# Los Angeles 100% Renewable Energy Study

# Advisory Group Meeting #5
# Thursday, June 7, 2018, 8:45 a.m. to 2:00 p.m.

# Meeting Summary

## Location

City of Los Angeles Department of Water and Power (LADWP)
John Ferraro Building
111 Hope St., Room 1514
Los Angeles, CA 90012

## Attendees

**Advisory Group Members**

Anthony Alexander, Los Angeles Alliance for a New Economy
Rebecca Andreassen, Office of the Mayor
Kendal Asuncion, Los Angeles Chamber of Commerce
Carlos Baldenegro, Port of Los Angeles
Jim Caldwell, Center for Energy Efficiency and Renewable Technology
Jean Claude Bertet, Los Angeles City Attorney, LADWP
Camden Collins, Office of Public Accountability (Rate Payer Advocate)
Molly Deringer Croll, California Energy Storage Alliance
Jack Durland, Valero Wilmington Refinery
Hilary Firestone, Natural Resource Defense Council
Ernesto Hidalgo, Neighborhood Council Sustainability Alliance
Brian Horsbryth, LAUSD – Energy Management Unit
Jack Humphreville, Greater Wilshire Neighborhood Council
Nurit Katz, University of California, Los Angeles
Michelle Kinman, Environment California Research & Policy Center
Adam Lane, Los Angeles Business Council
Andrea Leon-Grossman, Food and Water Watch
Loraine Lundquist, California State University, Northridge
Lee Morris, Valero
Alexandra Nagy, Food and Water Watch
Shane Phillips, Central City Association
Fred Pickel, Rate Payer Advocate
Andy Schrader, City of Los Angeles Council District 5
Allison Smith, Southern California Gas Company

Matthew Thomas, Los Angeles Unified School District (LAUSD)
Jasmin Vargas, RepowerLA
Stuart Waldman, Valley Industry and Commerce Association
Mike Webster, Southern California Public Power Authority

**LADWP Commissioners**
William Funderburk, Jr.
Aura Vasquez

**LADWP Staff**
James Barner
Dawn Cotterell
Dawn Cotterell
Vaughn Minassian
Eric Montag
Ashkan Nassiri
Brad Packer
Antique Rahman
Katherine Rubin
Armen Saiyan
Greg Sarvas
Dan Scorza
Anton Sy
Carol Tucker
Julie Van Wagner

**Consultants**
Aaron Bloom, National Renewable Energy Laboratory (NREL)
Paul Denholm, NREL
Ramin Faramarzi, NREL
Scott Haase, NREL
Jack Hughes, Kearns & West
Joan Isaacson, Kearns & West
Taylor York, Kearns & West

## Welcome and Introductions

Joan Isaacson, Lead Facilitator from Kearns & West, welcomed Advisory Group members to the fifth meeting of the Advisory Group for the Los Angeles 100% Renewable Energy Study (Study). She then overviewed the agenda (see Appendix A) and explained that the primary purpose of the meeting was to review the revised scenarios and sensitivities, which were modified based on feedback from Advisory Group members. She noted that all input received from Advisory Group on the preliminary scenarios and sensitivities was given significant consideration, and that the next step in the process is to review the changes with the Advisory Group at this meeting, before NREL initiates modeling of the scenarios.

Eric Montag, Senior Manager of Planning & Strategic Initiatives for LADWP, thanked the Advisory Group members for their dedication, time, and passion. He noted that Advisory Group members would receive an update on the Once-Through Cooling Study and the Intermountain Power Project (IPP) immediately following the Advisory Group meeting. He also shared observations from the Advisory Group site tour held on April 26, 2018 and noted that it provided valuable insight on some LADWP renewable energy projects and challenges.

Eric Montag, acknowledged that LADWP Commissioner Funderburk was in attendance at the Advisory Group meeting. The Commissioner provided brief comments, thanking Advisory Group members for their commitment and balanced approach to this important effort. LADWP Commissioner Aura Vasquez also joined and participated in the meeting.

Anton Sy, LADWP 100% Renewable Energy Study Project Manager, welcomed the Advisory Group and thanked them for their efforts and commitment. He also emphasized that the team is moving into the analytical phases of the Study and making good progress.

Slides from all presentations are contained in Appendix B and are available on the LADWP 100% Renewable Energy Study webpage, here.

## Update Exchange

Joan Isaacson invited attendees to participate in the Update Exchange agenda item.

**Owens Valley Site Tour**

Dawn Cotterell, LADWP, announced that the Owens Valley Site Tour is open to Advisory Group members. The two-day tour covers some of the facilities visited during the Advisory Group site tour but includes many more and extends further north. Dawn explained that the site tour includes hydropower, wind, and solar in addition to the Los Angeles Aqueduct and restoration projects. Early reservations are recommended, as space is limited. All tours are scheduled for two days over a Friday and Saturday, for the following dates:

- June 22-23, 2018
- September 21-23, 2018
- October 19-20, 2018
- November 2-3, 2018

Please contact Dawn for more information (Dawn.Cotterell@ladwp.com).

**Advisory Group Member Updates**

There were no updates provided by Advisory Group members.

## Consideration for Planning the 100% Electric Power System

Paul Denholm, LADWP, provided a presentation on considerations involved in planning a 100% renewable system. He noted that Los Angeles cannot achieve 100% renewable energy using

the same strategies used by smaller municipalities and companies such as Google and Apple. These entities might often buy renewable energy credits and secure power purchase agreements to achieve net 100% renewable energy. In contrast, the City of Los Angeles is a balancing authority, and is responsible for helping balance electricity demand on a second-by-second basis. It would not be feasible for them to simply buy credits.

NREL's task is to integrate their knowledge of the opportunities and challenges of renewable energy technologies, through the lens of the LADWP system. NREL will examine how different renewable energy scenarios impact energy supply and demand balance, and ensure resource adequacy. It is also critical to consider cost factors in this analysis, and to identify ways to integrate other industries, especially transportation, to enable transformation of the system as a whole. The Study process must also consider the need for new transmission infrastructure coming into the city, as well as the siting of wind and solar.

Paul identified two topics that are important when considering high levels of renewables in an energy system: supply demand balance and resource adequacy.

**Supply/Demand Mismatch**

Power engineers must address fluctuations in daily electricity demand. A major focus of this Study is how to meet demand without using fossil fuel generation, when resources such as wind and solar are offline. When relying on wind and solar electricity generation, demand can be met in the middle of the day but often not in afternoon, due to limitation of generation. LADWP will need to closely consider not just end-state challenges of high levels of renewables, but the transition period as well – how will the system maintain reliability during the transition?

As the percentage of renewable energy increases substantially, the issue of over-generation becomes a challenging issue. While solar and wind generators can be shut down when the supply of energy produced exceeds the demand, valuable energy generation potential is wasted. This issue is important on both a day-to-day and a seasonal basis. Storage can contribute to the solution – and LADWP system already has some storage resources – but storage is not as effective for addressing seasonality. Alternatively, excess energy could be sold to neighboring states. However, the market would be limited if neighboring states have similar climate and types of electricity generation (e.g. solar).

To date, there have been no comprehensive studies of the technical aspects of transmission adequacy, resource adequacy, and the economics of meeting the goal of 100% renewable energy in a large system like LADWP's. The technical core of the Study focuses on the extent of the required overgeneration and its associated costs. The marginal cost of energy goes up as more energy is wasted. This Study seeks to answer how to minimize such waste and its associated cost. The cost of eletricity must be managed in order to not create disincentives for to electrification of the transportation sector, which has a high cost of avoided carbon.

**Resource Adequacy**

LADWP must also account for how to guarantee reliable energy supply during emergencies and/or maintenance. For instance, if a transmission line goes down, or it is a much hotter day or year than forecasted, LADWP would normally operate contingency reserves, either long-term or short-term. Part of Western Interconnection, Los Angeles is electrically connected with Nevada, Montana, Utah, and Colorado, and all of these utilities, including LADWP, share the responsibility for maintaining grid reliability and providing a frequency response obligation to the others. Many of those reserves are currently met with fossil fuels, which cannot be easily swapped out for renewables since they are dependent on certain conditions to generate electricity.

The Los Angeles 100% Renewable Energy Study will seek to address how to meet reserve requirements. Possible solutions include dispatched renewables, biomass, spatially diverse wind and solar, demand response technologies and load shifting, energy storage, and net energy exchanges. For example, if a utility like LADWP added 3 gigawatts of batteries or similar storage, the marginal cost of additional solar PV is reduced because it can be used later rather than being wasted.

Renewables like solar and wind produce more energy in the spring, and not enough energy in the summer, so energy must be shifted from spring to summer. Short-term storage has become easier with the reduction in cost of batteries, but seasonal storage is more difficult. Hydrogen, biofuels and other technologies are possibilities that can be explored.

**Questions and Comments from Advisory Group Members**

<u>Question:</u> Why did the presentation display a 2012 demand profile as opposed to something more current?

> <u>Answer:</u> NREL used this example in the presentation to avoid data errors from inaccurate representation of behind-the-meter solar in the LADWP system. The Study will use multiple years of resource data.

<u>Comment:</u> The presentation slides seems to suggest there will be no growth in electricity demand.

> <u>Answer:</u> The intent was to focus on one aspect of the challenge of meeting 100% renewable energy – how to address and manage surplus energy generation capacity.

<u>Question:</u> What factors affect the rapid increase in marginal cost of renewable energy?

> <u>Answer</u>: Because more renewable energy is generated at certain times and seasons, the excess is wasted but the costs of development and operations of the infrastructure still have to be paid.

Comment: If marginal cost of renewables rises steeply around 80%, then maybe some scenarios should consider reaching 80 to 85% renewable energy rather than achieving a full 100%.

Question: Are we aiming for 100% renewable energy or zero carbon emissions? Is nuclear allowed in the goal for carbon emissions?

> Answer: That will be discussed during the second part of the meeting when the revised scenarios are presented.

Question: Can the Advisory Group members get copies of this presentation?

> Answer: Yes, the file will be posted online tomorrow.

Question: Is the curve for marginal cost of photovoltaic reflective of the cost of balancing or the direct cost of the technology?

> Answer: The curve represents the net cost of photo voltaic in a market environment after assuming that all of the generated energy is used.

Question: Are these cost curves made without demand response, load shifting, or rate design in mind?

> Answer: Yes. The problem with shifting energy use through rate design or demand response is that the technologies are competing against each other. We can shift energy day to day, but not seasonally.

Question: Is NREL looking into conservation and energy efficiency as a way to reduce peak demand?

> Answer: Energy efficiency will be seriously considered, especially in reducing demand on peak summer days.

Question: Can the Western Interconnection help with the seasonal electricity supply problem?

> Answer: It could help some, but solar resources in the states are similar. When it is sunny in California, it is usually sunny in other states. If Los Angeles was the only entity producing renewable energy, it could work, but the hope is that all places will adopt renewable energy.

Question: Has NREL considered the possibility of Los Angeles exporting excess energy to Mexico?

> Answer: There are not robust transmision connections between the US and Mexico, and Mexico has the same seasonal patterns as Los Angeles. Signficiant connections exist with Canada, but their peak load is also in the summer. Regional connections will be explored as well as distant connections.

Question: How much energy efficiency can be achieved, and how can electricity be priced to reduce demand?

Answer: It is difficult to answer that at this time. NREL will study what the opportunities are to modernize load and create deep energy efficiency.

Question: As utilities adopt more renewable energy sources, what is the point that seasonal storage become an issue?

Answer: A main point of the Study is to answer this question. Research on this question is limited now and has been highly academic.

Question: There are some gas generation facilities that are not used often. What do the cost curves look like for them?

Answer: Fossil fuels do not have the same steep curve, but the last kilowatt of energy LADWP serves is still expensive. These plants are designed as peaker plants and only operate during peaks.

Comment: People don't complain about the fact that we build those plants and they sit idle.

Discussion: That is partly because rates don't reflect the marginal cost of energy. Also, most utilities work hard to reduce the peak load. The scenarios will help clarify the different costs of producing renewable energy. There are also many costs to consider beyond the dollar amounts, such as the impact of emissions on communities and the environment.

Comment: Peak cost is reflected in rates, it's just averaged out over time.

Comment: One of the things we want to understand is rate structures and incentives, and how we get people to use electricity when the sun is shining and the wind is blowing, rather than during hours that we are not producing renewables. This Study should consider real-time pricing.

Question: How can electricity be priced ahead of time since renewable energy production is unpredictable?

Answer: There's uncertainty around nuclear and gas too, and it can be more impactful.

Comment: Real time prices won't encourage people to curtail unless they know in advance what the price will be.

Question: How much of the electrical demand in the LADWP system is industrial versus residential?

Answer: Approximately 60% commercial/industrial and 40% residential.

Question: Will LADWP customers pay for a 100% renewable system, or will the other states and utilities contribute?

Answer: LADWP notes that question and will bring back a response.

Question: What kinds of seasonal storage technologies exist? Are there any clean technologies?

Answer: Most technologies involve storing energy as a liquid or a gas. For example, storage of hydrogen for use in fuel cells or creation of synthetic methane. Hydrogen fuel cell operation only produces water vapor, resulting in no NOx or SOx air contaminants.

Question: Will the Study consider geothermal or tidal energy sources? Are their cost curves similar to solar and wind?

Answer: NREL is looking at a large range of technologies - the full list of sources is listed in the scenario slides. NREL is assuming that a certain amount of energy would come from sources like geothermal, but they only make up a small amount of generation compared to wind and solar. The analysis in this discussion is meant to be illustrative and will not be included in the Study.

Question: What is the cost of 3 megawatts of storage?

Answer: Six to eight hours of storage would be needed, with a cost of approximately four to five billion dollars. But it should be noted that the cost life of a new combustion turbine will soon have the same cost life of a storage plant.

Question: What is the physical footprint of 3 gigawatts of battery storage? Would it be located thein LADWP service territory?

Answer: This question will be considered in the Study.

Question: How much storage capacity is provided by the Beacon Solar Energy Project?

Answer: It has a 10 megawatt battery, which is a half hour of storage.

Comment: Many neighborhoods would not want this storage to be located nearby.

Response: The Study will consider siting of storage and geospatial components.

Advisory Group members were given the opportunity to participate in small group discussions, addressing the question "What are some challenges to achieving 100% renewable energy?" Groups discussed for fifteen minutes and then a representative reported back to the larger group on a few main discussion topics. These reported topics are listed by group below.

Group 1

- Paying for up upgrades
- Dealing with efficiency in existing building stock
- Maintaining interagency coordination
- Promoting behavior and social change
- Electrifying transportation

Group 2

- Identifying other seasonal energy solutions
- Promoting behavior change for energy efficiency
- Adding and siting new transmission infrastructure

Group 3

- Siting storage and ensuring public safety
- Exploring direct access options
- Determining costs

## Scenarios and Sensitivities

Aaron Bloom, NREL, presented the revised scenarios and sensitivities. He began with a recap of the City Council motions, noting important themes and considerations that drive the Study, including:

- Potential for a fossil fuel-free future
- Los Angeles as a global leader
- Ratepayer impacts and protections
- Prioritization of environmental justice communities, including incorporation of CalEnviroscreen data
- Consideration of both demand- and supply-side concepts
- Understanding of impacts on the broader economy

Based on the directives in the City Council Motion, the scenarios need to address three overarching goals:

- Address the full suite of issues raised by the City Council motions – understanding of impacts on future investment, local jobs and economic development, rates, air quality, health, and environmental justice communities.
- Consider the full suite of options - inclusion of demand-side, supply-side, and financial mechanisms.
- Be robust - sensitivity to current trends, plans, policies, and regulations; recognition of a broad set of future conditions and uncertainties (load evolution, balance between centralized and distributed supply, and opportunities for future transmission and distribution.)

### Advisory Group Feedback on Draft Scenarios

Many Advisory Group members provided feedback and comments on the draft scenarios presented at the February 2018 meeting, explained Aaron. When taken together, the comments had a number of themes:

- Accelerated compliance
- Financial versus physical compliance – considering costs as well as physically balancing the load
- Carbon neutral, combustion free, or 100% renewable – identify the differences and tradeoffs
- Detailed reporting of assumptions and exogenous inputs – what are the external inputs?
- Current policies, plans, and initiatives reflected in load forecasts
- Interim targets – are there percentage targets at which costs and impacts change markedly?

- Equity implications – understanding impacts versus benefits for different groups
- Environmental impacts beyond CO2 – understanding overall air quality
- Regionalization/further participation with the Western Energy Imbalance Market and the California Independent System Operator

**Revised Scenarios**

Based on a goal of accelerated compliance and informed by the 2017 Integrated Resource Plan and the Once-Through Cooling Study, the initial objective is to reach a 100% net renewable LADWP power system by 2030. The individual scenarios build on the 2030 net renewable target.

The revised scenarios presented by Aaron are listed below. Please refer to the presentation slides in Attachment B for the specific scenario definitions.

- 100% Renewable Energy reference case
- LA Leads
- Transmission Renaissance
- Limited Transmission
- Emissions Free
- Net 100%
- Load Modernization
- Western Initiatives

**Questions and Comments from Advisory Group Members**

<u>Question:</u>
My concern is that this Study doesn't consider impacts on the ratepayer.

> <u>Answer:</u> There are considerations in the Study that address ratepayers. For example, our results will be passed to the Rate Payer Advocate for a separate rate analysis conducted by another party. In addition, if you don't reach 100% affordably, incentivizing the transformation needed in other sectors, like transportation, to electrify, becomes far more difficult, thereby jeopardizing broader LA goals for improve air quality and combating global warming.

<u>Question:</u>
Why can't the Study identify ways to maximize benefits to environmental justice communities?

> <u>Answer:</u> There are many value judgments and subjective elements when considering maximization of benefits for different communities. This makes it challenging to appropriate modeling inputs and assumptions.

<u>Question:</u>
Are LADWP ratepayers the first to undertake this type of effort?

> <u>Answer:</u> Similar efforts have been undertaken elsewhere, but not at the same scale.

Question:
When scenarios address transmission, do they also address distribution? The Study should consider this in more depth.

Answer: In the analysis of each scenario, modifications to the distribution system will be assessed where needed. The primary consideration is transmitting the energy into the LADWP system from generation sources located outside of the Los Angeles region.

Comment:
The Study should consider electrification as its own category, rather than within the “Load” category – it can be a very complex issue.

Response: This issue will be addressed in the sensitivity analysis.

Comment:
Scenarios addressing transmission should be refined to differentiate between transmission *into* the basin and transmission *within* the basin.

Question:
While the WECC case assumes no major changes in the Western Interconnection, is it likely that others will follow LA’s lead?

Answer: Others may follow, but LA is a smaller portion of the system and may not have significant influence in the larger scheme.

Question:
Do all scenarios that assume new transmission allow upgrades?

Answer: Yes, when necessary.

Question:
Is nuclear energy included in the Emissions Free Scenario because it is dispatchable?

Answer: It is included because it does not produce greenhouse gas emissions.

Question:
What is meant by “hydropower upgrades?”

Answer: It could include new technology and practices for existing hydropower facilities. It does not include new hydropower projects.

Question:
For the Net 100% scenario, does the Study consider offsets other than renewable energy credits, such as vehicle offsets?

Answer: The project team has not yet considered this but will.

Question:
Has small hydropower been considered?

Answer: Much of the hydropower power potential in the West has been built out, and small hydropower projects are limited and challenging.

Question:
What is the phase-out date of the Palo Verde Nuclear Generating Station, and how is it considered in the 100% Renewable Energy Study?

Answer: Palo Verde's license expires between 2045 and 2047, which occurs beyond the target year of the Study.

Question:
Does the Load Modernization category include storage and distributed generation? It may be helpful to have high amounts of storage and distributed generation if significant load shifting is anticipated.

Answer: This scenario is generally focused on load.

Question:
Why isn't distributed generation high in the Load Modernization case?

Answer: The No Transmission scenario addresses this comment but the scenario title does not reflect this concept. The team will identify a scenario name for the No Transmission case to reflect this concept.

Question:
How is regionalization addressed in the WECC scenario? The other cases should also consider trading amongst balancing authorities. NREL should consider cases that include robust trades amongst the balancing authorities.

Answer: The team will need to look into this further.

Question:
Do all scenarios, except the WECC case, assume that SB100 is not passed?

Answer: The Study will be based on approved legislation. The exception is the Western Initiatives scenario, which does consider possibilities for new legislation.

Question:
Is there potential for consideration of regionalization and trading among regions?

Answer: The team will look into this.

Comment:
Are all scenarios the same until 2030, except to the 2017 IRP reference case? Should we consider different ways to ramp up the scenarios before 2030?

Answer: Yes, all scenarios are the same until 2030, following current plans to bring the system to net renewable by 2030. LA will be undertaking many efforts to get to this point, and the goal of the Study is to assess efforts past 2030. The current IRP achieves 65% physical renewable energy by 2036. Likely the last 10-15% will be renewable energy credits or something similar. The team will consider the possibility of ramping up specific scenarios earlier than 2030.

Comment:
In support of moving forward, we may be able to compare certain aspects across scenarios once they have been run, to get a fuller picture.

Answer: Yes, this is possible.

Comment:
In examining costs, the Study should consider personal costs –i.e. the cost to the ratepayer of getting to 100% renewable.

Answer: The Study will examine the cost of adding rooftop solar and increased distribution. However, it will not consider household costs for purchasing rooftop solar, an electric range top, etc. The Study will also not model incentives because they may not be available after 2021.

Comment:
If the LADWP system achieves net 100% renewable by 2030, what happens in the Net 100% scenario between 2030 and 2045?

Answer: The proportion of physical to new renewable energy could change during that time.

Joan Isaacson asked if the Advisory Group was sufficiently satisfied with the scenarios to move forward, and there was no disagreement.

## Conclusions and Next Steps

Joan Isaacson commented that Advisory Group members are welcome and encouraged to send comments or questions on any topic to Anton Sy, Project Manager: anton.sy@ladwp.com, or (213) 367-2332. If Advisory Group members have additional comments on the revised scenarios, the teams asks that they be sent by the end of the following week.

The next quarterly Advisory Group meetings are scheduled for August 16, 2018 and November 15, 2018.

City of Los Angeles
**100% Renewable Energy Study**

Advisory Group Meeting #5
Thursday, June 7, 2018, 8:45 a.m. to 2:00 p.m.

# Appendix A

Agenda

**City of Los Angeles 100% Renewable Energy Study**
**Thursday, June 7, 2018**
**8:45 am – 2:00 pm**
**Los Angeles Department of Water and Power, Room 1514**

| | | |
|---|---|---|
| **8:45 – 9:00 am** | **Arrive at LADWP / Networking / Continental Breakfast** |
| **9:00 – 9:05 am** | **Call to Order and Agenda Overview**<br>**Kearns & West (K&W):** Joan Isaacson, Facilitator |
| **9:05 – 9:10 am** | **Welcome and Introductions**<br>**LADWP:** Eric Montag and Anton Sy<br>**NREL:** Scott Haase |
| **9:10 – 9:20 am** | **Update Exchange**<br>• Tour Recap<br>• LA Aqueduct-Owens Valley Tours<br>**K&W:** Joan Isaacson<br>**LADWP:** Dawn Cotterell |
| **9:20 – 11:45 am** | **Considerations for Planning a 100% Electric Power System**<br>• **Supply/Demand Mismatch**<br>• **Resource Adequacy**<br>• **Discussion**<br>**NREL:** Paul Denholm |
| **11:45 – 12:15 pm** | **Lunch Break** |
| **12:15 – 1:50 pm** | **Scenarios and Sensitivities**<br>• **Comments and Input Preliminary Scenarios and Sensitivities**<br>• **Updated Scenarios and Sensitivities [**Break after presentation]<br>• **Round Table Discussion**<br>**NREL:** Aaron Bloom |
| **1:50 – 2:00 pm** | **Wrap-up and Next Steps**<br>• Next meeting dates: August 16, 2018 and November 15, 2018 |

Los Angeles Department of Water & Power

NATIONAL RENEWABLE ENERGY LABORATORY

**City of Los Angeles**
**100% Renewable Energy Study**

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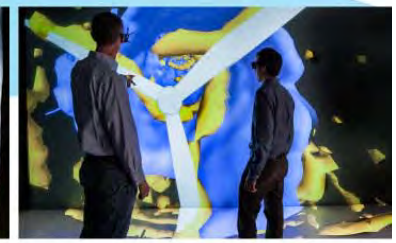
# Appendix B
Presentation







# Los Angeles 100% Renewable Energy Study
## Advisory Group Meeting #5
## June 7, 2018

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

# Agenda

- Call to Order and Agenda Overview
- Welcome and Introductions
- Update Exchange
- Considerations for Planning a 100% Electric Power System
- Lunch Served
- Revised Scenarios and Sensitivities
- Wrap-up and Next Steps

# Advisory Group Schedule

| QUARTER | Phase 1 \| 2017<br>LAUNCH AND ORGANIZATION | Phase 2 \| 2018<br>SCENARIOS | Phase 3 \| 2019<br>ANALYSIS AND MODELING | Phase 4 \| 2020<br>FINAL REPORT |
|---|---|---|---|---|
| Q1 | COMPLETED MEETINGS/TASKS<br>PLANNED MEETINGS/TASKS | • Advisory Group Meeting Plan<br>• Preliminary Scenarios and Sensitivities<br>• Field Trip Itinerary<br>• Power Strategic Long-Term Power Resources Plan<br>• Once-Through Cooling Study Update<br>FEBRUARY 15 | • Capacity Value<br>• Electricity Operations Modeling II<br>• Jobs & Economic Analysis II | • White Papers on Electricity Modeling Results<br>• Final Results 1) Jobs & Economic Analysis and 2) Environmental Analysis<br>• Final Visualization of Electricity Operations |
| Q2 | • Advisory Group Launch<br>• City Council Motion: 100% Renewable Energy Study<br>JUNE 23 | FIELD TRIP April 26<br>• Draft 100% Papers: Framing, Data, Methods<br>• Final Scenarios and Sensitivities<br>• Once-Through Cooling Study Update<br>JUNE 7 | • Planning Reserves<br>• Operating Reserves<br>• Load Modernization<br>• Environmental Analysis II<br>• Publication Plan | • Final Report<br>• Final Presentation |
| Q3 | • Advisory Group Charge and Operating Protocols<br>• Introduction to NREL and 100% Renewable Energy Study<br>AUGUST 3 | • Final 100% Papers<br>• Electricity Operations Modeling I<br>• Jobs & Economic Analysis I<br>• Environmental Modeling I<br>• Once-Through Cooling Study Update<br>AUGUST 16 | • Final Scenarios and Sensitivities Results<br>• Final Visualization of Scenarios<br>• Initial Electricity Operations Modeling Results | |
| Q4 | • Defining Clean Energy and Renewable Energy<br>• Considerations for Study<br>• Once-Through Cooling Study Overview<br>• Public Outreach Overview<br>NOVEMBER 16 | • Initial Scenario Results<br>• Draft Visualizations of Scenarios<br>• Once-Through Cooling Study Results<br>NOVEMBER 15 | • Final Electricity Operations Modeling Results and Draft Visualizations<br>• Draft results on Jobs and Economic Development<br>• Draft results on Environmental Analysis | |

Los Angeles Department of Water & Power

NATIONAL RENEWABLE ENERGY LABORATORY

*As of June 2018*

# LADWP Site Tour

## Recap

# Owens Valley Site Tour

**2018 Tour Dates**

- Fri., Jun. 22 – Sat., Jun. 23
- Fri., Sep. 21 – Sat., Sep. 22
- Fri., Oct. 19 – Sat., Oct. 20
- Fri., Nov. 2 – Sat., Nov. 3

- Tour the 233-mile route that the city's water travels to arrive at the tap.
- Two-day tour
- Learn about delivering water and power safely and reliably to the City of Los Angeles.

**Early reservations are recommended as availability is limited.**

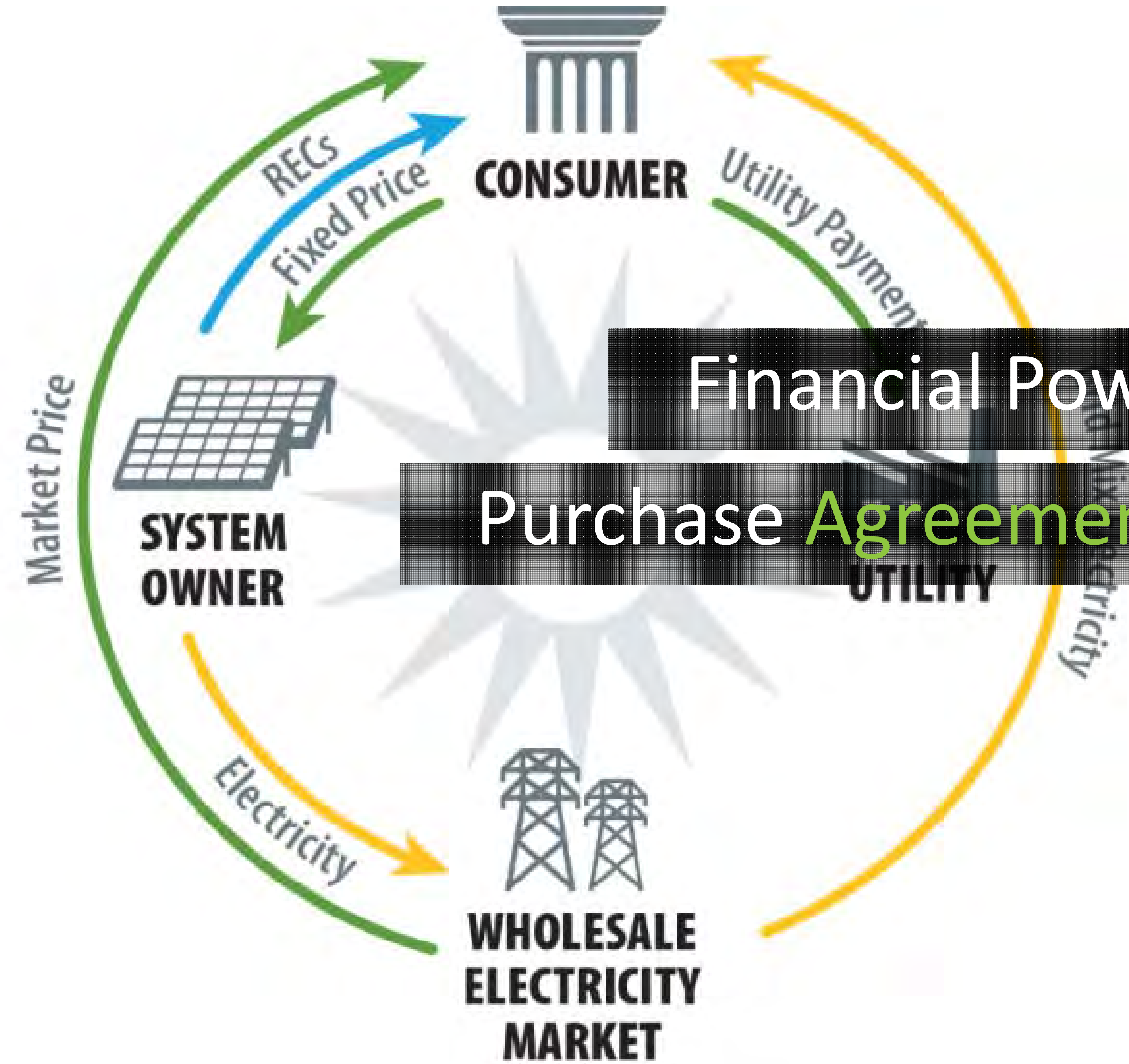
# Considerations for Planning a 100% Electric Power System

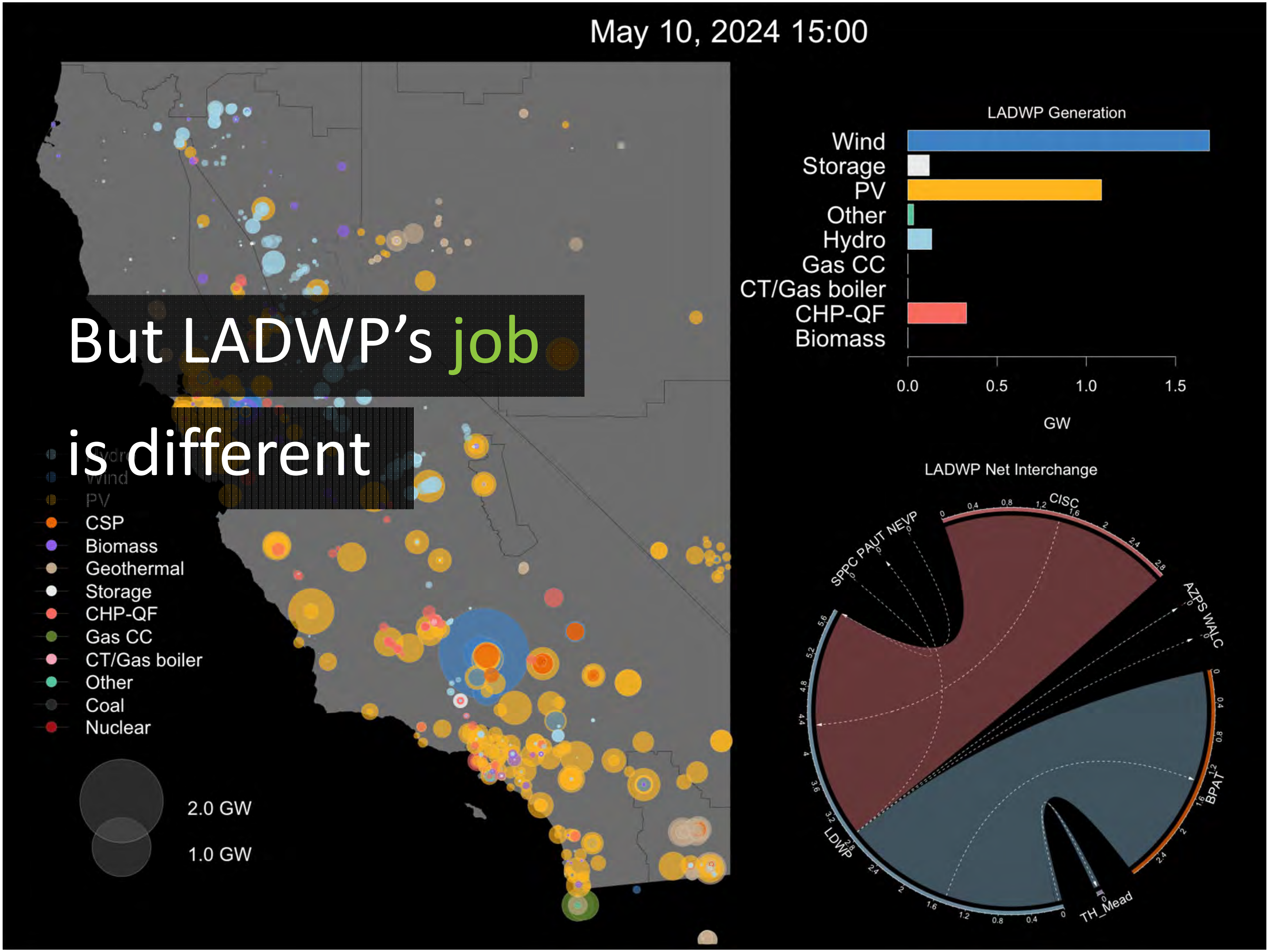
P. Denholm

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

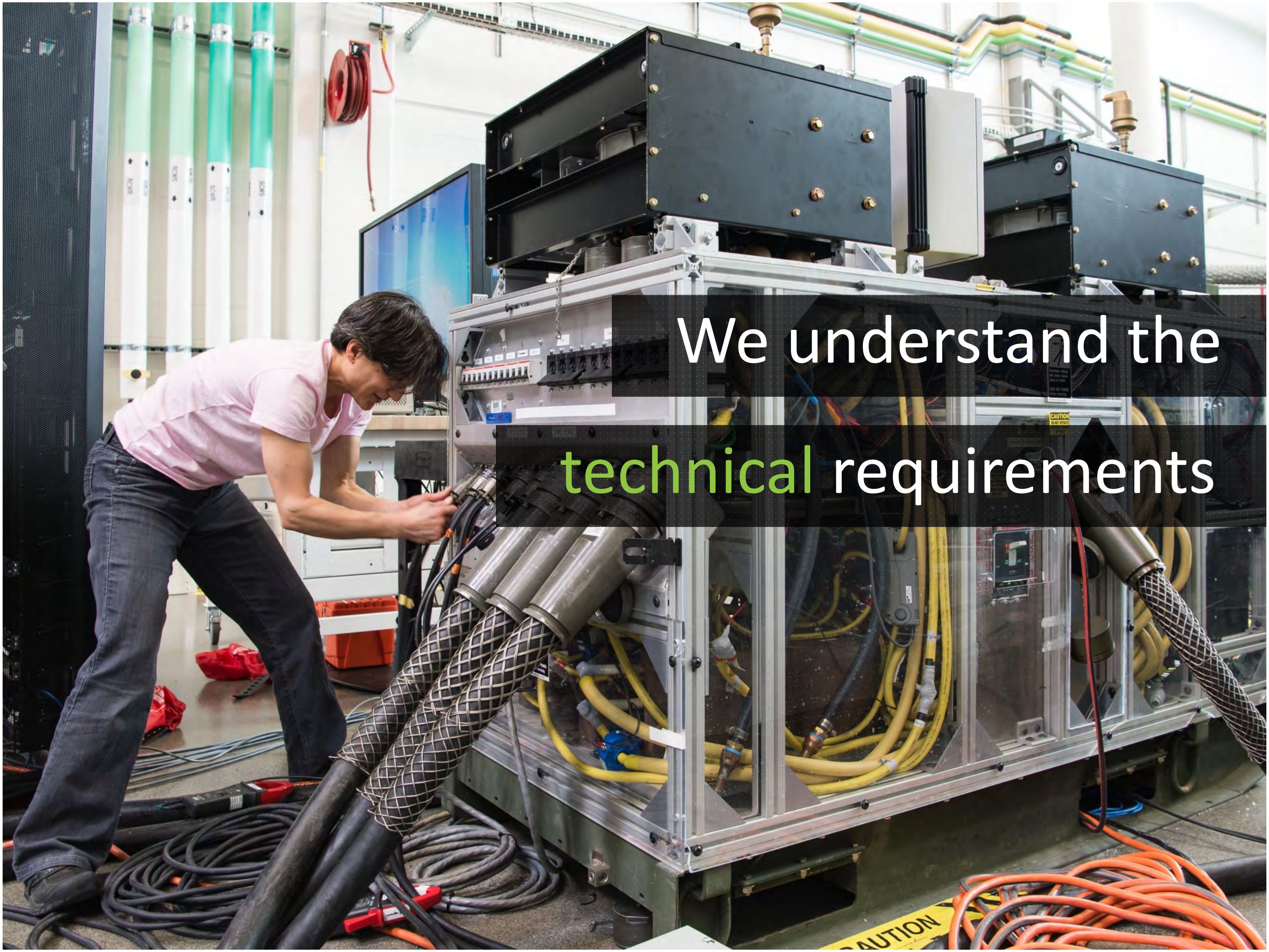
# How do most cities and corporations achieve 100%?

# Financial Power Purchase Agreements





May 10, 2024 15:00
But LADWP's job
is different
CSP
Biomass
Geothermal
Storage
CHP-QF
Gas CC
CT/Gas boiler
Other
Coal
Nuclear
2.0 GW
1.0 GW
LADWP Generation
Wind
Storage
PV
Other
Hydro
Gas CC
CT/Gas boiler
CHP-QF
Biomass
0.0
0.5
1.0
1.5
GW
LADWP Net Interchange
CISC
SPPC
PAUT
NEVP
AZPS
WALC
BPAT
TH_Mead
LDWP


We understand the
technical requirements


If electricity costs too much
You can’t unlock other sectors

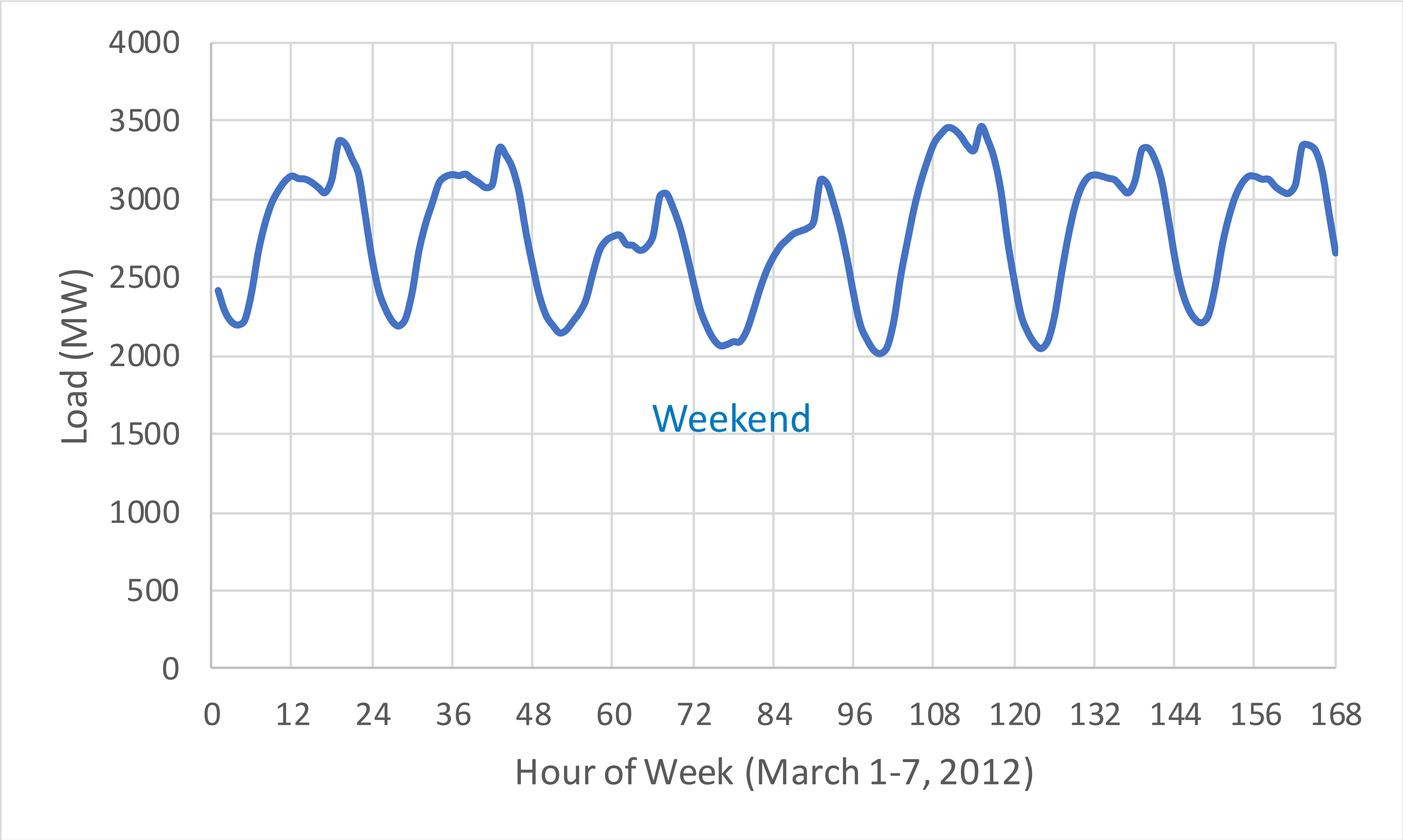
# The Two Topics

1. Maintaining economic generation of Variable Generation (VG) due to supply/demand mismatch
2. Maintaining resource adequacy overall time scales without the “backup” of fossil generators

# Important Topics We Will Not be Talking about Here

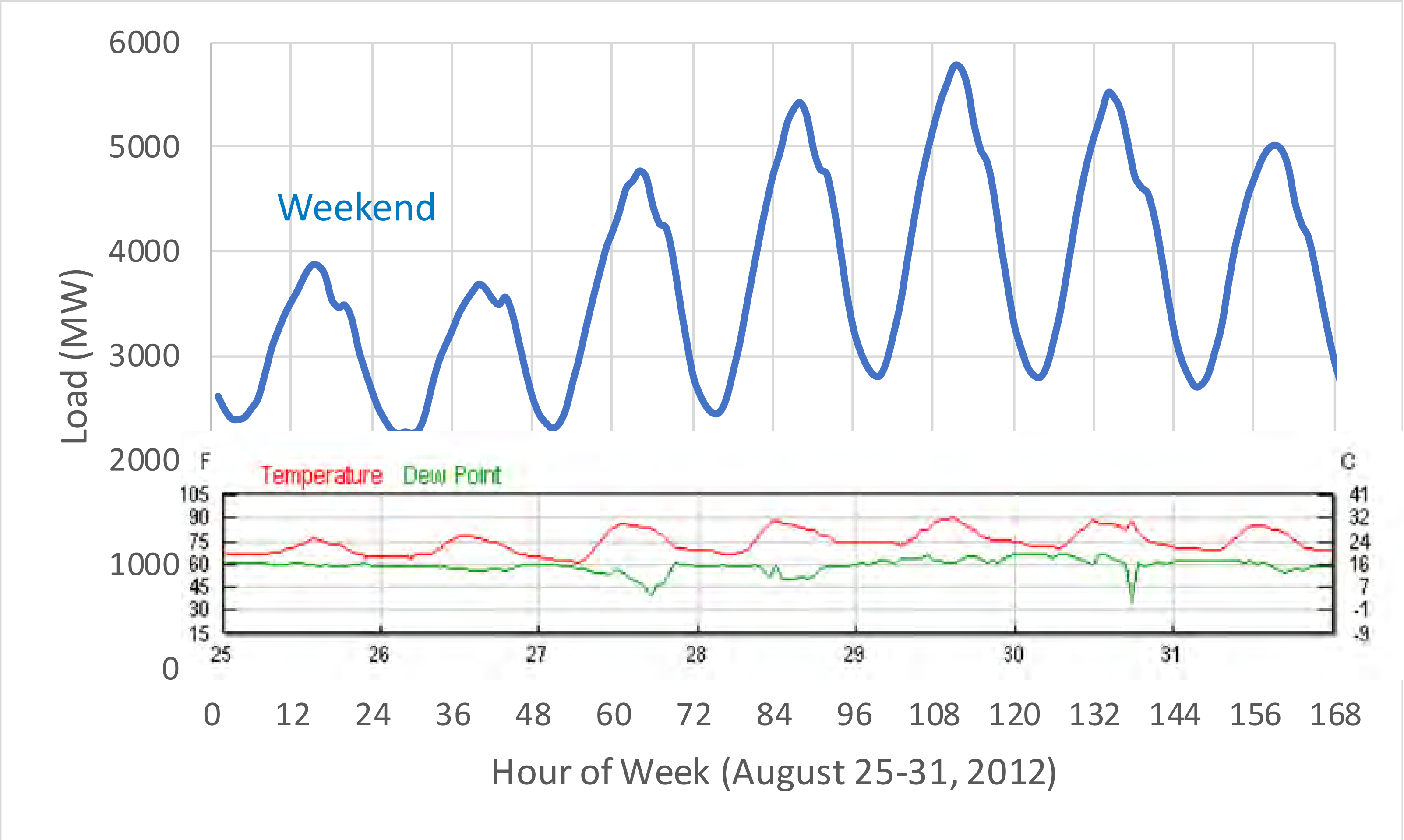
1. Transmission upgrades
2. Wind and Photovoltaic (PV) siting

# Topic #1:Economics of Supply/Demand Mismatch



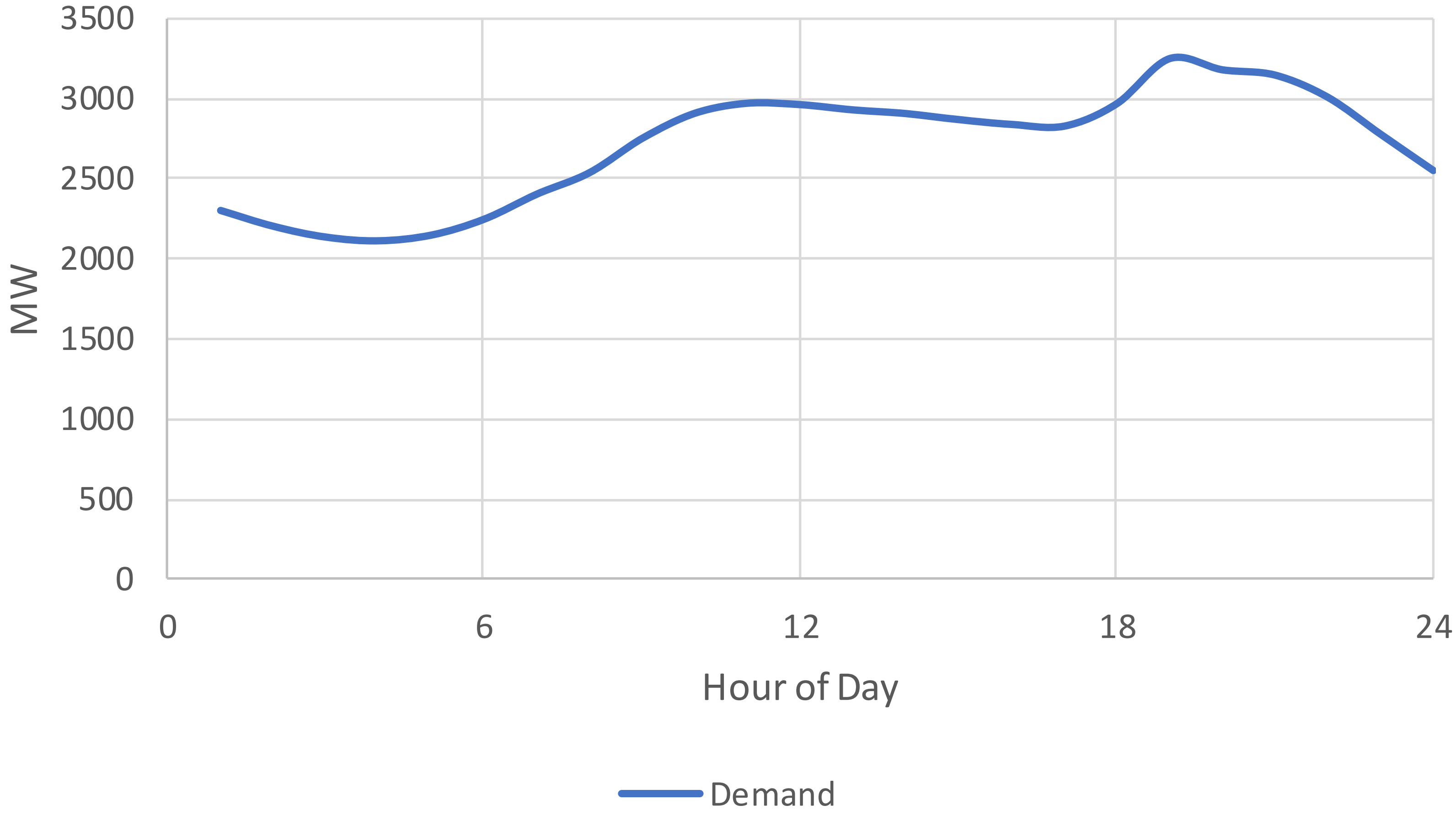

Here is there demand from March 1-7 (a low demand week).

# Topic #1:Economics of Supply/Demand Mismatch



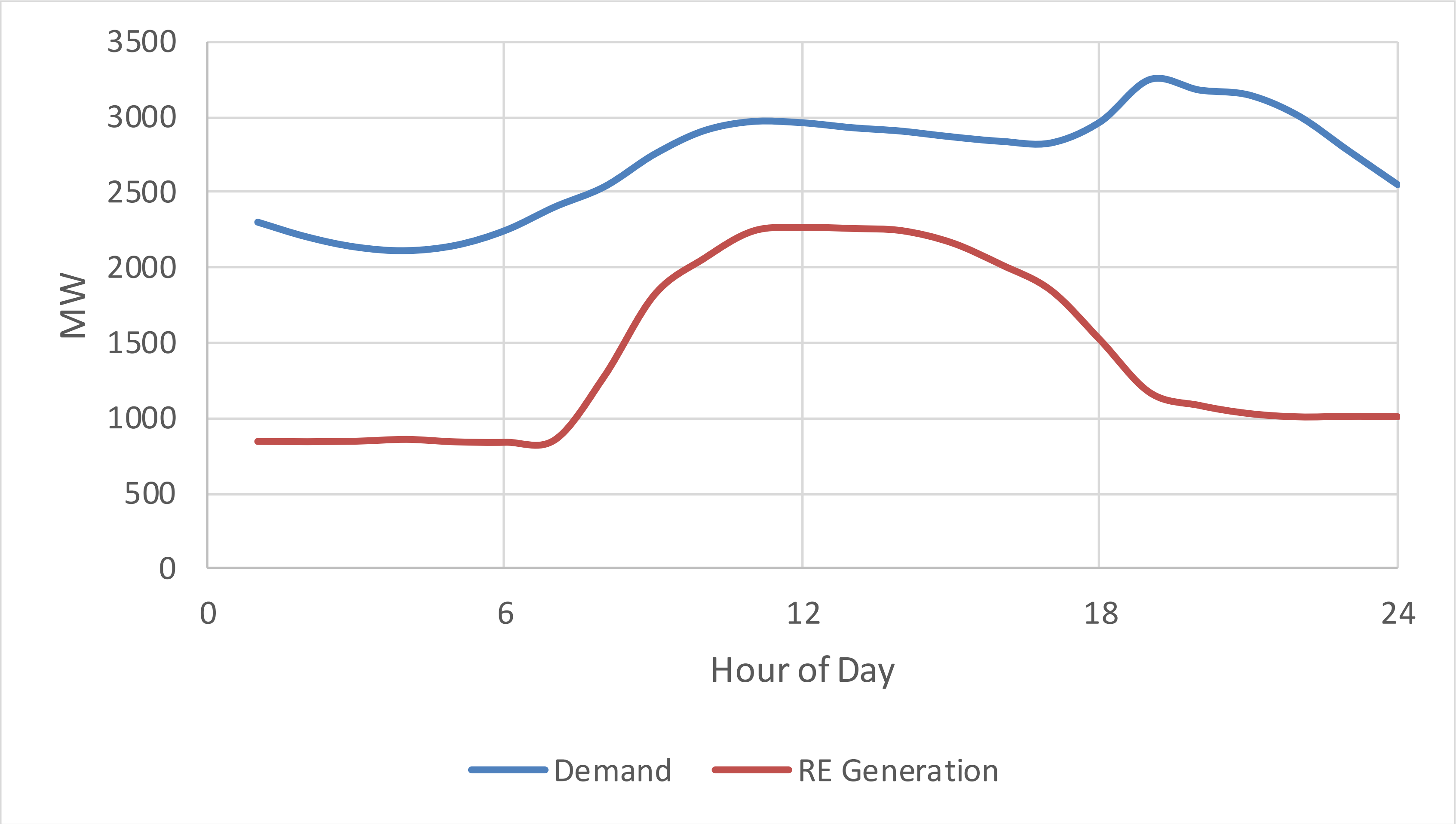

Here is there demand from August 25-31 (the week with highest demand).

# Topic #1:Economics of Supply/Demand Mismatch



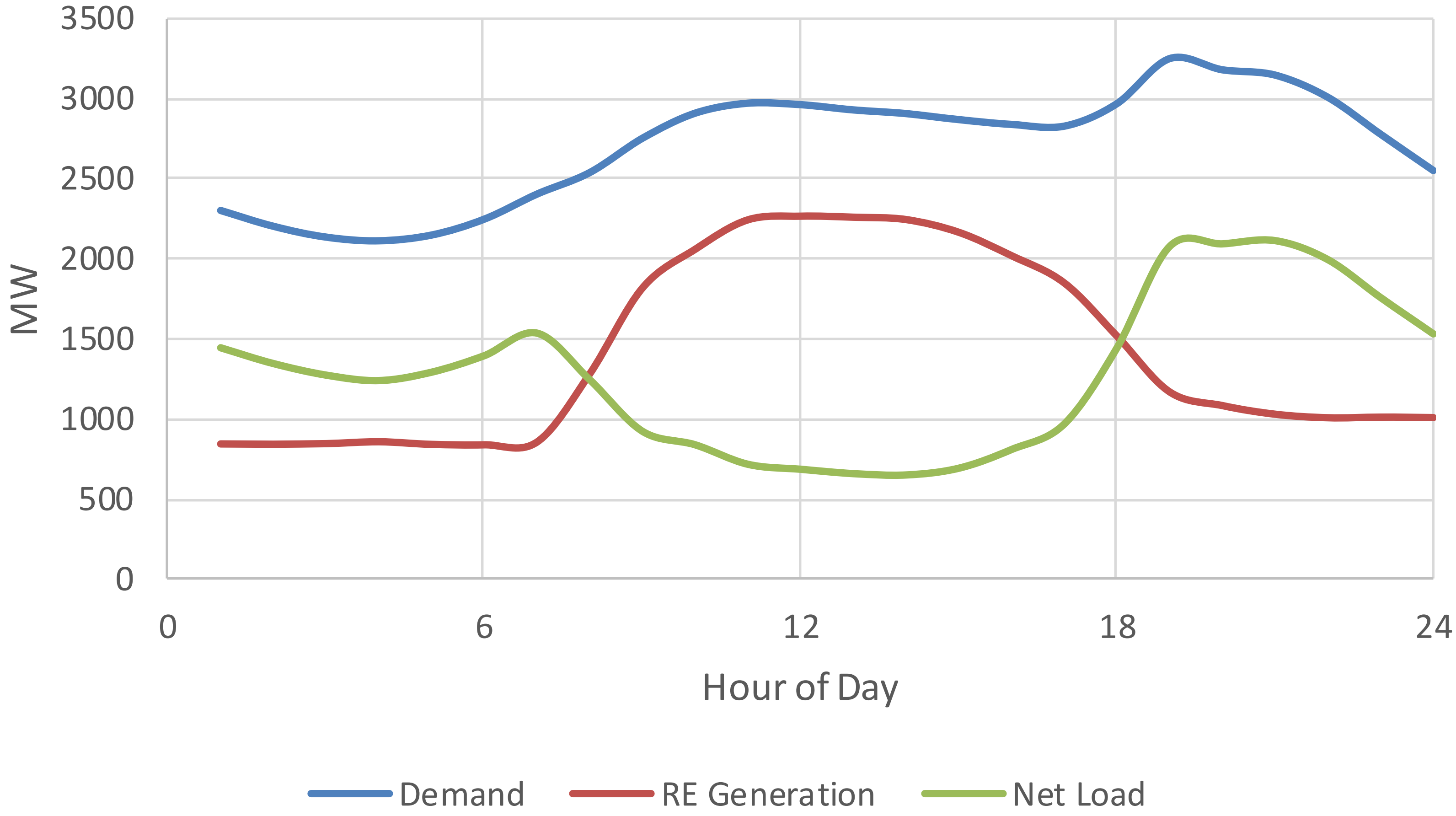

Here is the demand for electricity on Feb 20. This is a typical “low demand” period we see in the spring, or other periods with mild weather.

# Topic #1:Economics of Supply/Demand Mismatch




Here is the supply of renewable energy for this day.

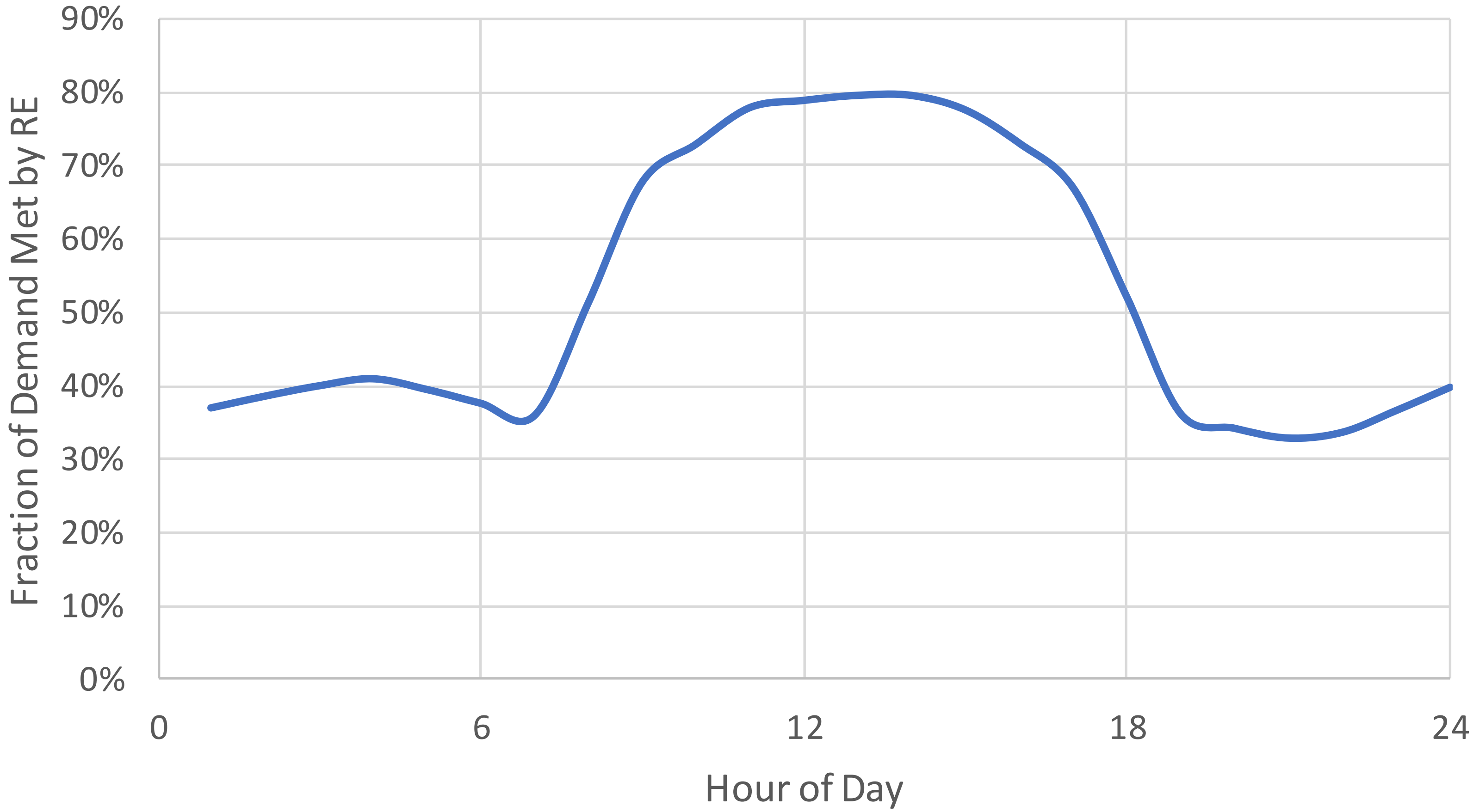
# Topic #1:Economics of Supply/Demand Mismatch




And here is the net demand, or the demand that LADWP must meet with other resources.

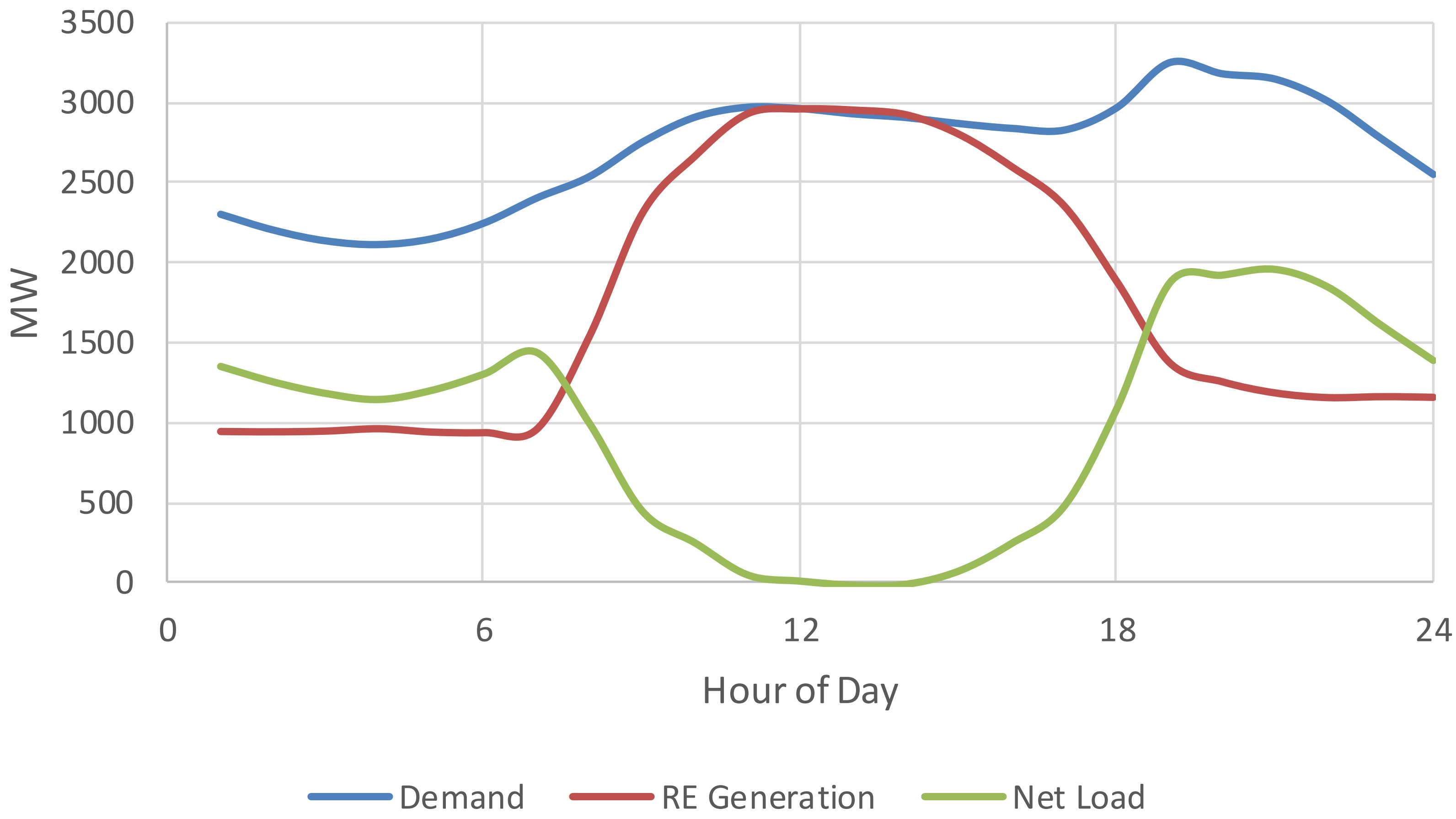
# Topic #1:Economics of Supply/Demand Mismatch

LA DWP



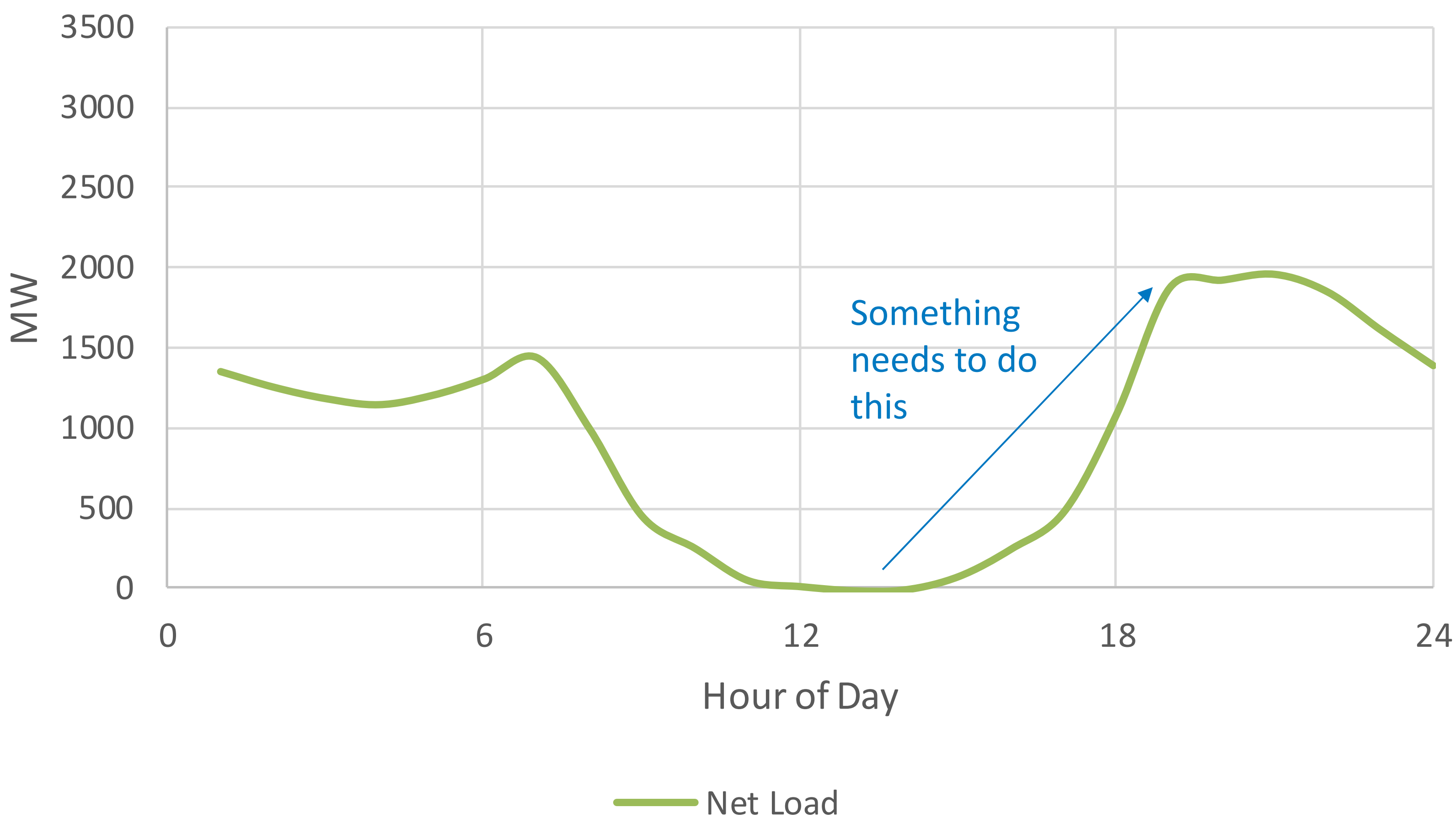

Because the mismatch of supply and demand, the fraction of demand met by RE in each hour varies considerably. Overall the fraction of demand met by RE on this day is 54% (compared to annual average of 40%).

# Topic #1:Economics of Supply/Demand Mismatch



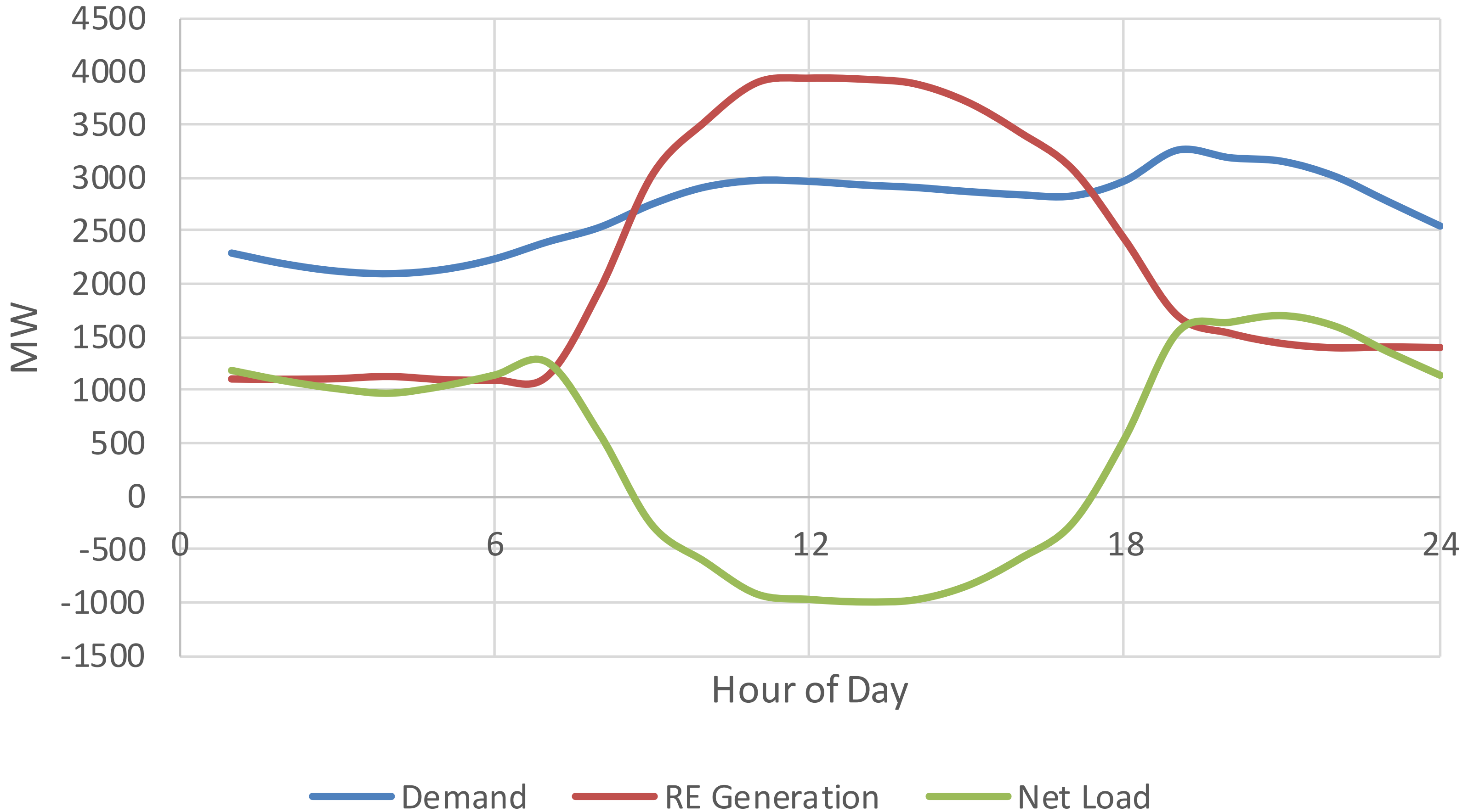

Adding another 300 MW of wind and 600 MW of solar gets us here. We are up to just under 50% annual energy from Renewable Energy (RE). During 1 hour of the day RE now provides 100% of the systems total demand.

# Topic #1:Economics of Supply/Demand Mismatch



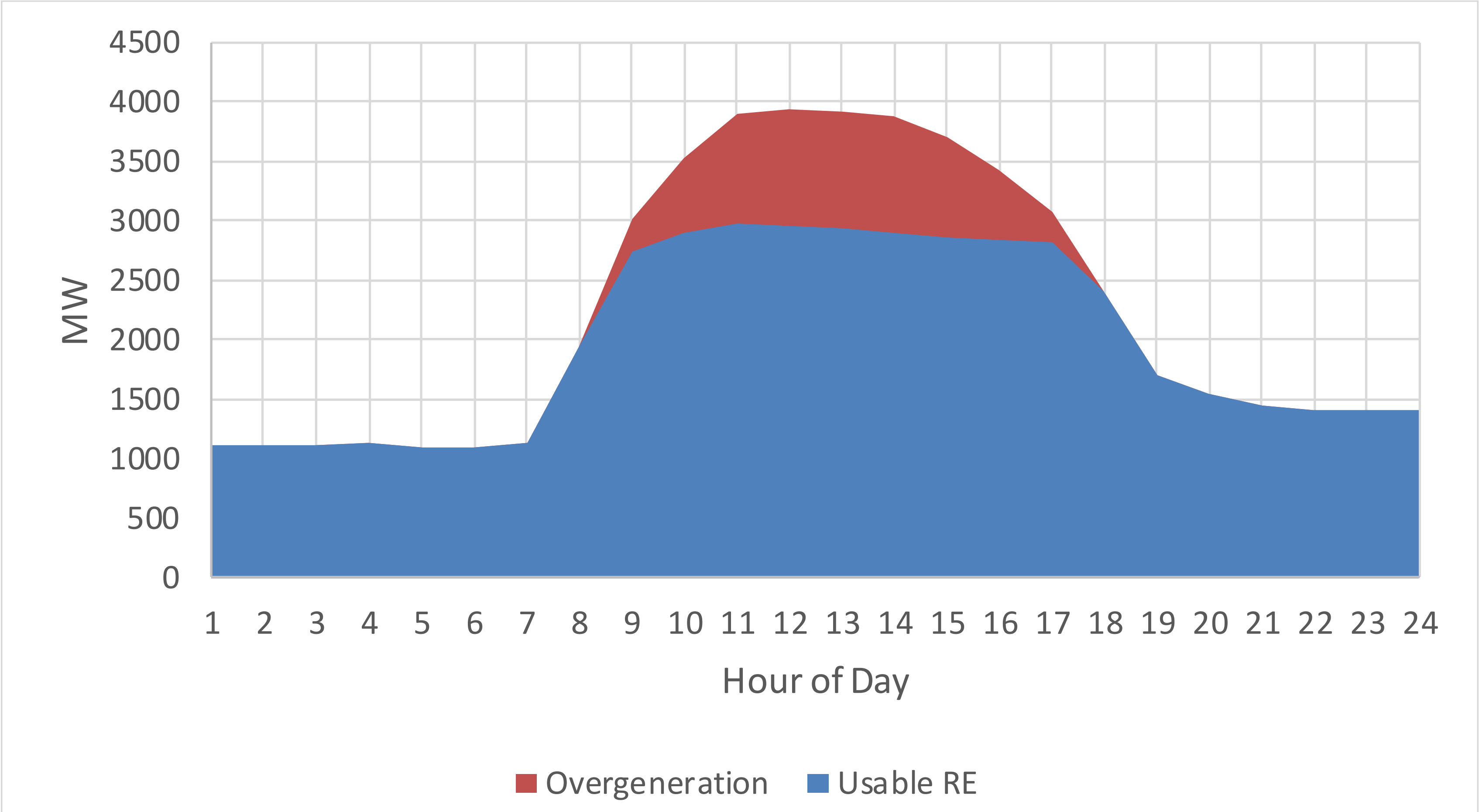

This presents some problems as we transition from a hydro/thermal based system to an all RE based system. Meeting this net load curve would require turning off all of LADWP's power plants for an hour, then turning them back on, and quickly ramping them back up. This isn't really possible, so we probably couldn't accommodate all this RE generation.

# Topic #1:Economics of Supply/Demand Mismatch




Even if we had “perfectly flexible” plants, we still have challenges as we increase RE penetration. Here is a case where we try to get 60% of LADWP’s energy from RE (including 1,800 MW of wind and 2,700 MW of solar). On this day the supply of RE exceeds demand.

# Topic #1:Economics of Supply/Demand Mismatch

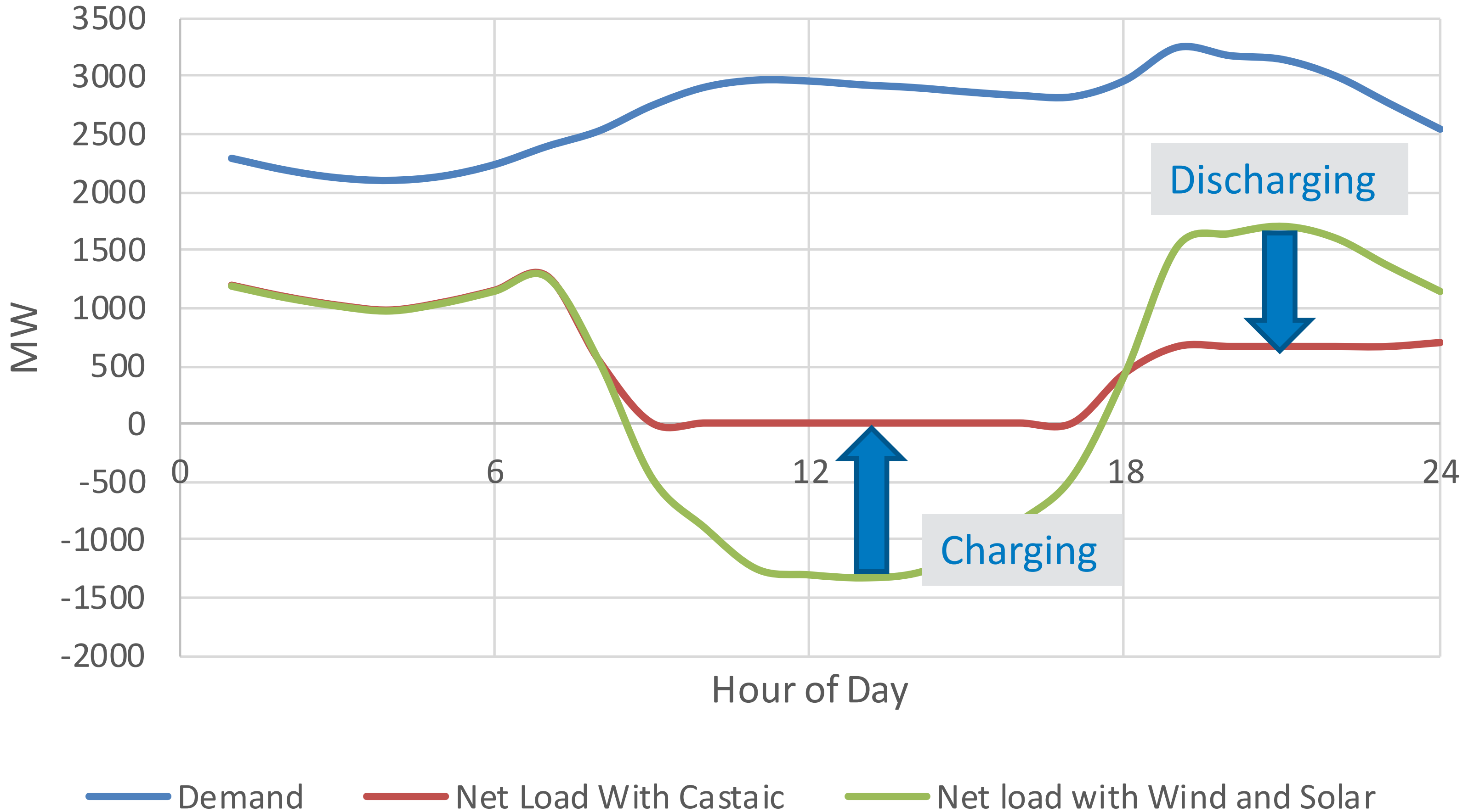



Even if LADWP could reduce the output of all its other generators to zero, it would still need to curtail or sell this surplus energy. This excess supply is sometimes called "overgeneration".

# Topic #1:Economics of Supply/Demand Mismatch

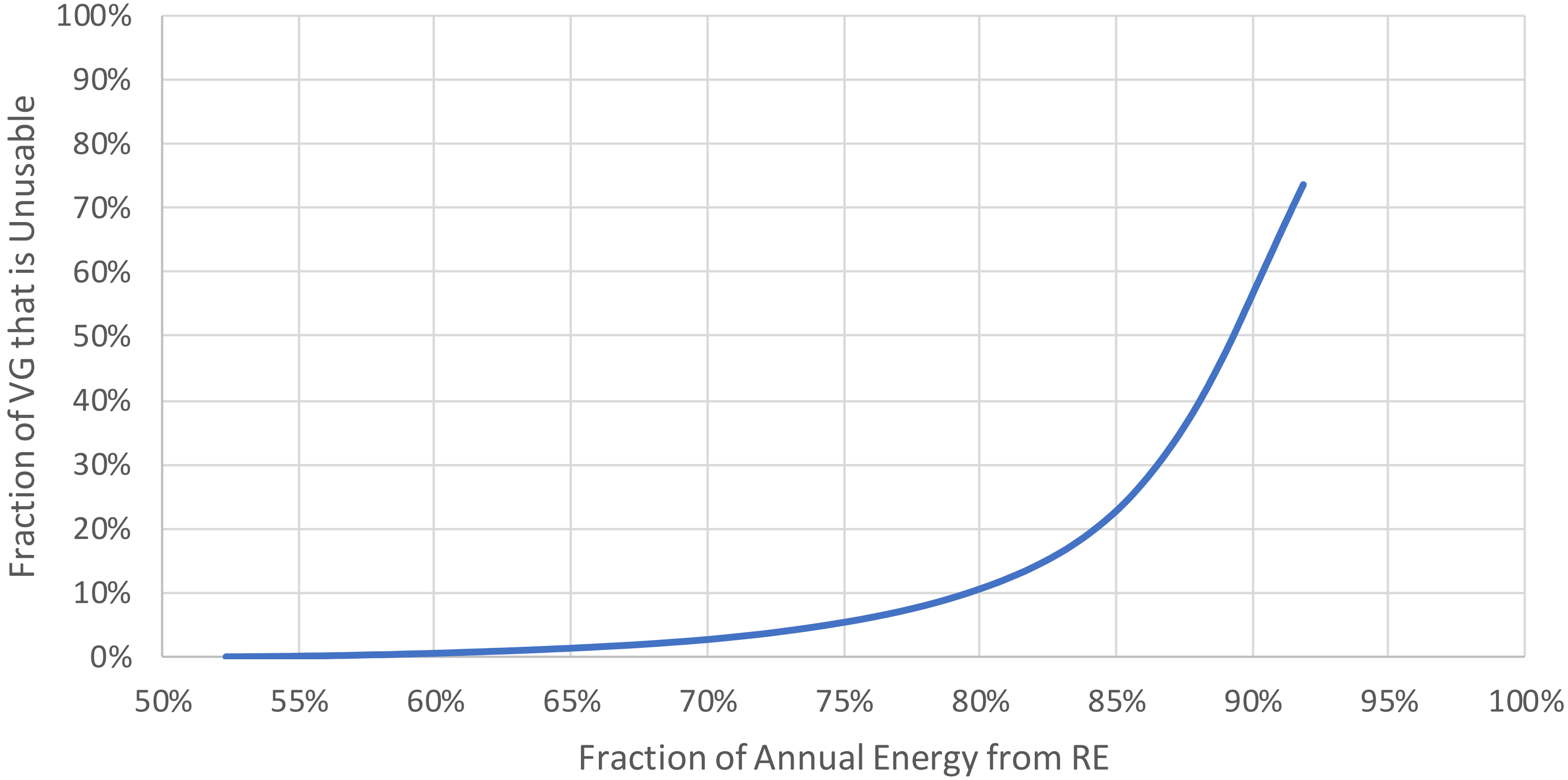
Currently deployed options to deal with overgeneration including storing energy in the Castaic pumped storage plant or selling the energy to its neighbors. Castaic is rated at about 1,175 MW of capacity and is about 70% efficient, meaning it throws away 30% of the energy it stores. Selling energy to neighboring utilities is an important options, but what happens when LA's neighbors are saturated with RE?

# Topic #1:Economics of Supply/Demand Mismatch



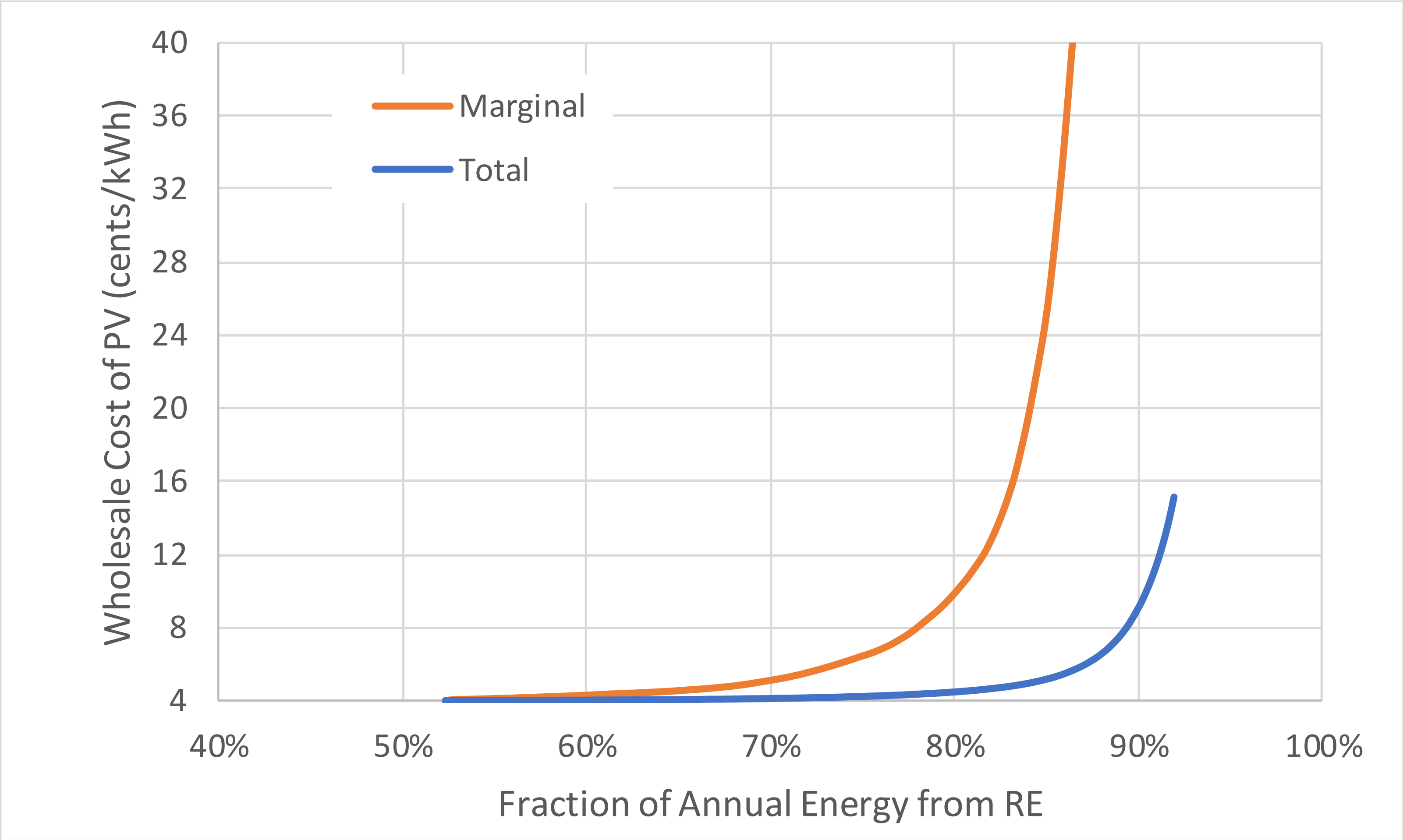

Adding in Castaic eliminates curtailment on Feb 20. But we have just about saturated the power capacity of this storage plant.  More solar on this day will create more overgeneration.

# Topic #1:Economics of Supply/Demand Mismatch



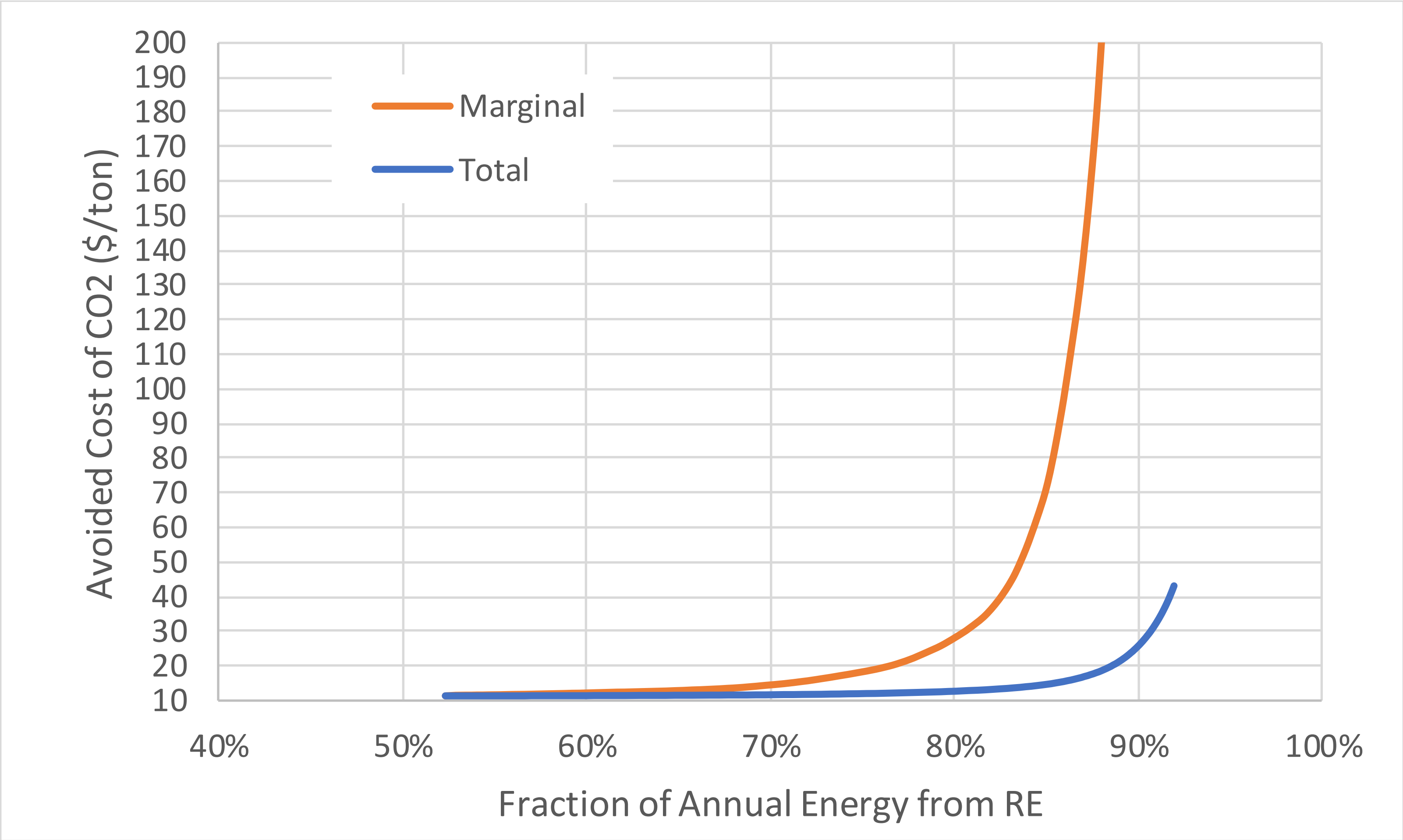

So without more storage or some other mechanism to improve the coincidence of supply and demand, the amount of unusable energy just keeps going up…

# Topic #1:Economics of Supply/Demand Mismatch




If we cannot sell overgeneration to surrounding utilities, find better ways of using RE, or build more storage, here is a rough estimate of what LADWP would have to pay for PV as it moves towards 100% RE.

# Topic #1:Economics of Supply/Demand Mismatch

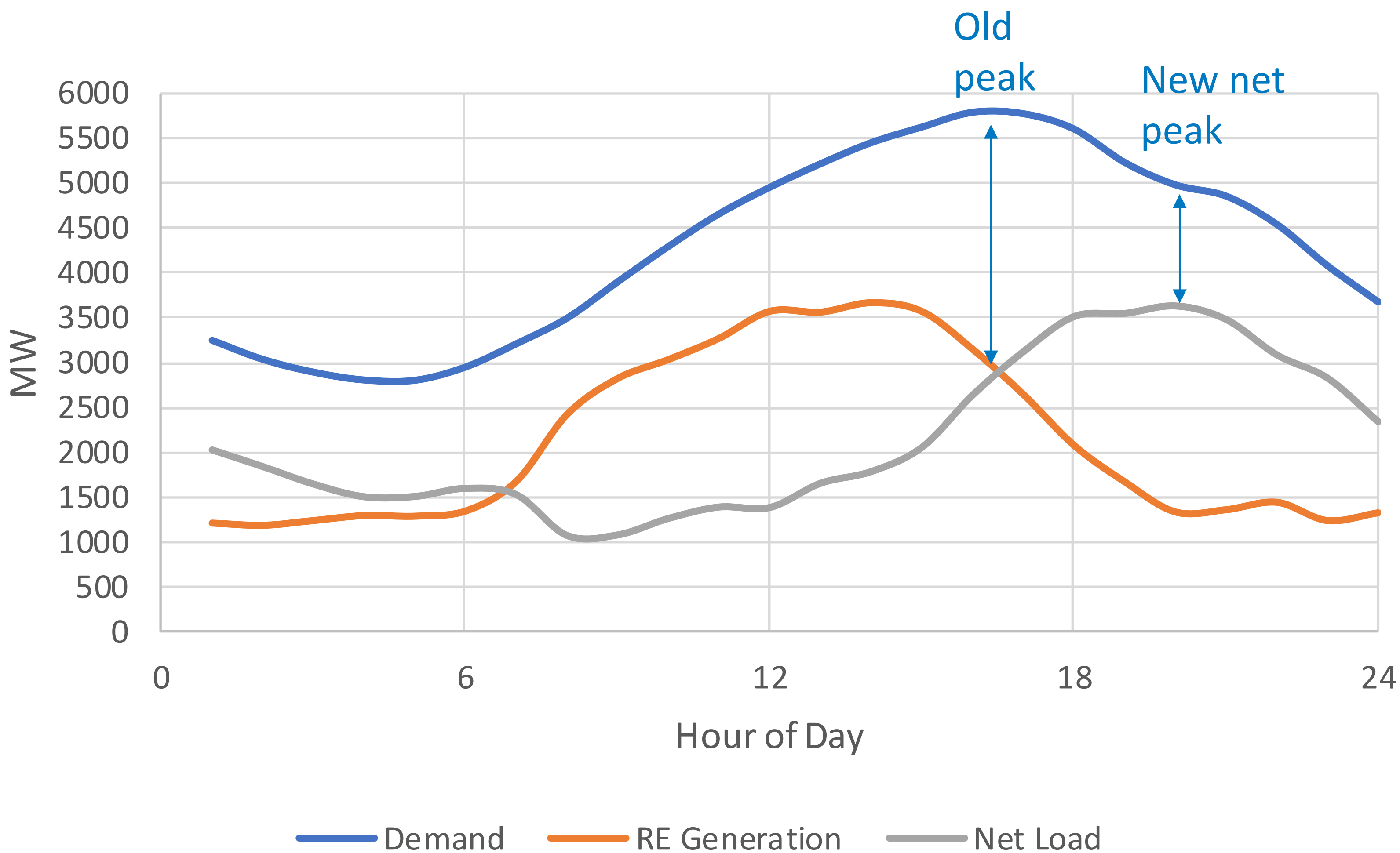



Here is a rough estimate of the avoided cost of CO2 in our base scenario. This assumes that RE avoids $4/MMBTU gas at a 7,500 BTU/kWh average heat rate.

# Before we start talking about solutions….

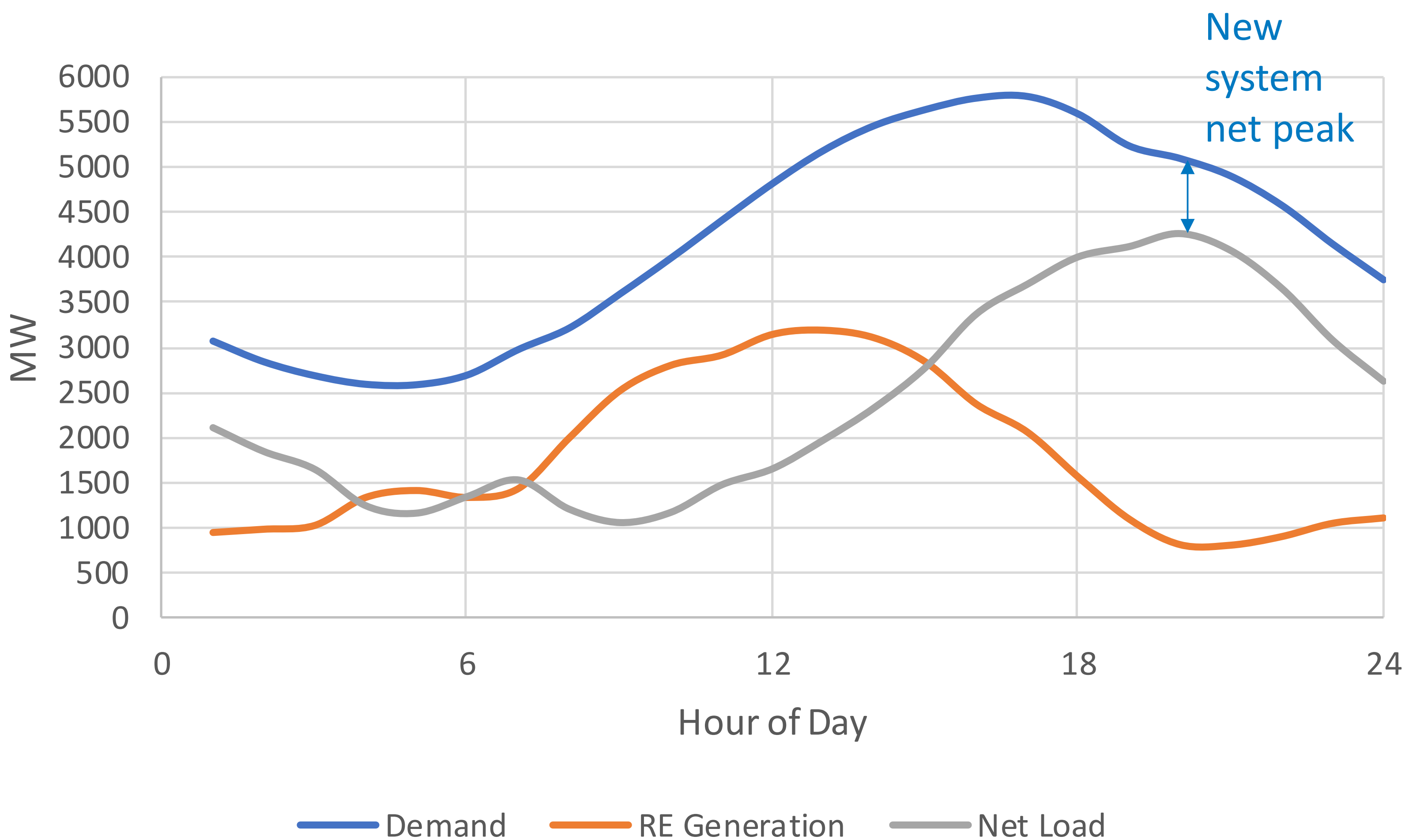
We need to talk about resource adequacy. Because topic two is closely related to topic one. So bear with us and we will get to the fun stuff…..

# Topic #2: Resource Adequacy



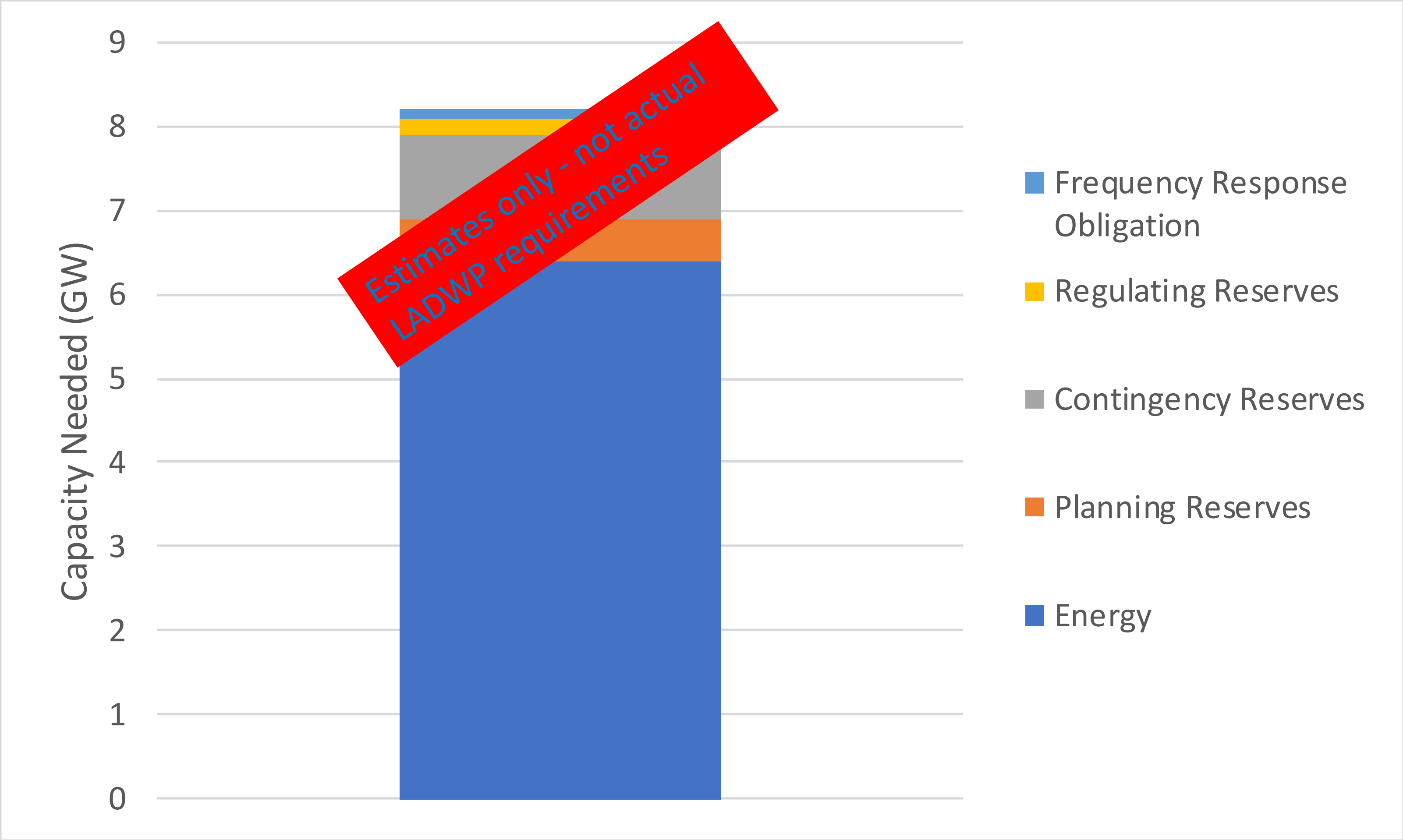

Here is LADWPs peak demand on August 29th in a 65% RE scenario. During the hour of peak demand, we got a decent amount of sun and wind. But the PV shifts the peak demand to later in the day after the sun has set and we still need about 3500 MW of something else.

# Topic #2: Resource Adequacy




Unfortunately, there are other hot days with even less RE supply. Here is September 14th. We have less wind, slightly earlier sunset, and a slightly later peak. Our 5,000 MW of wind and solar capacity is producing less than 500 MW and our net peak demand is over 4,000 MW. Even with Castaic, we need about 3,000 MW of additional capacity.

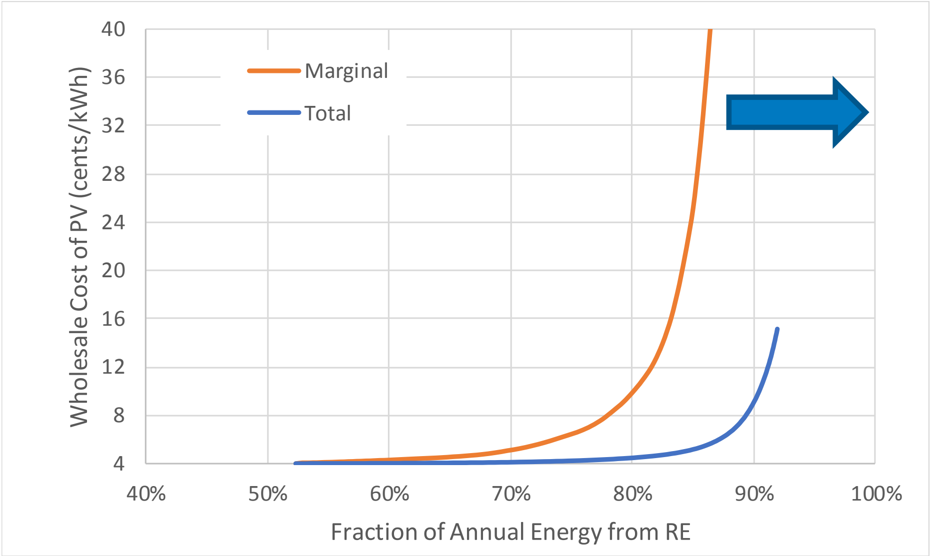
# Topic #2: Resource Adequacy



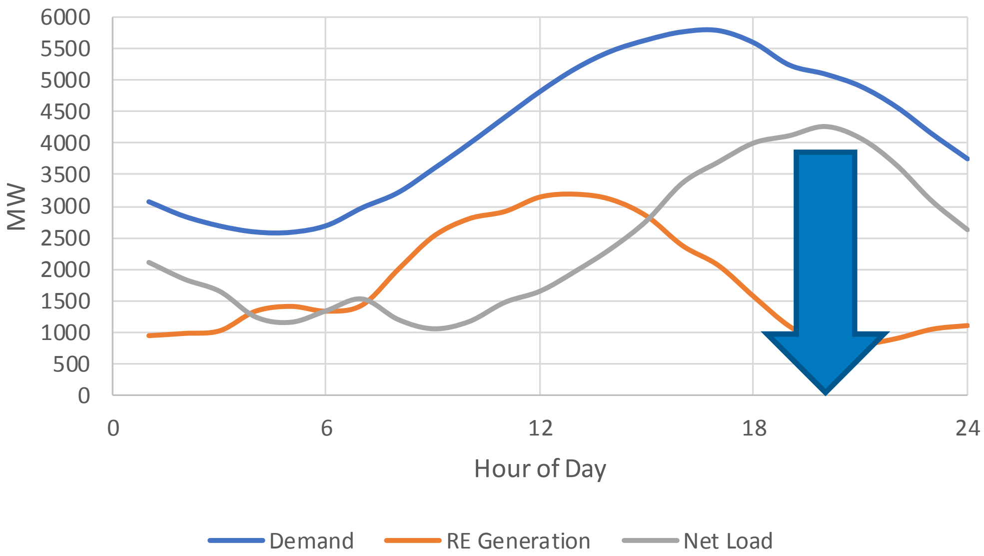

And LADWP also needs to plan around outages of their transmission network and generation resources. This means even more “firm” capacity is needed during the hours of peak demand. This capacity is unlikely to be provided from wind and solar, because as we have shown, there is relatively little solar and wind available during the hours of peak demand.

# Finding Solutions

This study is about finding solutions and understanding the technical and economic challenges of 100%. We need to find a mix of resources that shift the cost curve and meet the economic challenges…

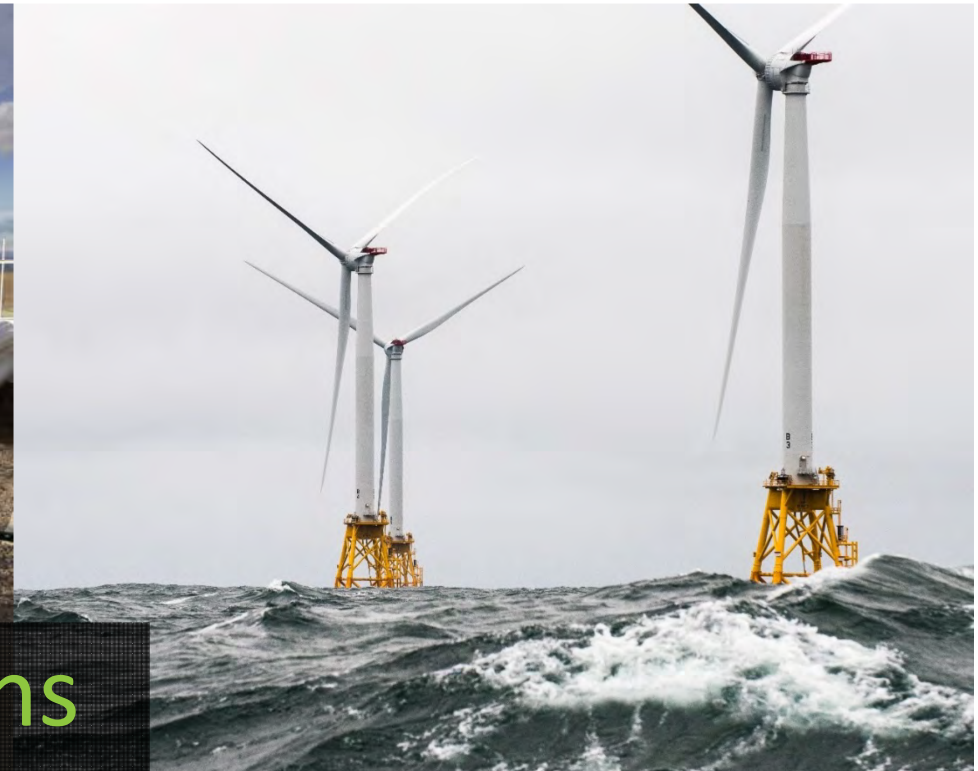



And find a mix of resources that will meet the demand for reliable energy during all hour of the year.



# We pioneer

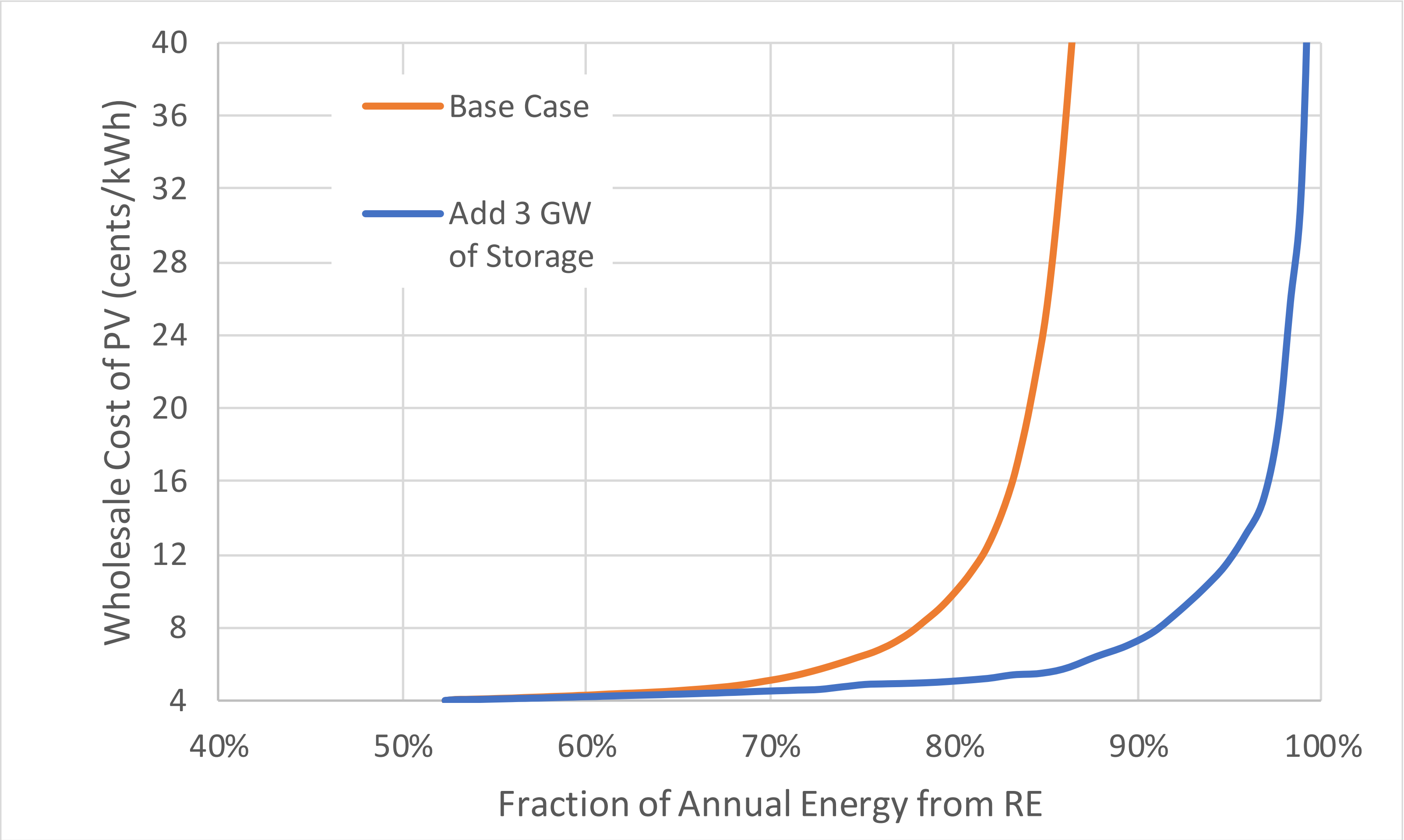
# Engineering solutions



# Possible Solutions

- Dispatchable renewables
- Spatially diverse wind and solar resources
- Demand response/load shifting
- Energy storage
- Net energy exchanges
- Controlled Electric Vehicle (EV) charging

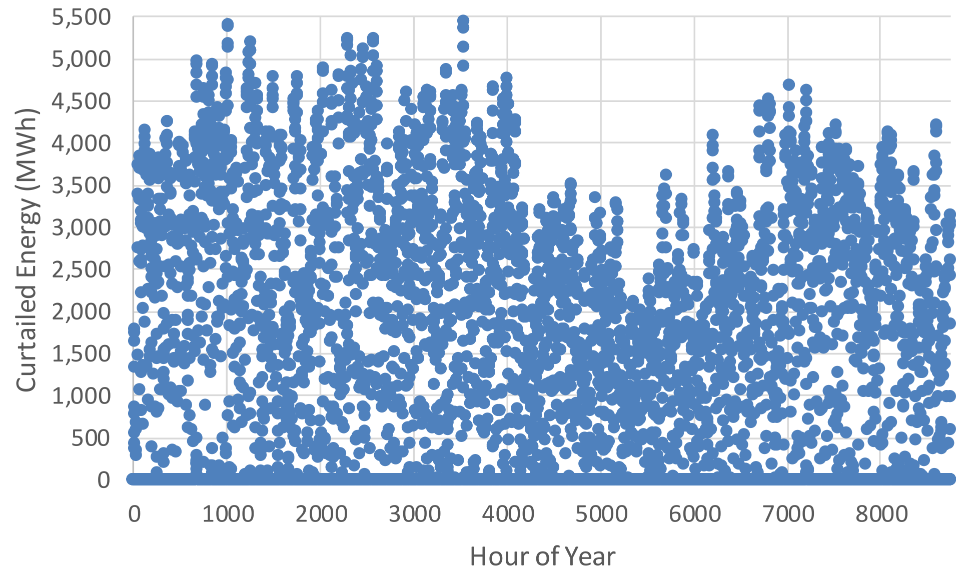
# Example: Storage and Load Shifting



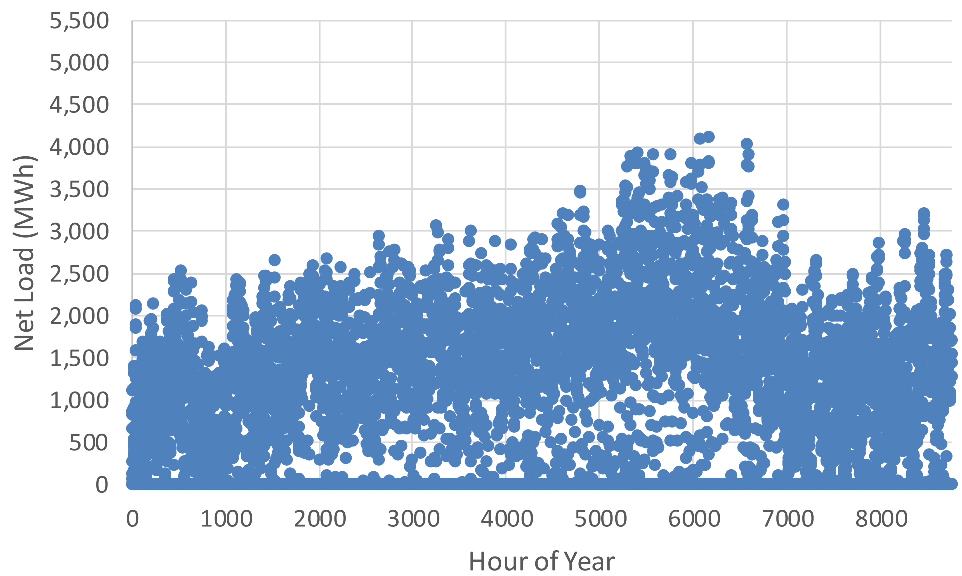

Here is an very simple example where adding 3 GW of battery storage gets us along way. But it doesn't get us all the way, and adding more batteries has very rapidly diminishing returns due to the seasonal mismatch problem.

# Managing the Seasons

Here is the curtailed energy in a system where we have built enough RE capacity to meet 100% of annual demand. We haven't added any storage or included Castaic.



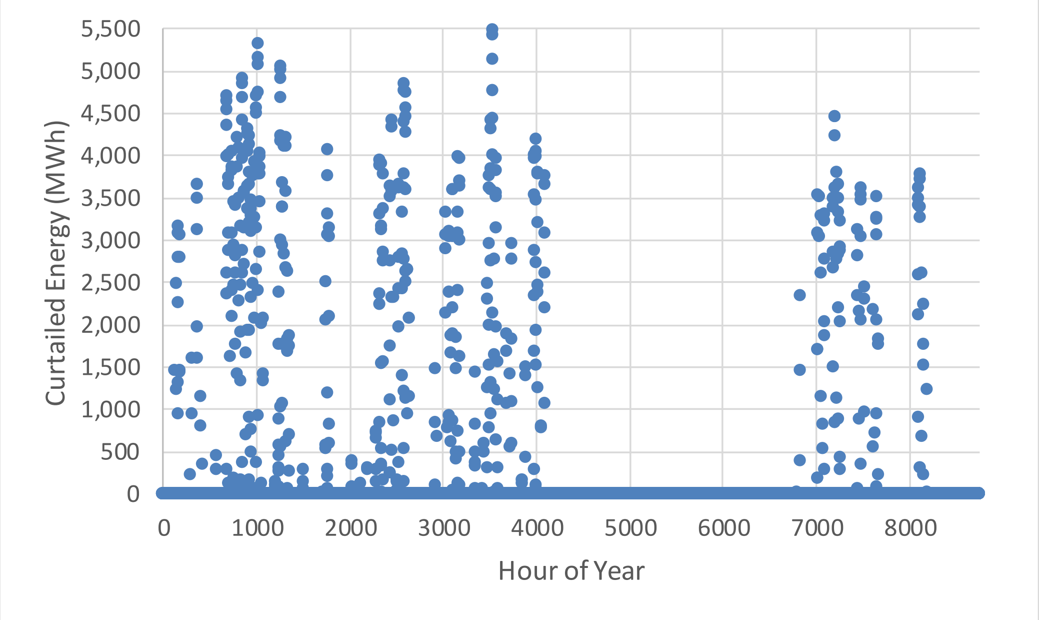

Here is the net load (the amount of demand left over that would need to be met with storage or something else).




Now lets see what happens when we ad Castaic and another 3 GW of batteries….

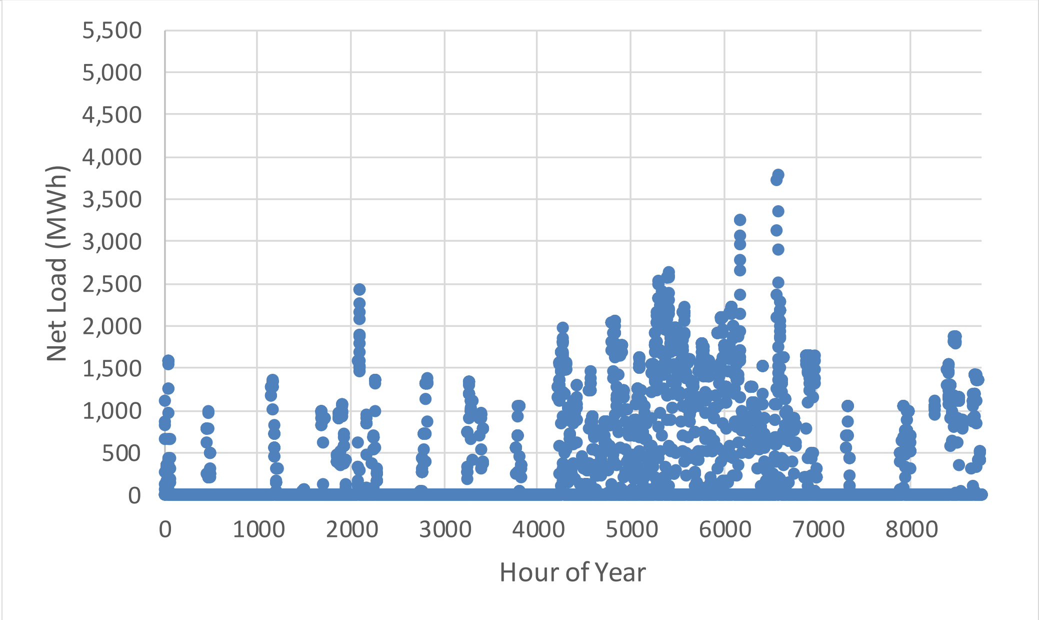
# Managing the Seasons

We have completely absorbed all the curtailed energy in the summer.  We still have some left in the spring.

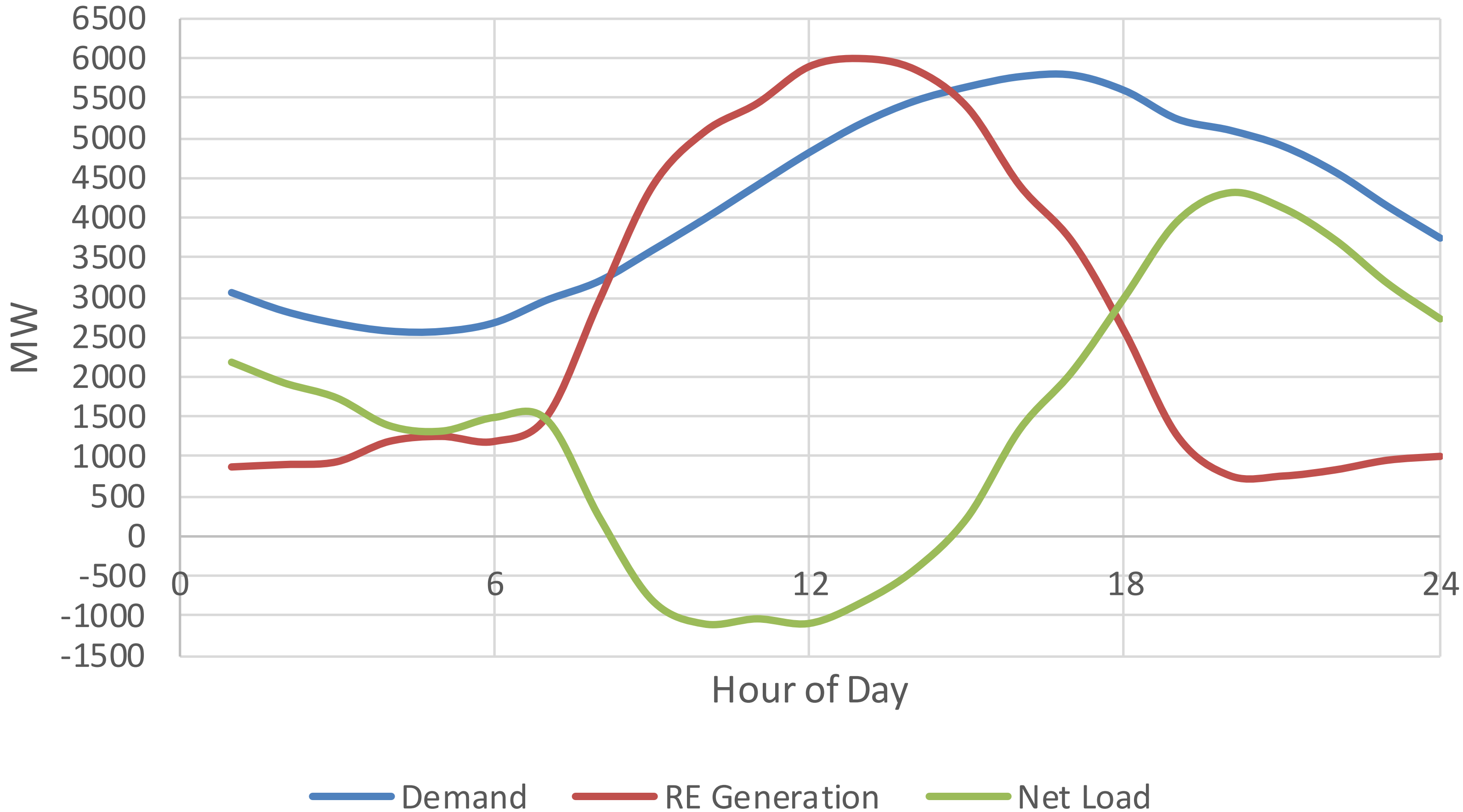



And we still have significant demand left in the summer.

So more short duration storage won’t help.  Let’s look at a peak day to look at this another way.

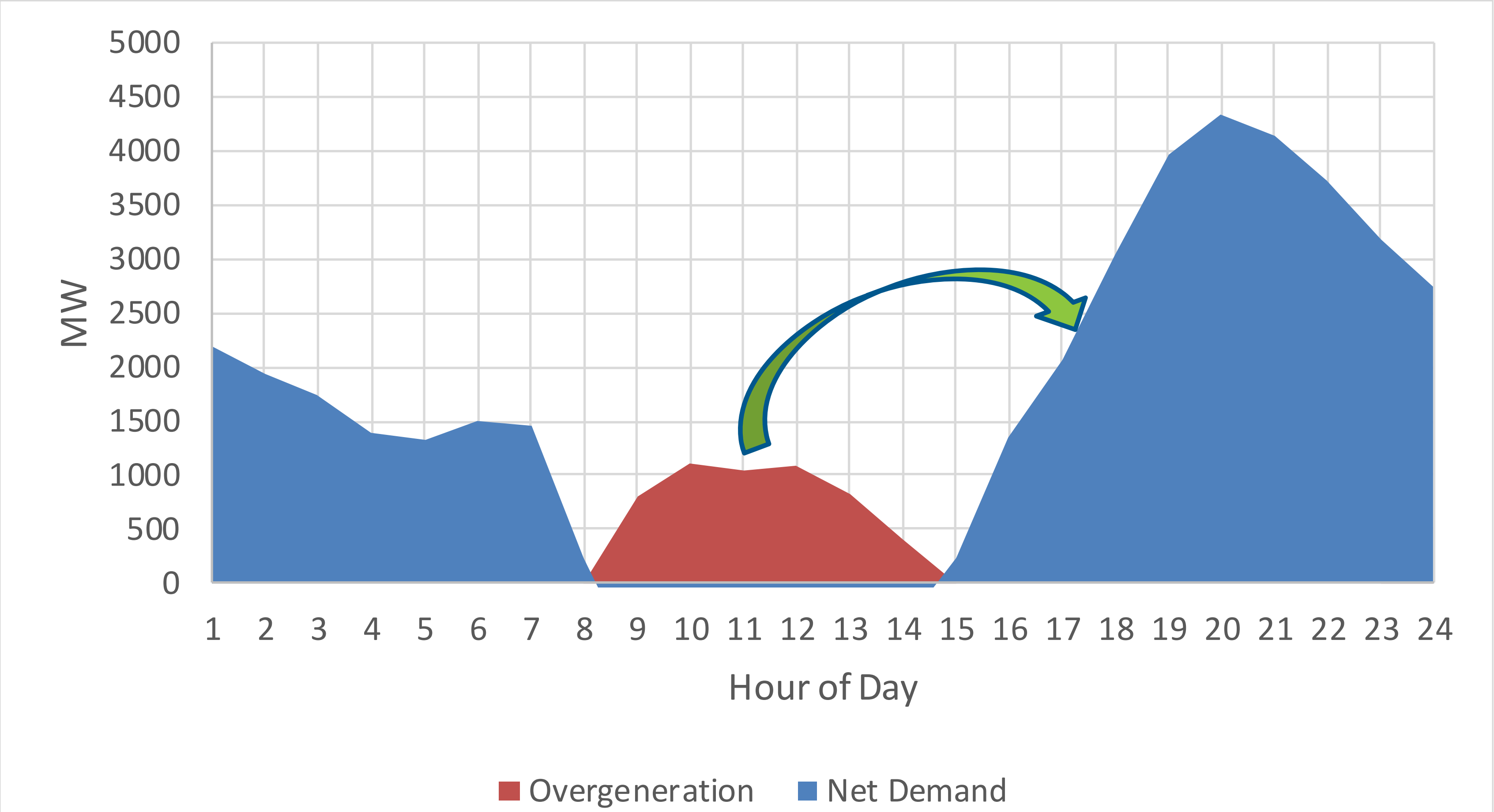


# Managing the Seasons




Here is a very high demand day in a case where we have built enough RE to meet 100% of demand. Our net load peaks at about 4,300 MW. So our storage case (Castaic plus 3 GW of batteries) could provide us almost enough capacity to meet the energy requirements. This ignores reserve requirements, so we do NOT have a reliable system.

# Managing the Seasons




But even with storage, there just isn't enough RE to shift. This means that load shifting doesn't solve the problem either. We simply have too much demand overall on this day. We could build more solar, but we don't need more energy during most of the year, so it would just be wasted during fall through spring.

# Possible Solutions

- Energy efficiency (targeted towards summer loads)
- Power to gas, hydrogen or other fuel production
- Bioenergy
- Net energy exchanges

# Key Take-aways

- There are fundamental economic and technical considerations for achieving a 100% power system.
- These are mostly centered around the mismatch of renewable supply and demand.
  - We need to address both the daily mismatch AND the seasonal mismatch.
- This study will examine the host of flexibility options which can minimize the cost impacts of achieving very high levels of RE.
- This overview has ignored many of the technical and engineering issues associated with designing, modeling and analyzing a 100% RE power system. However the study will address them in detail, and we will be doing a deep dive on many of them at future meetings.

# Discussion

# Thank you!

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Los Angeles Department of Water & Power

NATIONAL RENEWABLE ENERGY LABORATORY

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LA DWP

# LA100: Draft Scenarios
May 15, 2018

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

# Revisiting the Motions: March 2nd, 2016

"The city has an opportunity to re-create its utility in a way that recognizes the **potential for a fossil-free future**, demonstrates **global leadership** in its commitment to clean energy, and **protects ratepayers** from the increasing costs of carbon-based fuels."

"[T]he Council request that Los Angeles Department of Water and Power report with a program to develop and implement a research partnership…**with the objective of determining what investments should be made to achieve a 100% renewable energy** portfolio for the LADWP."

# Revisiting the Motions: September 16th, 2016

"[T]he Council request that the LADWP....**examine**, over the course of the research into a 100% renewable portfolio, **the potential for high quality careers and equitable local economic development**, including local hiring programs for work that must be performed to modernize the electric system infrastructure.."

# Revisiting the Motions: **August 1st, 2017**

"…incorporate into its research efforts the following:

a. An analysis by the Rate Payer Advocate on how each scenario fits within the **current rate structure** to **include the impact, if any, each scenario would have on low income customers**.

b. Incorporation of the **CalEnviro Screen into each research area**, and as the context for any analysis, study, and/or recommendation.

c. The prioritization of **environmental justice neighborhoods** as the **first immediate beneficiaries of localized air quality improvements and greenhouse gas reduction**."

# Goals of Scenarios

# Address full suite of questions and issues raised in the City Council Motions

- **Broad objective**: determine what investments should be made to achieve a 100% renewable energy
- Examine the impacts on **local jobs and economic development**
- Understand the **electricity rate, air quality, and health impacts of achieving a 100% renewable system; identify environmental justice neighborhoods to be first beneficiaries of improvements**

# Consider the full suite of options for achieving 100%

## Demand-side:

- Demand response, end-use efficiency, and electrification

## Supply-side:

- Renewable generation (utility scale and distributed), existing nuclear, fossil with carbon capture and storage, existing hydro

## Financial mechanisms:

- Renewable energy credits (RECs), greenhouse gas allowances

# Robust

- To current trends, plans, policies, and regulations…
- To a broad set of future conditions/uncertainties
  - Evolution of load—efficiency, flexibility (DR), and electrification
  - Balance between centralized and distributed supply
  - Ability to develop additional transmission & distribution

# Incorporates AG Feedback on Preliminary Scenarios

LA DWP

| | | 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* |

Draft scenarios presented at the February 15th, 2018 Advisory Group Meeting

# Summary of AG Feedback

- Accelerated compliance
- Financial vs physical compliance
- Carbon neutral, combustion free, or 100% renewable
- Detailed reporting of assumptions and exogenous inputs
- Current policies, plans, and initiatives reflected in load forecasts
- Interim targets—when do we reach 70, 80, 90%?
- Equity implications
- Environmental impacts beyond $CO_2$
- Regionalization/further participation with the Western EIM and CAISO

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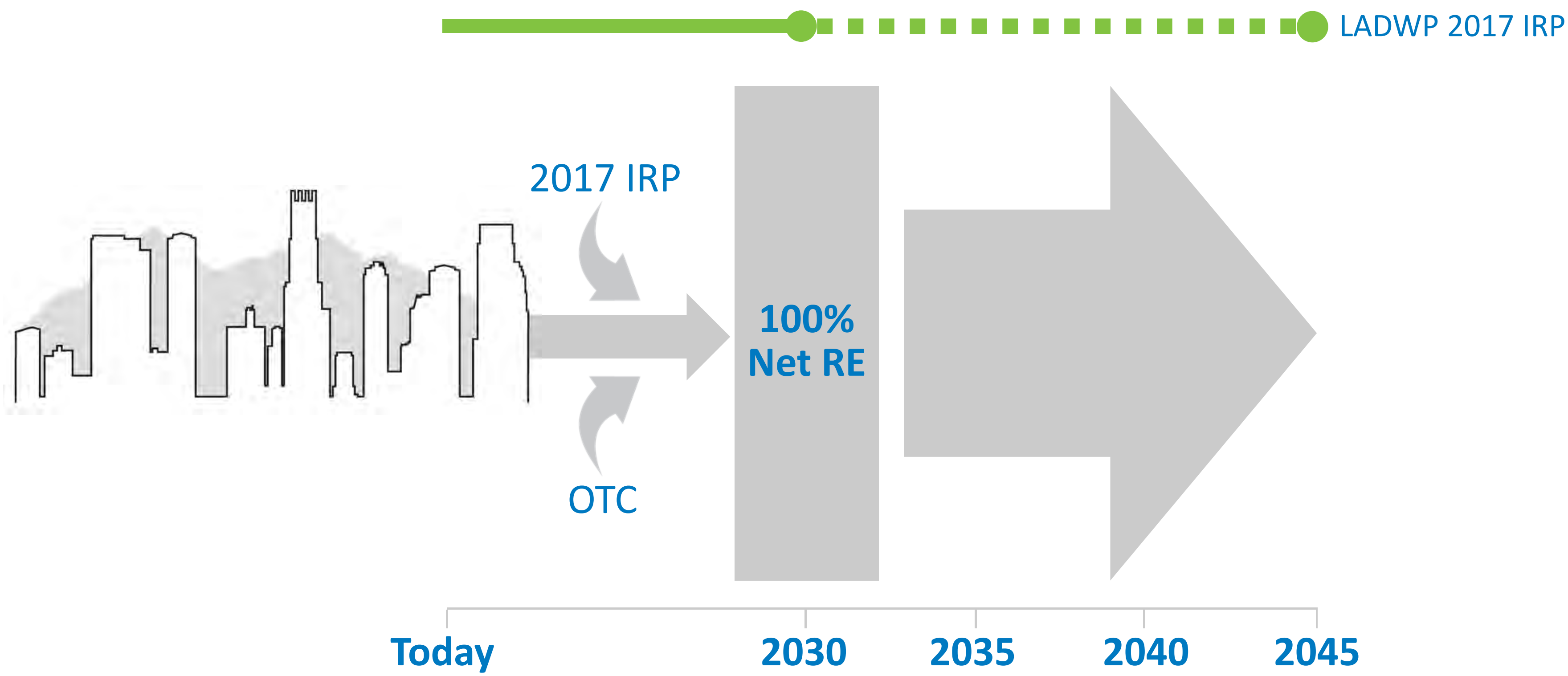
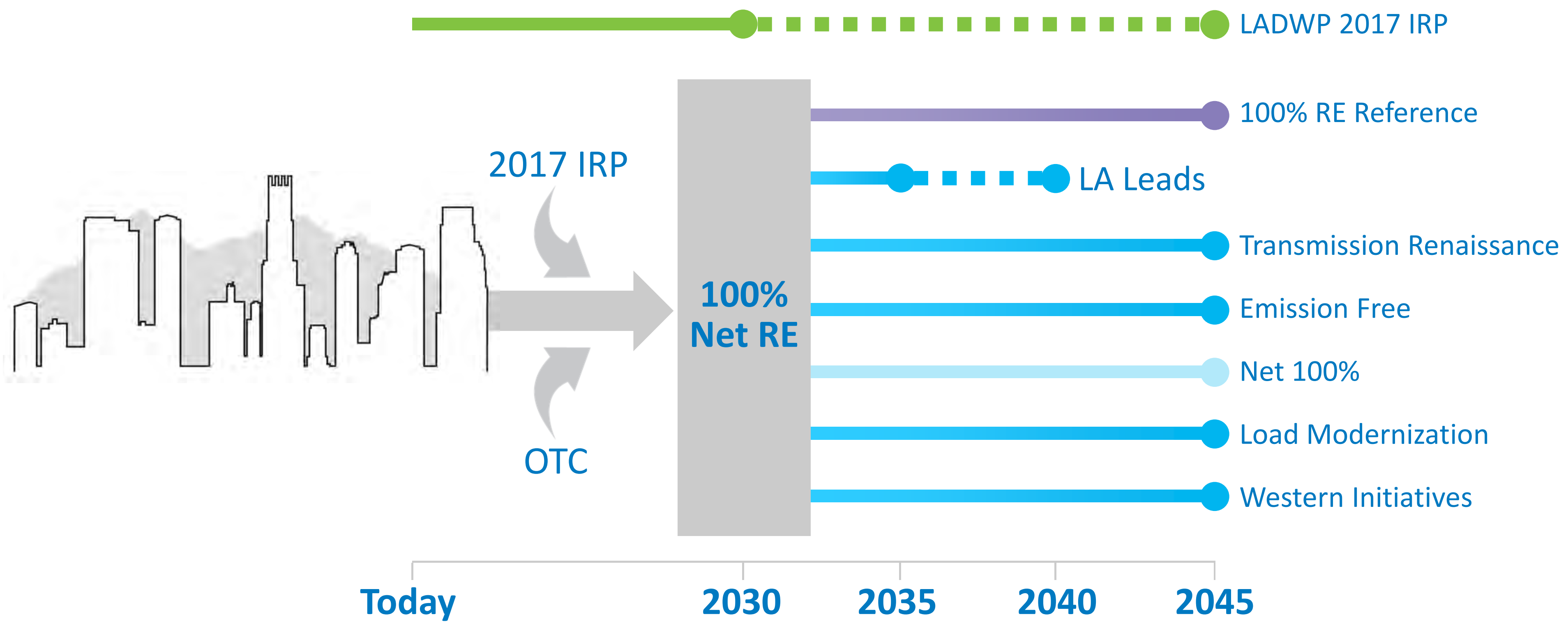
# Scenario Framework



# Scenario Framework



# Revised Scenarios—Comment Mapping

| | Scenarios | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Comment** | **LADWP 2017 IRP *Recommended Case*** | **100% Renewable Reference Case** | **LA-Leads** | **Transmission Renaissance** | **Limited Transmission** | **Emissions Free** | **Net 100%** | **Load Modernization** | **Western Initiatives** |
| **Accelerated Compliance** | | | √ | | | | | | |
| **Interim Targets** | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| **Financial vs Physical Compliance** | | √ | | | | | √ | | |
| **Current Policies, Plans, and Intiatives** | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| **Detailed Reporting** | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| **Current Policies, Plans, and Intiatives** | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| **Equity Implications** | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| **Environmental Impacts Beyond CO2** | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| **Regionalization, EIM, CAISO** | | | | | | | | | √ |

*All scenarios achieve net 100% renewable by 2030

# Scenario Matrix

LA DWP

| | | LADWP 2017 IRP *Recommended Case* | 100% RE Reference | LA-Leads | Transmission Renaissance | Limited Transmission | Emissions Free | Net 100% | Load Modern-ization | Western Initiatives |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Compliance Year:** | -- | 2045 | 2035/2040 | 2045 | 2045 | 2045 | 2045 | 2045 | 2045 |
| **Technol-ogies Eligible in the Compliance Year** | **Biomass** | Matches 2017 IRP Technology Mix | Y | Y | Y | Y | N | Y | Y | Y |
| | **Biogas** | | Y | Y | Y | Y | N | Y | Y | Y |
| | **Electricity to Fuel (e.g. H2)** | | Y | Y | Y | Y | Y | Y | Y | Y |
| | **Fuel Cells** | | Y | Y | Y | Y | Y | Y | Y | Y |
| | **Hydro - Existing** | | Y | Y | Y | Y | Y | Y | Y | Y |
| | **Hydro - New** | | N | N | N | N | N | N | N | N |
| | **Hydro - Upgrades** | | Y | Y | Y | Y | Y | Y | Y | Y |
| | **Natural Gas** | | N | N | N | N | N | Y | N | N |
| | **Nuclear - Existing** | | N | Y | N | N | Y | Y | N | N |
| | **Nuclear - New** | | N | N | N | N | N | N | N | N |
| | **Wind, Solar, Geo** | | Y | Y | Y | Y | Y | Y | Y | Y |
| | **Storage** | | Y | Y | Y | Y | Y | Y | Y | Y |
| **DG** | **Distributed Adoption** | Reference | Balanced | High | Low | High | Balanced | Balanced | Balanced | Balanced |
| **RECS** | **Financial Mechanisms (RECS/Allowances)** | - | N | N | N | N | N | Yes | N | N |
| **Load** | **Energy Efficiency** | Reference | Moderate | High | Moderate | High | Moderate | Moderate | High | Moderate |
| | **Demand Response** | Reference | Moderate | High | Moderate | High | Moderate | Moderate | High | Moderate |
| | **Electrification** | Reference | Moderate | High | Moderate | High | Moderate | Moderate | High | Moderate |
| **Trans-mission** | **New or Upgraded Transmission Allowed?** | Matches 2017 IRP | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors | New Corridors Allowed | No New Transmission | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors |
| **WECC** | **WECC VRE Penetration** | Reference | Reference | Reference | Reference | Reference | Reference | Reference | Reference | High |

*All scenarios achieve net 100% renewable by 2030

# Scenario Matrix

| | | LADWP 2017 IRP *Recommended Case* | 100% RE Reference | LA-Leads | Transmission Renaissance | Limited Transmission | Emissions Free | Net 100% | Load Modern-ization | Western Initiatives |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Compliance Year:** | -- | 2045 | 2035/2040 | 2045 | 2045 | 2045 | 2045 | 2045 | 2045 |
| **Technol-ogies Eligible in the Compliance Year** | Biomass | Matches 2017 IRP Technology Mix | Y | Y | Y | Y | N | Y | Y | Y |
| | Biogas | | Y | Y | Y | Y | N | Y | Y | Y |
| | Electricity to Fuel (e.g. H2) | | Y | Y | Y | Y | Y | Y | Y | Y |
| | Fuel Cells | | Y | Y | Y | Y | Y | Y | Y | Y |
| | Hydro - Existing | | Y | Y | Y | Y | Y | Y | Y | Y |
| | Hydro - New | | N | N | N | N | N | N | N | N |
| | Hydro - Upgrades | | Y | Y | Y | Y | Y | Y | Y | Y |
| | Natural Gas | | N | N | N | N | N | Y | N | N |
| | Nuclear - Existing | | N | Y | N | N | Y | Y | N | N |
| | Nuclear - New | | N | N | N | N | N | N | N | N |
| | Wind, Solar, Geo | | Y | Y | Y | Y | Y | Y | Y | Y |
| | Storage | | Y | Y | Y | Y | Y | Y | Y | Y |
| **DG** | Distributed Adoption | Reference | Balanced | High | Low | High | Balanced | Balanced | Balanced | Balanced |
| **RECS** | Financial Mechanisms (RECS/Allowances) | - | N | N | N | N | N | Yes | N | N |
| **Load** | Energy Efficiency | Reference | Moderate | High | Moderate | High | Moderate | Moderate | High | Moderate |
| | Demand Response | Reference | Moderate | High | Moderate | High | Moderate | Moderate | High | Moderate |
| | Electrification | Reference | Moderate | High | Moderate | High | Moderate | Moderate | High | Moderate |
| **Trans-mission** | New or Upgraded Transmission Allowed? | Matches 2017 IRP | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors | New Corridors Allowed | No New Transmission | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors |
| **WECC** | WECC VRE Penetration | Reference | Reference | Reference | Reference | Reference | Reference | Reference | Reference | High |

*All scenarios achieve net 100% renewable by 2030

# Scenario Matrix

| | | LADWP 2017 IRP *Recommended Case* | 100% RE Reference | LA-Leads | Transmission Renaissance | Limited Transmission | Emissions Free | Net 100% | Load Modern-ization | Western Initiatives |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Compliance Year:** | -- | 2045 | 2035/2040 | 2045 | 2045 | 2045 | 2045 | 2045 | 2045 |
| **Technol-ogies Eligible in the Compliance Year** | Biomass | Matches 2017 IRP Technology Mix | Y | Y | Y | Y | N | Y | Y | Y |
| | Biogas | | Y | Y | Y | Y | N | Y | Y | Y |
| | Electricity to Fuel (e.g. H2) | | Y | Y | Y | Y | Y | Y | Y | Y |
| | Fuel Cells | | Y | Y | Y | Y | Y | Y | Y | Y |
| | Hydro - Existing | | Y | Y | Y | Y | Y | Y | Y | Y |
| | Hydro - New | | N | N | N | N | N | N | N | N |
| | Hydro - Upgrades | | Y | Y | Y | Y | Y | Y | Y | Y |
| | Natural Gas | | N | N | N | N | N | Y | N | N |
| | Nuclear - Existing | | N | Y | N | N | Y | Y | N | N |
| | Nuclear - New | | N | N | N | N | N | N | N | N |
| | Wind, Solar, Geo | | Y | Y | Y | Y | Y | Y | Y | Y |
| | Storage | | Y | Y | Y | Y | Y | Y | Y | Y |
| **DG** | Distributed Adoption | Reference | Balanced | High | Low | High | Balanced | Balanced | Balanced | Balanced |
| **RECS** | Financial Mechanisms (RECS/Allowances) | - | N | N | N | N | N | Yes | N | N |
| **Load** | Energy Efficiency | Reference | Moderate | High | Moderate | High | Moderate | Moderate | High | Moderate |
| | Demand Response | Reference | Moderate | High | Moderate | High | Moderate | Moderate | High | Moderate |
| | Electrification | Reference | Moderate | High | Moderate | High | Moderate | Moderate | High | Moderate |
| **Trans-mission** | New or Upgraded Transmission Allowed? | Matches 2017 IRP | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors | New Corridors Allowed | No New Transmission | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors |
| **WECC** | WECC VRE Penetration | Reference | Reference | Reference | Reference | Reference | Reference | Reference | Reference | High |

*All scenarios achieve net 100% renewable by 2030

# Scenario Matrix

| | | LADWP 2017 IRP *Recommended Case* | 100% RE Reference | LA-Leads | Transmission Renaissance | Limited Transmission | Emissions Free | Net 100% | Load Modern-ization | Western Initiatives |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Compliance Year:** | -- | 2045 | 2035/2040 | 2045 | 2045 | 2045 | 2045 | 2045 | 2045 |
| **Technol-ogies Eligible in the Compliance Year** | **Biomass** | Matches 2017 IRP Technology Mix | Y | Y | Y | Y | N | Y | Y | Y |
| | **Biogas** | | Y | Y | Y | Y | N | Y | Y | Y |
| | **Electricity to Fuel (e.g. H2)** | | Y | Y | Y | Y | Y | Y | Y | Y |
| | **Fuel Cells** | | Y | Y | Y | Y | Y | Y | Y | Y |
| | **Hydro - Existing** | | Y | Y | Y | Y | Y | Y | Y | Y |
| | **Hydro - New** | | N | N | N | N | N | N | N | N |
| | **Hydro - Upgrades** | | Y | Y | Y | Y | Y | Y | Y | Y |
| | **Natural Gas** | | N | N | N | N | N | Y | N | N |
| | **Nuclear - Existing** | | N | Y | N | N | Y | Y | N | N |
| | **Nuclear - New** | | N | N | N | N | N | N | N | N |
| | **Wind, Solar, Geo** | | Y | Y | Y | Y | Y | Y | Y | Y |
| | **Storage** | | Y | Y | Y | Y | Y | Y | Y | Y |
| **DG** | **Distributed Adoption** | Reference | Balanced | High | Low | High | Balanced | Balanced | Balanced | Balanced |
| **RECS** | **Financial Mechanisms (RECS/Allowances)** | - | N | N | N | N | N | Yes | N | N |
| **Load** | **Energy Efficiency** | Reference | Moderate | High | Moderate | High | Moderate | Moderate | High | Moderate |
| | **Demand Response** | Reference | Moderate | High | Moderate | High | Moderate | Moderate | High | Moderate |
| | **Electrification** | Reference | Moderate | High | Moderate | High | Moderate | Moderate | High | Moderate |
| **Trans-mission** | **New or Upgraded Transmission Allowed?** | Matches 2017 IRP | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors | New Corridors Allowed | No New Transmission | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors |
| **WECC** | **WECC VRE Penetration** | Reference | Reference | Reference | Reference | Reference | Reference | Reference | Reference | High |

*All scenarios achieve net 100% renewable by 2030

# Scenario Matrix

| | | LADWP 2017 IRP *Recommended Case* | 100% RE Reference | LA-Leads | Transmission Renaissance | Limited Transmission | Emissions Free | Net 100% | Load Modern-ization | Western Initiatives |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Compliance Year:** | -- | 2045 | 2035/2040 | 2045 | 2045 | 2045 | 2045 | 2045 | 2045 |
| **Technol-ogies Eligible in the Compliance Year** | **Biomass** | Matches 2017 IRP Technology Mix | Y | Y | Y | Y | N | Y | Y | Y |
| | **Biogas** | | Y | Y | Y | Y | N | Y | Y | Y |
| | **Electricity to Fuel (e.g. H2)** | | Y | Y | Y | Y | Y | Y | Y | Y |
| | **Fuel Cells** | | Y | Y | Y | Y | Y | Y | Y | Y |
| | **Hydro - Existing** | | Y | Y | Y | Y | Y | Y | Y | Y |
| | **Hydro - New** | | N | N | N | N | N | N | N | N |
| | **Hydro - Upgrades** | | Y | Y | Y | Y | Y | Y | Y | Y |
| | **Natural Gas** | | N | N | N | N | N | Y | N | N |
| | **Nuclear - Existing** | | N | Y | N | N | Y | Y | N | N |
| | **Nuclear - New** | | N | N | N | N | N | N | N | N |
| | **Wind, Solar, Geo** | | Y | Y | Y | Y | Y | Y | Y | Y |
| | **Storage** | | Y | Y | Y | Y | Y | Y | Y | Y |
| **DG** | **Distributed Adoption** | Reference | Balanced | High | **Low** | High | Balanced | Balanced | Balanced | Balanced |
| **RECS** | **Financial Mechanisms (RECS/Allowances)** | - | N | N | N | N | N | Yes | N | N |
| **Load** | **Energy Efficiency** | Reference | Moderate | High | Moderate | High | Moderate | Moderate | High | Moderate |
| | **Demand Response** | Reference | Moderate | High | Moderate | High | Moderate | Moderate | High | Moderate |
| | **Electrification** | Reference | Moderate | High | Moderate | High | Moderate | Moderate | High | Moderate |
| **Trans-mission** | **New or Upgraded Transmission Allowed?** | Matches 2017 IRP | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors | **New Corridors Allowed** | No New Transmission | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors |
| **WECC** | **WECC VRE Penetration** | Reference | Reference | Reference | Reference | Reference | Reference | Reference | Reference | High |

*All scenarios achieve net 100% renewable by 2030

# Scenario Matrix

| | | LADWP 2017 IRP *Recommended Case* | 100% RE Reference | LA-Leads | Transmission Renaissance | Limited Transmission | Emissions Free | Net 100% | Load Modern-ization | Western Initiatives |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Compliance Year:** | -- | 2045 | 2035/2040 | 2045 | 2045 | 2045 | 2045 | 2045 | 2045 |
| **Technol-ogies Eligible in the Compliance Year** | **Biomass** | Matches 2017 IRP Technology Mix | Y | Y | Y | Y | N | Y | Y | Y |
| | **Biogas** | | Y | Y | Y | Y | N | Y | Y | Y |
| | **Electricity to Fuel (e.g. H2)** | | Y | Y | Y | Y | Y | Y | Y | Y |
| | **Fuel Cells** | | Y | Y | Y | Y | Y | Y | Y | Y |
| | **Hydro - Existing** | | Y | Y | Y | Y | Y | Y | Y | Y |
| | **Hydro - New** | | N | N | N | N | N | N | N | N |
| | **Hydro - Upgrades** | | Y | Y | Y | Y | Y | Y | Y | Y |
| | **Natural Gas** | | N | N | N | N | N | Y | N | N |
| | **Nuclear - Existing** | | N | Y | N | N | Y | Y | N | N |
| | **Nuclear - New** | | N | N | N | N | N | N | N | N |
| | **Wind, Solar, Geo** | | Y | Y | Y | Y | Y | Y | Y | Y |
| | **Storage** | | Y | Y | Y | Y | Y | Y | Y | Y |
| **DG** | **Distributed Adoption** | Reference | Balanced | High | Low | High | Balanced | Balanced | Balanced | Balanced |
| **RECS** | **Financial Mechanisms (RECS/Allowances)** | - | N | N | N | N | N | Yes | N | N |
| **Load** | **Energy Efficiency** | Reference | Moderate | High | Moderate | High | Moderate | Moderate | High | Moderate |
| | **Demand Response** | Reference | Moderate | High | Moderate | High | Moderate | Moderate | High | Moderate |
| | **Electrification** | Reference | Moderate | High | Moderate | High | Moderate | Moderate | High | Moderate |
| **Trans-mission** | **New or Upgraded Transmission Allowed?** | Matches 2017 IRP | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors | New Corridors Allowed | No New Transmission | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors |
| **WECC** | **WECC VRE Penetration** | Reference | Reference | Reference | Reference | Reference | Reference | Reference | Reference | High |

*All scenarios achieve net 100% renewable by 2030

# Scenario Matrix

| | | LADWP 2017 IRP *Recommended Case* | 100% RE Reference | LA-Leads | Transmission Renaissance | Limited Transmission | Emissions Free | Net 100% | Load Modern-ization | Western Initiatives |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Compliance Year:** | -- | 2045 | 2035/2040 | 2045 | 2045 | 2045 | 2045 | 2045 | 2045 |
| **Technol-ogies Eligible in the Compliance Year** | **Biomass** | | Y | Y | Y | Y | N | Y | Y | Y |
| | **Biogas** | | Y | Y | Y | Y | N | Y | Y | Y |
| | **Electricity to Fuel (e.g. H2)** | | Y | Y | Y | Y | Y | Y | Y | Y |
| | **Fuel Cells** | | Y | Y | Y | Y | Y | Y | Y | Y |
| | **Hydro - Existing** | | Y | Y | Y | Y | Y | Y | Y | Y |
| | **Hydro - New** | Matches 2017 IRP Technology Mix | N | N | N | N | N | N | N | N |
| | **Hydro - Upgrades** | | Y | Y | Y | Y | Y | Y | Y | Y |
| | **Natural Gas** | | N | N | N | N | N | Y | N | N |
| | **Nuclear - Existing** | | N | Y | N | N | Y | Y | N | N |
| | **Nuclear - New** | | N | N | N | N | N | N | N | N |
| | **Wind, Solar, Geo** | | Y | Y | Y | Y | Y | Y | Y | Y |
| | **Storage** | | Y | Y | Y | Y | Y | Y | Y | Y |
| **DG** | **Distributed Adoption** | Reference | Balanced | High | Low | High | Balanced | Balanced | Balanced | Balanced |
| **RECS** | **Financial Mechanisms (RECS/Allowances)** | - | N | N | N | N | N | Yes | N | N |
| **Load** | **Energy Efficiency** | Reference | Moderate | High | Moderate | High | Moderate | Moderate | High | Moderate |
| | **Demand Response** | Reference | Moderate | High | Moderate | High | Moderate | Moderate | High | Moderate |
| | **Electrification** | Reference | Moderate | High | Moderate | High | Moderate | Moderate | High | Moderate |
| **Trans-mission** | **New or Upgraded Transmission Allowed?** | Matches 2017 IRP | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors | New Corridors Allowed | No New Transmission | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors |
| **WECC** | **WECC VRE Penetration** | Reference | Reference | Reference | Reference | Reference | Reference | Reference | Reference | High |

*All scenarios achieve net 100% renewable by 2030

# Scenario Matrix

| | | *LADWP 2017 IRP Recommended Case* | 100% RE Reference | LA-Leads | Transmission Renaissance | Limited Transmission | Emissions Free | **Net 100%** | Load Modern-ization | Western Initiatives |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Compliance Year:** | -- | 2045 | 2035/2040 | 2045 | 2045 | 2045 | 2045 | 2045 | 2045 |
| **Technol-ogies Eligible in the Compliance Year** | **Biomass** | Matches 2017 IRP Technology Mix | Y | Y | Y | Y | N | Y | Y | Y |
| | **Biogas** | | Y | Y | Y | Y | N | Y | Y | Y |
| | **Electricity to Fuel (e.g. H2)** | | Y | Y | Y | Y | Y | Y | Y | Y |
| | **Fuel Cells** | | Y | Y | Y | Y | Y | Y | Y | Y |
| | **Hydro - Existing** | | Y | Y | Y | Y | Y | Y | Y | Y |
| | **Hydro - New** | | N | N | N | N | N | N | N | N |
| | **Hydro - Upgrades** | | Y | Y | Y | Y | Y | Y | Y | Y |
| | **Natural Gas** | | N | N | N | N | N | Y | N | N |
| | **Nuclear - Existing** | | N | Y | N | N | Y | Y | N | N |
| | **Nuclear - New** | | N | N | N | N | N | N | N | N |
| | **Wind, Solar, Geo** | | Y | Y | Y | Y | Y | Y | Y | Y |
| | **Storage** | | Y | Y | Y | Y | Y | Y | Y | Y |
| **DG** | **Distributed Adoption** | Reference | Balanced | High | Low | High | Balanced | Balanced | Balanced | Balanced |
| **RECS** | **Financial Mechanisms (RECS/Allowances)** | - | N | N | N | N | N | Yes | N | N |
| **Load** | **Energy Efficiency** | Reference | Moderate | High | Moderate | High | Moderate | Moderate | High | Moderate |
| | **Demand Response** | Reference | Moderate | High | Moderate | High | Moderate | Moderate | High | Moderate |
| | **Electrification** | Reference | Moderate | High | Moderate | High | Moderate | Moderate | High | Moderate |
| **Trans-mission** | **New or Upgraded Transmission Allowed?** | Matches 2017 IRP | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors | New Corridors Allowed | No New Transmission | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors |
| **WECC** | **WECC VRE Penetration** | Reference | Reference | Reference | Reference | Reference | Reference | Reference | Reference | High |

*All scenarios achieve net 100% renewable by 2030

# Scenario Matrix

| | | LADWP 2017 IRP *Recommended Case* | 100% RE Reference | LA-Leads | Transmission Renaissance | Limited Transmission | Emissions Free | Net 100% | Load Modern-ization | Western Initiatives |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Compliance Year:** | -- | 2045 | 2035/2040 | 2045 | 2045 | 2045 | 2045 | 2045 | 2045 |
| **Technol-ogies Eligible in the Compliance Year** | **Biomass** | Matches 2017 IRP Technology Mix | Y | Y | Y | Y | N | Y | Y | Y |
| | **Biogas** | | Y | Y | Y | Y | N | Y | Y | Y |
| | **Electricity to Fuel (e.g. H2)** | | Y | Y | Y | Y | Y | Y | Y | Y |
| | **Fuel Cells** | | Y | Y | Y | Y | Y | Y | Y | Y |
| | **Hydro - Existing** | | Y | Y | Y | Y | Y | Y | Y | Y |
| | **Hydro - New** | | N | N | N | N | N | N | N | N |
| | **Hydro - Upgrades** | | Y | Y | Y | Y | Y | Y | Y | Y |
| | **Natural Gas** | | N | N | N | N | N | Y | N | N |
| | **Nuclear - Existing** | | N | Y | N | N | Y | Y | N | N |
| | **Nuclear - New** | | N | N | N | N | N | N | N | N |
| | **Wind, Solar, Geo** | | Y | Y | Y | Y | Y | Y | Y | Y |
| | **Storage** | | Y | Y | Y | Y | Y | Y | Y | Y |
| **DG** | **Distributed Adoption** | Reference | Balanced | High | Low | High | Balanced | Balanced | Balanced | Balanced |
| **RECS** | **Financial Mechanisms (RECS/Allowances)** | - | N | N | N | N | N | Yes | N | N |
| **Load** | **Energy Efficiency** | Reference | Moderate | High | Moderate | High | Moderate | Moderate | **High** | Moderate |
| | **Demand Response** | Reference | Moderate | High | Moderate | High | Moderate | Moderate | **High** | Moderate |
| | **Electrification** | Reference | Moderate | High | Moderate | High | Moderate | Moderate | **High** | Moderate |
| **Trans-mission** | **New or Upgraded Transmission Allowed?** | Matches 2017 IRP | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors | New Corridors Allowed | No New Transmission | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors |
| **WECC** | **WECC VRE Penetration** | Reference | Reference | Reference | Reference | Reference | Reference | Reference | Reference | High |

*All scenarios achieve net 100% renewable by 2030

# Scenario Matrix

LADWP

| | | LADWP 2017 IRP *Recommended Case* | 100% RE Reference | LA-Leads | Transmission Renaissance | Limited Transmission | Emissions Free | Net 100% | Load Modern-ization | Western Initiatives |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Compliance Year:** | -- | 2045 | 2035/2040 | 2045 | 2045 | 2045 | 2045 | 2045 | 2045 |
| **Technol-ogies Eligible in the Compliance Year** | **Biomass** | | Y | Y | Y | Y | N | Y | Y | Y |
| | **Biogas** | | Y | Y | Y | Y | N | Y | Y | Y |
| | **Electricity to Fuel (e.g. H2)** | | Y | Y | Y | Y | Y | Y | Y | Y |
| | **Fuel Cells** | | Y | Y | Y | Y | Y | Y | Y | Y |
| | **Hydro - Existing** | | Y | Y | Y | Y | Y | Y | Y | Y |
| | **Hydro - New** | Matches 2017 IRP Technology Mix | N | N | N | N | N | N | N | N |
| | **Hydro - Upgrades** | | Y | Y | Y | Y | Y | Y | Y | Y |
| | **Natural Gas** | | N | N | N | N | N | Y | N | N |
| | **Nuclear - Existing** | | N | Y | N | N | Y | Y | N | N |
| | **Nuclear - New** | | N | N | N | N | N | N | N | N |
| | **Wind, Solar, Geo** | | Y | Y | Y | Y | Y | Y | Y | Y |
| | **Storage** | | Y | Y | Y | Y | Y | Y | Y | Y |
| **DG** | **Distributed Adoption** | Reference | Balanced | High | Low | High | Balanced | Balanced | Balanced | Balanced |
| **RECS** | **Financial Mechanisms (RECS/Allowances)** | - | N | N | N | N | N | Yes | N | N |
| **Load** | **Energy Efficiency** | Reference | Moderate | High | Moderate | High | Moderate | Moderate | High | Moderate |
| | **Demand Response** | Reference | Moderate | High | Moderate | High | Moderate | Moderate | High | Moderate |
| | **Electrification** | Reference | Moderate | High | Moderate | High | Moderate | Moderate | High | Moderate |
| **Trans-mission** | **New or Upgraded Transmission Allowed?** | Matches 2017 IRP | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors | New Corridors Allowed | No New Transmission | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors |
| **WECC** | **WECC VRE Penetration** | Reference | Reference | Reference | Reference | Reference | Reference | Reference | Reference | High |

*All scenarios achieve net 100% renewable by 2030

# Scenario Matrix

| | | LADWP 2017 IRP *Recommended Case* | 100% RE Reference | LA-Leads | Transmission Renaissance | Limited Transmission | Emissions Free | Net 100% | Load Modern-ization | Western Initiatives |
|---|---|---|---|---|---|---|---|---|---|---|
| | Compliance Year: | -- | 2045 | 2035/2040 | 2045 | 2045 | 2045 | 2045 | 2045 | 2045 |
| Technol-ogies Eligible in the Compliance Year | Biomass | Matches 2017 IRP Technology Mix | Y | Y | Y | Y | N | Y | Y | Y |
| | Biogas | | Y | Y | Y | Y | N | Y | Y | Y |
| | Electricity to Fuel (e.g. H2) | | Y | Y | Y | Y | Y | Y | Y | Y |
| | Fuel Cells | | Y | Y | Y | Y | Y | Y | Y | Y |
| | Hydro - Existing | | Y | Y | Y | Y | Y | Y | Y | Y |
| | Hydro - New | | N | N | N | N | N | N | N | N |
| | Hydro - Upgrades | | Y | Y | Y | Y | Y | Y | Y | Y |
| | Natural Gas | | N | N | N | N | N | Y | N | N |
| | Nuclear - Existing | | N | Y | N | N | Y | Y | N | N |
| | Nuclear - New | | N | N | N | N | N | N | N | N |
| | Wind, Solar, Geo | | Y | Y | Y | Y | Y | Y | Y | Y |
| | Storage | | Y | Y | Y | Y | Y | Y | Y | Y |
| DG | Distributed Adoption | Reference | Balanced | High | Low | High | Balanced | Balanced | Balanced | Balanced |
| RECS | Financial Mechanisms (RECS/Allowances) | - | N | N | N | N | N | Yes | N | N |
| Load | Energy Efficiency | Reference | Moderate | High | Moderate | High | Moderate | Moderate | High | Moderate |
| | Demand Response | Reference | Moderate | High | Moderate | High | Moderate | Moderate | High | Moderate |
| | Electrification | Reference | Moderate | High | Moderate | High | Moderate | Moderate | High | Moderate |
| Trans-mission | New or Upgraded Transmission Allowed? | Matches 2017 IRP | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors | New Corridors Allowed | No New Transmission | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors | Only Along Existing or Planned Corridors |
| WECC | WECC VRE Penetration | Reference | Reference | Reference | Reference | Reference | Reference | Reference | Reference | High |

*All scenarios achieve net 100% renewable by 2030

# Revised Scenarios—Comment Mapping

| | Scenarios | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Comment** | **LADWP 2017 IRP *Recommended Case*** | **100% Renewable Reference Case** | **LA-Leads** | **Transmission Renaissance** | **Limited Transmission** | **Emissions Free** | **Net 100%** | **Load Modernization** | **Western Initiatives** |
| **Accelerated Compliance** | | | √ | | | | | | |
| **Interim Targets** | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| **Financial vs Physical Compliance** | | √ | | | | | √ | | |
| **Current Policies, Plans, and Intiatives** | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| **Detailed Reporting** | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| **Current Policies, Plans, and Intiatives** | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| **Equity Implications** | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| **Environmental Impacts Beyond CO2** | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| **Regionalization, EIM, CAISO** | | | | | | | | | √ |

*All scenarios achieve net 100% renewable by 2030

# Scenario Descriptions

| Scenario Name | Scenario Abbreviation | Final Target Year | Scenario Description |
|---|---|---|---|
| LADWP 2017 IRP *Recommended Case* | DWP-IRP | - | The DWP-IRP scenario matches the planned generation, tranmission, and distribution system investments, as well as the planned end-use initiatives--energy efficiency, demand response, and electrification--from LADWP's 2017 IRP *Recommended Case* . In addition, this scenario will incorporate relevant results from the OTC Study. Under this scenario, renewable generation comprises 65% of load by 2036. |
| 100% Renewable Reference Case | 100-RE | 2045 | By 2030, a net-100% portfolio is achieved through a balanced mix of both distributed and utility scale renewable resources, implementation of energy efficiency, demand response, and electrification programs, as well as purchased RECs. By 2045 the use of RECs is phased out through further investments in both supply and demand side resources. |
| LA-Leads | LA-Leads | 2035/2040* | Through more aggressive pursuit of both energy efficiency, demand response, and electrification initiatives, as well as rapid deployment of both distributed and utility-scale resources, a 100% clean energy system is achieved by 2035. Importantly, the Palo Verde Nuclear Plant continues to provide generation through the early 2040s, but is retired by and offset with new renewable sources by 2045. |
| Transmission Renaissance | New-Trans | 2045 | Identical to the *100-RE* case, but new transmission corridors (along with upgrades to existing corridors) are allowed; adoption of distributed generation is decreased relative to the 100-RE case, due to the decreased barriers to importing utility scale renewable generation from out-of-basin. |
| Limited Transmission | No-Trans | 2045 | Identical to the 100-RE case, but <u>only</u> planned transmission upgrades (from the LADWP IRP) are allowed; adoption of distributed generation is substantially higher than the 100-RE case to make up for decreased ability to import out-of-basin renewable generation; similarly, energy efficiency, demand response, and electrification are rapidly implemented. |
| Emissions Free | No-Emis | 2045* | Identical to the 100-RE case, but compliance must be achieved without any combustion-based generation (including biomass and biofuels), and nuclear generation is allowed to contribute towards compliance. |
| Net 100% | Net-100 | 2045*ǂ | Identical to the 100-RE case, but renewable energy credits (RECs), both bundled and unbundled, and nuclear can be used as a source of compliance |
| Load Modernization | Load-Mod | 2045 | Identical to the 100-RE case, but energy efficiency measures, demand response measures, and electrification are rapidly implemented through robust incentives, programs, and technology breakthroughs |
| Western Initiatives | WECC | 2045 | Identical to the 100-RE case, but variable renewable generation achieves high penetration in the rest of WECC |

* Nuclear generation is allowed to contribute towards the 100% target
ǂ RECs can be used as a component of compliance

# Summary

- Revised scenarios address the spectrum of comments and perspectives from the Advisory Group.
- There are a broad set of pathways that could be pursued to achieve 100% renewable power system.
- All pathways will impact the investment and operational costs, emissions, air quality, jobs and economic development, and electricity rates in different ways.
- The revised suite of scenarios explore a broad set of pathways to 100% that will enable NREL, LADWP, and the AG to understand the tradeoffs between costs and the environmental, economic, equity outcomes.

# Thank you!

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NATIONAL RENEWABLE ENERGY LABORATORY

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# Discussion

# Advisory Group Schedule

LA DWP

| QUARTER | Phase 1 \| 2017<br>LAUNCH AND ORGANIZATION | Phase 2 \| 2018<br>SCENARIOS | Phase 3 \| 2019<br>ANALYSIS AND MODELING | Phase 4 \| 2020<br>FINAL REPORT |
|---|---|---|---|---|
| Q1 | | • Advisory Group Meeting Plan<br>• Preliminary Scenarios and Sensitivities<br>• Field Trip Itinerary<br>• Power Strategic Long-Term Power Resources Plan<br>• Once-Through Cooling Study Update<br>FEBRUARY 15 | • Capacity Value<br>• Electricity Operations Modeling II<br>• Jobs & Economic Analysis II | • White Papers on Electricity Modeling Results<br>• Final Results 1) Jobs & Economic Analysis and 2) Environmental Analysis<br>• Final Visualization of Electricity Operations |
| Q2 | • Advisory Group Launch<br>• City Council Motion: 100% Renewable Energy Study<br>JUNE 23 | FIELD TRIP April 26<br>• Draft 100% Papers: Framing, Data, Methods<br>• Final Scenarios and Sensitivities<br>• Once-Through Cooling Study Update<br>JUNE 7 | • Planning Reserves<br>• Operating Reserves<br>• Load Modernization<br>• Environmental Analysis II<br>• Publication Plan | • Final Report<br>• Final Presentation |
| Q3 | • Advisory Group Charge and Operating Protocols<br>• Introduction to NREL and 100% Renewable Energy Study<br>AUGUST 3 | • Final 100% Papers<br>• Electricity Operations Modeling I<br>• Jobs & Economic Analysis I<br>• Environmental Modeling I<br>• Once-Through Cooling Study Update<br>AUGUST 16 | • Final Scenarios and Sensitivities Results<br>• Final Visualization of Scenarios<br>• Initial Electricity Operations Modeling Results | |
| Q4 | • Defining Clean Energy and Renewable Energy<br>• Considerations for Study<br>• Once-Through Cooling Study Overview<br>• Public Outreach Overview<br>NOVEMBER 16 | • Initial Scenario Results<br>• Draft Visualizations of Scenarios<br>• Once-Through Cooling Study Results<br>NOVEMBER 15 | • Final Electricity Operations Modeling Results and Draft Visualizations<br>• Draft results on Jobs and Economic Development<br>• Draft results on Environmental Analysis | |

COMPLETED MEETINGS/TASKS
PLANNED MEETINGS/TASKS

LA DWP Los Angeles Department of Water & Power

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*As of June 2018*

# Wrap up and next steps

- Next Advisory Group Meeting
  - August 16
- Meeting Summary Posted online:
  - July 9th
- Owens Valley Tour
  - Fri., Jun. 22 – Sat., Jun. 23
  - Fri., Sep. 21 – Sat., Sep. 22
  - Fri., Oct. 19 – Sat., Oct. 20
  - Fri., Nov. 2 – Sat., Nov. 3
  - RSVP: owensvalleytour@ladwp.com