TOWARD A 100% RENEWABLE ENERGY FUTURE

INSIGHTS FROM THE CITY OF LOS ANGELES

SPRING 2019

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‘NOW BREWED WITH WIND POWER’? READ THE FINE PRINT IN BUDWEISER’S SUPER BOWL AD

THE DAILY CALLER NEWS FOUNDATION

THE STATES CONTINUE TO PUSH RENEWABLE ENERGY

California's SB100

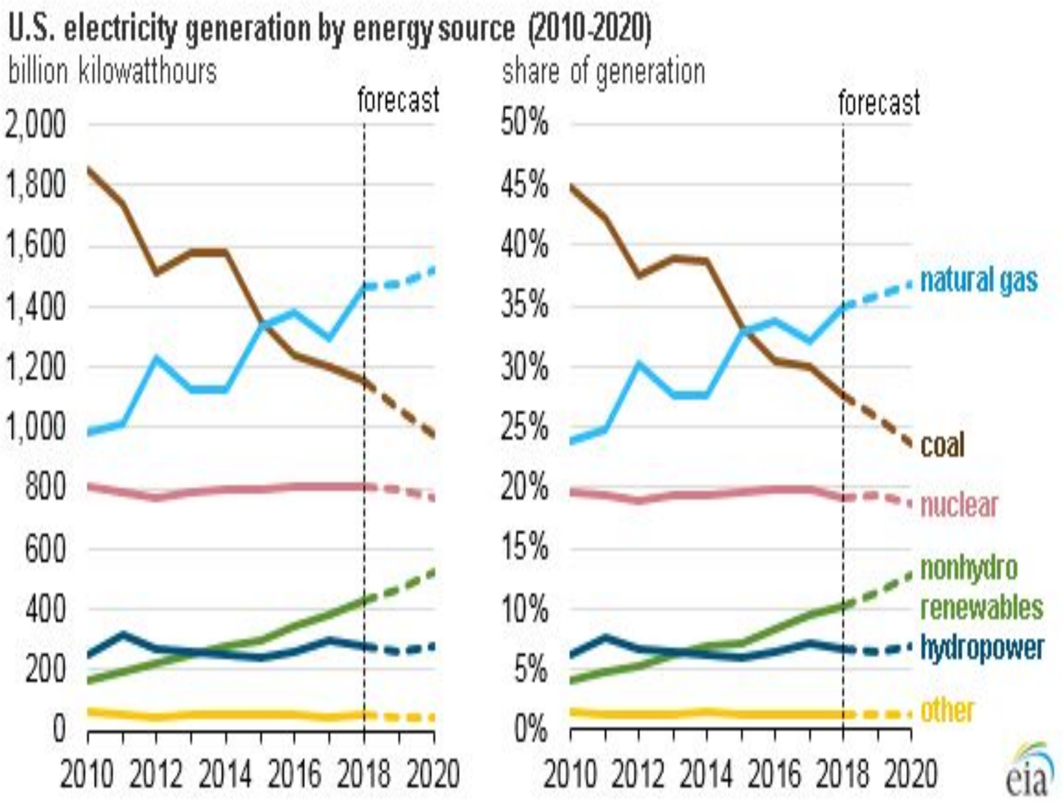
- Signed into law on September 10, 2018 by California Gov. Jerry Brown.
- Sets a target date for 100% renewable energy by 2045.
- Increases the RPS target from 50% to 60% by 2030.
- Remaining 40% from zero-carbon sources by 2045.

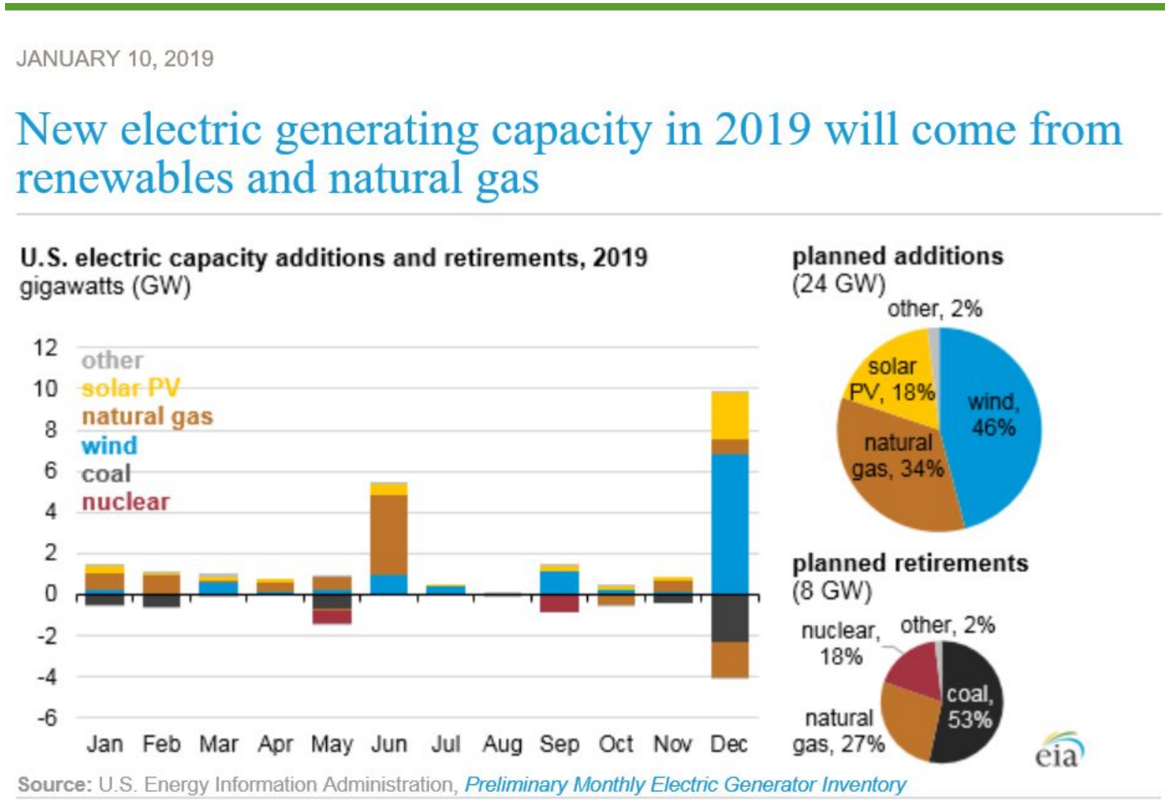
New York's Green New Deal

- Announced January 17, 2019 by New York Gov. Andrew Cuomo.
- Calls for state to achieve 100% clean power by ***2040.***
- Increases RPS target from 50% to ***70***% by 2030.
- Mandates power be 100 percent carbon free by ***2040***.

PERHAPS WE SHOULD REFER TO THIS AS THE RENEWABLE "ARMS" RACE?

THE UTILITIES AND DEVELOPERS HAVE RESPONDED





EIA.gov

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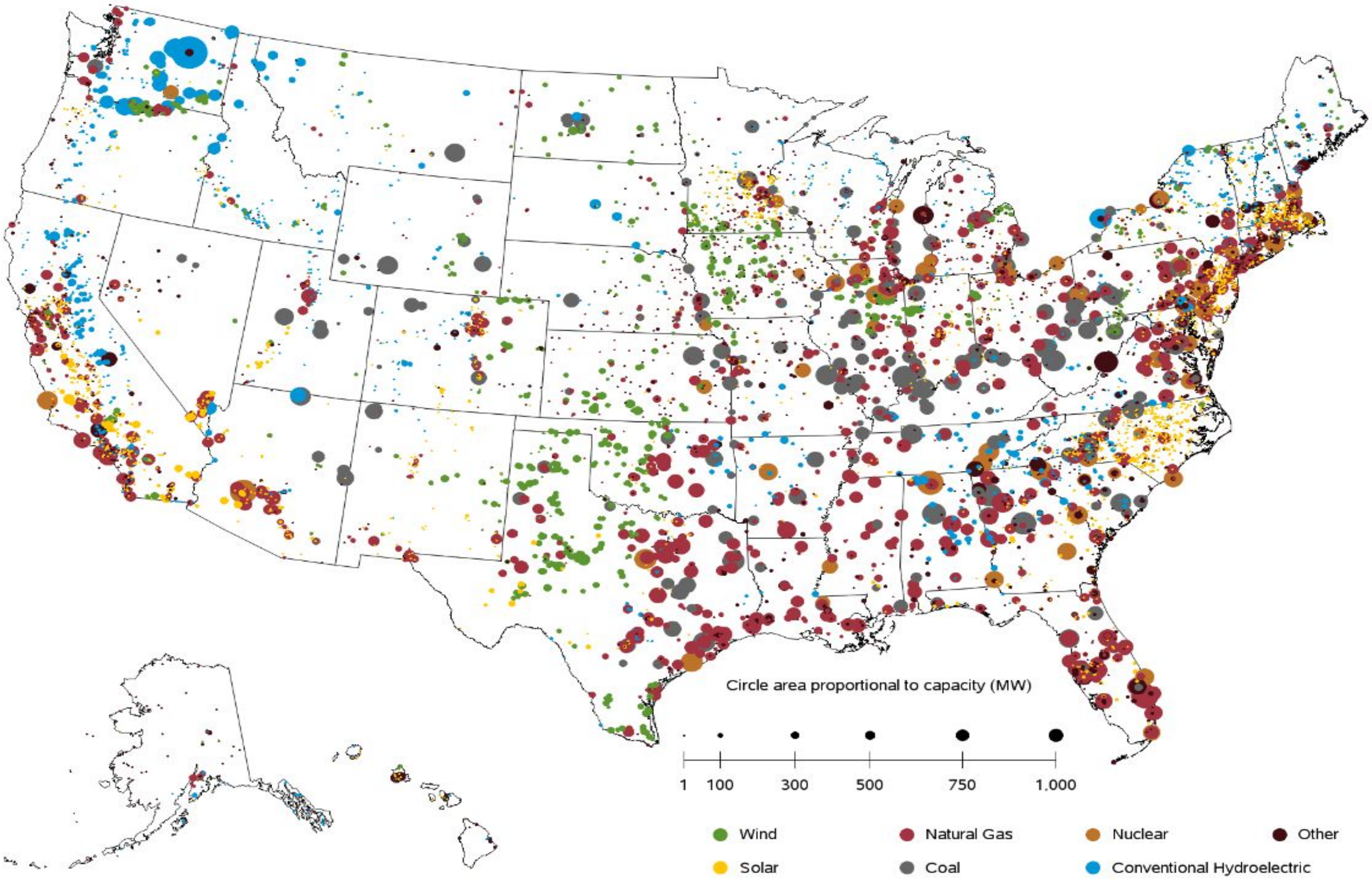
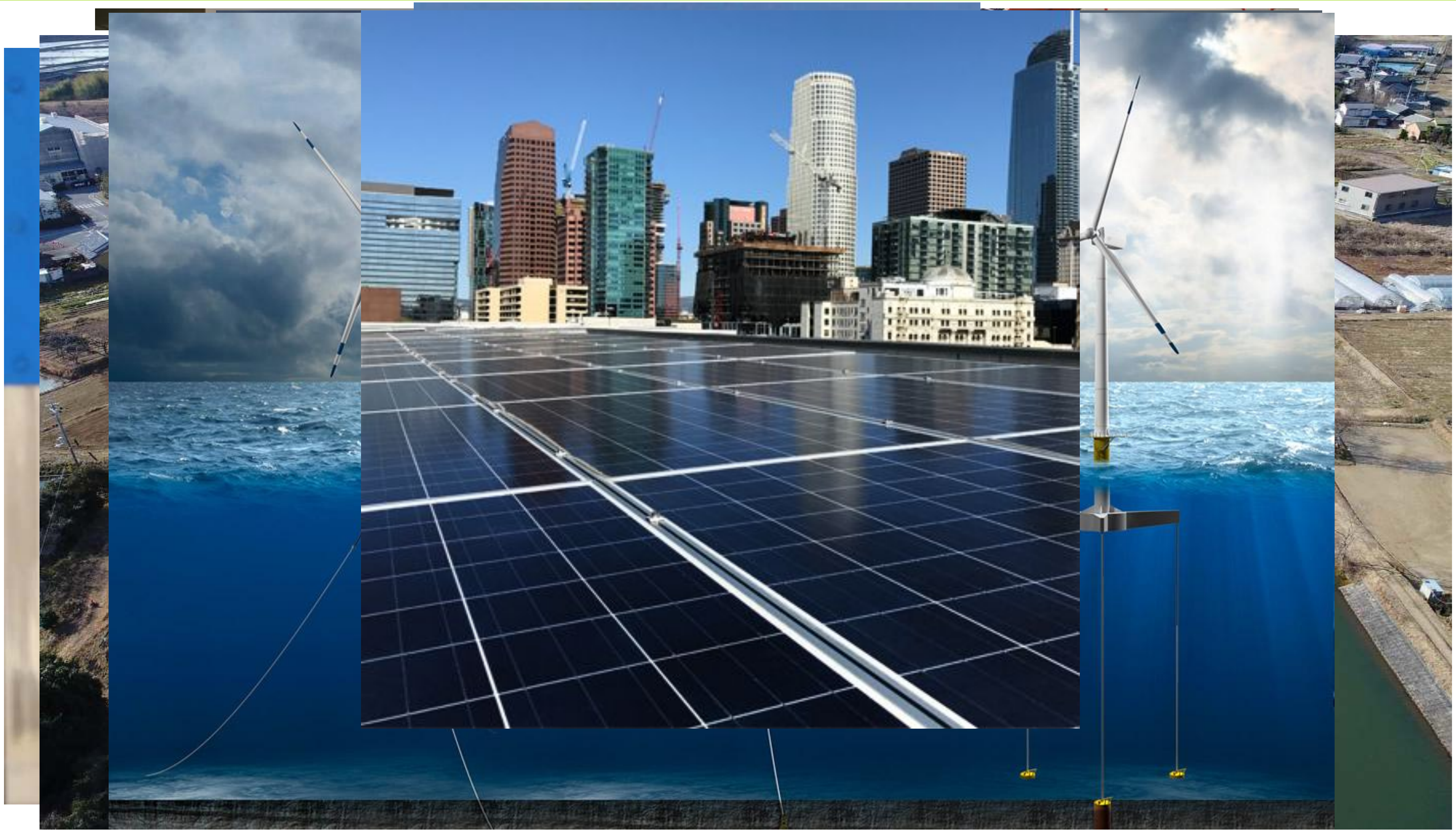
Operable utility-scale generating units as of November 2018



Sources: U.S. Energy Information Administration, Form EIA-860, 'Annual Electric Generator Report' and Form EIA-860M, 'Monthly Update to the Annual Electric Generator Report.'

THE OPTIONS KEEP EXPANDING - THERE ARE A MYRIAD OF CURRENT AND EMERGING CHOICES



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LADWP OVERVIEW

LADWP is the nation's largest municipal electric utility, and supplies over 25 million megawatt-hours each year to approximately 1.4 million electric service connections in Los Angeles as well as 5,000 customer connections in the Owens Valley.

- **Transmission**
  - 3,507 miles of overhead circuits (AC and DC)
  - 124 miles of underground circuits
  - 15,452 transmission towers
  - 126,000 transformers

- **In-Basin Generation**
  - 24 units of thermal electricity (located at Harbor, Haynes, Scattergood, and Valley Generating Stations)
  - 7 units of large hydro electricity (located at Castaic Power Plant)
  - 22 units of small hydro electricity (located at 14 individual plants)

- **Distribution**
  - 6,800 miles of 4.8 kV and 34.5 kV overhead lines
  - 3,597 miles of 4.8 kV and 34.5 kV underground cables
  - 162 distributing stations
  - 321,516 poles

LADWP 2016 Power Infrastructure Plan

LADWP CURRENT RENEWABLE RESOURCE CAPABILITY EXISTING AND PLANNED

LADWP aggressively plans for a diverse mix of resources

- 2016 IRP Calls for:
  - 404 MWs of Energy Storage
  - 1200 MWs of In-Basin Solar
  - 571 MWs of imported Geo-Thermal
  - 1645 MWs of imported Wind
  - 500 MWs of Demand Reduction
  - 3,968 GWHrs of Energy Efficiency

- Hit 20% renewables by 2010
- Will hit 33% renewables by 2020

LADWP's Transmission System is extensive and well positioned to access additional renewables

City of Los Angeles Investors Conference March 19, 2018

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OCEAN COOLED UNITS
WATER PERMIT COMPLIANCE DEADLINES

Existing Units				LADWP Repowering Strategy			
Unit Designation	Nameplate	Net Dependable	OTC Compliance Deadlines	Unit Designation	Technology	Capacity (net MW)	Net Dependable Capacity (MW)
Scattergood 1	185	131	**12/31/2024**	**Scattergood 8,9**	1 - CCCT Small F/G Class 1x1 Dry	346	337
Scattergood 2	185	131					
Haynes 1	230	217	**12/31/2029**	**Haynes 17,18**	1 - CCCT Small F/G Class 1x1 Dry	346	337
Haynes 2	230	217					
Haynes 8, 9 & 10	590	563	**12/31/2029**	**Haynes 19,20**	1 - CCCT Small F/G Class 1x1 Dry	346	337
				Haynes 21,22	1 - CCCT Small F/G Class 1x1 Dry	346	337
Harbor 1, 2 & 5	246	215	**12/31/2029**	**Harbor 15,16,17**	CCCT Mid Aero 2x1 Dry	251	245

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SUMMARY OF THE CHALLENGES

- Maintaining Reliability for the 2nd Largest City in the USA
- Facing hard shutdown dates for the largest generators
- Forecasted ***increased*** load due to electrification of transportation
- Extremely challenging regulatory environment
- Extremely difficult to get right of way

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INSIGHT 1 – THERE ARE SO MANY OPTIONS, NEED TO FOCUS ON THE KEY ONES

ALL TECHNOLOGIES ARE MATURING, BUT NOT ALL ARE MATURE

Renewables
- in-basin utility solar
- out-of-basin solar
- wind
- geothermal

Storage
- 4h battery storage

DER
- energy efficiency
- demand response
- rooftop solar

Transmission
- increased capacity on external transmission
- in-basin transmission system upgrades

Other resources should be considered, but they may need to be excluded based on technology maturity, construction timing, GHG emissions, or other issues.

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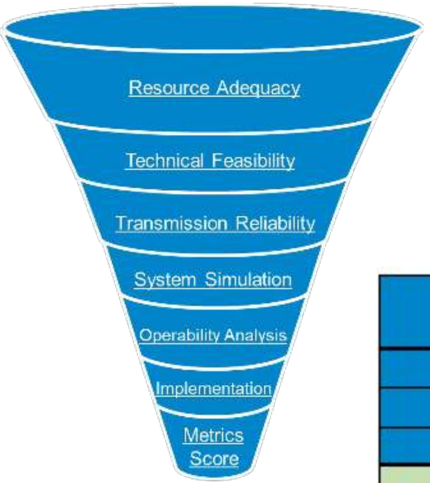
ILLUSTRATION OF THE DIFFICULTY – A SIMPLIFIED STUDY



- 9 Gas retirement scenarios (columns)
- 14 Non-emitting resource packages (rows)
- 126 Cases to analyze

Gas Projects Retired		Baseline	Scen1	Scen2	Scen 3	Scen4	Scen5	Scen6	Scen7	Scen8	Scen9
Gas Reduction (MW)		0	-245	-326	-460	-571	-630	-1,090	-1,335	-1,416	-1,661
Gas Repowered (MW)		1,635	1,390	1,298	1,298	1,053	943	597	346	251	0
Resource Alternatives		A	B	C	D	E	F	G	H	I	J
Solar, Wind	1	Calibrated Baseline according to 2016 IRP									
Solar, Wind, Geo	2										
ES	3										
EE, DR	4										
Transmission (Tx)	5										
Solar, ES	6										
Solar, ES, EE, DR	7										
Solar, ES (24 hr), EE, DR	8										
ES, Tx	9										
Solar, Wind, ES, Tx	10										
Geo, Tx	11										
Solar, Wind, Geo, Tx	12										
Solar, Wind, ES, Geo, Tx	13										
Solar, Wind, ES, Geo, EE, DR, Tx	14										

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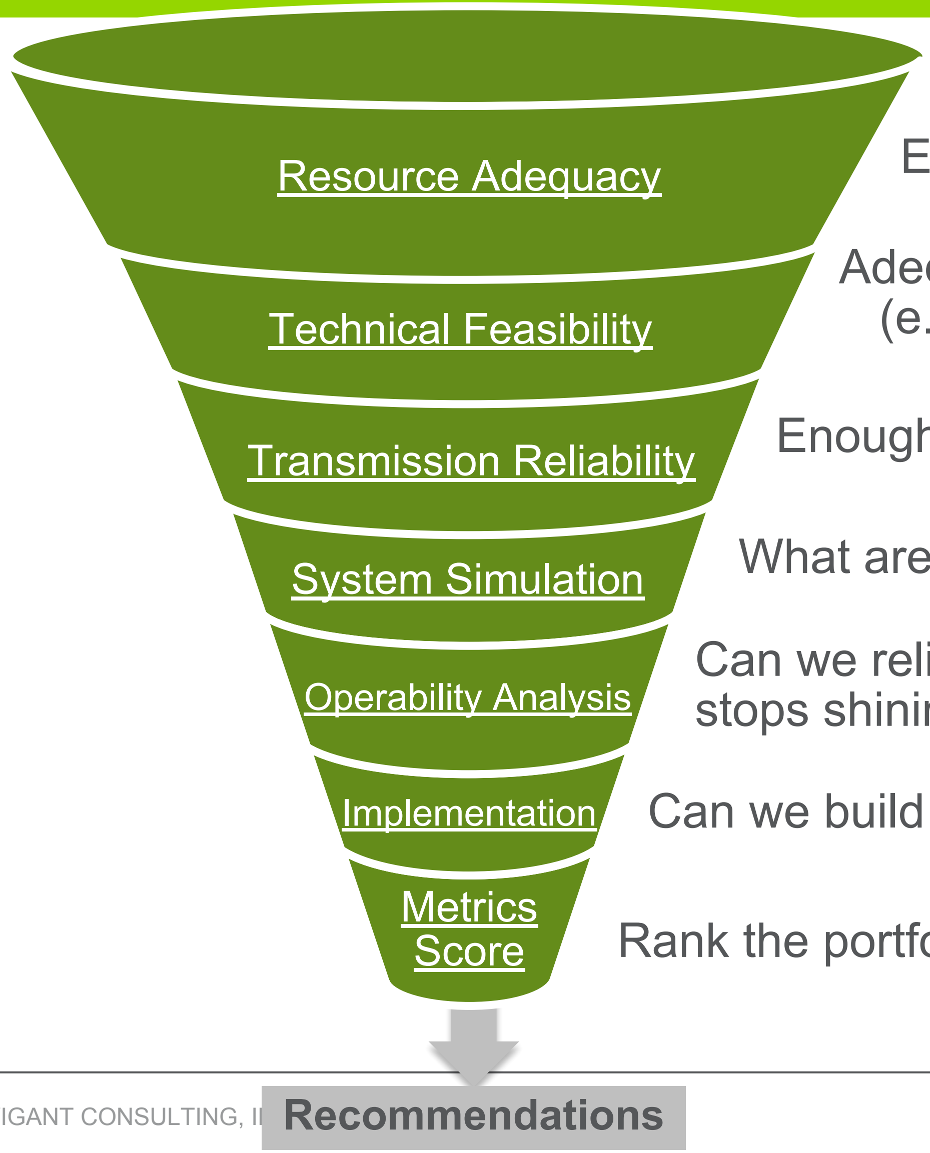
INSIGHT 2 – USE AN UNDERSTANDABLE BUT RIGOROUS METHODOLOGY



Enough generation to keep the lights on?

Adequate resources and space for development (e.g. geothermal, rooftop limits, real estate)?

Enough capacity in wires to transmit the power?

What are GHG & natural gas reductions and total costs?

Can we reliably operate the system if the sun suddenly stops shining / wind stops blowing?

Can we build projects and implement programs in time?

Rank the portfolios based on strategic / measurable metrics

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CRITICAL ATTRIBUTES OF SUCCESSFUL LARGE SCALE STUDIES WITH STAKEHOLDER INVOLVEMENT

- Open and Transparent
- Repeatable
- Quantifiable
- Balances technical issues with policy support and cost to customers
- Allows for input from key stakeholders to build a sense of ownership in the outcome

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INSIGHT 3 – BE HONEST AND REALISTIC ABOUT THE IMPLEMENTATION RISKS NOT ALL OPTIONS CAN BE IMPLEMENTED

Transmission Challenges

- Environmental Assessment process
  - (CEQA, NEPA)
- Long project and construction durations
- Land acquisition & easements
- Community impacts
  - (NIMBY, Local Permits)

Energy Storage Challenges

- Limited space at sites
  - 1.6 acres for 100MW (~1¼ football fields)
- Uncertainty with fire safety codes
- Environmental / building / noise permits
- Chemical disposal at end of life

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IMPLEMENTATION RISKS CONT.

Solar Challenges

- Limited usable rooftops
- Permitting for floating solar on reservoirs
- Disproportionate participation across customer base

ED/DR Challenges

- Predicting customer participation
- Disproportionate participation across customer base

Geothermal Challenges

- Limited availability in Nevada, California
- Transmission access near resources
- High cost versus other renewables

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INSIGHT 4 – BE CLEAR ABOUT WHAT THE OBJECTIVES ARE

1. Identify attributes that are critical for the project

2. Identify metrics that quantify those attributes

3. Use those metrics to compare and contrast

Category	Sub-Category	Legend	Description
Environmental Impact	Green House Gas Emission Reductions		Average GHG reduction over 20 years
	Natural Gas Use Reductions		Average natural gas usage over 20 years
Development Risk	Implementation Risk, e.g. construction and customer EE/DR		Ability to complete all projects through construction and implement customer programs
	Technology Risk		Maturity of the proposed technologies, especially utility scale energy storage and DERMS
	Outage Scheduling Risk		Ability to obtain necessary system outages to bring projects on-line into the system
Organizational	Organizational Risk		Changes in the organization structure, business processes, and decision making
Costs	Total Cost	$	NPV* over Base Case Scenario

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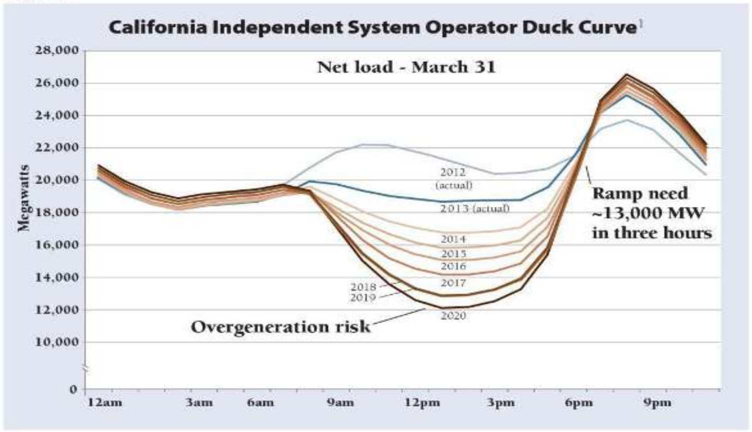
INSIGHT 5 – THERE IS NOT ONE KILLER TECHNOLOGY SOLUTION THE RIGHT "ANSWER" REQUIRES A SYSTEM SOLUTION

Renewables alone are not sufficient

- Solar alone is not sufficient
  - Not available when system peaks
- Wind alone is not sufficient
  - Not available when system peaks
- Regulation requires load following, so drops in production coupled with load increases results in increased operating reserves

Figure 1



Renewables and storage together may not be enough

- Energy Storage must be charged
- Renewables provide charging during evening or morning non-peak times
- However, system flows change and a source at peak times becomes a load during charging times

Energy storage alone is not sufficient

- Energy Storage must be charged which brings with it increased losses
- Either comes from gas
  - Increases Gas & GHG due losses in charging cycle
- Or comes from Market
  - California Regulations require undefined sources to be treated as a gas resource
  - Result is increased Gas and GHG attributions for State Reporting Requirements

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LOOKING INTO THE FUTURE . . .
CAN WE MAKE 100% RENEWABLE ENERGY A REALITY?

Five insights to make this a reality

1. Focus on those key non-emitting alternatives with appropriate technical maturity risk profiles.
2. Use a rigorous, but understandable process that key stakeholders (regulators, politicians, concerned citizens) can follow and replicate if needed.
3. Be realistic about all the installation risks associated with the alternatives by the target date.
4. Be clear about the objectives and use metrics that measure performance to allow decision makers to compare and contrast alternatives.
5. Successful implementation lies in a systems approach.

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