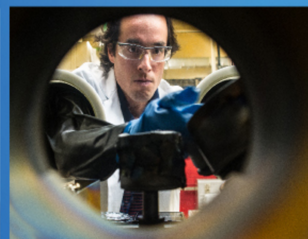




Los Angeles 100% Renewable Energy Study
Advisory Group Meeting #4
February 15, 2018

Focus of Today's Meeting

- Advisory Group Meeting Plan
- Advisory Group feedback on:
  - Preliminary Clean Energy Scenarios and Sensitivities
- Continued expansion of Advisory Group knowledge base

Today's Agenda

• 9:00 – 9:05 am	Call to Order and Agenda Overview
• 9:05 – 9:20 am	Welcome and Introductions
• 9:20 – 9:30 am	Update Exchange
• 9:30 – 9:45 am	Proposed Site Tour on April 26, 2018
• 9:45 – 10:30 am	Study Approach and AG Meeting Plan
• 10:40 – 12:00 pm	Preliminary Clean Energy Scenarios and Sensitivities
• 12:00 – 12:15 pm	Lunch Served
• 12:15 – 1:00 pm	Power Strategic Long-Term Resource Plan
• 1:00 – 1:15 pm	Wrap-up and Next Steps

Welcome and Introductions

www.nrel.gov

Update Exchange

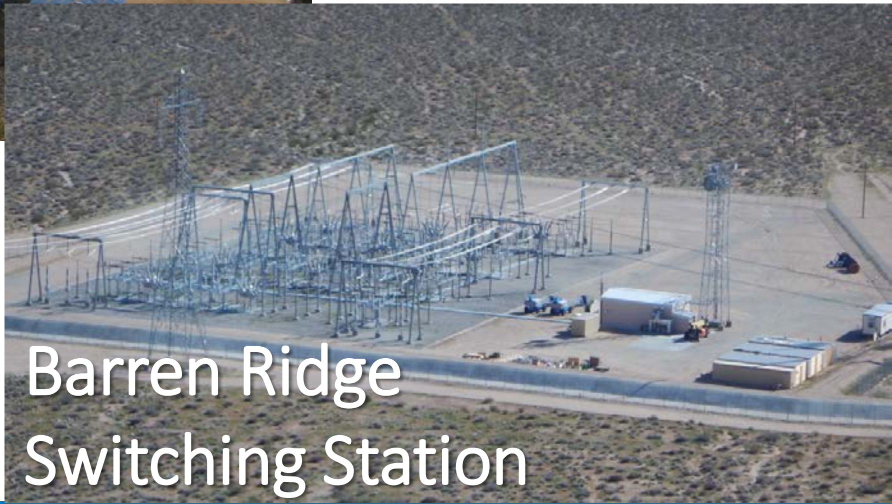
www.nrel.gov

Proposed Site Tour

www.nrel.gov

NATIONAL RENEWABLE ENERGY LABORATORY

LADWP Facilities



Site Tour!

A Sampling of the LADWP Power System

- Thursday, April 26th, 8 am to 6 pm
- Meet at the Valley Generating Station in Sun Valley to board bus
- Meals and snacks provided
- Closed-toe walking shoes, sunscreen, hat, light jacket, sunglasses, long pants, etc.
- RSVP required by March 15th – please watch for more info via email

- RSVP to Anton.Sy@ladwp.com by March 15, 2018

Joan Isaacson, Anton Sy, Dawn Cotterell

Quick Mixer!

- In pairs
- Introductions
- Share what you are looking forward to the most on the site tour

Advisory Group Meeting Plan

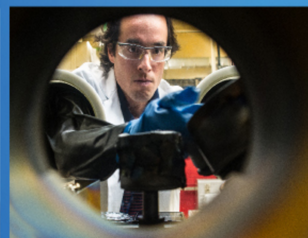
www.nrel.gov

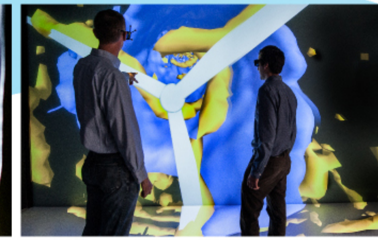
LA 100% Renewable Energy Study-Advisory Group Meeting Plan

- COMPLETED MEETINGS/TASKS
- PLANNED MEETINGS/TASKS

QUARTER	Phase 1 | 2017 LAUNCH AND ORGANIZATION	Phase 2 | 2018 SCENARIOS	Phase 3 | 2019 ANALYSIS AND MODELING	Phase 4 | 2020 FINAL REPORT
Q1		FEBRUARY 15 • Advisory Group Meeting Plan • Preliminary Scenarios and Sensitivities • Field Trip Itinerary • Power Strategic Long-Term Power Resources Plan • Once-Through Cooling Study Update	• Capacity Value • Electricity Operations Modeling II • Jobs & Economic Analysis II	• White Papers on Electricity Modeling Results • Final Results 1) Jobs & Economic Analysis and 2) Environmental Analysis • Final Visualization of Electricity Operations
Q2	JUNE 23 • Advisory Group Launch • City Council Motion: 100% Renewable Energy Study	EARLY JUNE FIELD TRIP April 26 • Draft 100% Papers: Framing, Data, Methods • Final Scenarios and Sensitivities • Once-Through Cooling Study Update • LADWP Financial Basics	• Planning Reserves • Operating Reserves • Load Modernization • Environmental Analysis II • Publication Plan	• Final Report • Final Presentation
Q3	AUGUST 3 • Advisory Group Charge and Operating Protocols • Introduction to NREL and 100% Renewable Energy Study	AUGUST 16 • Final 100% Papers • Electricity Operations Modeling I • Jobs & Economic Analysis I • Environmental Modeling I • Once-Through Cooling Study Update	• Final Scenarios and Sensitivities Results • Final Visualization of Scenarios • Initial Electricity Operations Modeling Results	
Q4	NOVEMBER 16 • Defining Clean Energy and Renewable Energy • Considerations for Study • Once-Through Cooling Study Overview • Public Outreach Overview	NOVEMBER 15 • Initial Scenario Results • Draft Visualizations of Scenarios • Once-Through Cooling Study Results	• Final Electricity Operations Modeling Results and Draft Visualizations • Draft results on Jobs and Economic Development • Draft results on Environmental Analysis	

As of January 23, 2018

Preliminary Clean Energy Scenarios and Sensitivities

Aaron Bloom, Paul Denholm, and Daniel Steinberg

February 15th, 2018

Outline for Scenario and Sensitivities Discussion

- Review Memo on Definitions of Renewable Energy
- Discussion Activity 1, November 14
  - What we heard
  - Preliminary Clean Energy Scenarios and Sensitivities
- Discussion Activity 2, November 14
  - What we heard
  - Research Design

Renewable Energy Definitions from November

Resource	California RPS	New Jersey RPS	Colorado RPS	Austin, Texas RPS	IEA	EIA	Renewable Energy Certificates	REN 21	RE100
Wind and Solar	√	√	√	√	√	√	√	√	√
Hydro	√*	√	√	√	√	√	√	√	√
Bioenergy	√*		√ (biomass)*	√ (biomass or biomass-based waste products)	√	√ (biomass)	√ (biomass)	√ (biopower)	√ (biomass and biogas)
Landfill Gas	√	√		√					
Fuel Cell	√	√		√					
Geothermal	√	√	√	√	√	√	√	√	√
Municipal Solid Waste Conversion	√								
Ocean Thermal	√*				√	√			√
Ocean Wave	√*	√		√	√	√			√
Tidal Current	√*	√		√	√	√			√
Other Minor Technologies	√	√	√						√
Tradable Renewable Energy Credits	√		√						

November 14 Discussion Activities

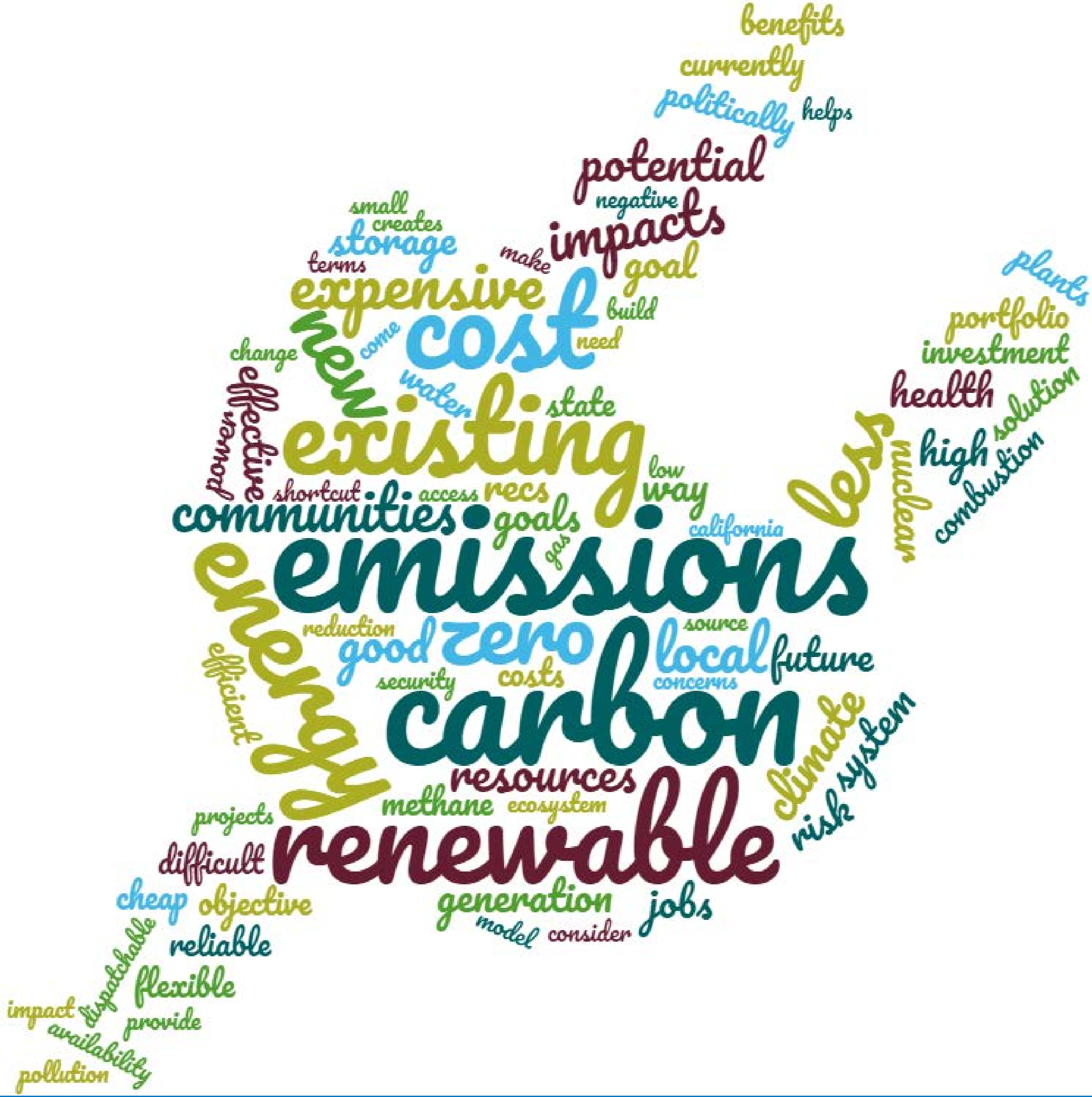
- Input on **advantages** and **disadvantages** of incorporating various technologies into the study

- Brainstorm: “What types of **questions**, **issues**, **topics**, and **ideas** should be **considered** as part of the study?”

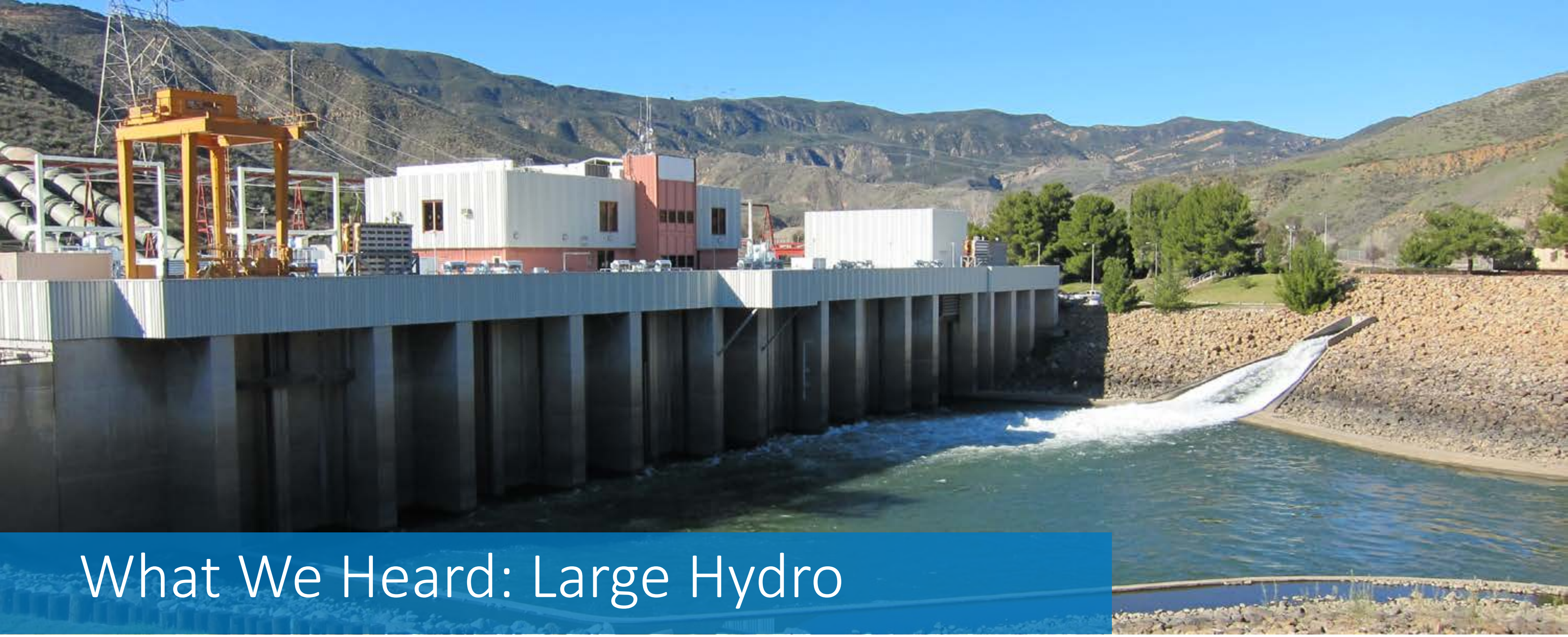
What we Heard

- Discussed trade-offs in technologies
- Discussed goals for the LADWP system
- Informed how the study should be structured
- Identified which study results are important
- Full input in Appendix B Handout

Discussion Activity #1



Discussion Activity #2



What We Heard: Large Hydro

- **Positives:** Flexible, cheap, existing, zero emissions, reliable*
- **Negatives:** Old, ecological impact, seasonality, drought
- **Themes:** Existing hydro should be grandfathered. How much new hydro resource is available?

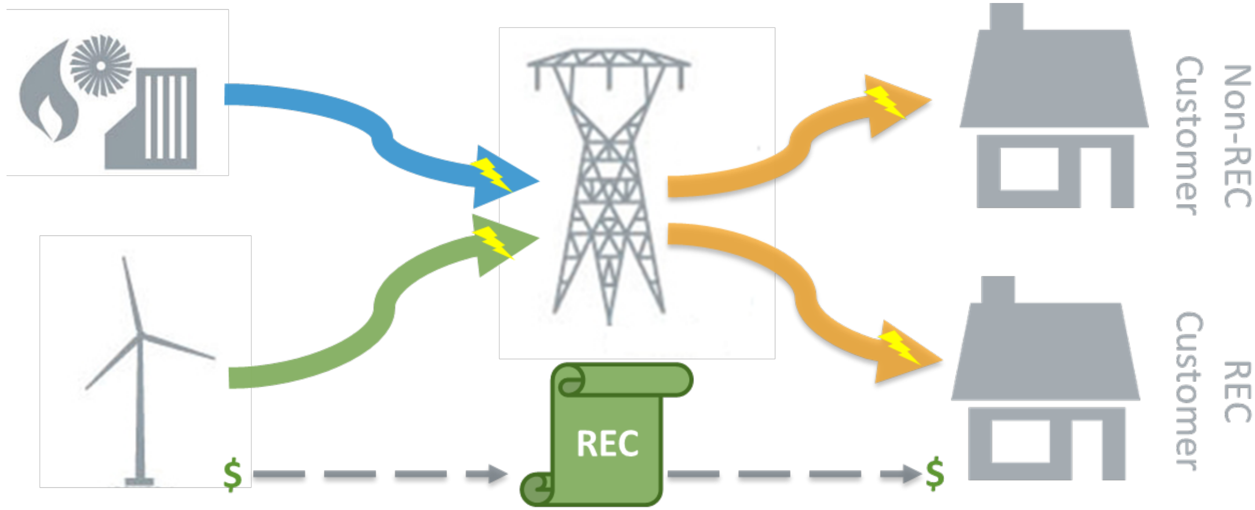
What We Heard: Bioenergy

- **Positives:** Flexible, uses existing waste, carbon neutral, reliable
- **Negatives:** Emissions, carbon accounting, resource availability, state limits
- **Themes:** What are the costs and benefits of allowing bioenergy? Can we differentiate between waste energy, biomass, and biofuels? Will resource availability limit resource potential?

What We Heard: Nuclear Energy

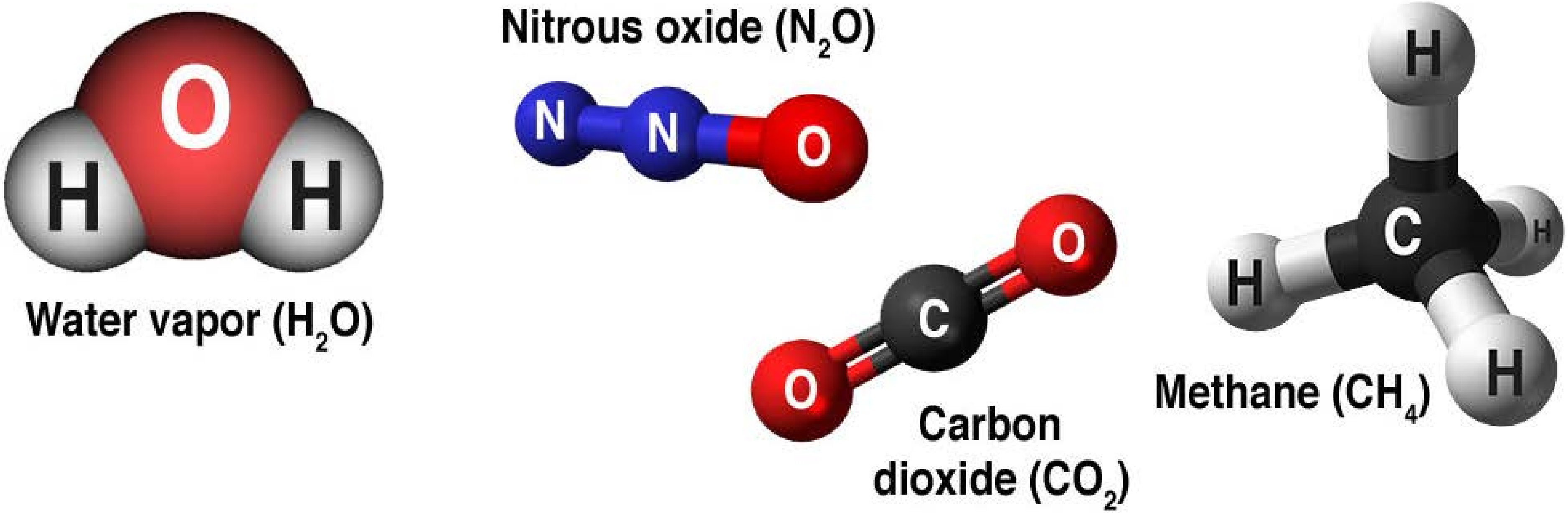
- **Positives:** Zero carbon, baseload, inertia, cost, existing units, reliable
- **Negatives:** Cost, nuclear waste, security, public health, ownership/risk
- **Themes:** Input ranged from grandfathering existing nuclear, to assessing the costs and benefits of allowing new nuclear and avoiding all nuclear.

The LADWP capacity at Palo Verde is scheduled to have a staggered retirement from 2045-2047.



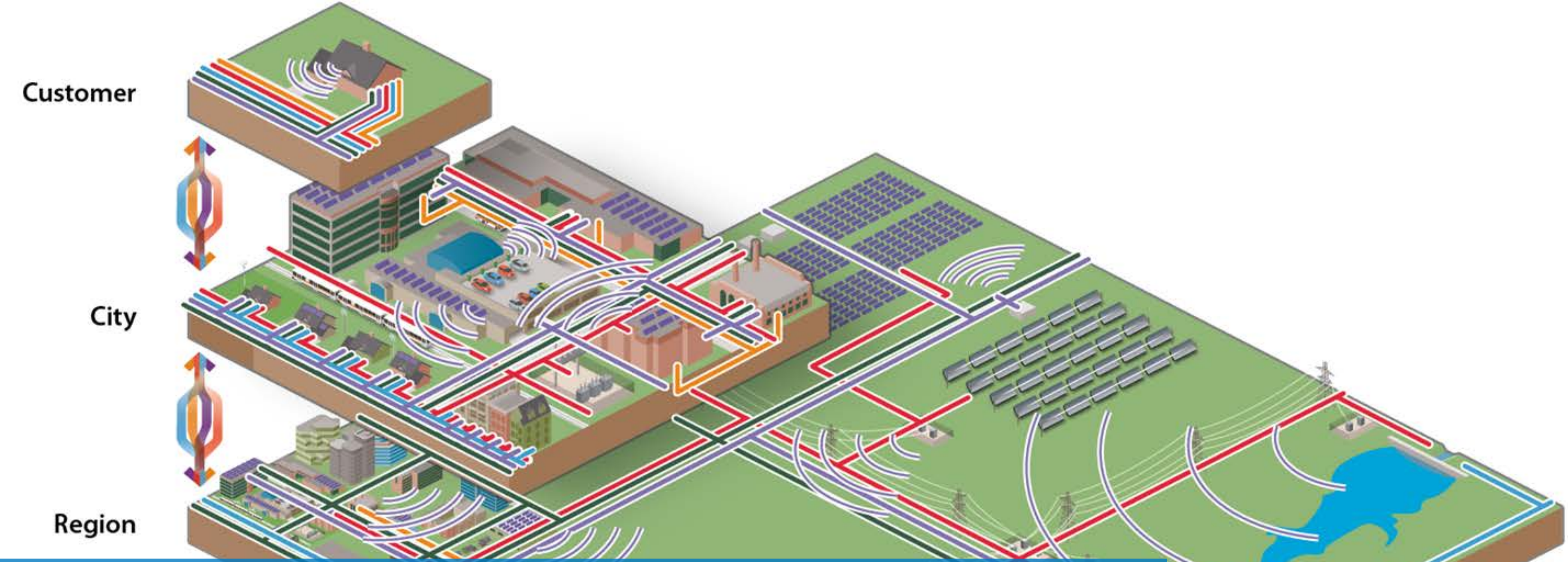
What We Heard: Credits and Allowances

- **Positives:** Cheap, balance margins, fast, practical for the last 10-20%
- **Negatives:** Beneficiaries don't pay, shortcut, credibility
- **Themes:** RECs may be an effective strategy, but there is concern about the legitimacy of RECs. Another concern is that environmental justice neighborhoods will not receive any benefits.



What We Heard: Zero Carbon Emissions Objective

- **Positives:** Significant support, addresses climate goals, easier to define than “renewable”
- **Negatives:** What about other greenhouse gases?
- **Themes:** Picking technologies can get complicated quickly; focusing on carbon sounds straightforward.



What We Heard: Load Modernization

- Topic identified in Discussion Activity 2
- **Positives:** Focus on local resources, energy efficiency, EVs, storage, local beneficiaries
- **Negatives:** Potentially expensive new tech, insufficient natural resource
- **Themes:** Distributed resources and energy efficiency

Preliminary
Clean Energy Scenarios and Sensitivities
for Advisory Group Input

NREL Goals for Scenario Development

- Start with the City Council Motions and Advisory Group Comments:
  - Identify least-cost pathway(s) to a clean energy future by 2050
  - Determine what investments are necessary to reach a clean energy future
  - Identify the potential economic and environmental impacts of a clean energy future on LADWP ratepayers

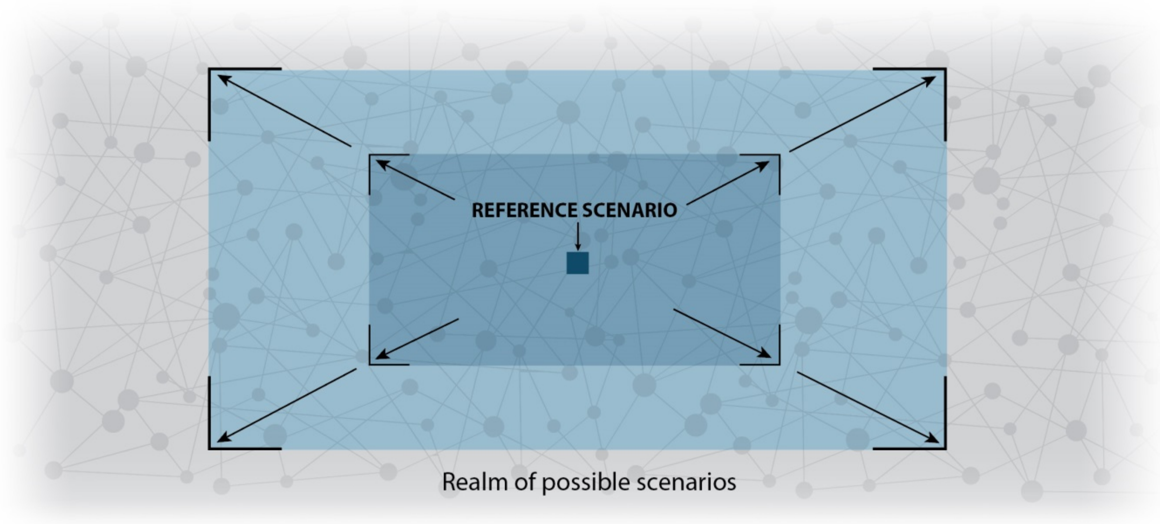
- Consider full set of opportunities:
  - Demand-side (demand response, end-use efficiency, and electrification)
  - Supply-side (renewable generation, nuclear, carbon capture and storage)
  - Financial mechanisms (allowances, offsets, and credits)

- Produce results that are robust to a broad set of future conditions/uncertainties:
  - Changes in load—quantity, flexibility, and efficiency
  - Balance between centralized and distributed supply
  - Ability to develop additional transmission
  - Evolution of key technologies (e.g., batteries, PV, wind)

Scenario and Sensitivity Definitions

Scenarios: Identify the overarching policy or technological driver for achieving a clean energy future

Sensitivities: Under a given scenario, explore how changes in future conditions could alter the pathway and outcomes for that scenario



Preliminary Clean Energy Scenarios

		Reference Cases		LA Leads			
	Candidate Technologies	**2018 IRP**	**Draft SB 100**	**100% Carbon Neutral**	**100% Renewable**	**100% Carbon Neutral – Accelerated**	**Load Modernization**
Scenarios	Natural Gas	●	●	●		●	
	Wind, Solar, Geothermal	●	●	●	●	●	●
	Existing Nuclear	●	●	●		●	
	New Nuclear			●		●	
	Bioenergy	●	●	●		●	
	Carbon Capture and Sequestration			●		●	
	Existing Hydro	●	●	●	●	●	●
	New Hydro	●	●	●		●	
	CO2 Allowances	●	●	●		●	
	RECs	●	●	●		●	
	Storage	●	●	●	●	●	●
Sensitivities	Electric Vehicles	Expected	Expected	Expected	Expected	Expected	HIGH
	Energy Efficiency	Expected	Expected	Expected	Expected	HIGH	HIGH
	Demand Response	Expected	Expected	Expected	Expected	HIGH	HIGH
	Transmission Feasibility	Expected	Expected	Expected	Expected	NEW PATHS	NEW PATHS
	Decentralization	Expected	Expected	Expected	Expected	Expected	HIGH
	Technology Cost	Expected	Expected	Expected	Expected	Low	Low
	Timeframe	2020-2050*	2020-2050*	2020-2050*	2020-2050*	2020–2045*	2020–2050*

*We will wait until May 2018 to finalize the scenario timeframe and sensitivities to give opportunity for further legislative development.

Preliminary
Clean Energy Scenario: **2018 Integrated Resource Plan**

- ***Definition*** – The evolution of the LA power system is influenced by existing policies (local, state, and federal). Current LADWP policy is driven by SB 350, aspirational city targets, and the Once-Through Cooling study. This definition will be similar with the 2018 LADWP PSLTRP process but not identical.
- ***Justification*** – A base case is essential to measure the costs and benefits of future scenarios.

	Candidate Technologies	2018 IRP
Scenarios	Natural Gas	●
	Wind, Solar, Geothermal	●
	Existing Nuclear	●
	New Nuclear	
	Bioenergy	●
	Carbon Capture and Sequestration	
	Existing Hydro	●
	New Hydro	●
	CO2 Allowances	●
	RECs	●
	Storage	●
Sensitivities	Electric Vehicles	Expected
	Energy Efficiency	Expected
	Demand Response	Expected
	Transmission Feasibility	Expected
	Decentralization	Expected
	Technology Cost	Expected
	Timeframe	2020–2050*

Preliminary Clean Energy Scenario: **DRAFT SB 100**

- ***Definition*** – The evolution of the LA power system is driven by policies that extend existing policies to obtain 100% renewable energy.
- ***Justification*** – This scenario is intended to be a proxy for last year's S.B. 100. It extends existing statutory resource constraints to create a 100% RPS.

	Candidate Technologies	DRAFT SB 100
Scenarios	Natural Gas	●
	Wind, Solar, Geothermal	●
	Existing Nuclear	●
	New Nuclear	
	Bioenergy	●
	Carbon Capture and Sequestration	
	Existing Hydro	●
	New Hydro	●
	CO2 Allowances	●
	RECs	●
	Storage	●
Sensitivities	Electric Vehicles	Expected
	Energy Efficiency	Expected
	Demand Response	Expected
	Transmission Feasibility	Expected
	Decentralization	Expected
	Technology Cost	Expected
	Timeframe	2020–2050*

Preliminary
Clean Energy Scenario:
100% Carbon Neutral

- ***Definition*** – LA achieves a net-zero carbon emissions power system. This scenario is a technology-agnostic pathway to achieving a net-zero emissions future. A carbon cap-and-trade program is implemented that ramps to zero-carbon.
- ***Justification*** – Reflects Advisory Group input to study a diverse set of resource options. This approach is proposed because of the urgent need to reduce carbon dioxide emissions, as described by the Advisory Group. It is the most flexible scenario to reaching a decarbonized electricity system.

	Candidate Technologies	100% Carbon Neutral
Scenarios	Natural Gas	●
	Wind, Solar, Geothermal	●
	Existing Nuclear	●
	New Nuclear	●
	Bioenergy	●
	Carbon Capture and Sequestration	●
	Existing Hydro	●
	New Hydro	●
	CO2 Allowances	●
	RECs	●
	Storage	●
Sensitivities	Electric Vehicles	Expected
	Energy Efficiency	Expected
	Demand Response	Expected
	Transmission Feasibility	Expected
	Decentralization	Expected
	Technology Cost	Expected
	Timeframe	2020–2050*

Preliminary
Clean Energy Scenario: **100% Renewable**

- ***Definition*** – LA achieves a power system in which 100% of load is met with generation from a limited selection of renewable resources.
- ***Justification*** – This scenario is the strictest interpretation of 100% renewable energy. As per discussions with the Advisory Group, this case does not include any generation that uses combustion. This scenario is less flexible than the 100% Carbon Neutral.

	Candidate Technologies	100% Renewable
Scenarios	Natural Gas	
	Wind, Solar, Geothermal	●
	Existing Nuclear	
	New Nuclear	
	Bioenergy	
	Carbon Capture and Sequestration	
	Existing Hydro	●
	New Hydro	
	CO_2 Allowances	
	RECs	
	Storage	●
Sensitivities	Electric Vehicles	Expected
	Energy Efficiency	Expected
	Demand Response	Expected
	Transmission Feasibility	Expected
	Decentralization	Expected
	Technology Cost	Expected
	Timeframe	2020–2050*

Preliminary Clean Energy Scenario: **100% Carbon Neutral – Accelerated**

- ***Definition*** **–** LA achieves a power system that has net-zero emissions. This scenario is identical to the *Carbon Neutral* scenario but is on an accelerated timeline.
- ***Justification*** – This scenario reflects the Advisory Group's interest in rapidly reducing the impact of LADWP on carbon dioxide emissions. It allows the model to select from a full range of options to find the cheapest options for rapidly decarbonizing the electricity system.

	Candidate Technologies	100% Carbon Neutral – Accelerated
Scenarios	Natural Gas	●
	Wind, Solar, Geothermal	●
	Existing Nuclear	●
	New Nuclear	●
	Bioenergy	●
	Carbon Capture and Sequestration	●
	Existing Hydro	●
	New Hydro	●
	CO2 Allowances	●
	RECs	●
	Storage	●
Sensitivities	Electric Vehicles	Expected
	Energy Efficiency	HIGH
	Demand Response	HIGH
	Transmission Feasibility	NEW PATHS
	Decentralization	Expected
	Technology Cost	Low
	Timeframe	2020–2045*

Preliminary Clean Energy Scenario: **Load Modernization**

- *Definition* – This scenario aims to reach the 100% renewable goals by leveraging distributed energy resources. It includes very high levels of electric vehicles, energy efficiency, and demand response. This scenario focuses on leveraging local resources.
- *Justification* – The Advisory Group expressed strong preferences for a strategy that leveraged local resources to meet climate goals.

	Candidate Technologies	Load Modernization
Scenarios	Natural Gas	
	Wind, Solar, Geothermal	●
	Existing Nuclear	
	New Nuclear	
	Bioenergy	
	Carbon Capture and Sequestration	
	Existing Hydro	●
	New Hydro	
	CO2 Allowances	
	RECs	
	Storage	●
Sensitivities	Electric Vehicles	HIGH
	Energy Efficiency	HIGH
	Demand Response	HIGH
	Transmission Feasibility	NEW PATHS
	Decentralization	HIGH
	Technology Cost	Low
	Timeframe	2020–2050*

Preliminary Clean Energy Scenarios

		Reference Cases		LA Leads			
	Candidate Technologies	**2018 IRP**	**Draft SB 100**	**100% Carbon Neutral**	**100% Renewable**	**100% Carbon Neutral – Accelerated**	**Load Modernization**
Scenarios	Natural Gas	●	●	●		●	
	Wind, Solar, Geothermal	●	●	●	●	●	●
	Existing Nuclear	●	●	●		●	
	New Nuclear			●		●	
	Bioenergy	●	●	●		●	
	Carbon Capture and Sequestration			●		●	
	Existing Hydro	●	●	●	●	●	●
	New Hydro	●	●	●		●	
	CO2 Allowances	●	●	●		●	
	RECs	●	●	●		●	
	Storage	●	●	●	●	●	●
Sensitivities	Electric Vehicles	Expected	Expected	Expected	Expected	Expected	HIGH
	Energy Efficiency	Expected	Expected	Expected	Expected	HIGH	HIGH
	Demand Response	Expected	Expected	Expected	Expected	HIGH	HIGH
	Transmission Feasibility	Expected	Expected	Expected	Expected	NEW PATHS	NEW PATHS
	Decentralization	Expected	Expected	Expected	Expected	Expected	HIGH
	Technology Cost	Expected	Expected	Expected	Expected	Low	Low
	Timeframe	2020-2050*	2020-2050*	2020-2050*	2020-2050*	2020–2045*	2020–2050*

*We will wait until May 2018 to finalize the scenario timeframe and sensitivities to give opportunity for further legislative development.

Discussion Activity #2: Considerations for Study

- Study must show the system is:
  - Reliable
  - Healthy
  - Just
  - Affordable

Research Approach

	Objective	Informs
ECONOMIC ANALYSIS:	Determine the economic and jobs impact of select study scenarios	
ENVIRONMENTAL ANALYSIS:	Identify and quantify the air quality, GHG, and environmental justice impacts of select study scenarios	
ELECTRICITY ANALYSIS:	Conduct a suite of engineering and economic studies to determine the future composition of the LADWP system and how it might operate. Considers all time scales on both the transmission and distribution networks.	
ELECTRIC LOAD MODELING:	Develop a range of load forecast and profiles for use in electric system modeling	

What could future **Demand** look like?

- Takes into consideration a variety of ways demand could change in the future
- Includes detailed accounting for energy efficiency, demand response, electrification

ECONOMIC ANALYSIS:	Jobs & Economic Development
ENVIRONMENTAL ANALYSIS:	Air Quality, GHG, & Public Health
ELECTRICITY ANALYSIS:	AC Power Flow
	Operations
	Expansion
ELECTRIC LOAD MODELING:	Demand Forecast

Are the scenarios **Reliable**?

- Full-scale power systems analysis
- Integrated transmission and distribution modeling
- Near complete transformation of the LADWP system

ECONOMIC ANALYSIS:	Jobs & Economic Development
ENVIRONMENTAL ANALYSIS:	Air Quality, GHG, & Public Health
ELECTRICITY ANALYSIS:	AC Power Flow
	Operations
	Expansion
ELECTRIC LOAD MODELING:	Demand Forecast

How could the scenarios impact **Public Health** and the **Environment**?

- Detailed analysis of impact of changes in air quality and their impact on public health, as well as changes to GHG emissions
- Designed to identify comparative environmental impacts of selected scenarios
- Relies on data from electricity analysis and demand forecasts

ECONOMIC ANALYSIS:	Jobs & Economic Development
ENVIRONMENTAL ANALYSIS:	Air Quality, GHG, & Public Health
ELECTRICITY ANALYSIS:	AC Power Flow
	Operations
	Expansion
ELECTRIC LOAD MODELING:	Demand Forecast

Are the scenarios **Just?**

- Designed to understand how environmental justice communities are impacted by the transformation in terms of changes in public health outcomes.
- Informs how jobs and the broader economy could be impacted by a 100% renewable future.

ECONOMIC ANALYSIS:	Jobs & Economic Development
ENVIRONMENTAL ANALYSIS:	Air Quality, GHG, & Public Health
ELECTRICITY ANALYSIS:	AC Power Flow
	Operations
	Expansion
ELECTRIC LOAD MODELING:	Demand Forecast

Are the scenarios **Affordable**?

- Study will provide detailed capital and variable costs for the electricity sector
- Study will quantify the economic impact of the energy transition
- Study will analyze the jobs and economic impact of a 100% future

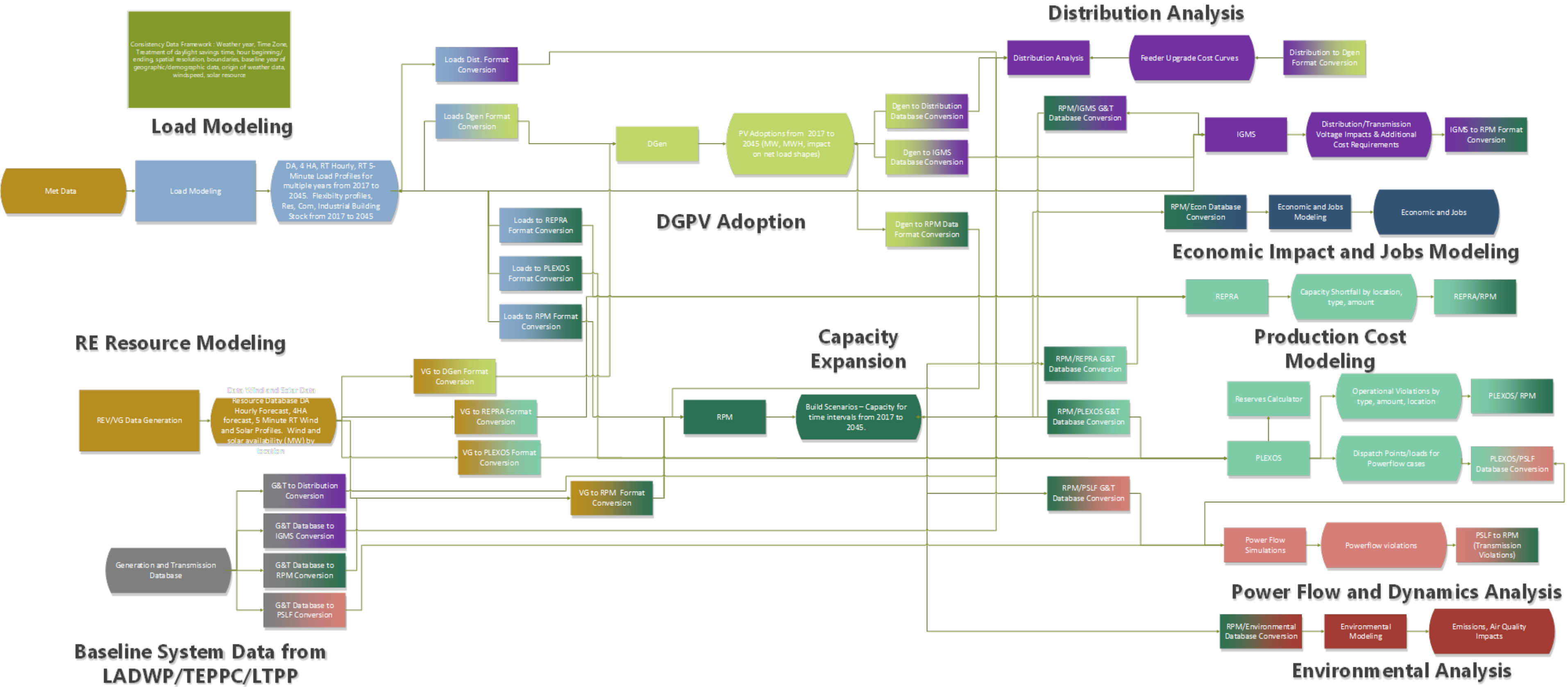
+ RATEPAYER ADVOCATE

ECONOMIC ANALYSIS:	Jobs & Economic Development
ENVIRONMENTAL ANALYSIS:	Air Quality, GHG, & Public Health
ELECTRICITY ANALYSIS:	AC Power Flow
	Operations
	Expansion
ELECTRIC LOAD MODELING:	Demand Forecast

What does this mean from a technical perspective?

Modeling Flow Chart

Note: This flowchart only includes data needed by other models. It does NOT include general results for the study as a whole



Discussion Activity – Roundtable Input

"Do these preliminary scenarios and sensitivities provide the framework for a study that 1) Meets the directives of the City Council motion and related amendments, and 2) Reflects the input themes from the November Advisory Group meeting?"

Tips for Productive Discussions

- Let one person speak at a time
- Help to make sure everyone gets equal time to give input
- Keep your input concise so others have time to participate
- Actively listen to others and seek to understand their perspectives

Lunch

www.nrel.gov

Power Strategic Long-Term Resource Plan

during lunch

www.nrel.gov

NATIONAL RENEWABLE ENERGY LABORATORY

Wrap Up and Next Steps

www.nrel.gov