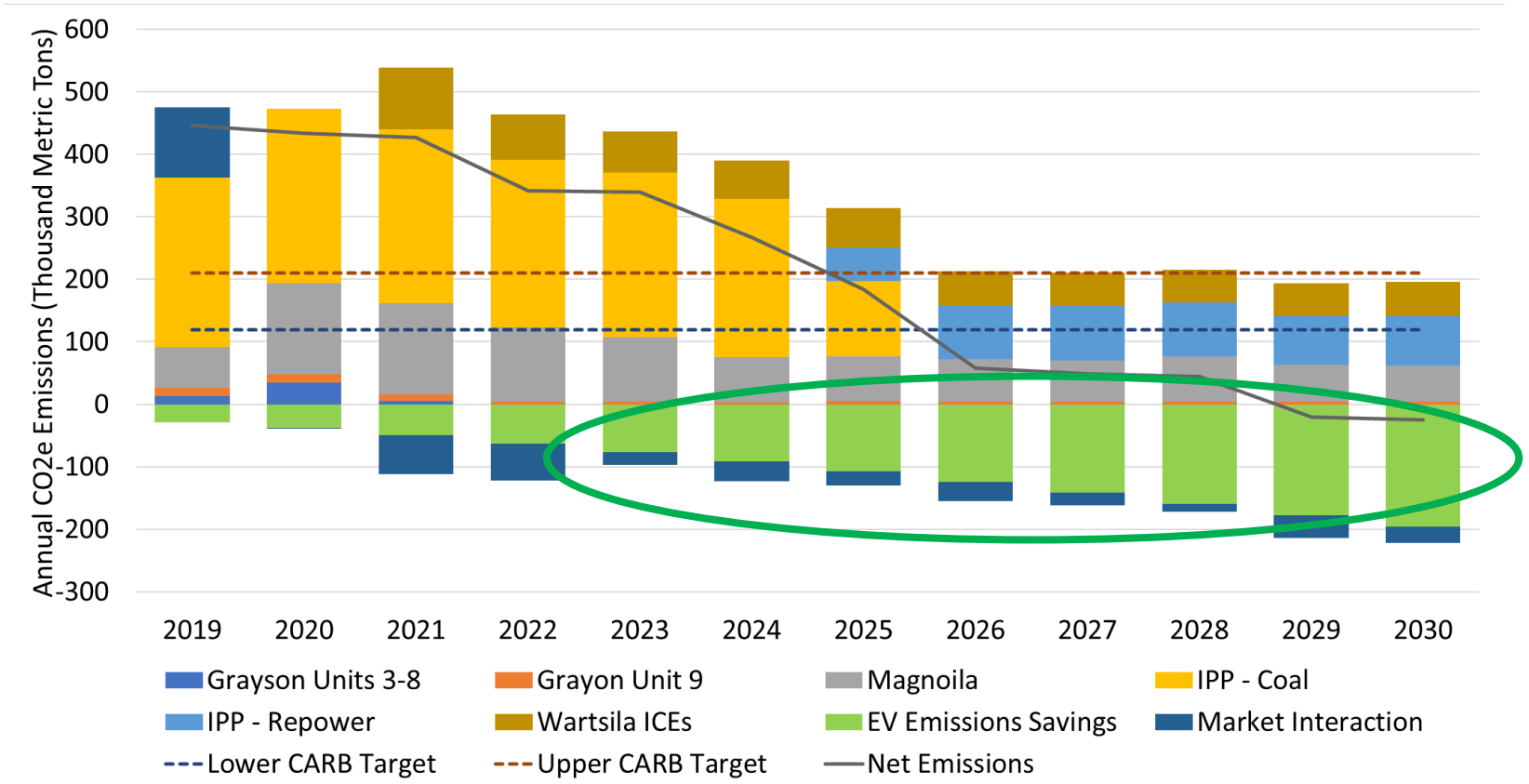
Clean and Renewable

Clean and renewable resources to compromise over 71% of energy in 2030



GWP will exceed emissions reductions goals through clean energy and transportation electrification

- EV emissions savings is calculated to account for tailpipe emissions avoided with new EVs
- This emissions credit shows that GWP's net emissions become negative starting in 2029



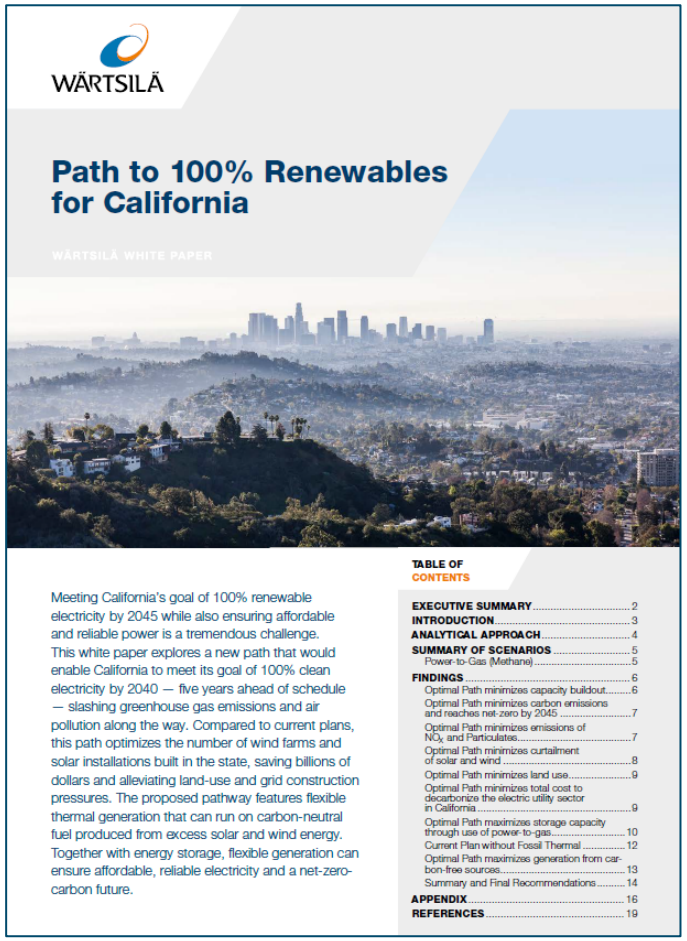
Electric utilities enable transition to clean fuels and should take credit for the emissions reductions

Key Lessons Learned

- Listen to your stakeholders, hire an external professional facilitator and address concerns
- Issue the RFP to inform your resource procurement and plan
- Leverage advanced modeling and share results in a clear transparent manner
- Frame choice set not only in terms of electricity options but also transportation and built environment
- Emphasize the option of using renewable fuels by the early 2040s to fully decarbonize

City Council Adopted the IRP 5 – 0.
The plan was deemed acceptable to local environmental organizations.

THANK YOU!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White Paper available at PATHTO100.ORG

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