Pasadena 100

PWP Tutorial

or

Clean Energy Without the Hot Air

December 20, 2022

R. Haw

What is electricity?

Main idea to remind you of:

- grid electricity *always* flows
  - — never static, never in a ‘reservoir’ (conventionally)

Power is served to us successfully …

- via control rooms full of people monitoring line voltages, turning plants off&on, and balancing electrons across the grid — 24/7, 365 days per year

Batteries

The concept of *storing* energy, legacy-wise, is novel to power utilities (*e.g.* large battery). Only after a quarter-century are they starting to come ‘round.

Brief overview of technical vocabulary

Two related, but different, parameters: *energy* and *power*

Water analogy

Power - no. of sprinkler heads in a garden (potential to spray water)

Energy - amount of water sprayed onto the garden
(manifestation of that potential - *e.g.* keeping plants alive)

Power measures how fast *energy* is used-up.
(More sprinklers use more water.
(Incandescent bulbs use more energy than LEDs - for equal illumination.)

Power unit: kW (kilowatt)
Energy unit: kWh (kilowatt-hour)

Power & energy *synonyms*:
load, demand, capacity, & dispatch …

Load - total electricity used by a home (or city) => “energy”
Demand - how fast that electricity is being used => “power”
Capacity - power needed to meet *peak* demand
(number of sprinklers needed to keep lawn from going brown during hottest heat wave)

Dispatch - *discretionary* release (or sale) of power by utility

Load forecasting - estimate of future electricity-needs to ensure that PWP can reliably serve its customers energy, when the switch is flipped-on.

Demand forecasting - based on historical usage (as well as outside air temperature, EV-charging, and rooftop solar).
  - used by PWP to understand whether its equipment and power sources are adequate (so that you can flip-on the switch)

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Customer-oriented

Engineer-oriented

Operating Principles of PWP

1. Adequacy
2. Reliability
3. Rates (always)

This is the vocabulary *Pasadena 100* needs in order to communicate with PWP.

What is the problem?

Aridification

Lake Oroville, CA

Brian vanderBrug-LAT

Los Angeles Times

Dec 8, 2022

Household water wells are drying up in record numbers as California drought worsens

Angeles Times

latimes.com

Dec 15, 2022

Entire region under drought emergency

Southern California water agencies are asked to reduce use of imported supplies.

By Hayley Smith and Ian James

As California faces the prospect of a fourth consecutive dry year, officials

agencies together about 19 million people

"Since this drough gan, we have been st increasing our call fo servation. If we don' an extremely wet win will need to elevate highest level — a wat ply allocation for Southern California MWD General M Adel Hagekhalil. "S

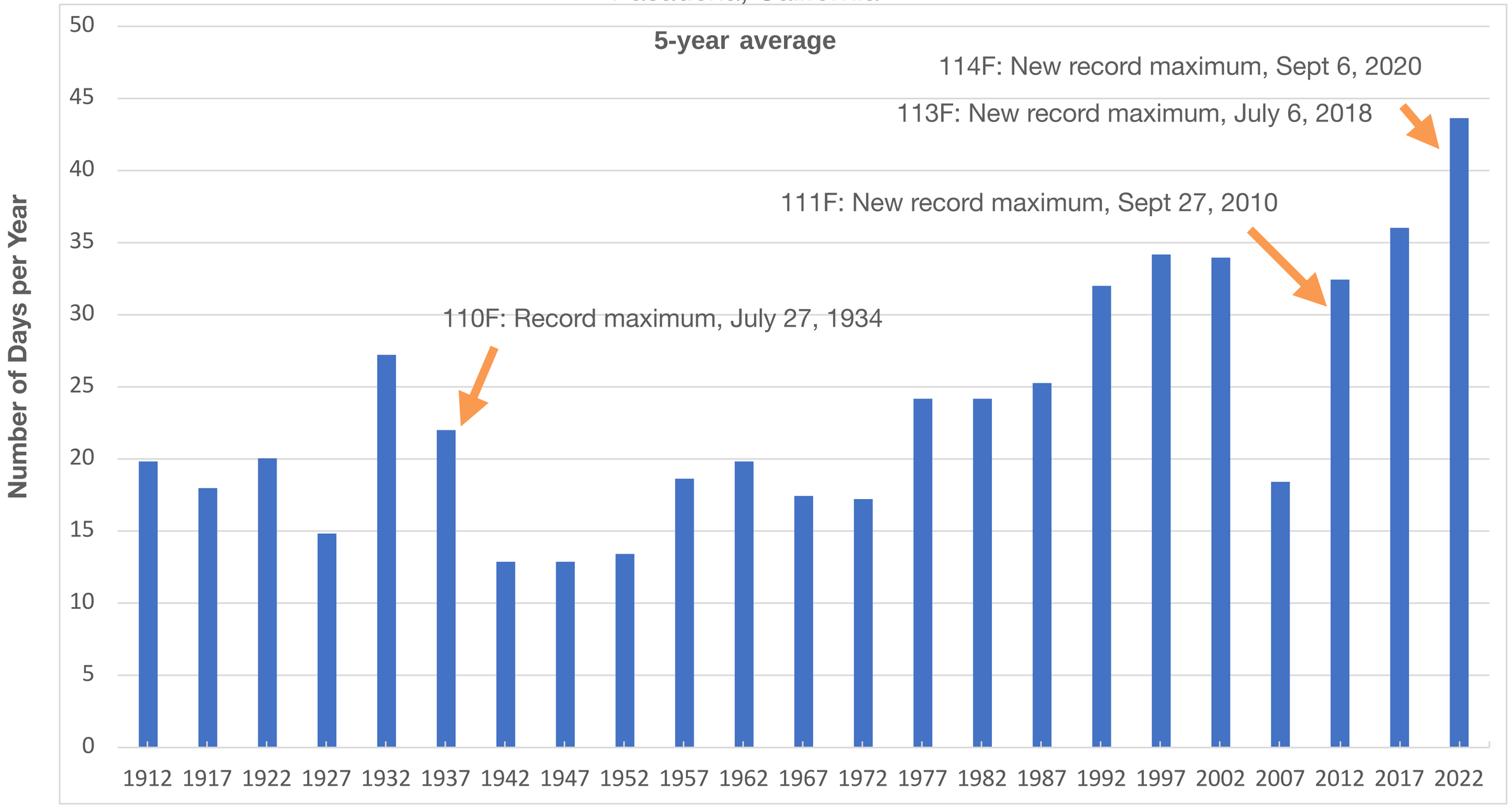
Woodland Hills CA

121 deg – all time record high for LA County

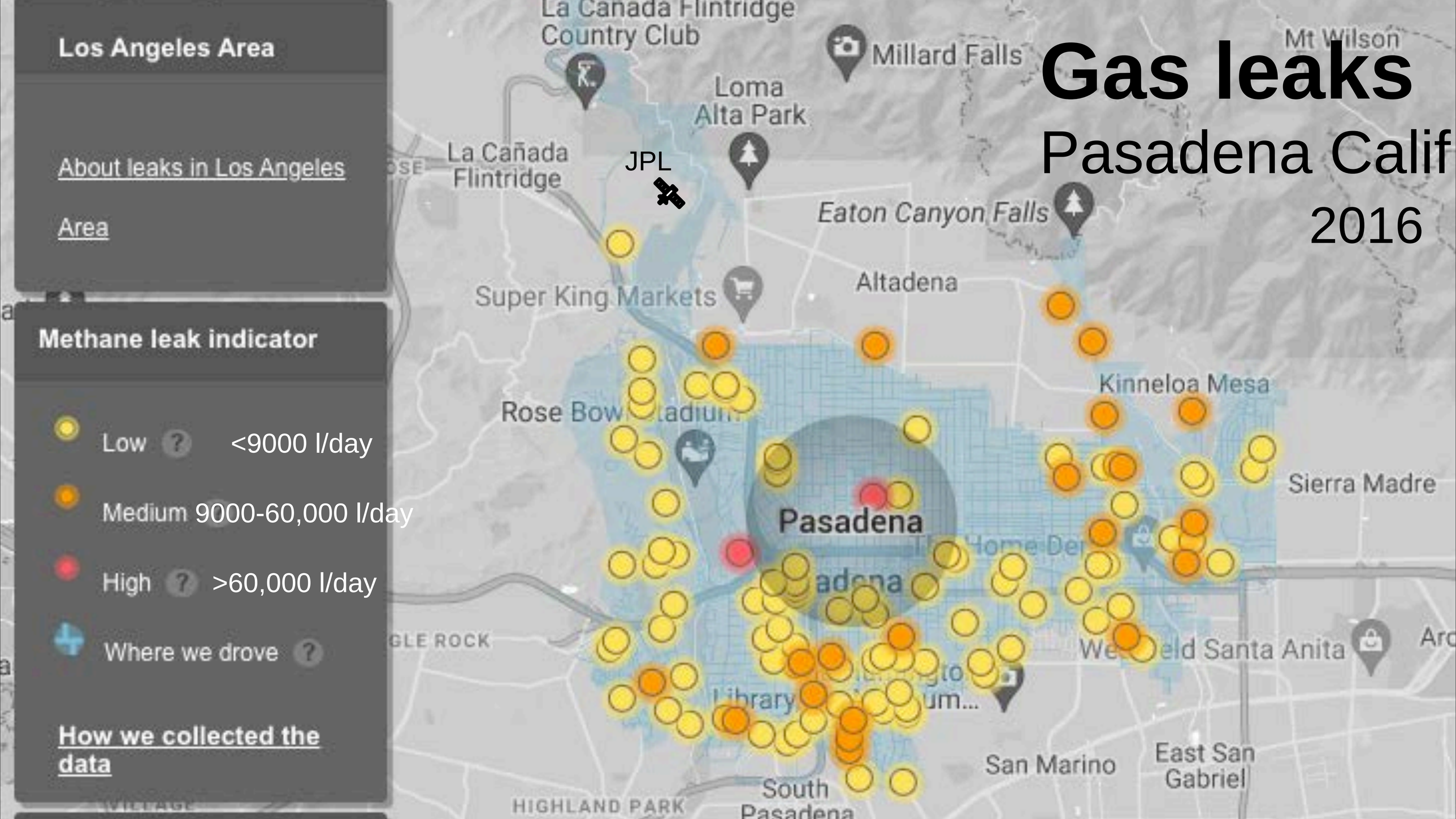
Sept 6, 2020

Annual Number of Days Equal to or Greater than 95F (35C)

Pasadena, California



Data from: National Weather Service, NOAA


Los Angeles Area
About leaks in Los Angeles Area
Methane leak indicator
Low <9000 l/day
Medium 9000-60,000 l/day
High >60,000 l/day
Where we drove
How we collected the data
Gas leaks
Pasadena Calif
2016
La Canada Flintridge Country Club
Millard Falls
Mt Wilson
Loma Alta Park
La Cañada Flintridge
JPL
Eaton Canyon Falls
Altadena
Super King Markets
Rose Bowl Stadium
Kinneloa Mesa
Pasadena
Sierra Madre
Santa Anita
San Marino
East San Gabriel
South Pasadena
HIGHLAND PARK

Global Warming Potential

methane = **84X** carbon dioxide

UN Secretary-General on climate crisis

“Code Red for Humanity” - Aug 9 2021

“highway to climate hell with our foot still on the accelerator” - Nov 7 2022

“cooperate or perish” - Nov 8 2022

U.N. plea: Reduce emissions in half by 2030

Our concern

Fossil fuel combustion (& leaks) release heat-trapping gases — leading to rising temperatures, fires, unpredictable storms, ocean acidification, water scarcity, food shortages, respiratory illnesses. It's harming lives *now* and will inflict future suffering everywhere.

What is State law (per SB1020)?

- 2030 - 60% renewable energy
- 2035 - 90% zero-carbon energy
- 2040 - 95% zero-carbon energy
- 2045 - 100% zero-carbon energy

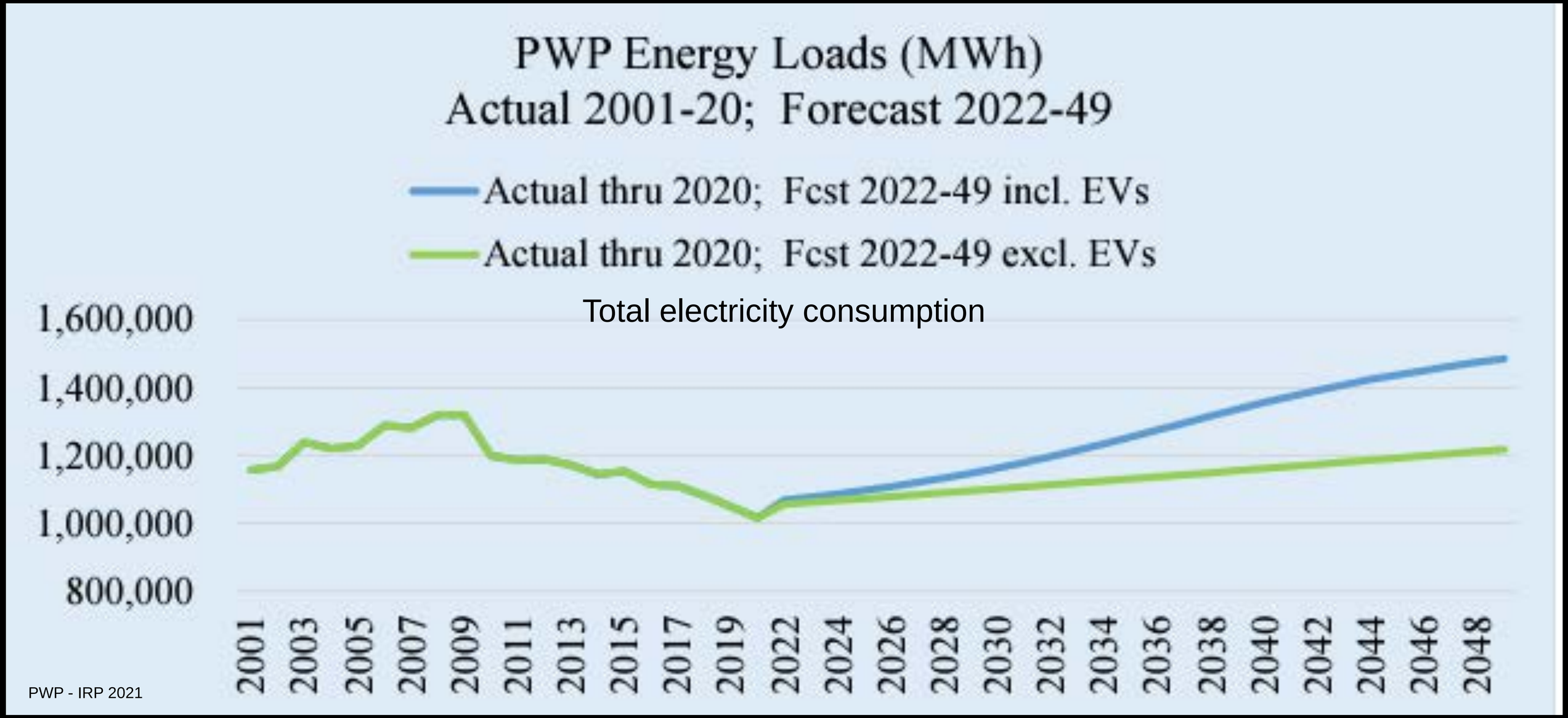
- “zero-carbon”, “carbon-free” or “clean” include big hydro, nukes, carbon-capture-and-sequestration, and renewables

Without a push,
Pasadena will slow-walk the energy transition

- PWP will continue using gas-fired electricity until 2045 unless City Council tells them different

J. Stronberg, Renewable Energy World

Pasadena’s Energy Use



PWP - IRP 2021

What can Pasadenans do?

Urge City to provide leadership & direction

- **EITHER**
- **1**. City-wide electrification by 2030
  - one ordinance already in place
    - not too significant, requires *some* new construction to electrify
  - 40,000 fossil gas customers
-

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- **1**. City-wide electrification by 2030
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  - 40,000 fossil gas customers
- **OR**
- **2**. Decarbonize city grid by 2030
  - PWP's portfolio ~45% carbon-free today
  - 68,000 electricity customers
-

Urge City to provide leadership & direction

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- **OR**
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  - PWP's portfolio ~45% carbon-free today
  - 68,000 electricity customers

- Achieving *either* objective will approximately equal the UN's plea of halving carbon emissions by 2030

What does *Pasadena 100* want?

For Pasadena City Council to direct PWP to transition to 100% zero-carbon energy by 2030.

- in agreement with President Biden’s Executive Order 14057, as well as United Nations’ climate goals

PWP - big fan of coal

- In 2009 PWP published a plan to reduce its ‘take’ of coal-fired power in **2016** by 32%
  - i.e. decrease dependence on IPP from 108 MW to 73 MW

- **Never happened**
  - PWP continues to rely on IPP for 108 MW of coal-fired power in 2022

Feb 13, 2009
IRP Report

Exhibit 1: Summary of Preferred Resource Plan

Year	Remote Renewables (MW)				Local Renewables (MW)			Fossil (MW)		
	LFG	Geo	Wind	Solar Thermal	DR	Solar PV	Feed-in Tariff	CC	Gas Peaker	Coal
2008						0.9				
2009						1.0				
2010						1.1	0.7			
2011						1.1	0.7			
2012	5	5	5	5	5	1.2	0.7			
2013						1.4	0.7			
2014						1.5	0.7	65	-65	
2015						1.7	0.7			
2016	5	5	5	5		1.9	0.7			-35
2017	5	5				2.2	0.7			
2018						0.7	0.7			
2019						0.7	0.7			
2020			10	10		0.7	0.7			
2021						0.7	0.7			
2022						0.7	0.7			
2023						0.7	0.7			
2024						0.7				
2025										
Total	15	15	20	20	5	19	10	65	-65	-35

PWP - not a big fan of rooftop solar

- PWP *does* offer customer net metering
  - 2100 customers with 19 MW nameplate-capacity
- 12-13 years ago PWP also planned to offer a Feed-in Tariff
  - was eliminated — which slowed solar growth in Pasadena
- PWP won’t install community solar and utility rooftop solar
  - too expensive
  - *localness* and *cleverness* can compensate for rooftop’s higher cost

How to make 100% happen?

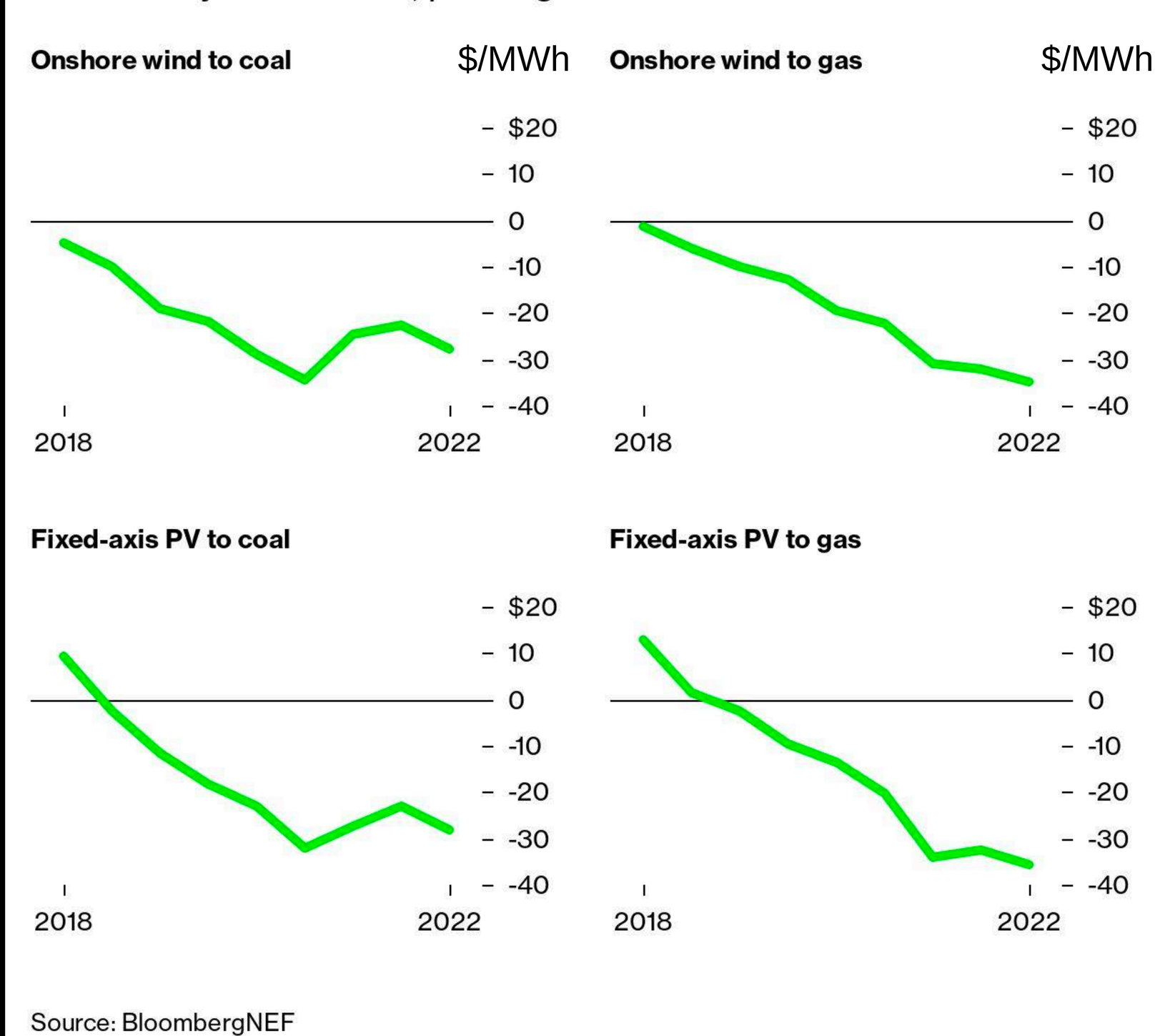
- Roadmap 1
  - PWP adds the Social Cost of Carbon fee to all retail sales starting 2025
    - increments annually
    - monetizes, in today's $, future damages caused by *today's* emissions
  - by 2030, gas-powered facilities will be 'way uneconomical to operate
    - clean-energy will replace gas - but uncertainty when 100% would be achieved
- Roadmap 2
  - PWP aims for a 100% clean-energy portfolio in 2030
    - Recommendation: hire an Energy Management Services company to build-out 100% portfolio (similar to business plan used by CCAs)

Is 100% zero-carbon energy costly?

- Wind, water, and big solar are less expensive than coal, oil, and gas
  - desert solar (utility solar)
    - by far the cheapest
  - wind - also inexpensive
  - rooftop solar - 3X costlier than desert solar
    - due to large number of site installations
    - transmission lines from desert don’t offset higher cost (much)
  - geothermal, wave, tide, hydro, fuel cells, green-hydrogen turbines, nuclear
    - more expensive than gas (except for hydro) - but not by a lot
    - usually represent small fraction of total portfolio

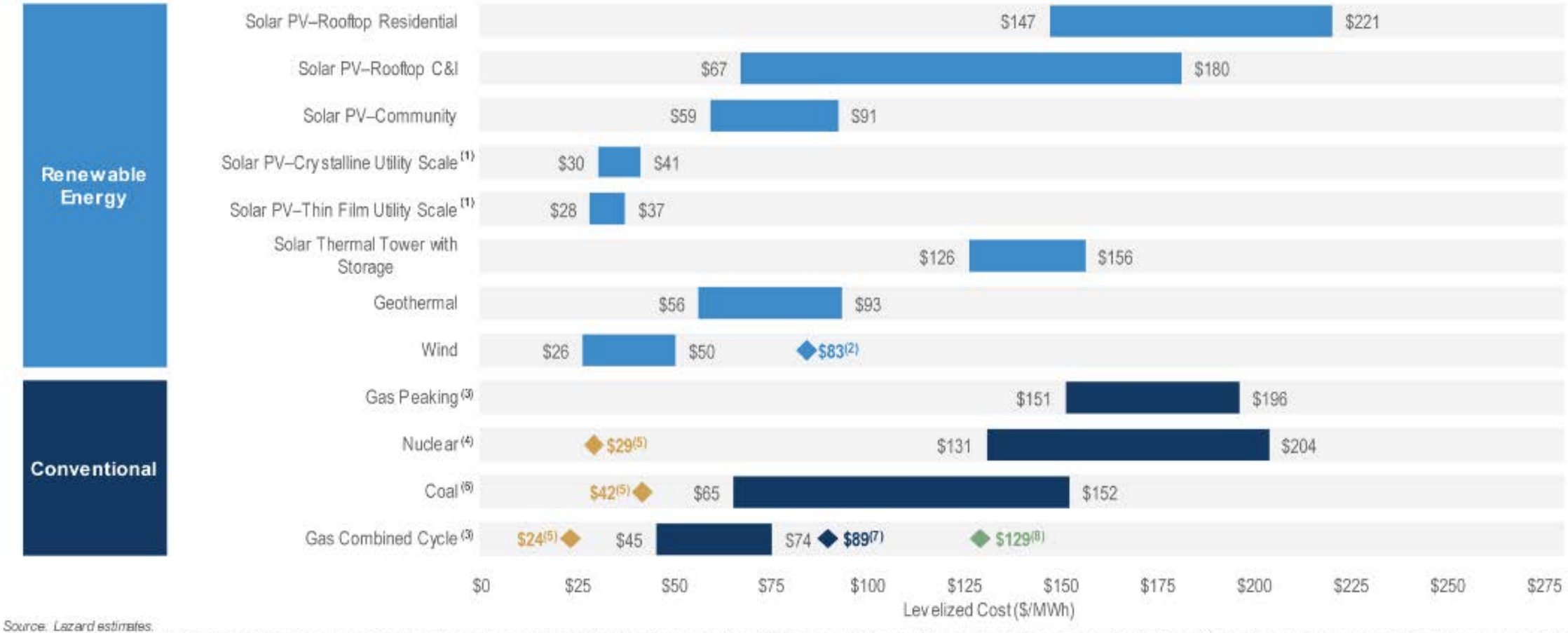
Electricity Cost Comparison

Wind & Solar
versus
Coal & Gas



Source: BloombergNEF

Selected renewable energy generation technologies are cost-competitive with conventional generation technologies under certain circumstances



Source: Lazard estimates.

Note: Here and throughout this presentation, unless otherwise indicated, the analysis assumes 60% debt at 8% interest rate and 40% equity at 12% cost. Please see page titled "Levelized Cost of Energy Comparison—Sensitivity to Cost of Capital" for cost of capital sensitivities. These results are not intended to represent any particular geography. Please see page titled "Solar PV versus Gas Peaking and Wind versus CCGT—Global Markets" for regional sensitivities to selected technologies.

(1) Unless otherwise indicated herein, the low case represents a single-axis tracking system and the high case represents a fixed-tilt system.

(2) Represents the estimated implied midpoint of the LCOE of offshore wind, assuming a capital cost range of approximately $2,500 – $3,600/kW.

(3) The fuel cost assumption for Lazard's global, unsubsidized analysis for gas-fired generation resources is $3.45/MMBTU.

(4) Unless otherwise indicated, the analysis herein does not reflect decommissioning costs, ongoing maintenance-related capital expenditures or the potential economic impacts of federal loan guarantees or other subsidies.

(5) Represents the midpoint of the marginal cost of operating fully depreciated gas combined cycle, coal and nuclear facilities, inclusive of decommissioning costs for nuclear facilities. Analysis assumes that the salvage value for a decommissioned gas combined cycle or coal asset is equivalent to its decommissioning and site restoration costs. Inputs are derived from a benchmark of operating gas combined cycle, coal and nuclear assets across the U.S. Capacity factors, fuel, variable and fixed operating expenses are based on upper- and lower-quartile estimates derived from Lazard's research. Please see page titled "Levelized Cost of Energy Comparison—Renewable Energy versus Marginal Cost of Selected Existing Conventional Generation" for additional details.

(6) High end incorporates 90% carbon capture and storage. Does not include cost of transportation and storage.

(7) Represents the LCOE of the observed high case gas combined cycle inputs using a 20% blend of "Blue" hydrogen, (i.e., hydrogen produced from a steam-methane reformer, using natural gas as a feedstock, and sequestering the resulting CO_2 in a nearby saline aquifer). No plant modifications are assumed beyond a 2% adjustment to the plant's heat rate. The corresponding fuel cost is $5.20/MMBTU, assuming $1.39/kg for Blue hydrogen.

(8) Represents the LCOE of the observed high case gas combined cycle inputs using a 20% blend of "Green" hydrogen, (i.e., hydrogen produced from an electrolyzer powered by a mix of wind and solar generation and stored in a nearby salt cavern). No plant modifications are assumed beyond a 2% adjustment to the plant's heat rate. The corresponding fuel cost is $10.05/MMBTU, assuming $4.15/kg for Green hydrogen.

Prepare for push-back on clean energy — especially cost of battery storage

- Lithium batteries (e.g. “Megapack”)
  - NREL predicts costs to halve by 2030
  - DOE predicts deployment to triple by 2025
- Redox flow batteries
  - industrial-size
  - probably cheaper than Li
- **Weakest link in our campaign**

2018's Cost of power (2018 IRP)

- Retail charge for residential customers (average)
  - 20 cents/kWh
- Option 8: **carbon-free-power** retail charge, resid. customers
  - 43 cents/kWh
    - energy-alone cost: 4X that of the preferred portfolio
    - energy contributes only 50% of total billing, so rate ~*doubles*

2018's Cost of power (2018 IRP)

- Retail charge for residential customers (average)
  - 20 cents/kWh
- Option 8: **carbon-free-power** retail charge, resid. customers
  - 43 cents/kWh
    - energy-alone cost: 4X that of the preferred portfolio
    - energy contributes only 50% of total billing, so rate ~*doubles*
- => in **2021** IRP update, Option 8 rate **only 15% higher** (no longer 215% higher)

Cost of power today

- Base rate retail charge, residential customers (representative)
  - 23 cents/kWh
- 100% Green Power
  - 25 cents/kWh
  - power doesn’t come from an identifiable source
  - sign-up for green power here: ww5.cityofpasadena.net/water-and-power/greenpoweroption/
    - only a few hundred customers

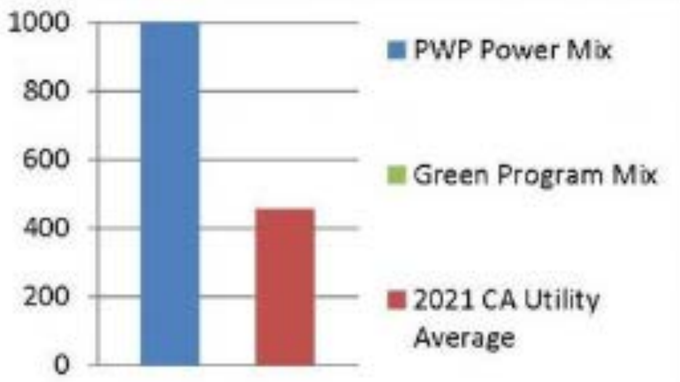
Pasadena Water and Power

Power Content Label

2021 POWER CONTENT LABEL
City of Pasadena
www.PWPweb.com/PCL

Greenhouse Gas Emissions Intensity (lbs CO_2e/MWh)

PWP Power Mix	Green Program Mix	2021 CA Utility Average
1031	0	456



Energy Resources	PWP Power Mix	Green Program Mix	2021 CA Power Mix
Eligible Renewable[1]	**33.2%**	**100.0%**	**33.6%**
Biomass & Biowaste	9.3%	0.0%	2.3%
Geothermal	1.9%	0.0%	4.8%
Eligible Hydroelectric	0.0%	0.0%	1.0%
Solar	6.6%	0.0%	14.2%
Wind	15.4%	100.0%	11.4%
Coal	**47.6%**	**0.0%**	**3.0%**
Large Hydroelectric	**4.8%**	**0.0%**	**9.2%**
Natural Gas	**5.9%**	**0.0%**	**37.9%**
Nuclear	**8.5%**	**0.0%**	**9.3%**
Other	**0.0%**	**0.0%**	**0.2%**
Unspecified Power[2]	**0.0%**	**0.0%**	**6.8%**
TOTAL	**100.0%**	**100.0%**	**100.0%**
Percentage of Retail Sales Covered by Retired Unbundled RECs[3]**:**	**6%**	**0%**	

[1]The eligible renewable percentage above does not reflect RPS compliance, which is determined using a different methodology.
[2]Unspecified power is electricity that has been purchased through open market transactions and is not traceable to a specific generation source.
[3]Renewable energy credits (RECs) are tracking instruments issued for renewable generation. Unbundled renewable energy credits (RECs) represent renewable generation that was not delivered to serve retail sales. Unbundled RECs are not reflected in the power mix or GHG emissions intensities above.

For specific information about this electricity portfolio, contact:	**City of Pasadena 626-744-6970**
For general information about the Power Content Label, visit:	http://www.energy.ca.gov/pcl/
For additional questions, please contact the California Energy Commission at:	Toll-free in California: 844-454-2906 Outside California: 916-653-0237

Clean Power Alliance

<= Power Generation Mix

close to 1 million customers

2021 Electric Power Generation Mix**	CPA Lean Power	CPA Clean Power	CPA 100% Green Power
Specific Purchases	Percent of Total Retail Sales (kWh)		
Renewable	**0.0%**	**40.6%**	**100.0%**
Biomass & biowaste	0.0%	3.1%	0.0%
Geothermal	0.0%	6.6%	0.0%
Eligible hydroelectric	0.0%	1.1%	0.0%
Solar	0.0%	7.4%	47.9%
Wind	0.0%	22.4%	52.1%
Coal	0.0%	0.0%	0.0%
Large hydroelectric	40.1%	21.6%	0.0%
Natural gas	0.0%	0.0%	0.0%
Nuclear	0.0%	0.0%	0.0%
Other	0.0%	0.0%	0.0%
Unspecified Power* **	59.9%	37.8%	0.0%
Total	100.0%	100.0%	100.0%

Power Price

2022 Schedule Domestic Comparison	CPA Lean Power	CPA Clean Power	CPA 100% Green Power
Generation Rate ($/kWh)	$0.10496	$0.10804	$0.11727
SCE Delivery Rate ($/kWh)	$0.19273	$0.19273	$0.19273
Surcharges ($/kWh)	$0.00455	$0.00455	$0.00455
Total Costs ($/kWh)	$0.30224	$0.30532	$0.31455
Average Monthly Bill ($)	$170.46	$172.20	$177.41

PWP Power Purchase Agreements - 2018 IRP

Exhibit 9: Summary of PWP's Contracts

SI No.	Asset Name	PWP Capacity (MW)	Online Date	Contract Expiration	Estimated Energy Cost ($2017/MWh)
1	Antelope Big Sky Ranch Solar Project	6.5	8/19/2016	12/31/2041	66.15*
2	Summer Solar Project	6.5	7/25/2016	12/31/2041	66.15*
3	Columbia II Solar Project	2.6	12/10/2014	12/9/2034	69.98
4	Kingbird Solar Project	20.0	4/30/2016	12/31/2036	68.5
5	Windsor Reservoir Solar Project	0.6	5/31/2011	5/30/2031	104.49
6	Milford Wind Corridor Phase	5.0	11/15/2009	11/14/2029	70.47
7	High Winds Generation Facility	6.0	8/25/2003	12/31/2024	53.5
8	Hoover Uprating Hydroelectric Project	20.2	10/1/2016	9/30/2067	18.07
9	Puente Hills Landfill Gas	12.6	1/1/2017	12/31/2030	80
10	Chiquita Canyon Landfill Gas-to-Energy	8.3	11/23/2010	11/22/2030	65.25
11	Heber South Geothermal Project	2.1	6/18/2006	12/31/2031	71.2
12	Magnolia Power Plant	14.0	9/22/2005	N/A	26.92
13	SCPPA Palo Verde Nuclear Station	9.9	1/29/1986	N/A	40.08
14	Intermountain Power Project	108.0	7/1/1986	6/15/2027	63.27**

*Energy portion only (does not include the renewable energy credit price)

** Debt service includes

15	**Sapphire Solar[1]**	**25**	**12/31/2026**	**01/01/2047**	**45.00**

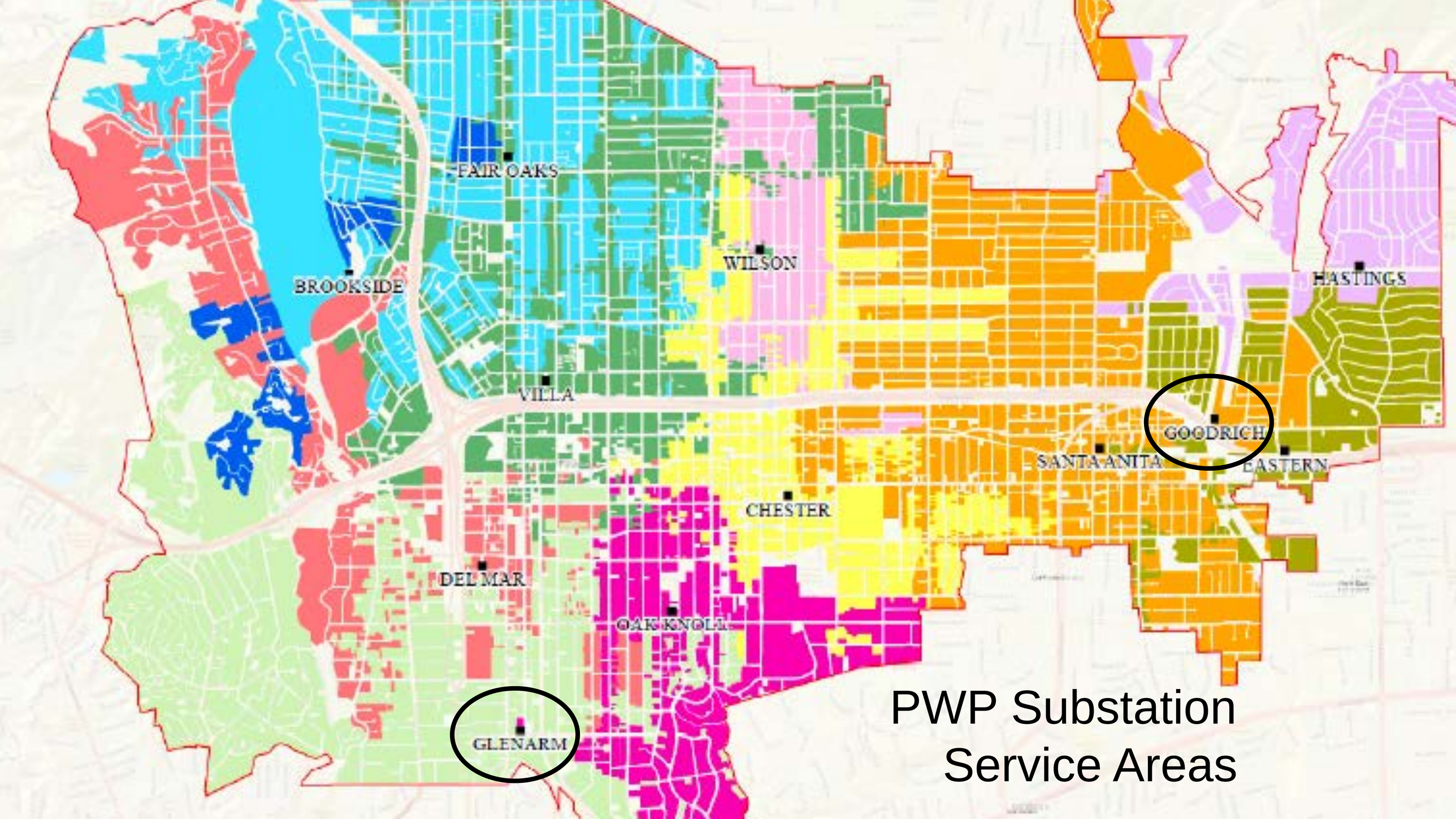
[1]includes 20 MWh storage

CPUC, CAISO & PWP

- CPUC has a rule limiting rooftop solar generation to 5% of investor-owned utility's total load
  - PWP is not subject to CPUC but nevertheless follows-along
    - might prohibit more rooftop solar since 5% limit has been reached (TBD)
    - might eliminate net energy metering (TBD)
- CAISO has a rule that utilities must demonstrate sufficient capacity margin
  - => PWP must show capacity = 115% of predicted load
    - Glenarm Power Plant fills that backup role

Where does PWP's power come from?

- Day-by-day:
  - peak load - usually around 305 MW
    - maximum historical load = 320 MW
      - forecast to go higher with EVs and electrification
  - City imports almost all its power (coming from distant sources) thru a **single** sub-station: Goodrich Connector (in E Pasadena)
    - limited to 280 MW
      - altho PWP has contractual right for up to 336 MW
- Combining "peak load" and "resource adequacy"
  - need local power generation (320x1.15-280= **88 MW**)
    - reason for Glenarm Power Plant (140 MW)



PWP Substation Service Areas

Cost of future base rate power

- Projections of retail rates in the 2020s *decreases* in 2021's IRP vis-a-vis 2018's IRP
  - altho *fewer* energy sales to other utilities in 2021's IRP
  - lower renewable energy costs in 2021's IRP
  - faster renewable energy acquisition in 2021's IRP
- **take-away message**
  - installing lowest-cost electricity plants *sooner* decreases electricity rates *faster*

State-of-the-art energy modeling:
-> buying (cheap) power *piece-meal* is not optimal!

- Infrastructure costs based on *peak* loads
  - flattening peak loads reduces capital costs & utility rates
- Optimal clean-energy grid design
  - roughly 75% desert solar & wind (+ storage)
  - roughly 10-15% rooftop solar + storage (and/or community solar)
    - eliminates need to build extra peaker-plants for peak loads
  - balance consists of local, opportunistic clean-energy sources

Where will future power come from?

- Option 1: upgrade Goodrich Connector
  - **expensive** (~$30M) - increases PWP import capacity to 336 MW
    - less than resource adequacy limit (320x1.15 = **368 MW**)
    - **Do we want PWP to do this?**
- Option 2: assist LADWP
  - install phase shift transformer at Glenarm so PWP can connect to LADWP
    - **expensive** (~$10M) - allows PWP to import 40 MW from LADWP
    - will facilitate LADWP's integration into CAISO **(revenue source for PWP?)**
- Option 3: expand rooftop solar, end gas-fired power
  - our favorite option
    - can combine with Option 2

Expanding rooftop solar

- Rooftop solar (+ battery storage) could replace Glenarm's gas turbines and still provide local "resource adequacy" in the following way
  - ignore 5% limit on rooftop solar
  - PWP installs smart inverters at each rooftop solar facility
  - PWP installs batteries near rooftop solar facilities
    - in-front-of customer meter
  - => provides PWP with:
    - potentially 50-60 MW rooftop-solar power-plant
    - sufficient flexibility for dispatch control

How to pay for the energy transition?

IRA tax credits pertinent to PWP

- PWP doesn’t have tax liability so can’t take advantage of tax credits
  - IRA allows it to transfer credit to contractor who in turn can reduce fee
- Investment credits - construction must begin before 2025
  - Wind - 30%
  - Solar - 30%
  - Storage - 30%
- Production credits
  - Wind - $27.50/MWh
  - Solar - $27.50/MWh
- Bonus ITC & PTC credits - for domestic content & siting choices

PWP must apply for benefits & credits

Put those dollars to work in Pasadena!

- Community Solar
- Battery storage for rooftop solar
- Battery storage at Glenarm Power Plant

Pertinent rebates & benefits to PWP ratepayers

- Pasadena https://ww5.cityofpasadena.net/water-and-power/underoneroof/
- California https://goldenstaterebates.clearesult.com/
- https://gogreenfinancing.com/residential
- http://www.aqmd.gov/home/programs
- https://energyupgradeca.org/home-energy-efficiency
- Federal https://www.rewiringamerica.org/app/ira-calculator
- https://www.whitehouse.gov/briefing-room/statements-releases/2022/11/02/fact-sheet-biden-harris-administration-announces-new-actions-to-lower-energy-costs-for-families/

Questions?