OTC Study Update

November 15, 2018 – 100% RE Advisory Group
Benjamin J. Hwang
Don Morrow

Draft and Preliminary

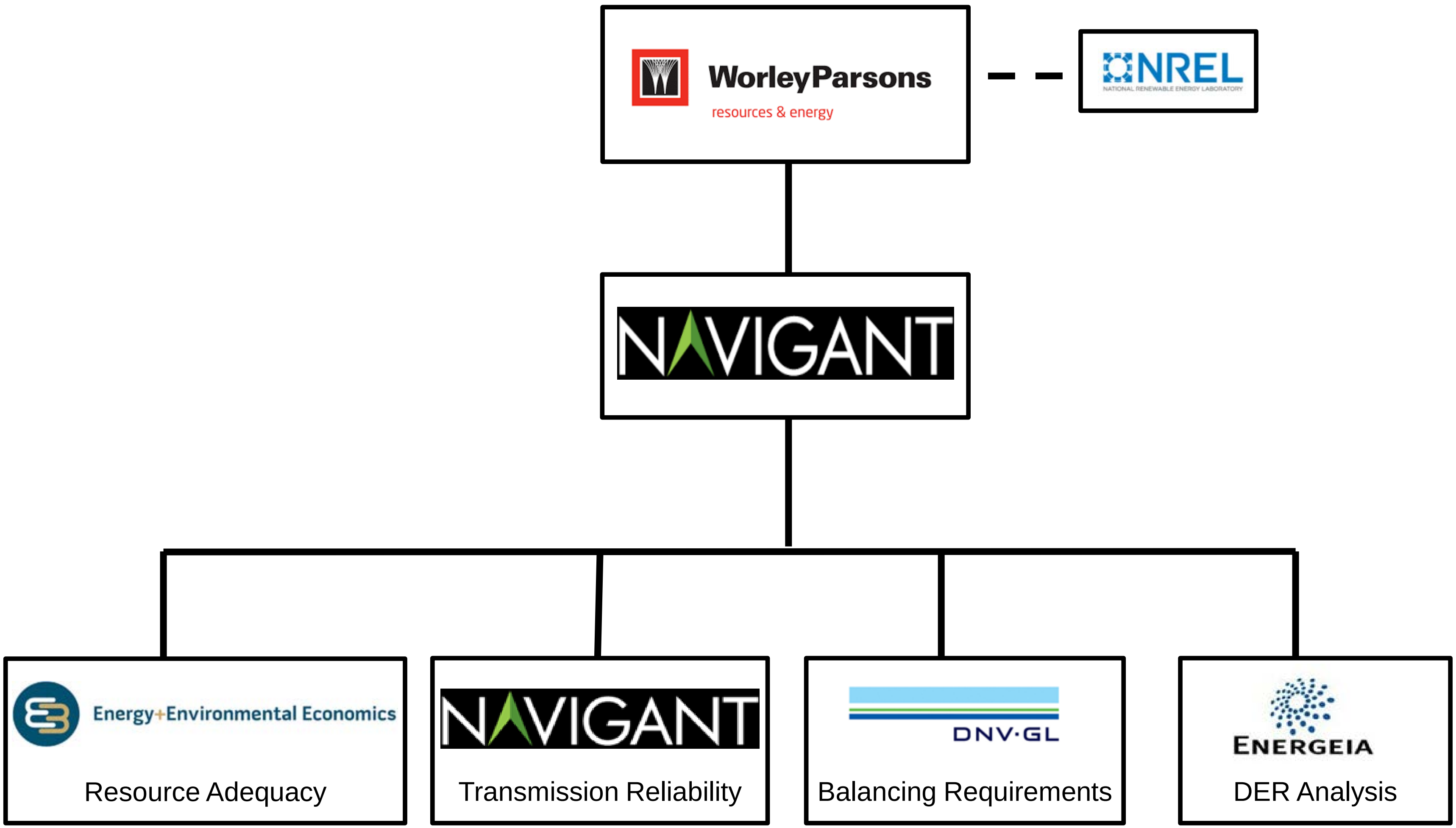
Contents

Study Scope and Objective

Holistic system analysis and evaluation of alternatives to LADWP's 2016 IRP OTC repowering plan

- Third party, independent study
- Maintains system reliability through 2036
- Evaluates all non-emitting, proven alternatives
- Adopts and expands on the 2016 IRP Recommended Case (excluding OTC repowering) and Ten-Year Transmission Plan
  - Adopts 2016 IRP Load Profile with 580,000 EVs
  - Additional 160MW load for Port of LA electrification
  - Additional 75MW load for LAX expansion
- Evaluates the cost associated with various alternatives
- Provides key insights

Study Organization Chart



Initial Repowering Projects

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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Study Scenarios

Study Scenarios			
Scenario	**OTC Units Retired**	**Retired Gas Capacity (MW)**	**Repowered Gas Capacity (MW)**
A	None	0	1,635
B	HAR	-245	1,390
C	SCAT	-326	1,298
D	HAYx1	-460	1,298
E	HAR, SCAT	-571	1,053
F	HAYx2	-630	943
G	HAYx3	-1,090	597
H	HAR, HAYx3	-1,335	346
I	SCAT, HAYx3	-1,416	251
J	All OTC Units	-1,661	0

Final Resource Alternatives Considered

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Renewables	Storage	DER	Transmission
in-basin utility solar	4h battery storage	energy efficiency	increased capacity on external transmission
out-of-basin solar		demand response	in-basin transmission system upgrades
wind		rooftop solar	
geothermal			

Other resources were considered but excluded due to technology maturity, construction timing, and GHG emissions

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Study Methodology

Resource Adequacy	Enough generation to keep the lights on?
Technical Feasibility	Adequate resources and space for development (e.g. geothermal, rooftop limits, real estate)?
Transmission Reliability	Enough capacity in wires to transmit the power?
System Simulation	What are GHG & natural gas reductions and total costs?
Operability Analysis	Can we reliably operate the system if the sun suddenly stops shining / wind stops blowing?
Implementation	Can we build projects and implement programs in time?
Metrics Score	Rank the portfolios based on strategic / measurable metrics

Recommendations

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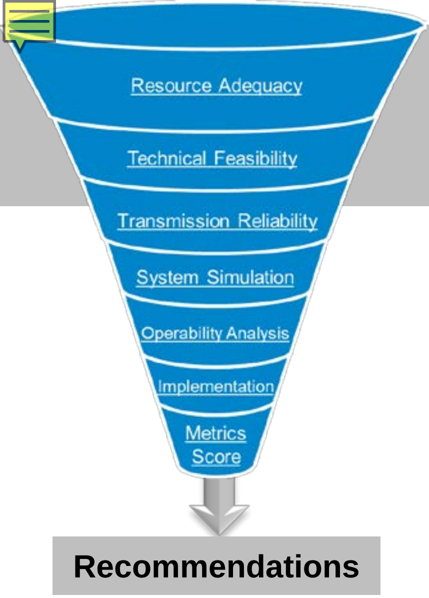
Evaluation Process



- Gas retirement scenarios (columns)
- Non-emitting resource alternatives (rows)

Gas Projects Retired		None	HAR	SCAT	HAY 1,2	SCAT & HAR	HAY 8,9,10	HAY	HAY & HAR	HAY & SCAT	All OTC Units
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										
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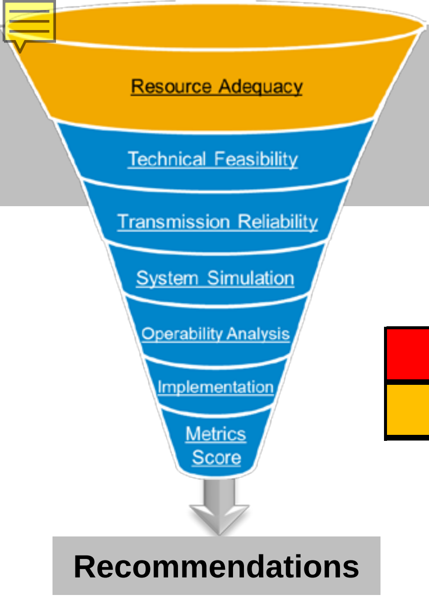
Solar, Wind, ES, Geo, EE, DR, Tx	14										



Resource Adequacy

Does not pass resource adequacy requirements

Passes resource adequacy requirements

Gas Projects Reduced		None	HAR	SCAT	HAY 1,2	SCAT & HAR	HAY 8,9,10	HAY	HAY & HAR	HAY & SCAT	All OTC Units
Gas Reduction (MW)		0	-245	-326	-460	-571	-630	-1,090	-1,335	-1,416	-1,661
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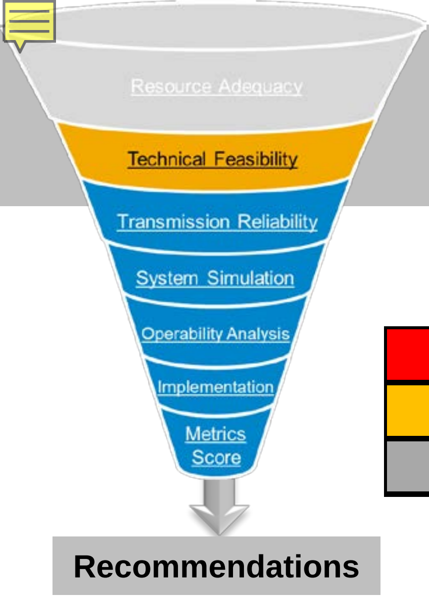

Technical Feasibility

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Energy+Environmental Economics

- Does not pass technical feasibility requirements
- Passes technical feasibility requirements
- Did not pass previous requirements

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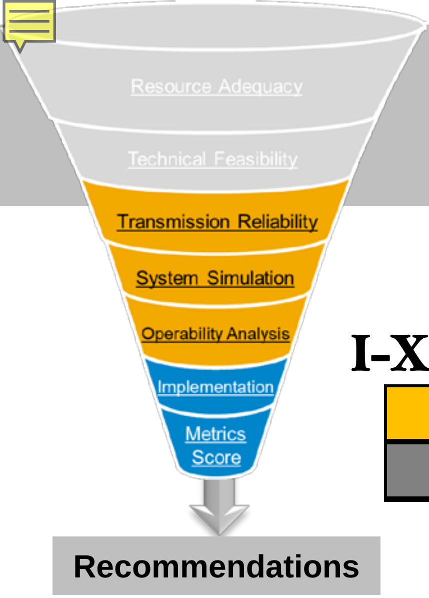

Cases for Analysis

Transmission Reliability, System Simulation, and Operability

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I-XII Case identifier

Future analysis as needed

Did not pass previous requirements

Gas Projects Reduced		None	HAR	SCAT	HAY 1,2	SCAT & HAR	HAY 8,9,10	HAY	HAY & HAR	HAY & SCAT	All OTC Units
Gas Reduction (MW)		0	-245	-326	-460	-571	-630	-1,090	-1,335	-1,416	-1,661
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Solar, Wind, ES, Geo, EE, DR, Tx	14							VIII	IX	X	XII

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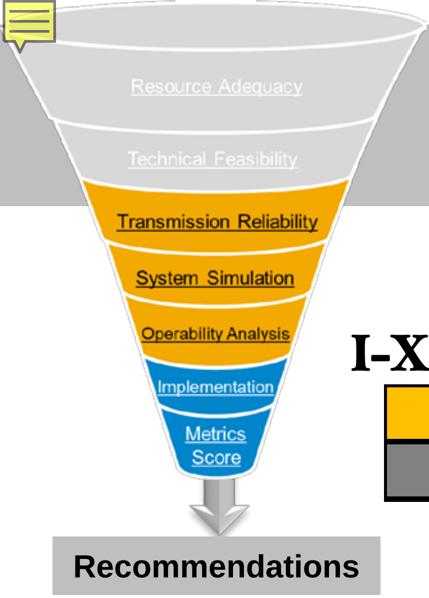
Summary of 12 Cases

Case Identifier	Eliminated Gas Repowering	Replaced with Resource Alternatives
I	Retire 245 MW at Harbor	Energy Storage
II	Retire 326 MW at Scattergood	Energy Storage
III	Retire 460 MW at Haynes	Energy Storage
IV	Retire 245 MW at Harbor Retire 326 MW at Scattergood	Energy Storage
V	Retire 630 MW at Haynes	Energy Storage
VI	Retire 630 MW at Haynes	Energy Storage, Solar, DR, and EE
VII	Retire 1,090 MW at Haynes	Energy Storage, Solar, DR, and EE
VIII	Retire 1,090 MW at Haynes	Energy Storage, Solar, DR, and EE, Wind, Geothermal, and External Transmission
IX	Retire 1,090 MW at Haynes Retire 245 MW at Harbor	Energy Storage, Solar, DR, and EE, Wind, Geothermal, and External Transmission
X	Retire 1,090 MW at Haynes Retire 326 MW at Scattergood	Energy Storage, Solar, DR, and EE, Wind, Geothermal, and External Transmission
XI	Retire 1,661 MW at Haynes, Harbor, and Scattergood	Energy Storage, Solar, Wind, Geothermal, and External Transmission
XII	Retire 1,661 MW at Haynes, Harbor, and Scattergood	Energy Storage, Solar, DR, EE, Wind, Geothermal, and External Transmission



Transmission Upgrades Required for Cases I-IV

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Energy+Environmental Economics

I-XII Case identifier

Future analysis as needed

Did not pass previous requirements

Gas Projects Reduced		None	HAR	SCAT	HAY 1,2	SCAT & HAR	HAY 8,9,10	HAY	HAY & HAR	HAY & SCAT	All OTC Units
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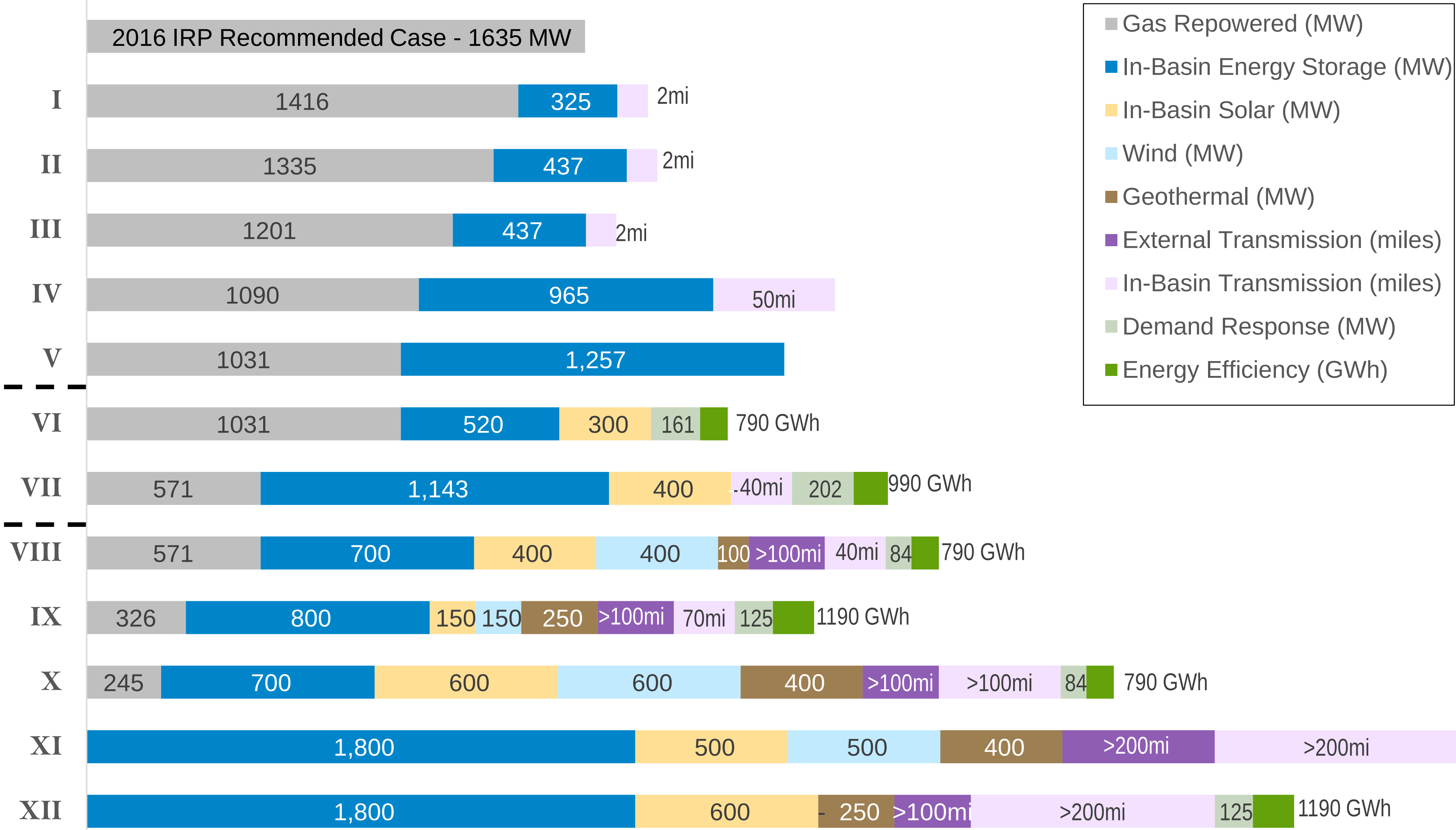
Portfolio of 12 Alternatives

Transmission Reliability, System Simulation, and Operability



Note: **Non-OTC quantities are above and beyond 2016 IRP targets and ten-year transmission plan**

2016 IRP targets include 404MW ES, 1300MW Solar, 500MW DR, 3968GWh EE, 1645 MW Wind and 571 MW Geothermal

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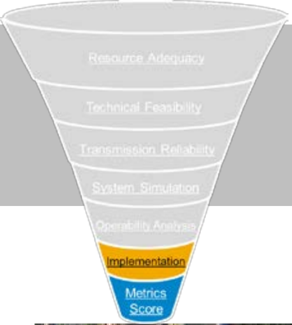

Implementation Risk Analysis

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Transmission Project Challenges

- Environmental Assessment process (CEQA, NEPA)
- Long project and construction durations
- Land acquisition & easements
- Community impacts (NIMBY, Local Permits)
  - Westside, San Fernando valley, mid-City

Energy Storage Challenges

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

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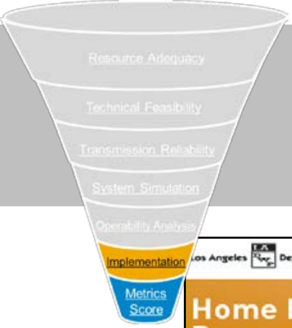
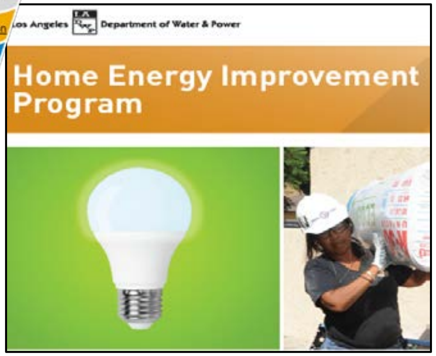
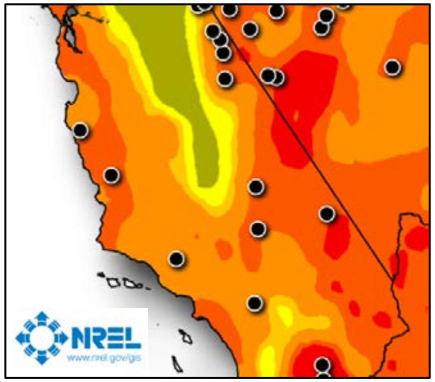


Implementation Risk Analysis



EE / DR Achievability

- Predicting customer participation
- Disproportionate participation across customer base



Geothermal Resources Access

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

In-basin Solar Challenges

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

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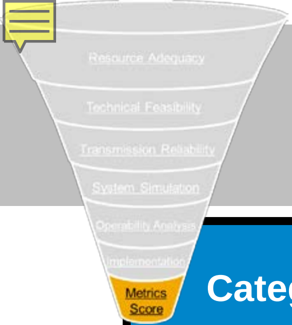

Model Output Metrics

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

*NPV does not include financial analysis of financing costs or reduced revenue through energy efficiency

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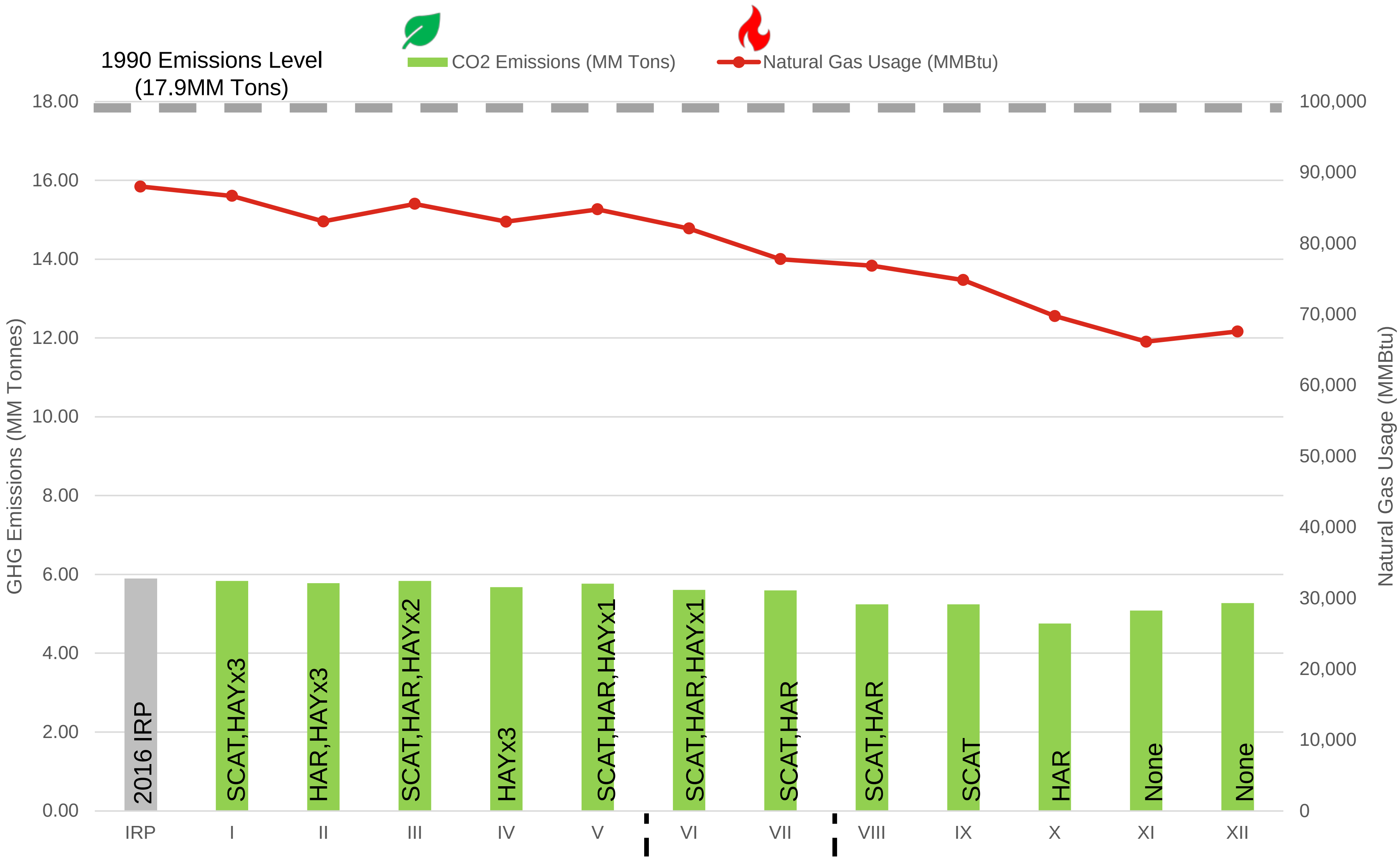
Environmental Benefits

GHG Reductions and Natural Gas Reductions



Note: GHG emissions and natural gas usage are expected averages from the 2022, 2027 and 2036 simulations

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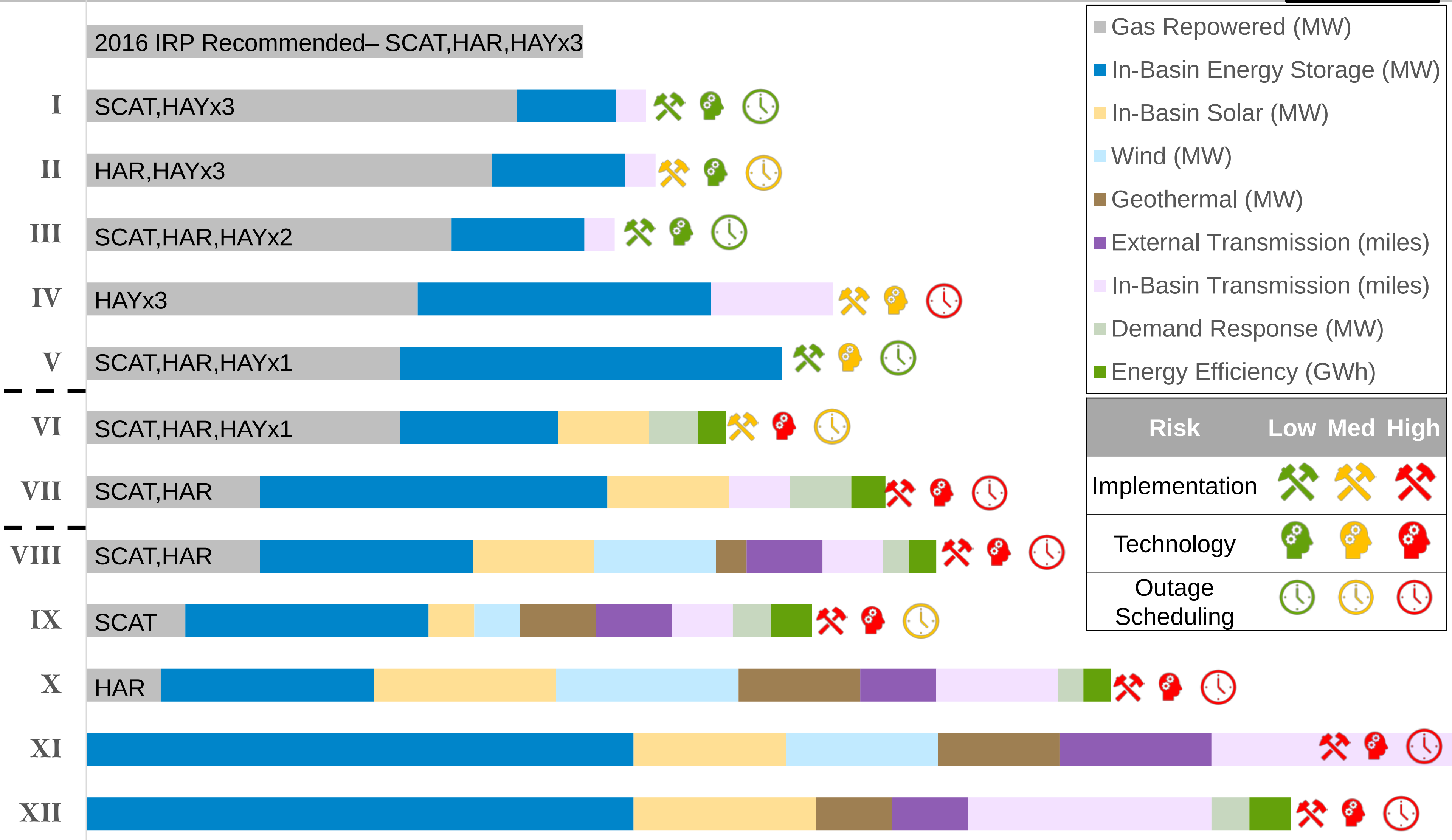
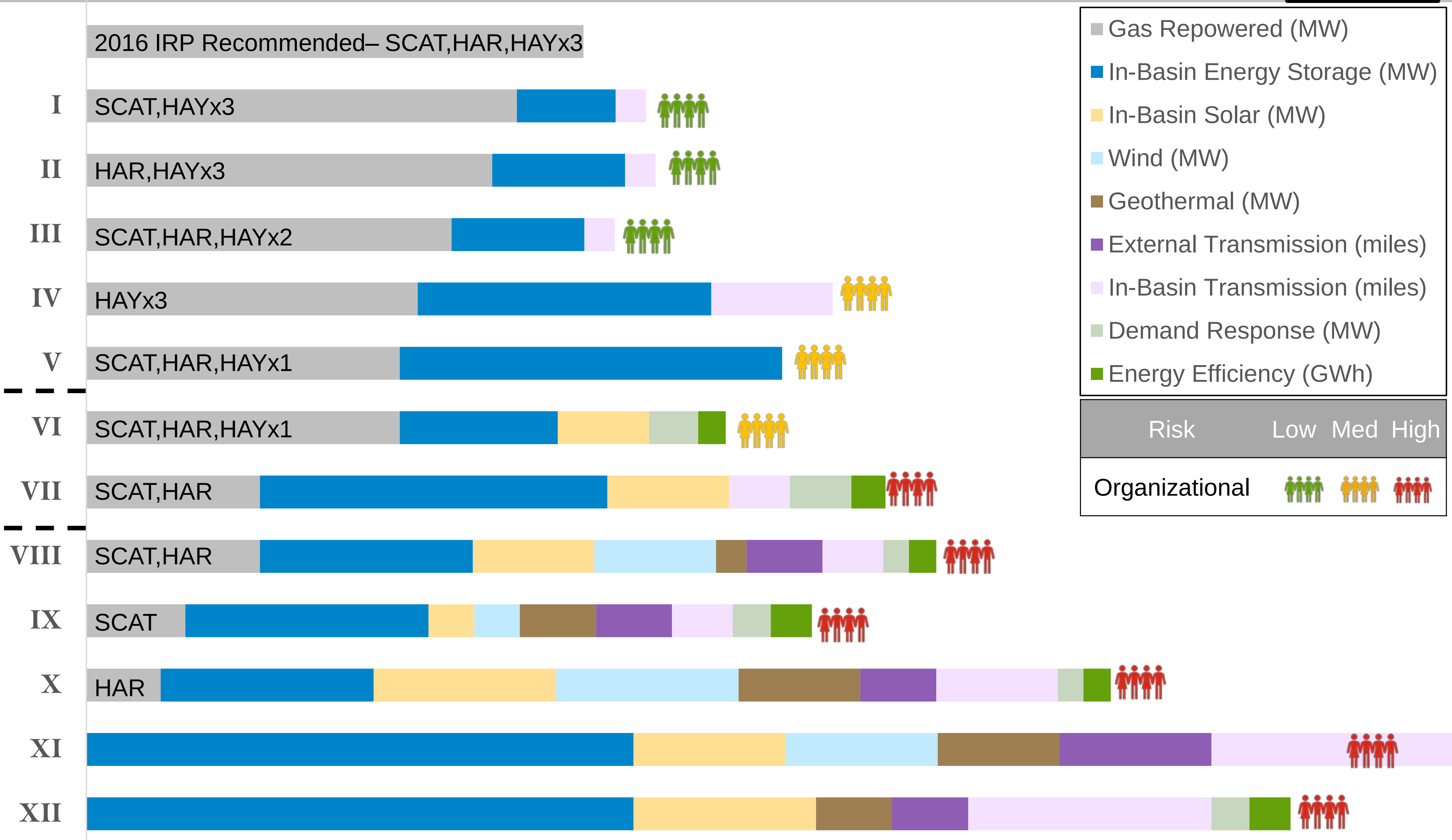
Development Risk Assessment

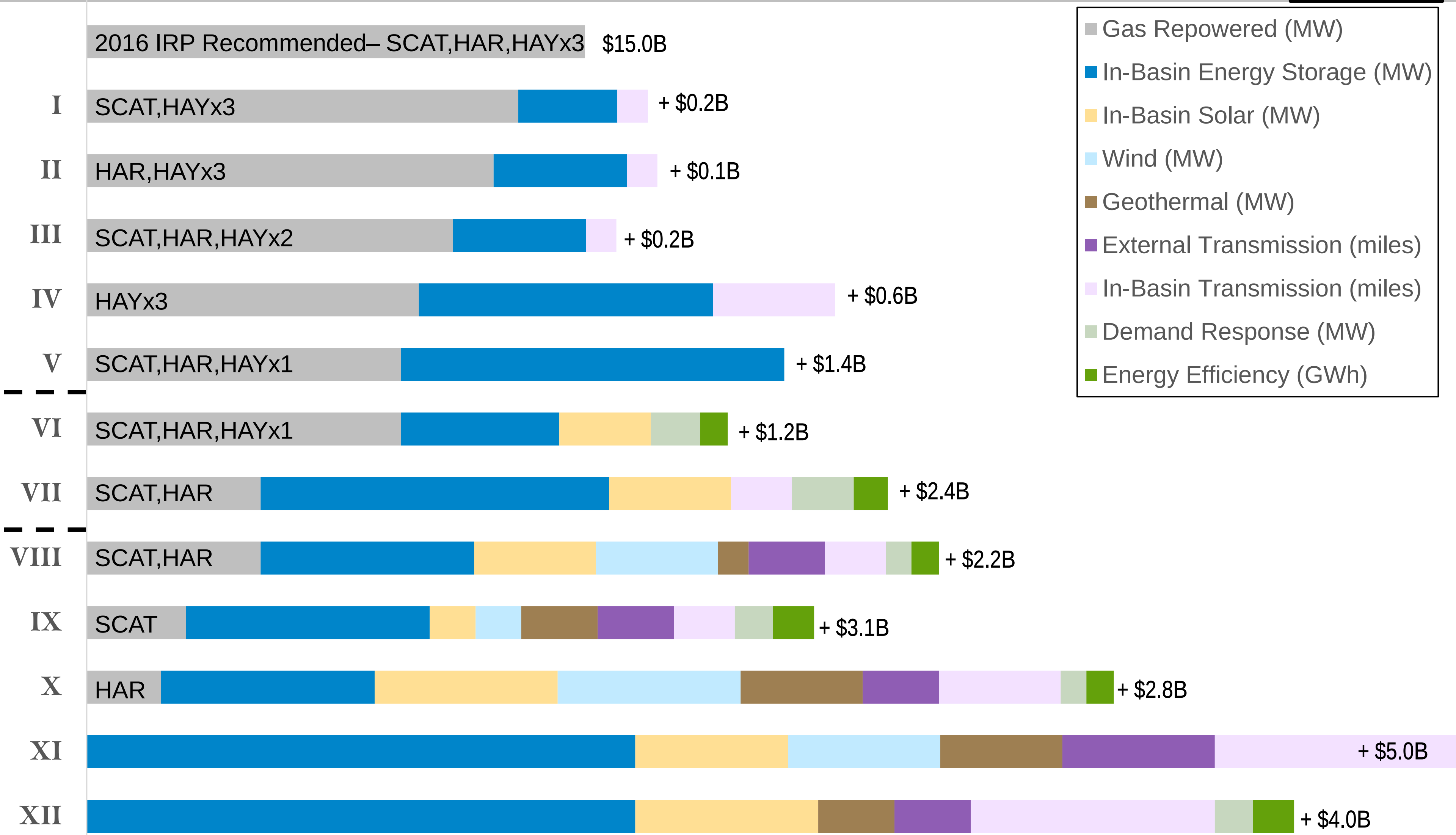
Implementation Risk, Technology Risk, and Outage Scheduling Risk



Organizational Risk Assessment



Total Costs
Net Present Value



Notes: 1) NPV does not include financial analysis of financing costs or reduced revenue through energy efficiency

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Insights from the Study

- Solar or wind alone doesn't satisfy the resource adequacy objectives
- Energy storage must be paired up with renewable PPAs
- Number of transmission upgrades increase with higher levels of non-emitting alternatives
- Utilization of remaining, non-OTC gas units increases as more gas repowering projects are eliminated
- All cost estimates are more expensive than 2016 IRP repowering plan
- Increasing complexity of resource portfolios adds risks* such as organizational change

*Diversification of resources from these alternatives increase cybersecurity exposure versus a single repowering project

Haynes Repowering Assessment

- Best opportunity to replace some or all repowering projects
  - Relatively high levels of environmental benefit
    - Replacing two projects at Haynes-only achieves meaningful GHG savings over IRP (Cases V and VI)
  - Transmission development is reduced
    - Replacing two combined cycle projects does not require transmission upgrades
  - Development risks are better managed due to site access and timing
    - Location has the ability to support up to 800 MW of Storage
    - Later time period allows for further refinement of energy storage designs and critical software to control DR such as DERMS
  - Costs are moderately higher than the IRP
    - Replacing two projects at Haynes-only is about 10% higher than the IRP (Cases V and VI)
    - Costs increase substantially when used in combination with eliminating other repowering projects

Harbor Repowering Assessment

- Potential to replace the repowering project
  - Critical location on system, necessary to support Port of LA electrification and large industrial customers
  - Least environmental impact if only reduce Harbor repower (Case I)
  - Limited space for energy storage on site
  - Scattergood + Harbor elimination results in a high amount of transmission projects (Case IV)
  - Eliminating Harbor repowering alone is 2^{nd} lowest cost alternative assessed (Case I)
    - Costs increase substantially when used in combination with eliminating other repowering projects

- Least opportunity / highest risk to replace the repowering project
  - Critical location on system, necessary to support LAX expansion and local reliability
  - Relatively high environmental impact of single site options due to earliest use of non-emitting resources (Case II)
  - Highest development risks, including regulatory and permitting risks
    - Real estate acquisition for energy storage is among highest risks identified
    - Utility-scale energy storage (100MW) still in development stage, but will require to be in service within 4 to 5 years
  - Scattergood + Harbor elimination results in a high amount of transmission projects (Case IV)
  - Eliminating Scattergood alone is lowest cost (Case II)
    - Development delays could increase costs
    - Costs increase substantially when used in combination with eliminating other repowering projects

Resource increase above IRP

Case ID	Gas Repowered (MW)	Gas Delta	In-Basin Energy Storage (MW)	ES Delta	In-Basin Solar (MW)	Solar Delta	Demand Response (MW)	DR Delta	EE (GWh)	EE Delta	Wind (MW)	Wind Delta	Geo (MW)	Geo Delta
2016 IRP	1661		404		1300		500		3968		1645		571	
I	-245	-15%	325	80%										
II	-337	-20%	437	108%										
III	-460	-28%	437	108%										
IV	-571	-34%	965	239%										
V	-630	-38%	1,257	311%										
VI	-630	-38%	520	129%	300	23%	161	32%	790	20%				
VII	-1090	-66%	1,143	283%	400	31%	202	40%	988	25%				
VIII	-1090	-66%	700	173%	400	31%	84	17%	790	20%	400	24%	100	18%
IX	-1335	-80%	800	198%	150	12%	125	25%	1,185	30%	150	9%	250	44%
X	-1416	-85%	700	173%	600	46%	84	17%	790	20%	600	36%	400	70%
XI	-1661	-100%	1,800	446%	500	38%					500	30%	400	70%
XII	-1661	-100%	1,800	446%	600	46%	125	25%	1,185	30%			250	44%

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Ranking Metrics / Metric Weights

Category	Category Weight	Sub-Category	Legend	Description
Environmental Impact	**45%**	Green House Gas Emission Reductions		Average GHG reduction over 20 years
		Natural Gas Use Reductions		Average natural gas usage over 20 years
Development Risk	**40%**	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	**5%**	Organizational Risk		Changes in the organization structure, business processes, and decision making
Costs	**10%**	Total Cost	$	NPV* over Base Case Scenario

*NPV does not include financial analysis of financing costs or reduced revenue through energy efficiency

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Next Steps - Study

OTC Consultants

- Presentation of results
  - 100% Renewable Advisory Group – Nov 15, 2018
  - Present to LADWP Board – November 27, 2018
- Finalize Report
  - Completion – February 2019

Questions?

QUESTIONS?

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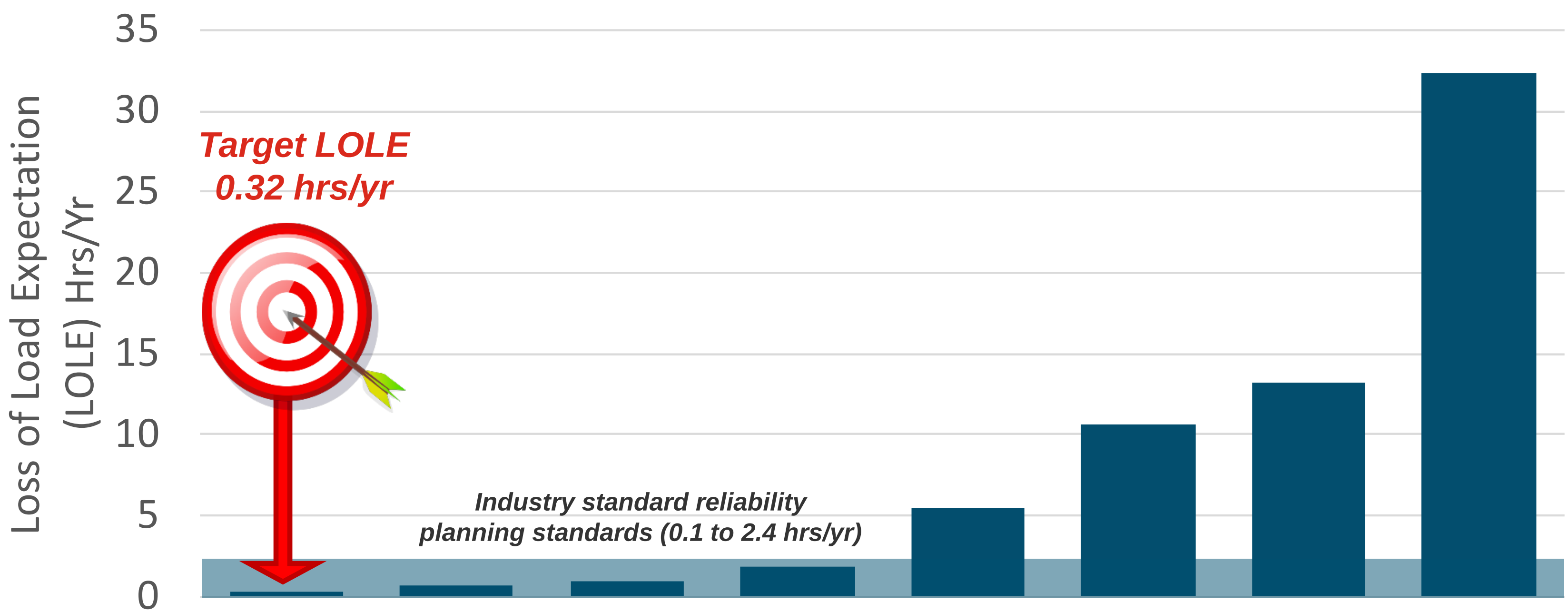
LOLE Requirements

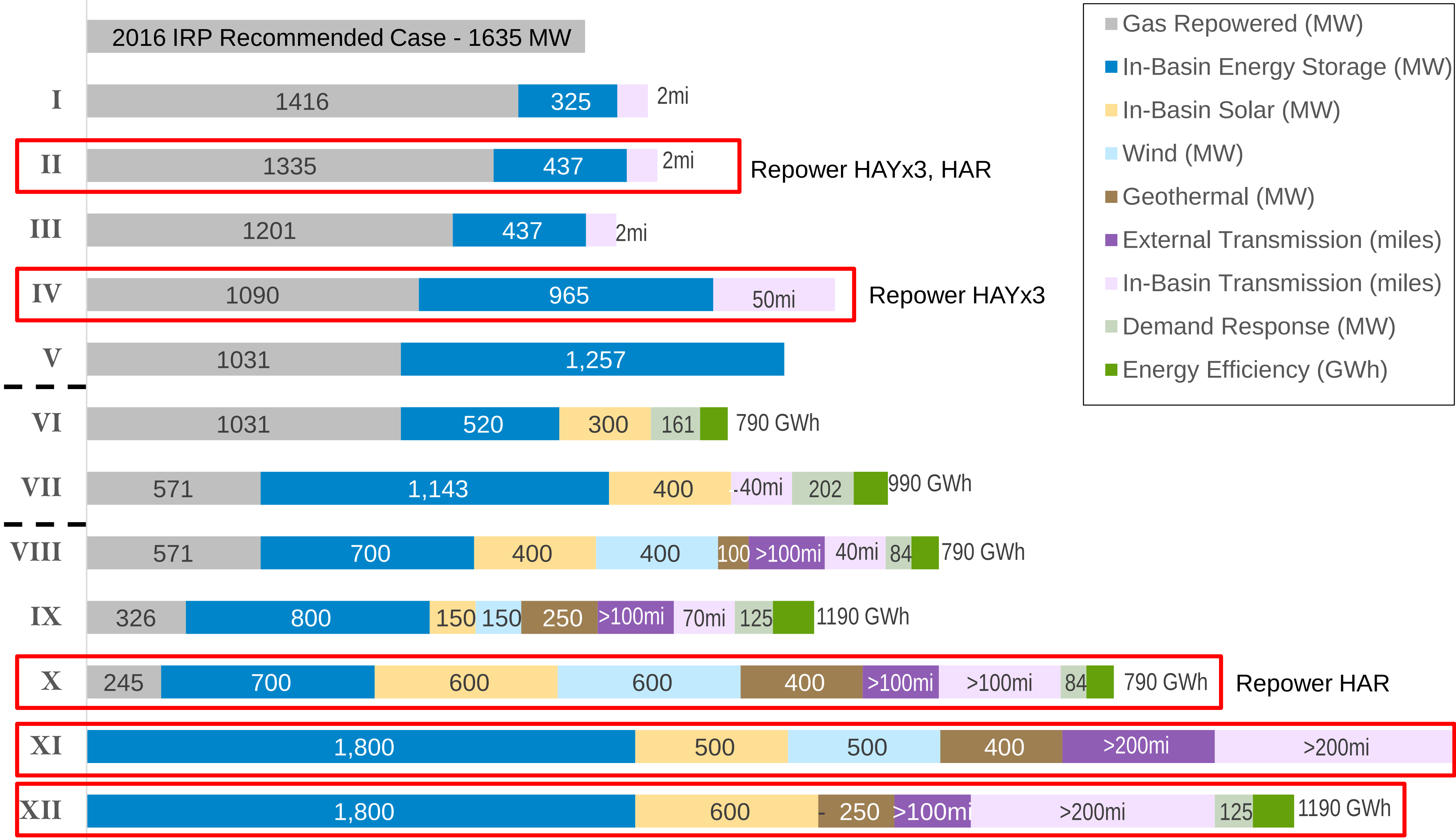
- Objective
  - Determine what combination of mitigation alternatives can provide equivalent or better reliability to OTC repowering



Scenario	Full Repowering	Harbor Retirement	Scattergood Retirement	Harbor + Scattergood Retirement	Haynes Retirement	Harbor + Haynes Retirement	Haynes + Scattergood Retirement	All Retirement
MW NDC Repowered *	1593	1348	1256	1011	582	337	245	0
MW NDC Retired	0	245	337	582	1011	1256	1348	1593
LOLE (hrs/yr)**	0.32	0.74	0.93	1.92	5.49	10.65	13.28	32.32

** NDC = Net Dependable Capacity*
***lower LOLE by scenario due to assumption on higher max output from Castaic*

Options without Scattergood Require Difficult Transmission Upgrades



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