

LADWP 2017-18 POWER INFRASTRUCTURE PLAN



Los Angeles
Department of
Water & Power



Introduction

LADWP has built a vast power generation, transmission and distribution system that spans five Western states, and delivers electricity to about 4 million people in Los Angeles via thousands of miles of overhead conductors and underground cables. The Power Infrastructure Plan evaluates and prioritizes maintenance and replacement of major power infrastructure components. The infrastructure plan is part of the Power System’s five-year capital plan, budgeted at \$8 billion through fiscal year 2022.

Overall Objectives

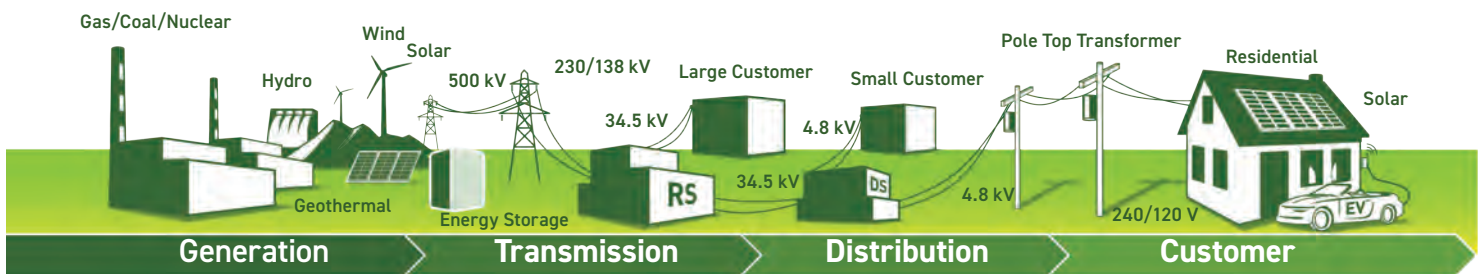
Improve reliability of Power System, including:

- Generation
- Transmission
- Substation
- Distribution
- Provide proactive replacement and maintenance
- Minimize operational and repair costs
- Standardize materials and processes

Background

LADWP launched its initial Power Reliability Program after major heat storms in 2006 and 2007 caused widespread and prolonged power outages. The program targeted replacing overloaded transformers and other distribution equipment. Since then, LADWP has seen a 20% reduction in outages.

In fiscal year 2014-2015, LADWP introduced the broader Power System Reliability Program (PSRP), which encompasses generation, transmission, and substation equipment in addition to distribution equipment. This is especially important as new energy sources, such as wind and solar, are integrated into an aging infrastructure. As this power supply transformation unfolds, the PSRP offers a blueprint to safely improve and maintain future reliability for LADWP’s customers.



Generation

Generation assets are either wholly or jointly owned, providing a diverse portfolio of power that is supplemented by long-term power purchase agreements and spot market purchases. Of this, wholly owned and operated in-basin generation sources include:

- 29 units of thermal electricity (located at Harbor, Haynes, Scattergood, and Valley Generating Stations)
- 7 units of large hydro electricity (located at Castaic Power Plant)
- 22 units of small hydro electricity (located at 14 individual plants)
- 168 generation transformers

Key Points:

- Inspections will determine the need for overhauls or replacements of generating units. Replacements are typically multi-year projects.
- LADWP has put a hold on plans to modernize existing thermal generating units that still use once-through-cooling (OTC) systems until completing an analysis of the current strategy. LADWP is required to eliminate the use of OTC under the federal Clean Water Act. See below for more information.
- 22 small hydroelectric units are performing beyond their design life of 50 years, which is a testament to the hard work of LADWP maintenance personnel. The Control Gorge generator ran until it failed, and was refurbished from January 2012 to September 2014.

Once-Through Cooling Study

To reduce the use of fossil fuel power and create a clean energy future for Los Angeles, an independent third-party analysis is underway to assess LADWP's current modernization strategy for the remaining thermal generating units that still operate with OTC systems at Scattergood, Haynes, and Harbor generating stations. LADWP is required to eliminate the use of OTC under the federal Clean Water Act, and has negotiated a schedule for compliance by the end of 2029. Results and recommendations from the OTC study are expected in summer 2018. ^[1]_{SEP}

Affected generating units and compliance deadlines:

- Scattergood GS - Units 1 and 2 by 2024
- Haynes GS - Units 1,2 and 8 by 2029
- Harbor GS - Unit 5 by 2029

2016-17 Achievements:

- Completed 3 major inspections (Big Pine Power Plant, Haynes Unit 14, Castaic Unit 2)
- Completed installation of Harbor units 10-14 dissolved gas-in-oil analyzers. These extend the lives of generating units by continually monitoring and sending data to notify operations of potential problems prior to catastrophic failure.

2017-18 Goals:

- Complete 18-month decommissioning of Scattergood Generation Station Unit 3.
- Complete third-party study to assess modernization strategy for remaining coastal generating units that still operate with OTC systems. Determine need for all or some of this generation to meet reliability requirements while also achieving OTC compliance.

Long-Term Goals:

- Inspect 4 units of thermal generation, 1 unit of large hydro, 2 units of small hydro annually by 2020.
- Replace 2 generator step-up transformers and 2 generator station transformers annually by 2020.
- Complete modernization of all Castaic Power Plant units by 2018.

OTC Study Objectives:

- To reevaluate LADWP's OTC repowering strategy
- To study various combinations of repowering projects, and environmentally responsible alternatives, to ensure system reliability

Timeline:

August 2018: Final report



Transmission System

LADWP maintains 3,760 miles of overhead and underground transmission circuits that are part of a vast transmission system spanning five Western states. Of these, LADWP’s wholly-owned and operated in-basin transmission network includes the following key components:

- 3,636 miles of overhead circuits (115 kV to 500 kV)
- 124 miles of underground circuits (138 kV to 230 kV)
 - Includes 9 low pressure oil-filled (LPOF) circuits
- 15,452 towers
- 506 maintenance holes (138 kV)
- 154 maintenance holes (230 kV)
- 1,293 joints (138 kV)
 - Includes 213 LPOF cable stop joints

Key Points include:

- Priorities for replacements are based on inspections and outage history.
- Inspection of transmission towers is currently done on a one-year to five-year basis, depending on criticality.
- Existing 230 kV underground circuits have a high degree of reliability for the next 20 years.
- The 138 kV LPOF cable was originally placed in service in 17 circuits from 1943 to 1959. These 17 circuits are considered critical for replacement due to increasing outages.
- LADWP is also eliminating the problem of stop joint failures on these circuits by rebuilding the lines with synthetic cable.

2016-17 Achievements:

- Replaced 5.5 circuit-miles of 138 kV LPOF cable identified for replacement.
- Replaced 2 more 138-kV LPOF cable stop joints.
- Retrofitted 28 maintenance hole covers with restraints.
- Reached 90% completion milestone on 12-mile Scattergood-Olympic Cable A

2017-18 Goals:

- Replace 2 138-kV underground transmission circuits
- Replace 36 maintenance hole restraints

Long-Term Goals:

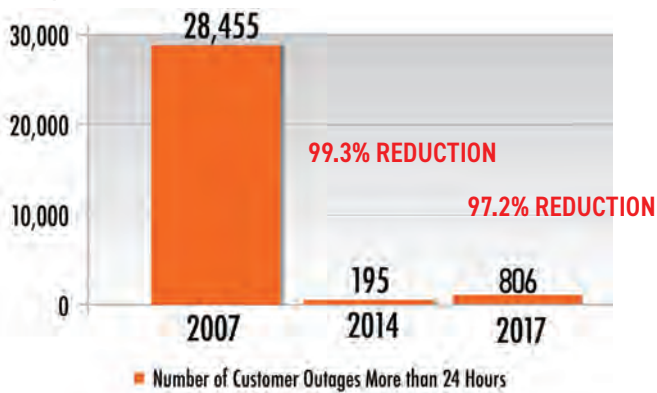
- Replace up to 30 circuit-miles of 138 kV LPOF cable annually with goal of replacing all by 2021.
- Replace 15 LPOF cable stop joints annually; continue to identify those needing replacement.
- Ramp up to 40 maintenance-hole cover restraints per year by 2020, with the goal of retrofitting the remaining maintenance hole covers in 6 years. After FY2016-17 goals were met, 164 have been completed, 198 more will be installed, and 152 do not need restraints.
- Put in place a multi-year painting contract for the 1,400 wholly-owned in-basin galvanized steel transmission towers.
- Upgrade the land and marine cable portion of the Pacific DC Intertie by 2018.
- Install Castaic to Haskell Line 3 by 2019.
- Upgrade 115 kV Power Plant 1 & 2 Line to 230 kV by 2023.

Benefits of Proactive Infrastructure Replacement

Planned and sustained infrastructure replacement is both a cost-efficient and highly effective approach to maintaining reliability.

This is clearly evident when comparing the outages experienced by customers during the 2007 heat storm with similar heat storms in 2014 and 2017, following a period of sustained investment in infrastructure replacement. As a result of planned infrastructure replacement, customer outages lasting over 24 hours were reduced by 99.3% during the 2014 heat storm and by 97.2% during the 2017 heat storm when compared to the 2007 heat storm.

Comparison of 2007 and 2014 Heat Storms:



Control Gorge Power Plants

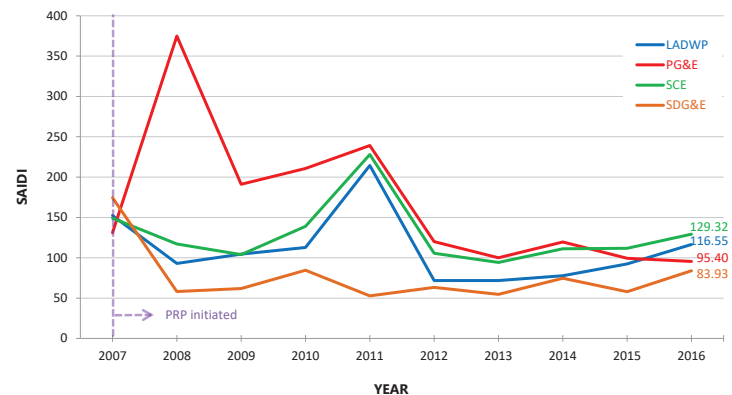
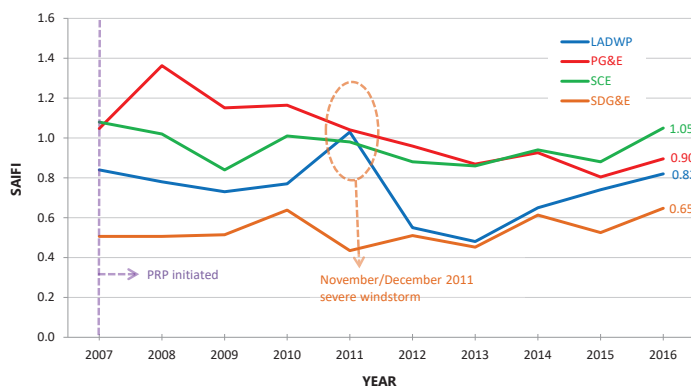
Another example of the benefits of proactive maintenance involves the Control Gorge Power Plant, one of three small hydro plants in the Owens Gorge. Due to funding constraints, LADWP had deferred scheduled maintenance on the plant. When the plant malfunctioned, a forced outage required the same amount of work but on an emergency basis at a higher cost.



Reliability

LADWP's Power System reliability fares better when compared to most peer utilities in the state. However, outage levels in recent years have increased in terms of frequency and duration due to heat and rain storms, and additional investment is necessary to maintain the high reliability levels that our customers have relied upon for a century.

To track system performance, the electric utility industry has developed standard measures of reliability. SAIFI (system average interruption frequency index) represents the number of times the average LADWP customer experienced a sustained power Interruption (over five minutes) in a given year. SAIDI (system average interruption duration index) measures the number of minutes of sustained interruptions (in minutes) the average LADWP customer experienced in a given year.



Distribution System

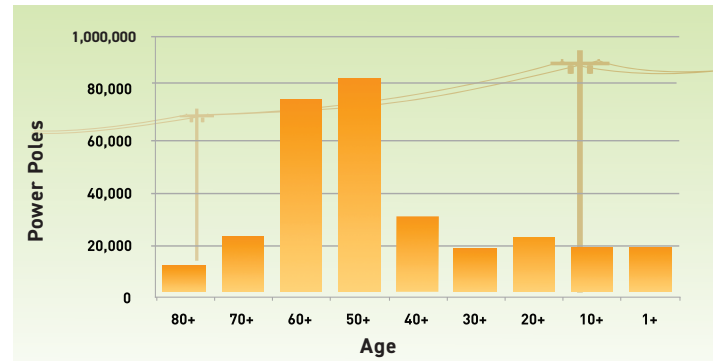
LADWP's distribution infrastructure is the backbone of the city's power grid and crucial for maintaining neighborhood power reliability. Key components include:

- 308,373 poles
- 1,287,120 crossarms
- 128,693 transformers
- 6,763 miles of overhead distribution lines
- 3,732 miles of underground distribution cables

Key Points:

- There are over 60,000 “fix-it” tickets in the queue. These are job orders for permanent repairs on circuits that were repaired temporarily to resolve an outage, but need further engineering work, design or construction for long-term reliability.
- The challenges facing our distribution system vary by location. For example, higher temperatures in the San Fernando Valley have different effects on transformer performance as a function of age than in the coastal areas.
- Infrared inspections are utilized in overhead and underground distribution systems to identify potential failure points.
- Key distribution infrastructure targeted for replacement include poles, crossarms, transformers, and cables. Inspections identify recommended repairs or replacements. Priorities for each component are based on:
 - Poles – age and pole condition
 - Crossarms – inspections and existing work
 - Transformers – trouble call logs, engineering overload assessments, and inspections
 - Cables – cable type and availability, outage record performance, age and location
- Other criteria for prioritization are:
 - Annual worst-performing circuits
 - Abnormal circuits
 - Outage records
 - Engineering and field crew inspections

The graph below shows the majority of LADWP poles were installed in the 1940s through 1960s. Over 65% of poles are at least 50 years old. More than 40% are older than 60 years, which is the average lifespan of a pole. LADWP needs to increase its investment in repair and replacement of aging poles and other components of the power distribution system.



2016-17 Achievements:

- Replaced 2,656 poles
- Replaced 7,064 crossarms
- Replaced 919 transformers
- Replaced 39 miles of lead & synthetic cables (this includes the 8.5 miles replaced from the Pacific Intertie Ground Return)
- Resolved 9,001 “fix-it” tickets

FY 2017-18 Goals:

- Pole replacement: 3,000 poles (up from 2,500)
- Underground cable replacement: 48 miles (same as FY 16-17)
- Crossarm replacement: 10,000 crossarms (up from 7,000)
- Distribution transformer replacement: 800 transformers (up from 700)

Long-Term Goals:

- Replace 4,000 poles, 10,000 crossarms, 800 transformers, 55 miles of lead and synthetic cables annually by 2020.
- Ramp up to resolve an additional 5,000 “fix-it” tickets annually to reduce backlog to an acceptable level of 2,000 in 10 years.

Substations

Transformers and circuit breakers are considered the most critical assets within the LADWP Power System's 3 converter stations (CS), 13 switching stations (SS), 8 switchyards (SY) 22 receiving stations (RS), 127 distributing stations (DS), and 50 pole-top distributing stations. Keeping thousands of transformers and circuit breakers functioning at their best is at the heart of substation reliability.

Key components include:

- 86 transmission level transformers (RS, SS, CS, and SY)
- 100 sub-transmission level load bank transformers (RS)
- 933 distribution level load bank transformers (DS)
- 612 transmission level substation circuit breakers (RS)
- 2,373 34.5 kV sub-transmission level circuit breakers (RS and DS)
- 2,946 4.8 kV distribution circuit breakers (DS)

Key Points:

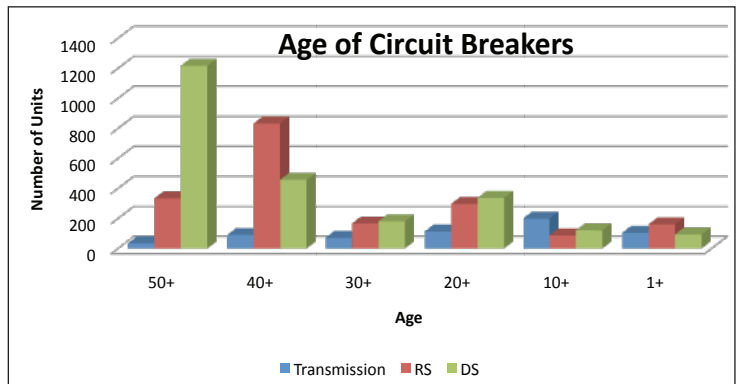
- LADWP prioritizes which substation transformers to replace based on specialized tests (e.g. dissolved gas and furan analysis), critical location, and age.
- Priorities for circuit breaker replacement are based on outage history, maintenance record, and location.
- Circuit breakers have a 30-year design life but many are older than that. The median age of substation transmission circuit breakers is 16 years old; the RS circuit breaker median age is 44 years old; and the DS circuit breaker median age is 49 years old, underscoring the need to ramp up investment in replacing critical infrastructure.

2016-17 Achievements:

- Replaced 4 525-kV reactors
- Replaced 3 sub-transmission level load bank transformers (RS)
- Replaced 6 distribution load bank transformers (DS)
- Replaced 8 (3 RS, 5 DS) 34.5 kV circuit breakers (RS and DS)
- Replaced 5 4.8 kV circuit breakers (DS)

FY 2017-18 Goals:

- Replace 2 transmission level transformers (RS, SS, CS, SY)
- Replace 2 sub-transmission level load bank transformers (RS)
- Replace 13 distribution level load bank transformers (DS)
- Replace 16 (5 RS, 11 DS) sub-transmission level circuit breakers (RS, DS)
- Replace 28 distribution level circuit breakers (DS)



- Automate 12 substations
- Replace 40 industrial and customer station transformers

Long-Term Goals:

- Install 1 400MVA transmission level spare bank by 2022
- Replace 1 converter transformer by 2019
- Replace 14 transmission level substation circuit breakers by 2022 (RS, SS, CS, SY)
- Replace 2 high side transformers (RS), 1 load side transformer (RS), 18 local substation transformers, 6 substation transmission circuit breakers, 20 circuit breakers (RS), 40 circuit breakers (DS) and automate 12 substations annually by 2020.
- Standardize major assets such as transformers and circuit breakers within each substation to allow for more efficient maintenance, inventory of spare parts, and training of personnel.
- Renovate aging substations and construct new facilities to accommodate load growth and maintain reliability.
- Automate all substations in the next 20 years to improve operational capabilities and communications while reducing operation and maintenance costs.
- Replace Sylmar Converter Station filters by 2020.





LADWP is the nation's largest municipal electric utility, and supplies over 26 million megawatt-hours each year to approximately 1.5 million electric service connections in Los Angeles as well as 5,000 customer connections in the Owens Valley.

Infrastructure

Transmission

3,636 miles of overhead circuits (AC and DC)

124 miles of underground circuits

15,452 transmission towers

Distribution

6,763 miles of 4.8 kV and 34.5 kV overhead lines

3,732 miles of 4.8 kV and 34.5 kV underground cables

177 substations

308,373 poles

128,693 transformers



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