

A close-up photograph of several fresh green zucchinis in a dark-colored basket. The zucchinis are vibrant green with some yellow at the stem ends. They are piled together, and the lighting creates highlights on their smooth surfaces.

Pathways to 100 (or darn close).

Ken Regelson
August, 2019

Intro

Quite good with numbers & graphs.

When I speak to a general audience, I ask:

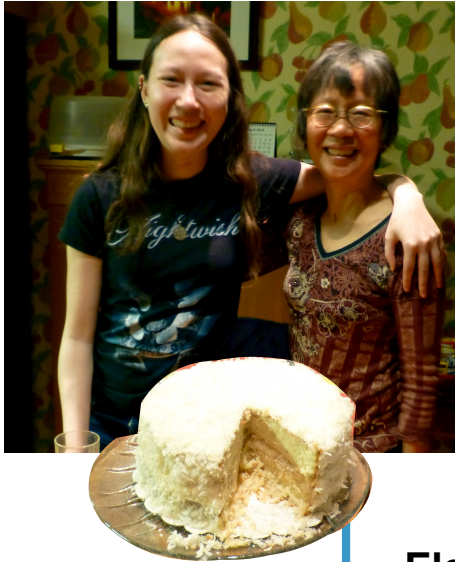
If the goal is

100% Renewables by 2030

how many would be satisfied with 95 or 98% by 2030?

My Daughter Bakes Really Great Cakes!

Like most bakers, she follows a recipe.



Colorado Energy Recipe

1 part 100% Renewable Electricity

1 part Electrify Everything Else

Just Colorado

	% of CO2	Cost (2016 Billions)	Increase in current electricity use to electrify all	Cost of electricity electrify all (based on 10 ¢ / kWh)
Electricity (all coal + gas used for electricity)	40%	\$5.5 B	-	No Change \$5.5 B
Oil (gasoline & diesel)	35%	\$6.5 B	40%	\$2.3 B
Natural Gas (gas NOT used for electricity)	20%	\$1.5 B	20%	\$1.2 B
Total		\$13.5 B	60%	\$9 B

\$4.5 Billion Savings per year!

Notes: Most of data from 2016 EIA with analysis by EnergyShouldBe.org. The electricity use to electrify transportation is conservative. 10 cents per kWh is the blended cost of Colorado electricity. Divide EIA Table 10 all Colorado revenue by MWh Sales,

The most speculative number is the electricity to electrify nat. gas use. This is based on using heat pumps with a COP of 3. Air source heat pumps are available now (2019) for Colorado at that COP.

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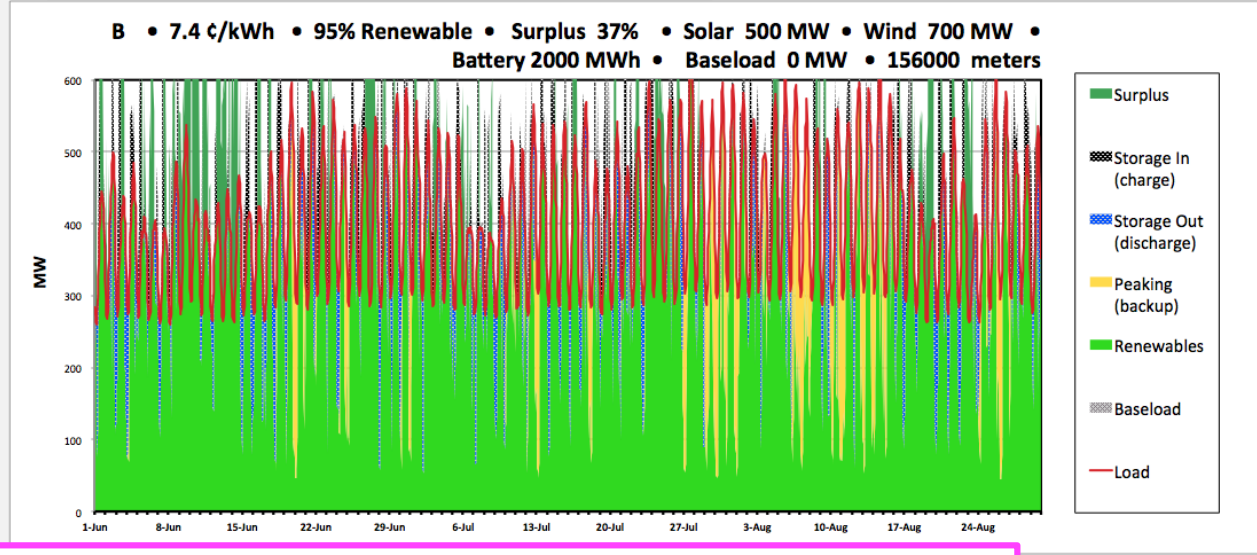
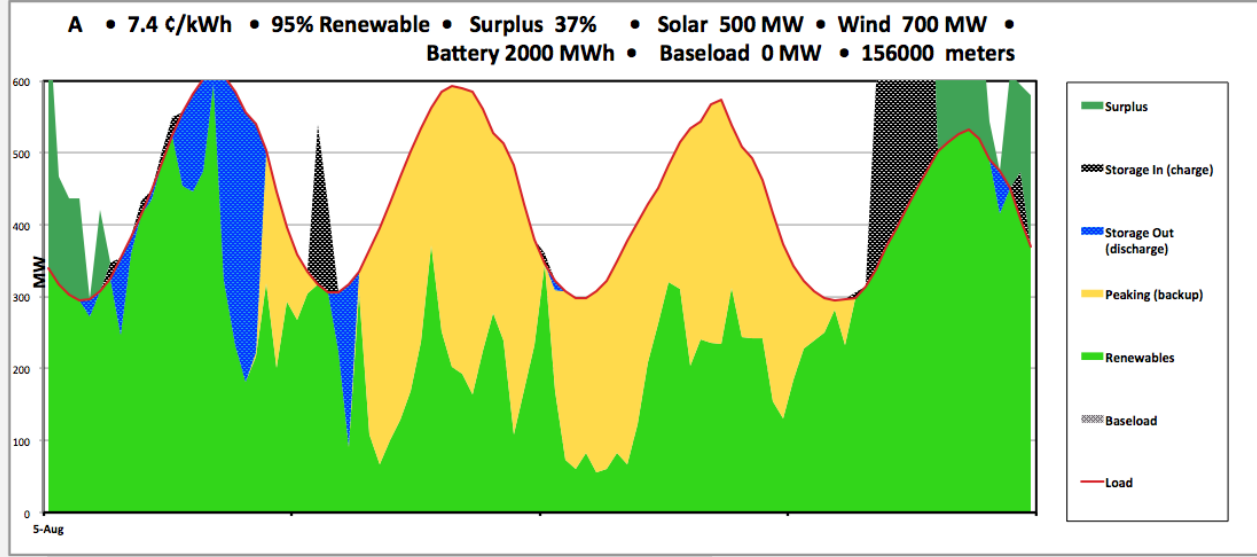
	% of CO2	Cost (2016 Billions)	Increase in current electricity use to electrify all	Cost of electricity electrify all <small>(based on 10 ¢ / kWh)</small>	Average Life of Fleet
Electricity (all coal + gas used for electricity)	40%	\$5.5 B	-	No Change \$5.5 B	
Oil (gasoline & diesel)	35%	\$6.5 B	40%	\$2.3 B	~ 15 years
Natural Gas (gas NOT used for electricity)	20%	\$1.5 B	20%	\$1.2 B	50 - 100 years
Total		\$13.5 B	60%	\$9 B	

Notes: Most of data from 2016 EIA with analysis by EnergyShouldBe.org. The electricity use to electrify transportation is conservative. 10 cents per kWh is the blended cost of Colorado electricity. Divide EIA Table 10 all Colorado revenue by MWh Sales,

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Modeling Electric Grids and Renewables

	A	B	C	D	F	G
1	Use this model at your own risk.					
2	Meters (use to adjust load up or down)	156,000	156,000	Meters		
4					colorado 2,600,000 meters	
5	Battery	2,000	2,000	Storage	17000 MW wind 10100	
6	Hydro	90	90	MWh	PV 4 hr 40,000 MWh	
7	Solar	500	500	Hydro	wind 1.9 c/kWh PV Stor	
9	Wind	700	700	MW	3.8 c/kWh	
11					PRPA 2018 About	
16					6.5 c/kWh	
17		"normal" 500 90 500 700				
18	Annual LOAD	3,201,193	3,201,193	MWh		
19	Annual RE GENERATED	4,200,473	4,200,473	MWh		
20	Renewables Used & Useful When Net Load > 0					
21	Annual RE USED	3,028,326	3,028,326	MWh		
22	Annual RE USED	95%	95%	%		
23	Annual RE OVER-GENERATED	1,172,147	1,172,147	MWh		
24	Annual RE OVER-GENERATED	37%	37%	%		PRPA peak avg min
25	Annual HOURS CURTAILED	3846	3846	Hours		630 370 270
26	Peak (max of load minus renewables)	449	449	MW		388 MW nat gas
27	Annual Backup Gen. (Peaker) Usage	202818	202818	MWh		Use of Peak Annual
28	Minimum (load minus renewables)	-906	-906	MW		PRPA about 6% of whole state
29	Energy Withdrawn From Storage	269,556	269,556	MWh		so 16 times PRPA
30	BASELOAD Generation	0	0	MW	BaseLoad	135
31	Annual LOAD	3,201,193	3,201,193	MWh		storage utilization
32	Annual BASELOAD	0	0	MWh		
33	Net Annual LOAD - BASELOAD	3,201,193	3,201,193	MWh		
34	Annual RE GENERATED	4,200,473	4,200,473	MWh		
35	Renewables Used & Useful When Net Load > baseload (assumes baseload is "must take")					
36	Annual RE USED	3,028,326	3,028,326	MWh		
37	Annual RE USED	95%	95%	%		
38	Annual RE OVER-GENERATED	1,172,147	1,172,147	MWh		
39	Annual RE OVER-GENERATED	37%	37%	%		
40	Annual HOURS CURTAILED	3846	3846	HOURS		
41	Simple Cost Model					
42	Hydro (wght avg of WAPA CRSP & LAP	\$0.028	\$0.028	\$/kWh (PPA)		
43	Solar (from Xcel 2017 PPAs)	\$0.023	\$0.023	\$/kWh (PPA)		
44	Wind (From Xcel 2017 PPAs)	\$0.015	\$0.015	\$/kWh (PPA)		
45	Battery (upfront cost)	\$0.125	\$0.125	\$/MWh (upfront cost)		
46						
47	Interest Rate	3.5%	3.5%	%		
48	Term	20	20	years		
49	Sell Excess Overgeneration at	\$0.010	\$0.010	\$/kWh		
50	Annual Operating Expense	\$125	\$125	MS		
51	Cost of baseload & peaking power	\$0.015	\$0.015	\$/kWh		
52	Loans	\$224	\$224	MS		
53	Transmission (all kWh. Assumes no local generation)	\$0.003	\$0.003	\$/kWh		
54	\$/kWh blended (no separate rates residential, comn	\$0.074	\$0.074	\$/kWh		
55						
56						



Models don't predict THE FUTURE.



They SUGGEST POSSIBLE FUTURES based on assumptions.

How Many Hours of Year Renewables Meet Load

Simplified view.

Every hour of the year is shown.

Perfect 50% Renewables



Perfect 100% Renewables



**Half
Year**

**Whole
Year**

The Cost, Use, and Generation Data Came From...

Xcel Colorado

Platte River Power Authority - PRPA

EIA (DOE)



Platte River
Power Authority

Estes Park • Fort Collins • Longmont • Loveland

Compare For and Non-Profit Self-Generators. Colorado.

	Long Term Goal	50% Renewable	100%	% Colorado Served Retail	Blended Rate (cents/kWh)
PRPA non-profit	100% non-carbon	2020	2030	6%	8.0
Xcel for profit	100% reduction in carbon dioxide	2023	2050	54%	9.5
Tri-State non-profit	(none)	?		15%	11.0
Colorado Springs Muni non-profit	(none)	?		9%	9.2
IREA non-profit	(none)	?		6%	12.4
Black Hills for profit	(none)	?		4%	12.8

Lowest Rates in CO. Excellent Reliability.

If Xcel charged PRPA's rates we would save About \$400 Million per year on electricity.



Bigger is not better.

Source: EIA Table 10 2015 retail sales by utility. Blended rate for Tri-State and PRPA are a weighted average for Colorado retail utilities by MWh sales. % Colorado served is by number of customers (meters). Number of customers turns out to track well with MWh sales. "?" means data not available.

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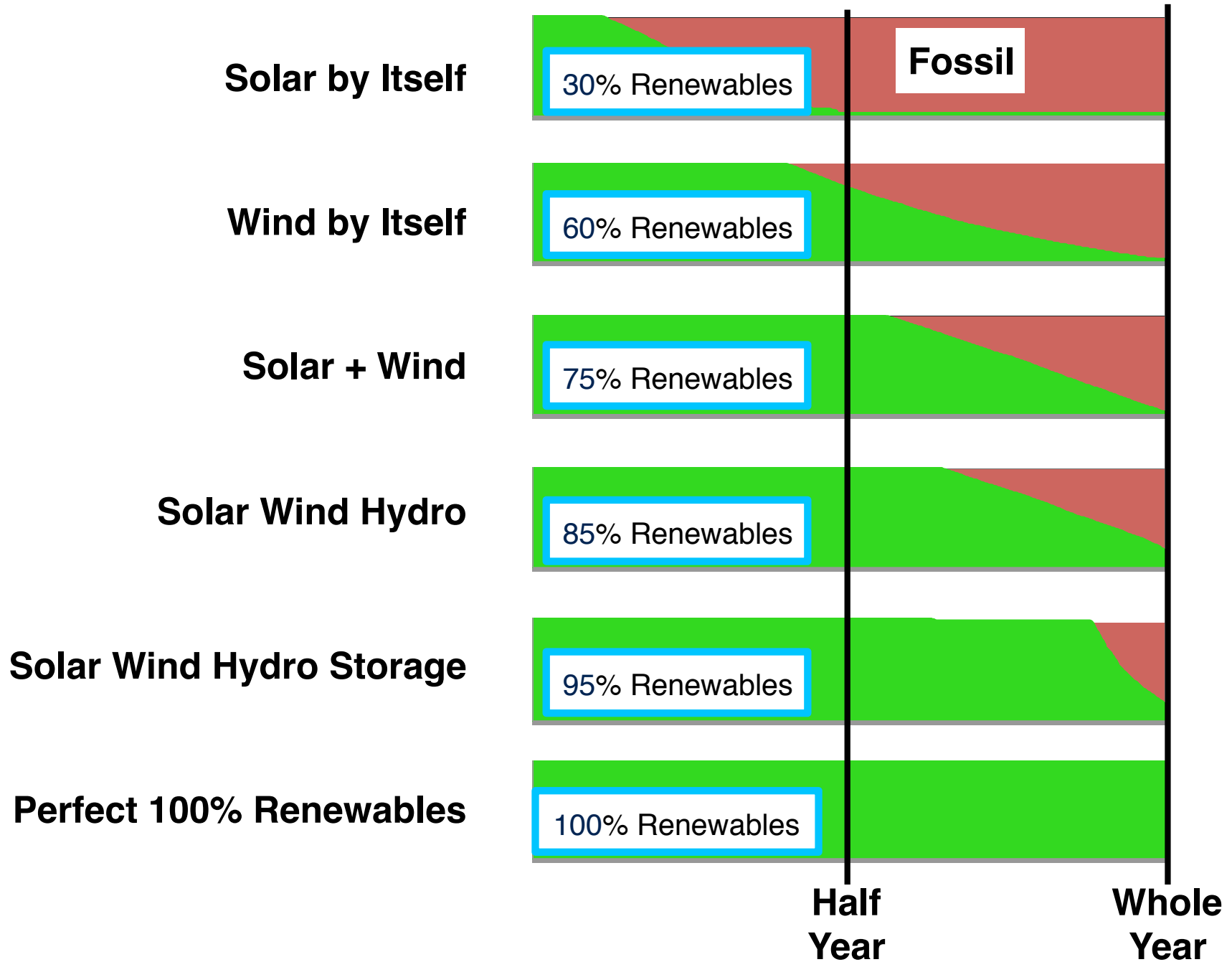
Reliable,

Cheap,

100% Renewables by 2030

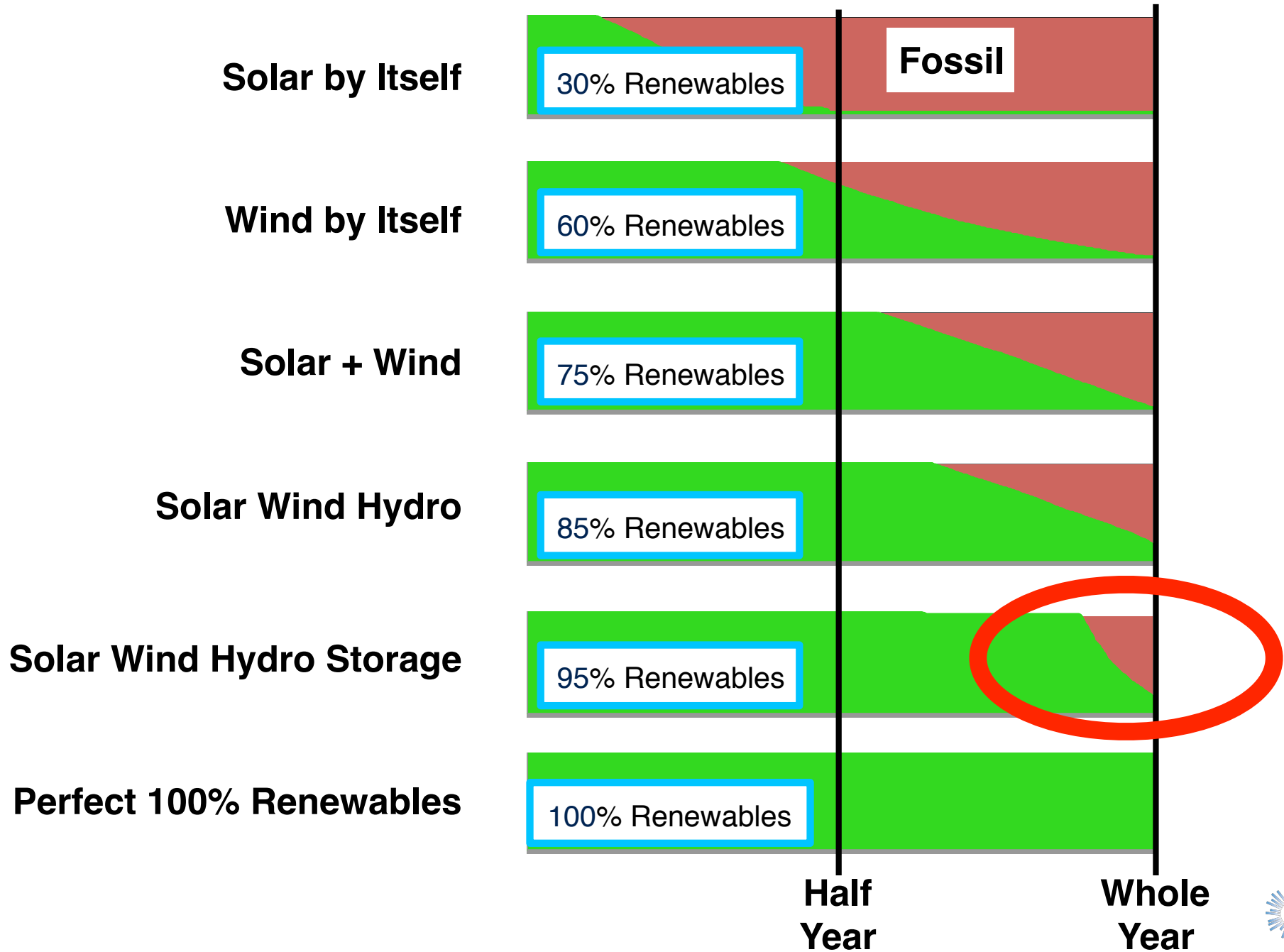
How Many Hours of Year Renewables Meet Load

Reliable Cheap
100%



How Many Hours of Year Renewables Meet Load

Reliable Cheap
100%



Filling in With Gas

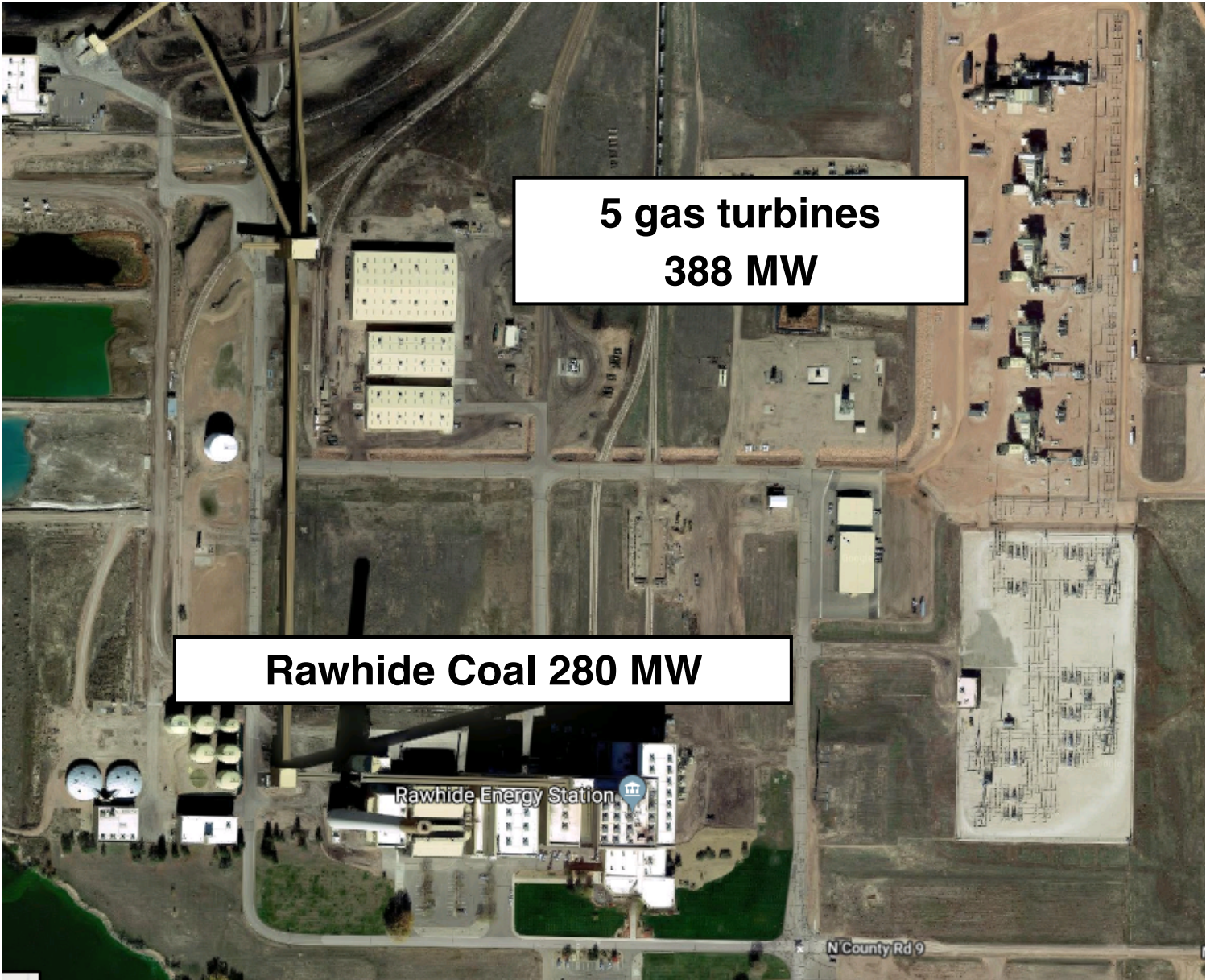
95% Renewable Hourly.

PRPA's Rawhide Station

**5 gas turbines
388 MW**

Rawhide Coal 280 MW

**Craig
Coal 154 MW**



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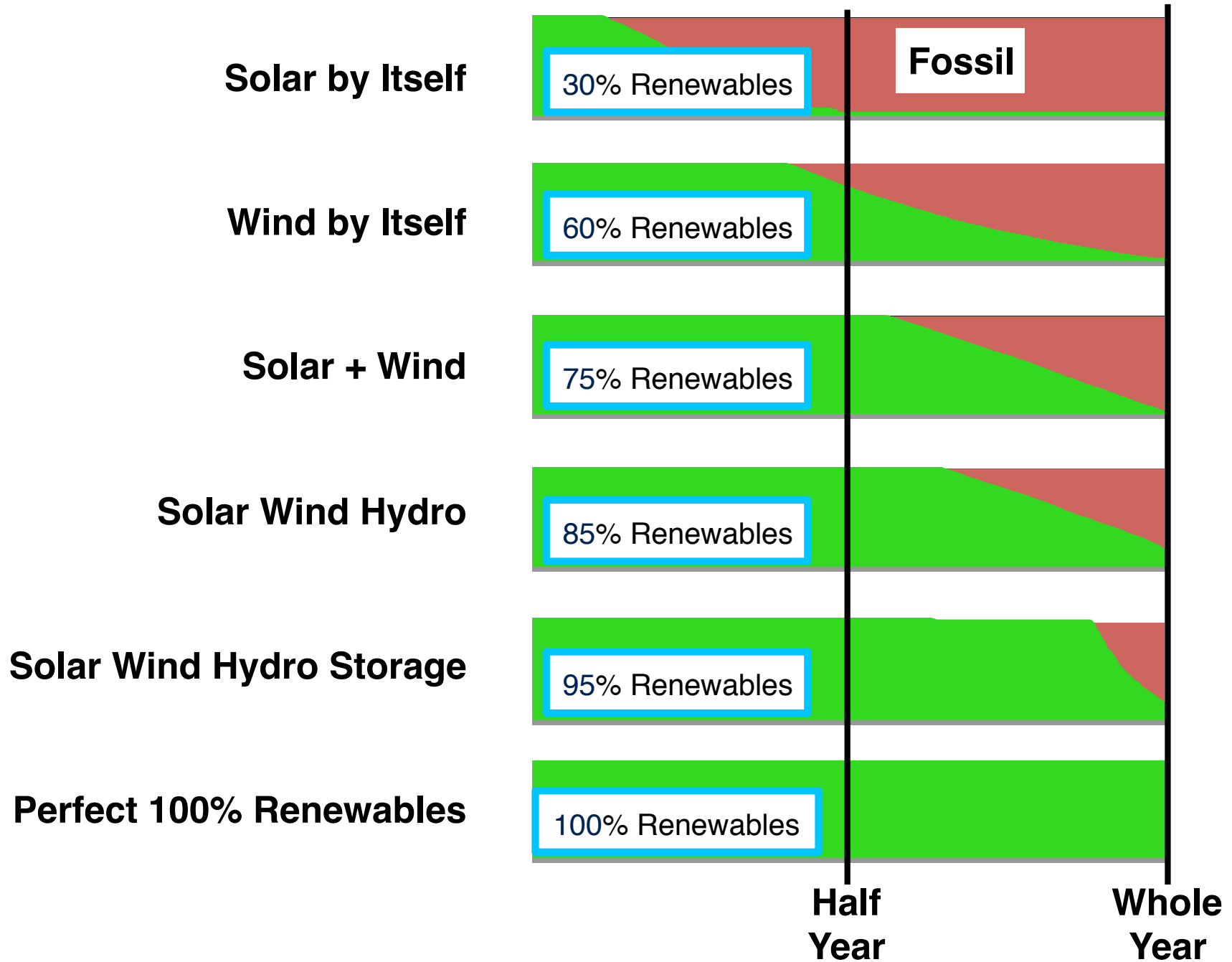
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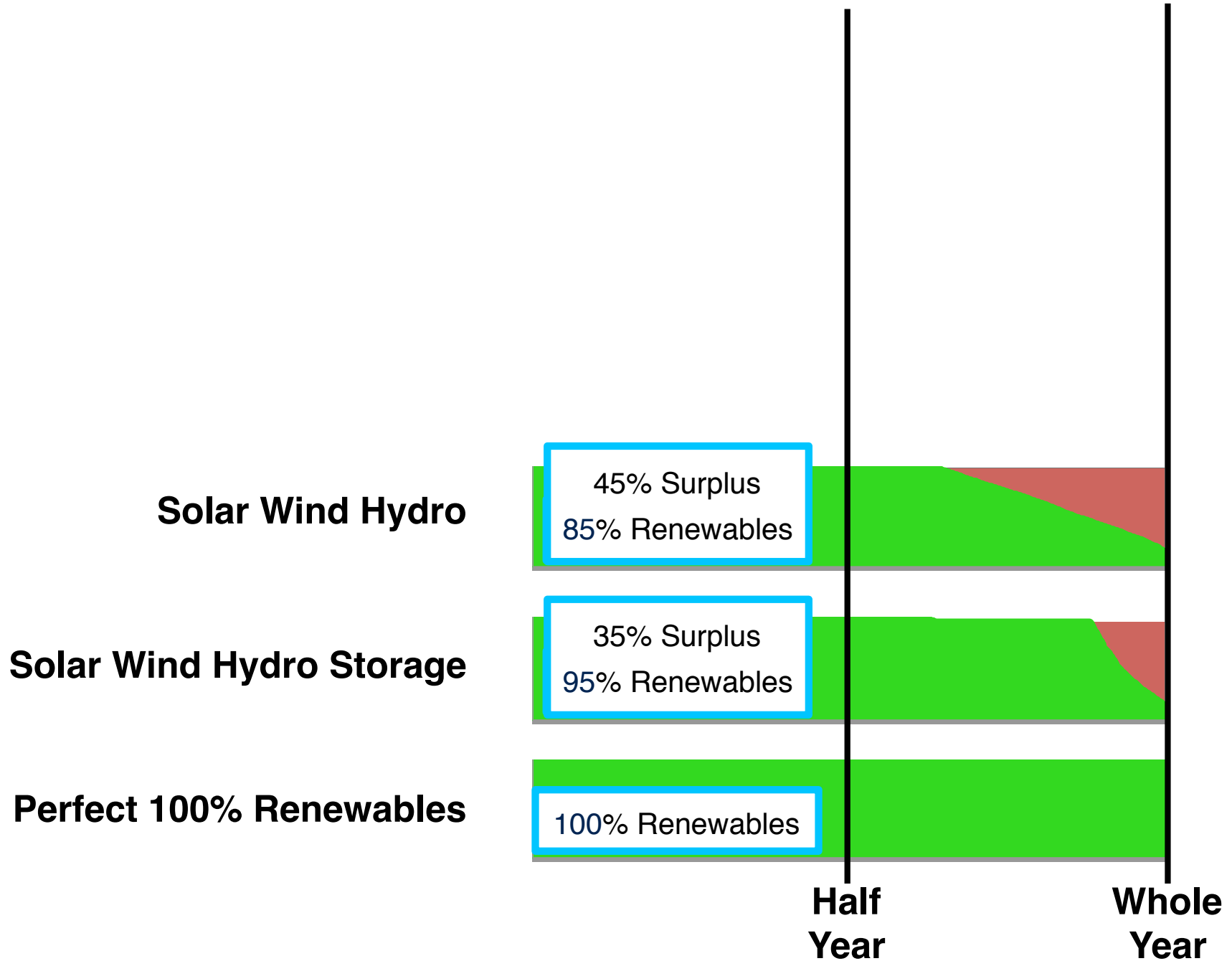
How Many Hours of Year Renewables Meet Load

*Reliable Cheap
100%*



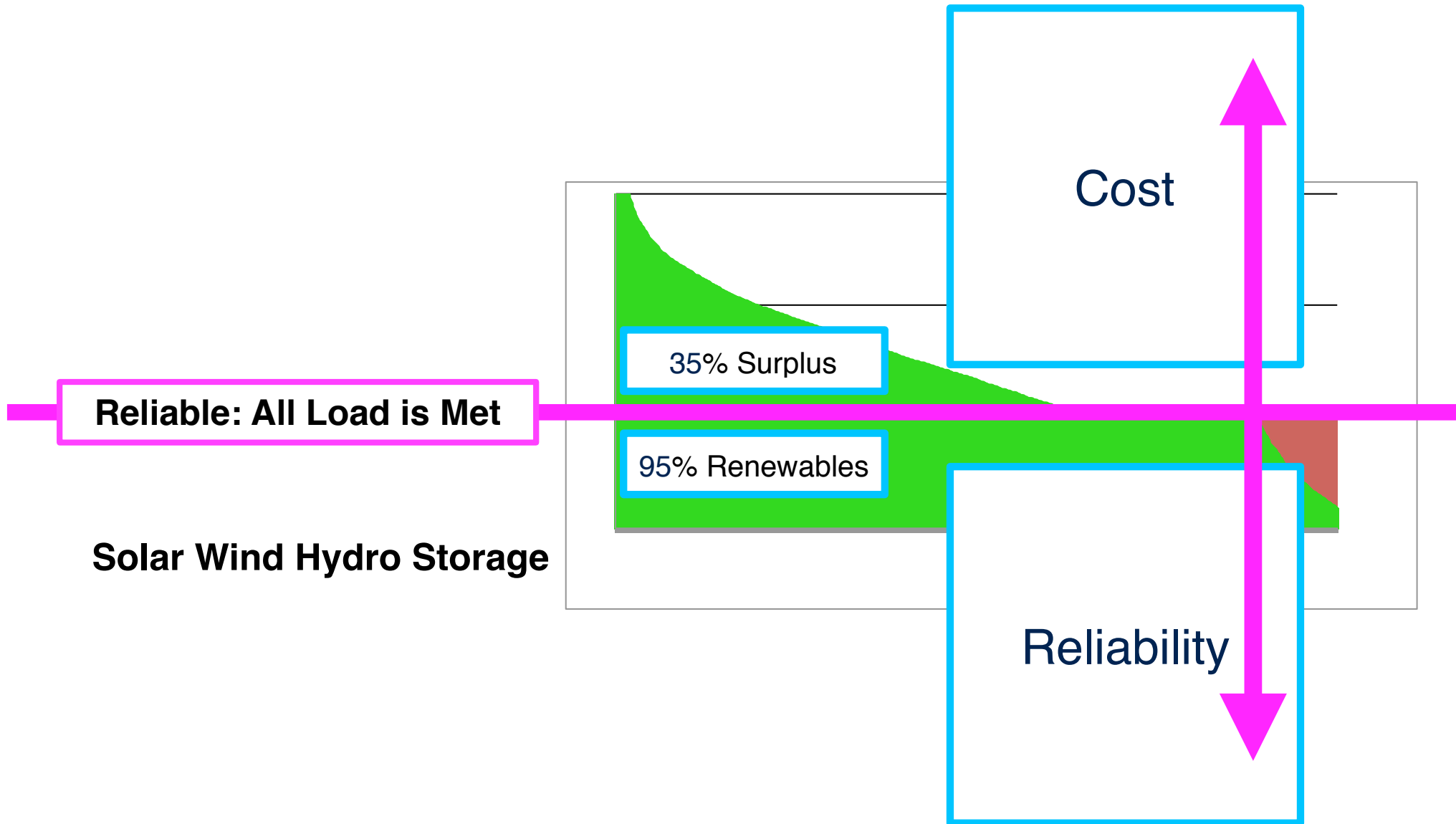
How Many Hours of Year Renewables Meet Load

*Reliable Cheap
100%*



How Many Hours of Year Renewables Meet Load

*Reliable Cheap
100%*



A modified load duration chart. Load is shown as a percentage.
The big horizontal purple line is 100%.
Note the long flat section of the curve is caused by use of storage.

Short Term Storage Utilization

*Reliable Cheap
100%*

	Renewable %	Surplus %	Storage (MWh)	Storage used (annual discharge / total storage) (times per year)
Solar Wind Hydro	85%	45%	0	n/a
Solar Wind Hydro Small Storage	90%	40%	500	500 266
Solar Wind Hydro Storage	95%	35%	2,000	500 500 500 135
Solar Wind Hydro Big Storage	99%	31%	13,000	500 500 500 500 500 500 500 500 500 500 500 500 500 500 32
Solar Wind Hydro Ginormous Storage	100%	30%	47,000	500 10

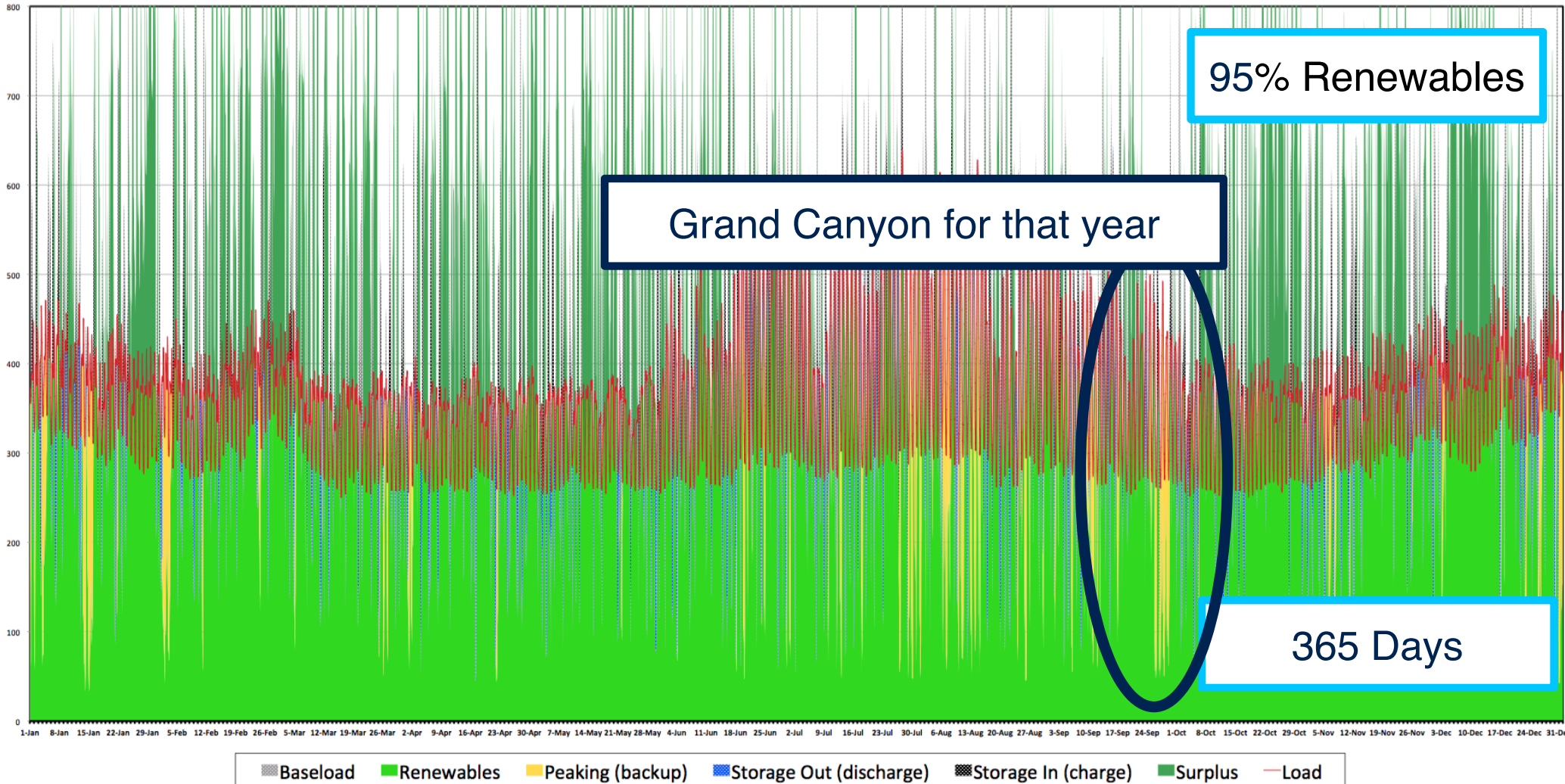
Short Term Storage Utilization

Reliable Cheap
100%

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Solar Wind Hydro Ginormous Storage	100%	30%	47,000	500 500 500 500 500 500 500 500 500 500 500 500 500 500 Why? 500 500 500 500 500 500 500 500 500	10

Solar Wind Hydro & Storage

Reliable Cheap
100%



How do we demonstrate for the public that savings from transportation electrification will more than cover increases in their electric bills?

Worst weather for Renewables: From 100 years of weather data...

What is the worst case no solar no wind number of days?

How likely is the wind to be blowing when we are having a cold snap?

How likely is the sun shining during heat waves?



Short Term Storage Utilization

Reliable Cheap
100%

	Renewable %	Surplus %	Storage (MWh)		Storage used (annual discharge / total storage) (times per year)
Solar Wind Hydro	85%	45%	0		n/a
Solar Wind Hydro Small Storage	90%	40%	500	500	266
Solar Wind Hydro Storage	95%	35%	2,000	500 500 500 500	135
Sweet spot?					
Solar Wind Hydro Big Storage	99%	31%	13,000	500 500 500 500 500 500 500 500 500 500 500 500 500 500	32
Solar Wind Hydro Ginormous Storage	100%	30%	47,000	500 500	10

Long Term Storage? **Surplus Electricity to “natural” gas or liquid fuel?** **or, super cheap used EV batteries.**

Long Term Storage

Reliable Cheap
100%

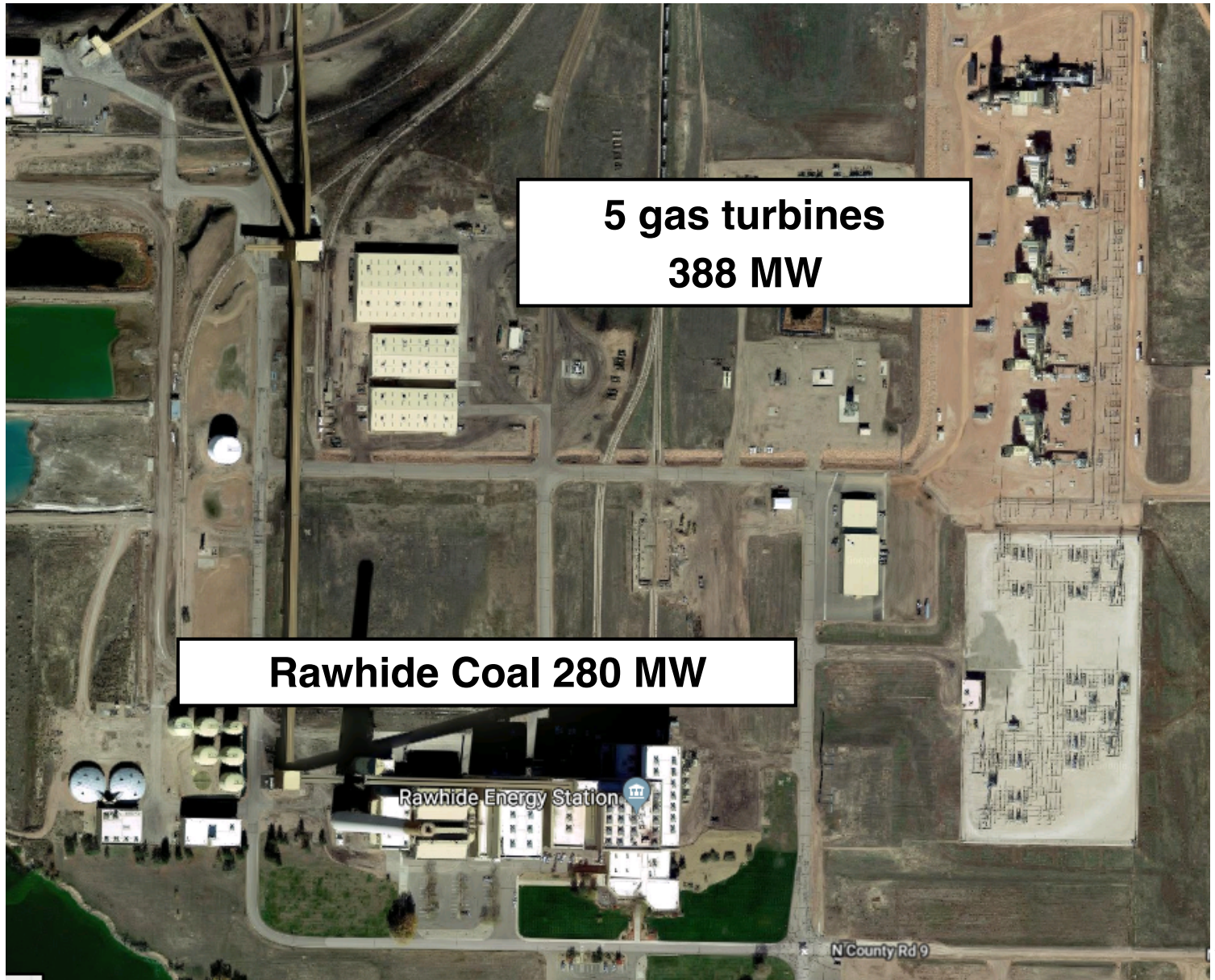
PRPA's Rawhide Station

5 gas turbines
388 MW

Rawhide Coal 280 MW

Low capital
Use surplus

Make a Fuel?



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Reliable, ✓

Cheap,

100% Renewables by 2030

PUBLIC VERSION Updated Attachment A

RFP Responses by Technology

Generation Technology	# of Bids	Bid MW	# of Projects	Project MW	Median Bid	
					Price or Equivalent	Pricing Units
Combustion Turbine/IC Engines	29	6,365	19	4,436	\$ 5.08	\$/kW-mo
Combustion Turbine with Battery Storage	7	804	3	476	6.21	\$/kW-mo
Gas-Fired Combined Cycles	3	873	3	873	█	\$/kW-mo
Stand-alone Battery Storage	28	2,144	24	1,945	10.53	\$/kW-mo
Compressed Air Energy Storage	1	317	1	317	█	\$/kW-mo
Wind	96	41,915	42	16,949	\$ 19.30	\$/MWh
Wind and Solar	5	2,601	4	2,151	19.96	\$/MWh
Wind with Battery Storage	11	5,700	5	2,700	20.63	\$/MWh
Solar (PV)	148	28,382	78	14,085	30.96	\$/MWh
Wind and Solar and Battery Storage	7	4,048	7	4,048	30.41	\$/MWh
Solar (PV) with Battery Storage	79	14,980	57	10,098	38.30	\$/MWh

Left 95% of bids on the table.

“The (plan) includes **unprecedented** low pricing across a range of generation technologies including wind at levelized pricing between **\$11-18/MWh**, solar between **\$23-\$27/MWh**, solar with storage between **\$30-\$32/MWh...**”

- Xcel

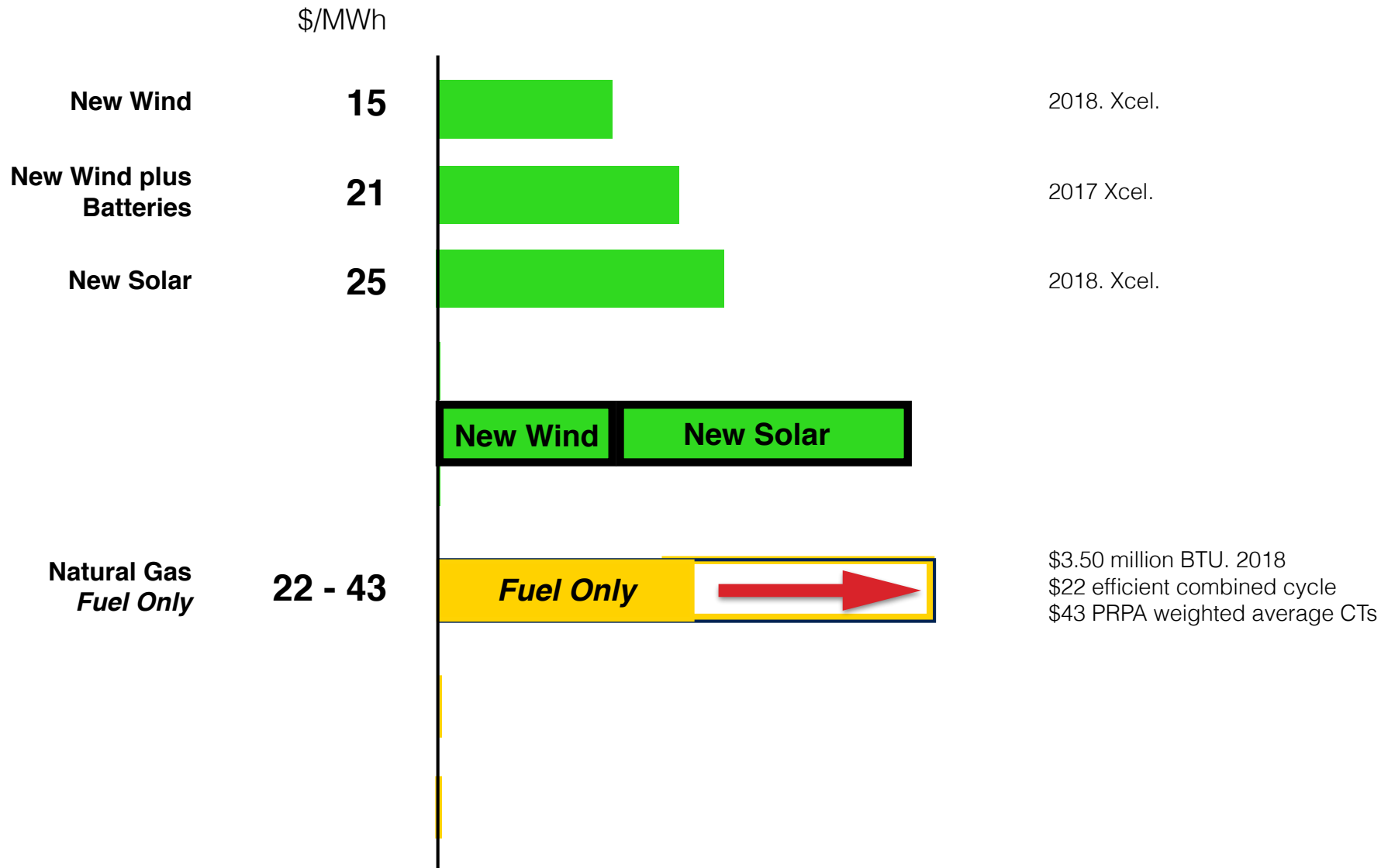
In 2022, Xcel Colorado 55% Renewables

Left 95% of bids on the table.

Xcel Energy (bottom P 51) <https://www.documentcloud.org/documents/4546891-Xcel-Energy-Electric-Resource-Plan-120-Day-Report.html>

What are the Cheapest Sources of Electricity in Colorado?

*Reliable Cheap
100%*



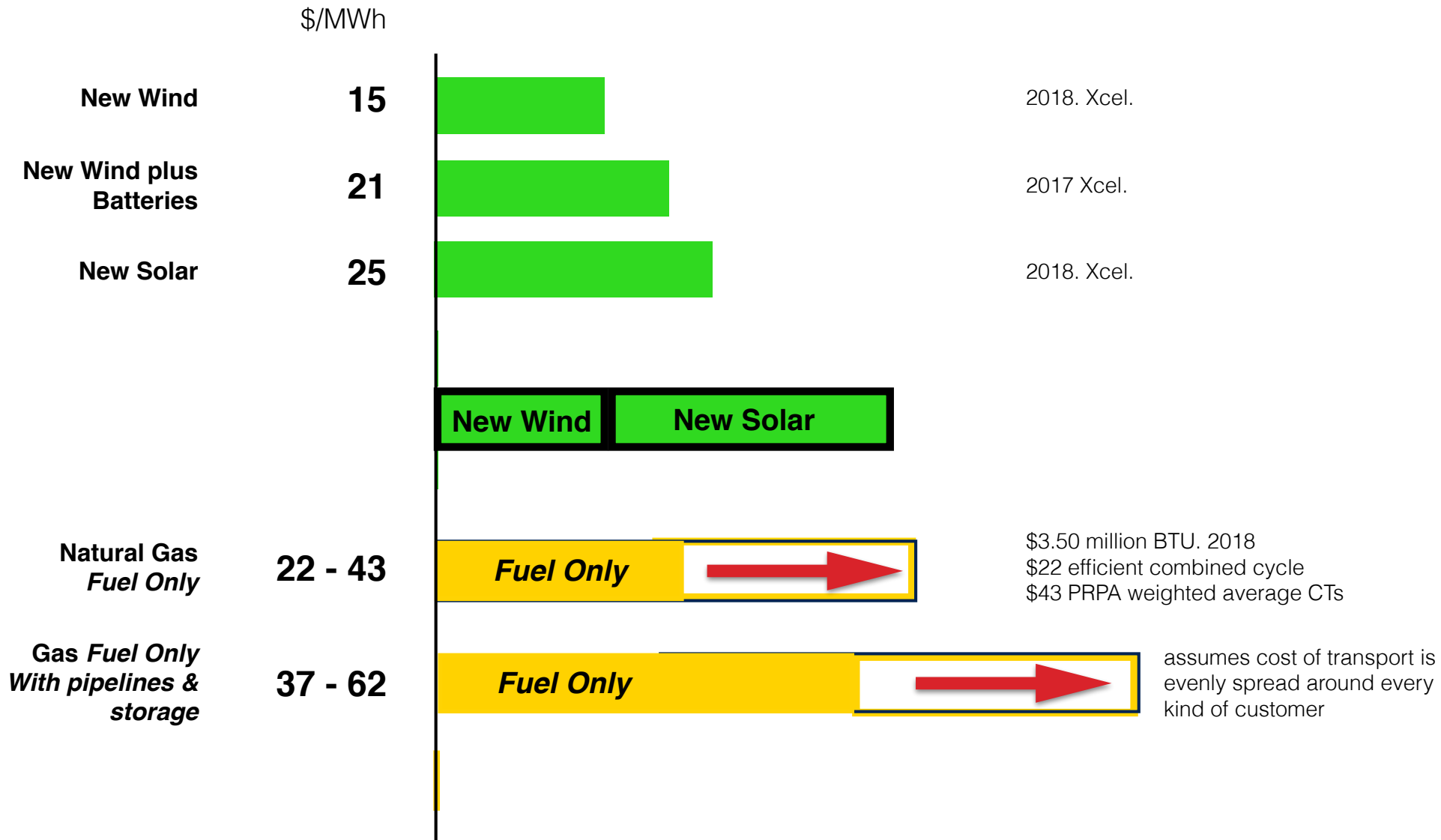
Renewable Fossil

2019 Study: Replacing All Colorado coal plants with wind, solar & storage saves \$2.5 Billion.
<https://www.communityenergyinc.com/press>

Guzman offers to buy and close Craig and Trapper mine, and replace with 70% renewables at lower costs.
<https://energynews.us/2019/05/28/west/a-small-company-sees-opportunity-in-revolutionizing-colorados-energy-supply/>

What are the Cheapest Sources of Electricity in Colorado?

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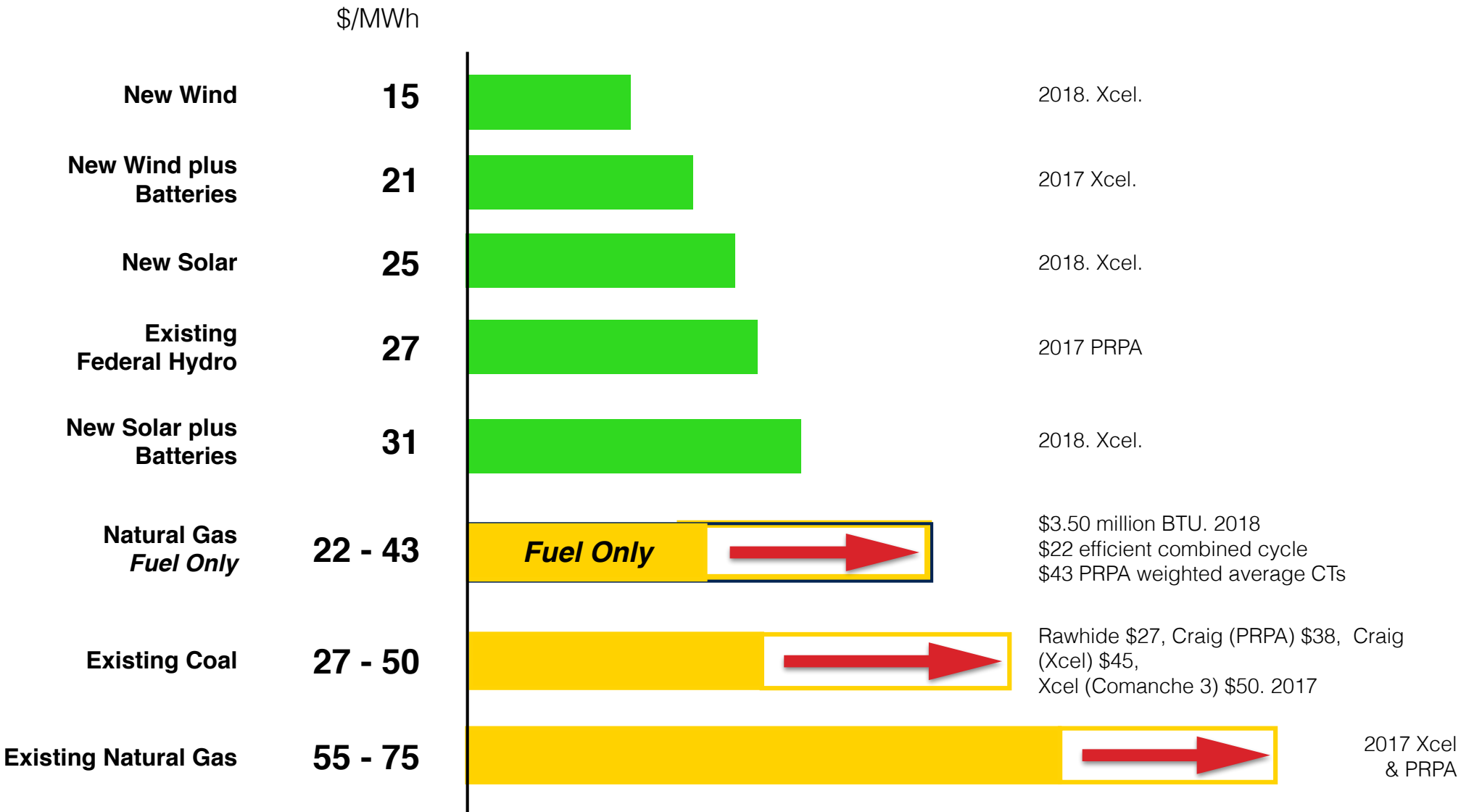
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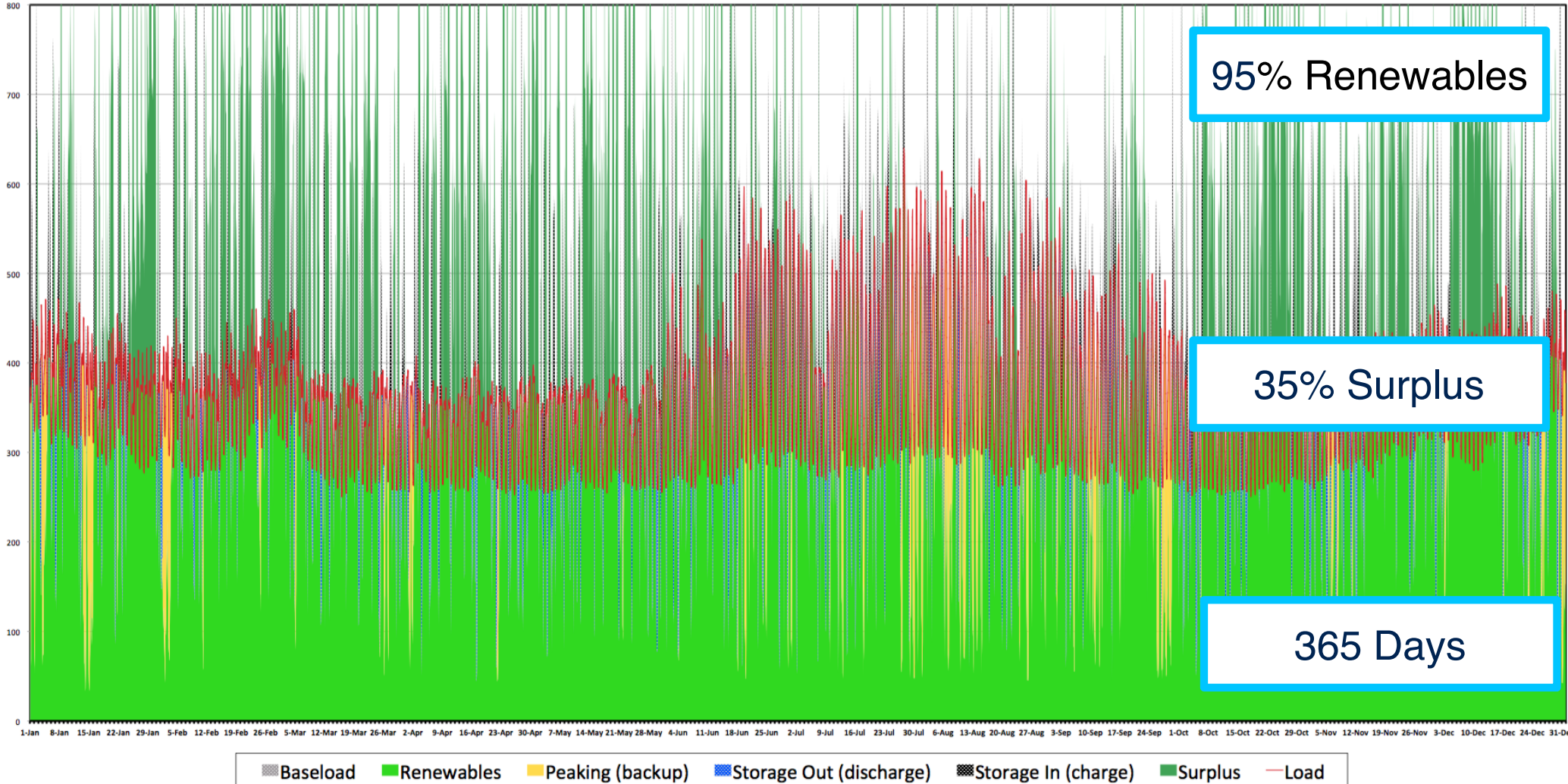
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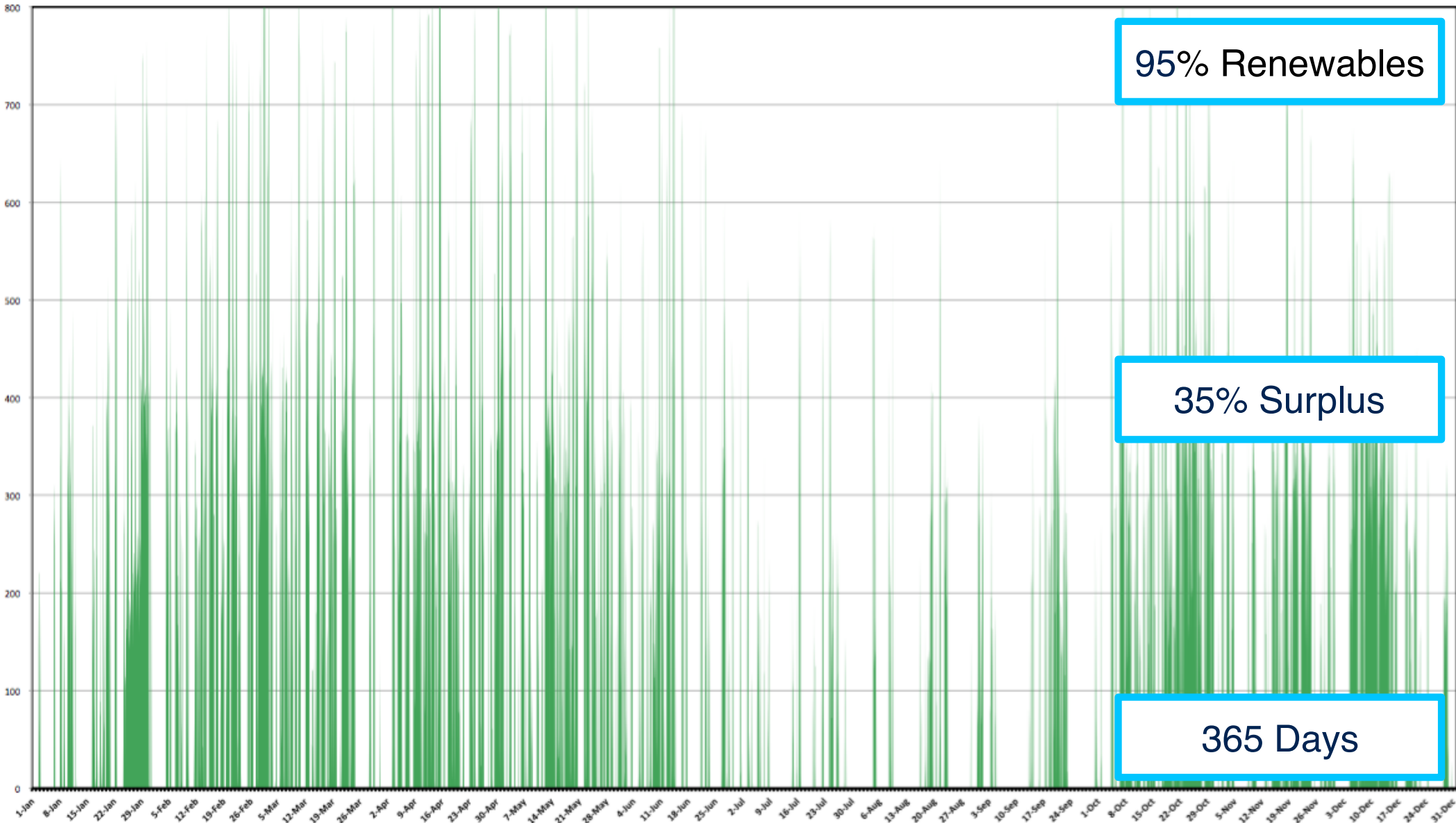
Solar Wind Hydro & Storage

Reliable Cheap
100%



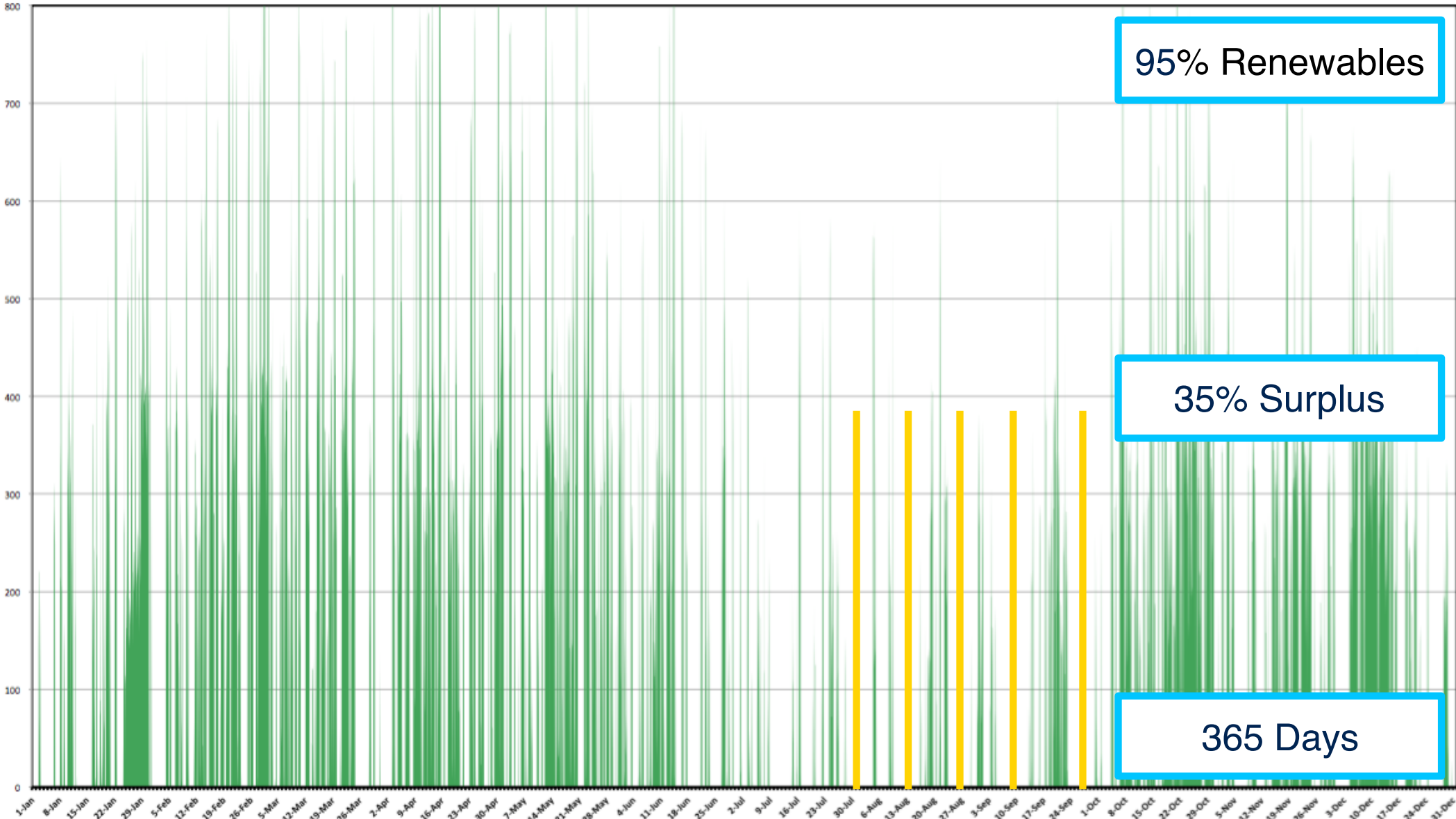
Just the Surplus Electricity

Reliable Cheap
100%



Using Natural Gas to Fill in a Small Amount Makes Selling Surplus Easier

Reliable Cheap
100%



Just the Surplus

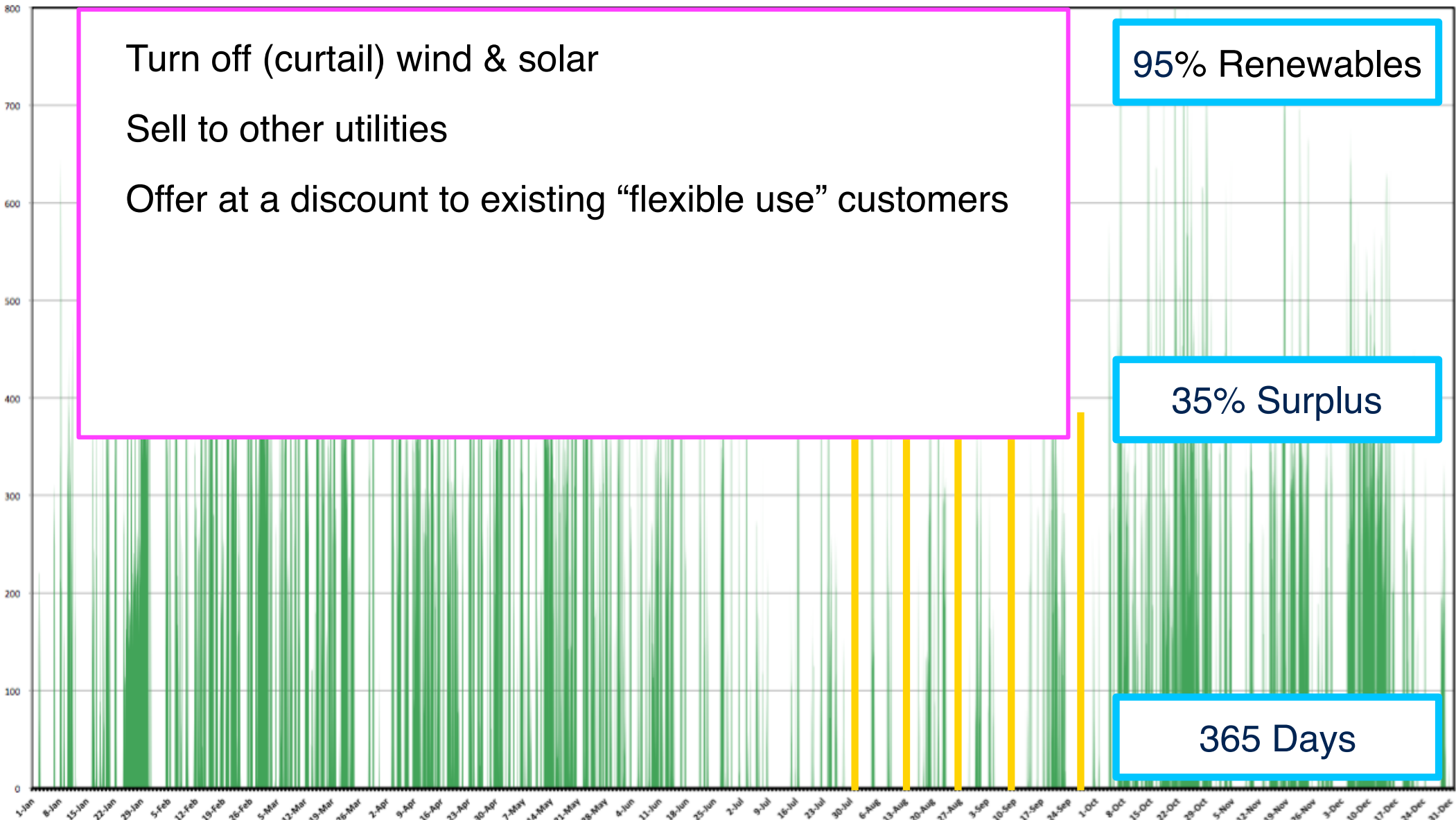
Reliable Cheap
100%

Turn off (curtail) wind & solar
Sell to other utilities
Offer at a discount to existing “flexible use” customers

95% Renewables

35% Surplus

365 Days



Just the Surplus

Reliable Cheap
100%

Turn off (curtail) wind & solar

Higher Cost.

Have to pay for wind & solar electricity curtailed.

Have to pay for Wind 10 year

Production Tax Credit that would have been earned.

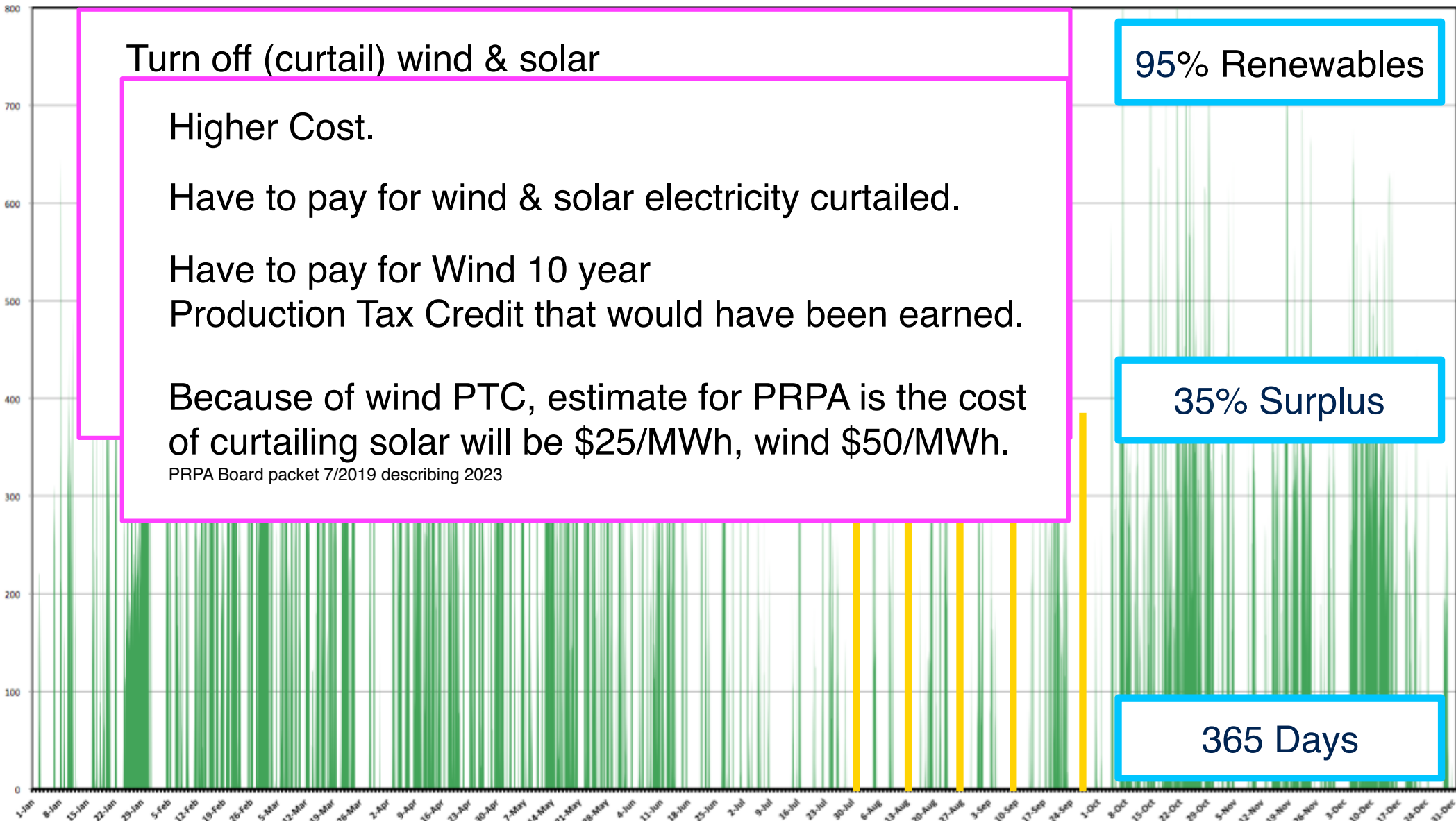
Because of wind PTC, estimate for PRPA is the cost of curtailing solar will be \$25/MWh, wind \$50/MWh.

PRPA Board packet 7/2019 describing 2023

95% Renewables

35% Surplus

365 Days



Just the Surplus

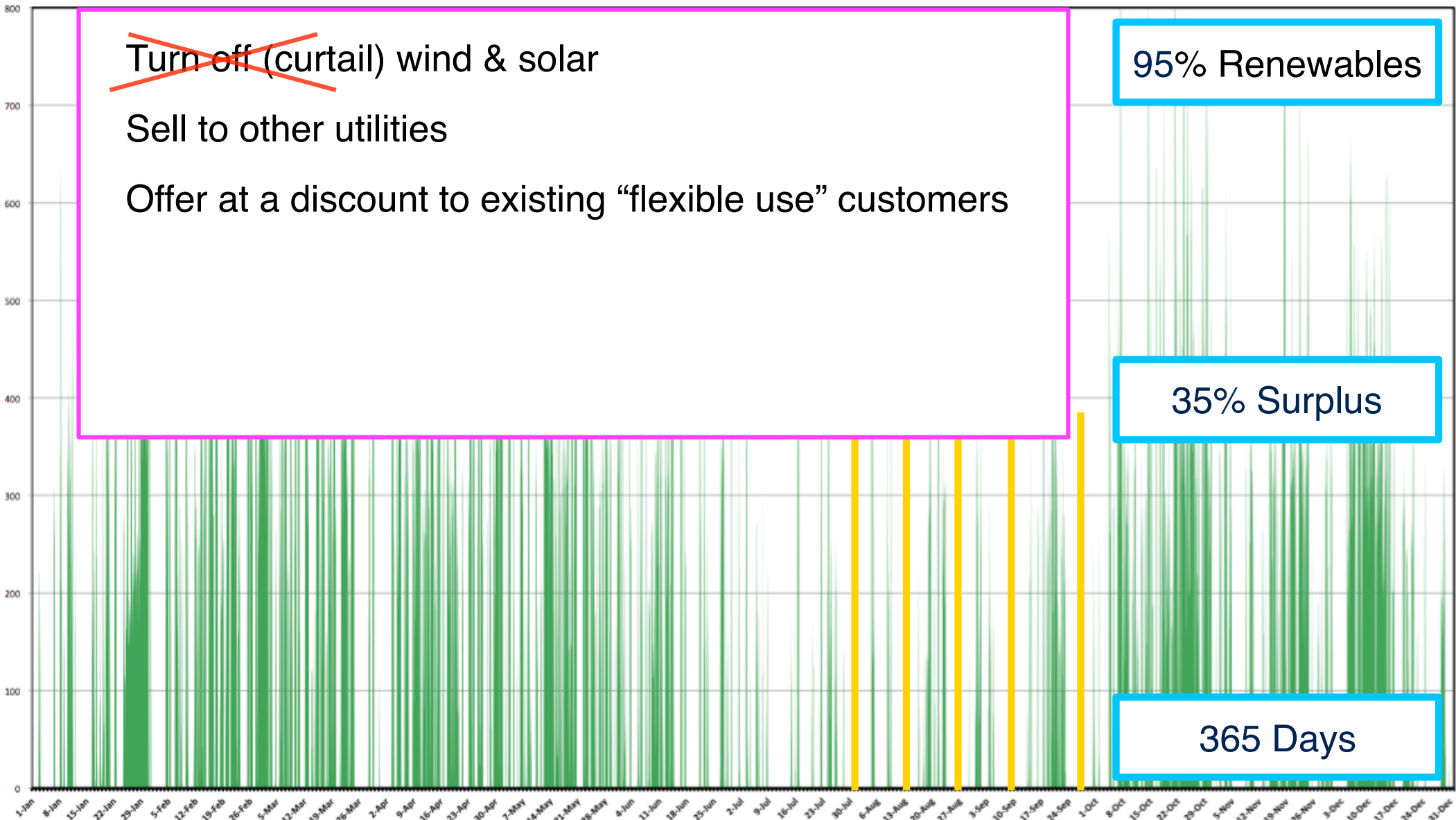
Reliable Cheap
100%

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Sell to other utilities
Offer at a discount to existing “flexible use” customers

95% Renewables

35% Surplus

365 Days



Just the Surplus

Reliable Cheap
100%

~~Turn off (curtail) wind & solar~~

Sell to other utilities

2,000 MWhs of storage.
More than half of all pumped hydro in Colorado
assumed for 95% Renewables - 3 hours of peak.

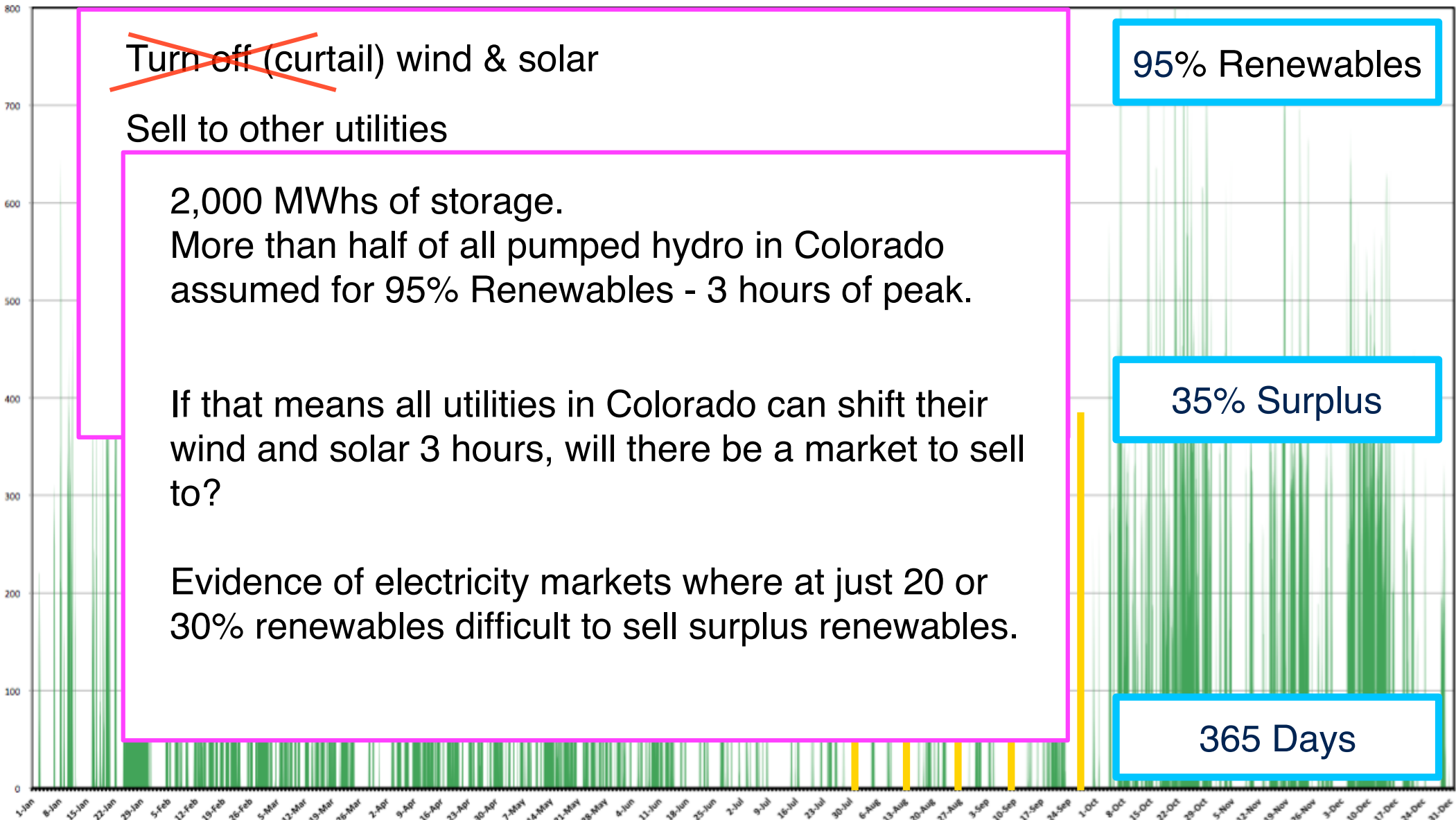
If that means all utilities in Colorado can shift their
wind and solar 3 hours, will there be a market to sell
to?

Evidence of electricity markets where at just 20 or
30% renewables difficult to sell surplus renewables.

95% Renewables

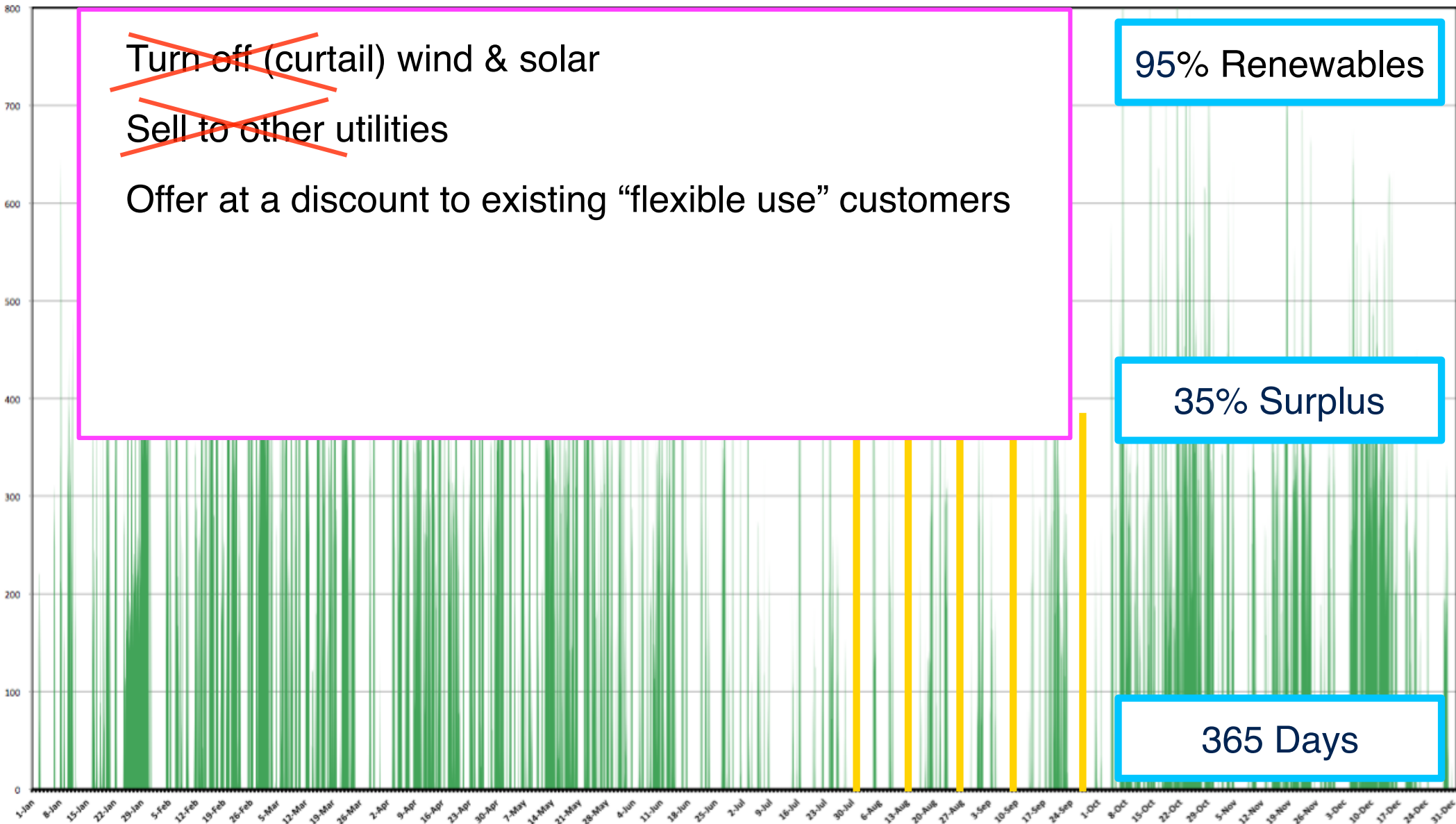
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365 Days



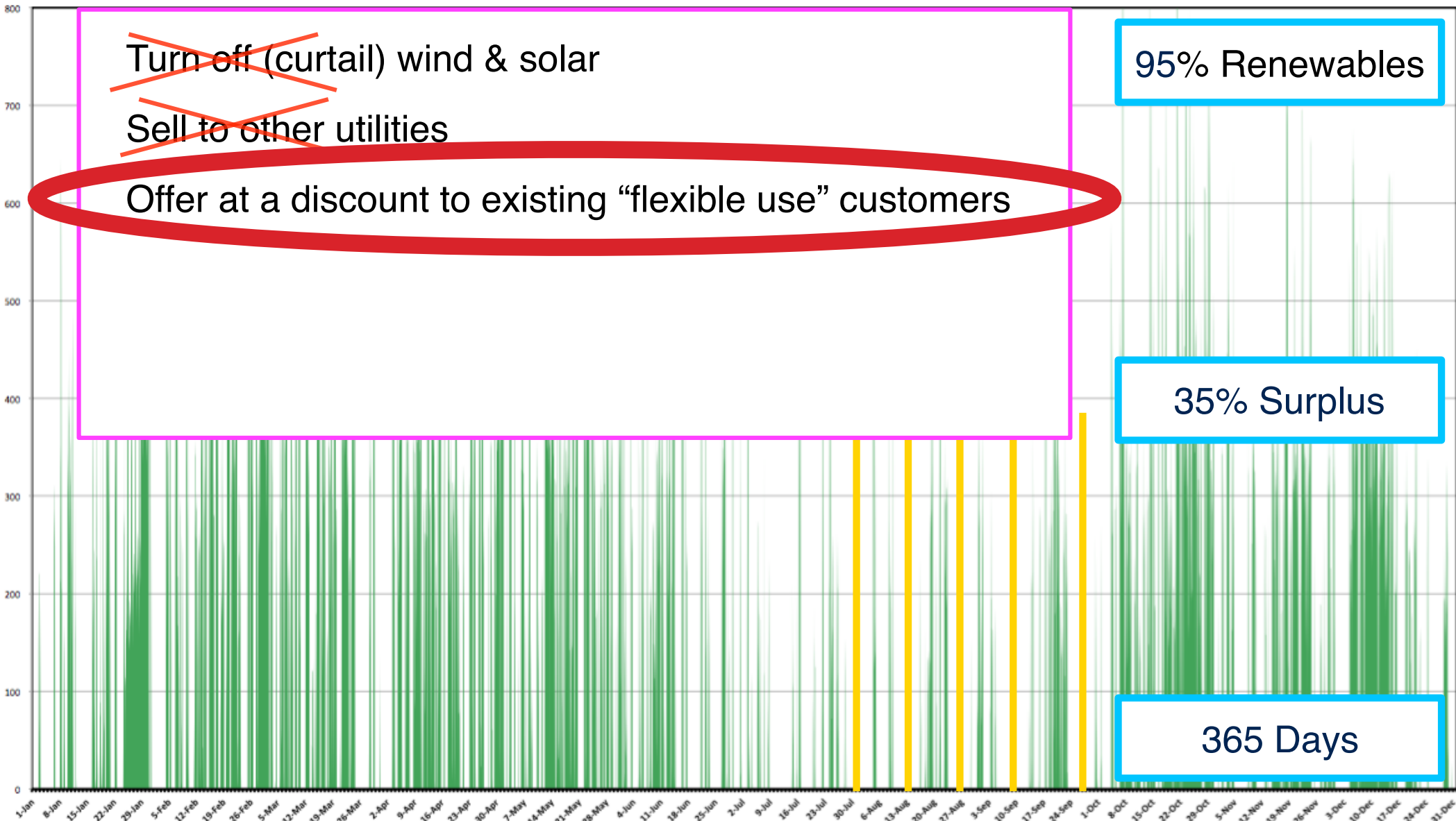
Just the Surplus

Reliable Cheap
100%



Just the Surplus

Reliable Cheap
100%



Show of hands

Reliable Cheap
100%

How much did you pay per gallon or equivalent?

About \$2.29

\$1.00

\$0.20



Show of hands

*Reliable Cheap
100%*

How much did you pay per gallon or equivalent?

About \$2.29

\$1.00

\$0.20

Offer really cheap electricity
when there is surplus - the
sun shining/wind blowing.



Show of hands

Reliable Cheap
100%

Do EV chargers exist today that allow charging when the sun is shining or wind blowing?

Yes

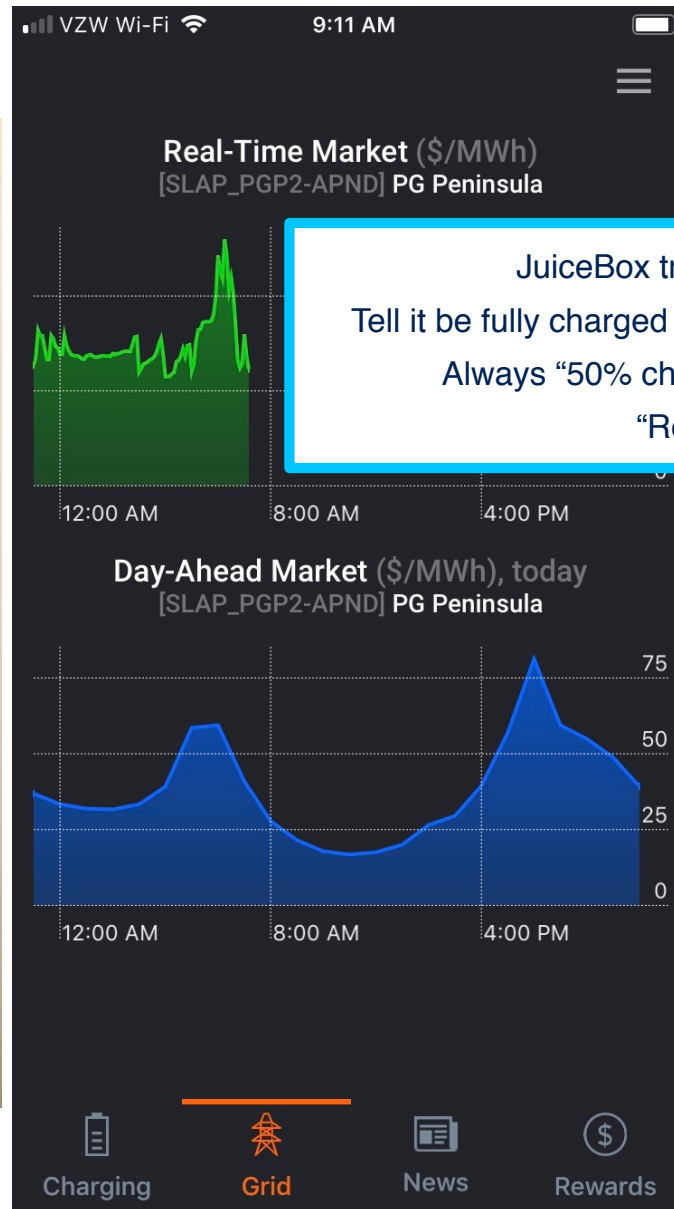
No

Ken's New Charger & App

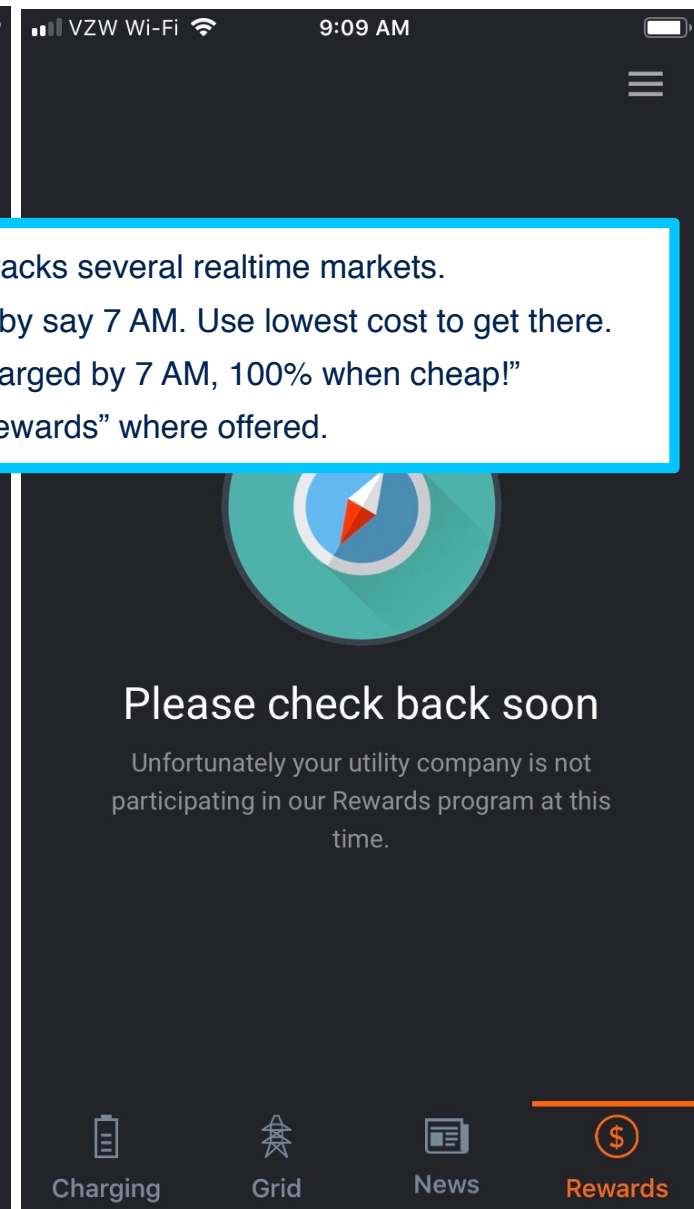
Reliable Cheap
100%

Grid

Rewards



JuiceBox tracks several realtime markets.
Tell it be fully charged by say 7 AM. Use lowest cost to get there.
Always "50% charged by 7 AM, 100% when cheap!"
"Rewards" where offered.



PRPA EV Charger *Rebates*

*Reliable Cheap
100%*



Estes Park • Fort Collins • Longmont • Loveland

Electric vehicle distributed charging study



Photo credit: eMotorWerks

Of the light-duty vehicles registered in Platte River's service territory, 0.4 percent are EVs, nearly twice the Colorado state average, according to the 2018 City of Fort Collins' EV Readiness Roadmap. Ultimately, EV energy usage could reach 60 GWh per year by 2026, and peak demand for EV charging may be as much as 99 MW (assuming all vehicles are charged simultaneously).^[1]

Why are we conducting this study?

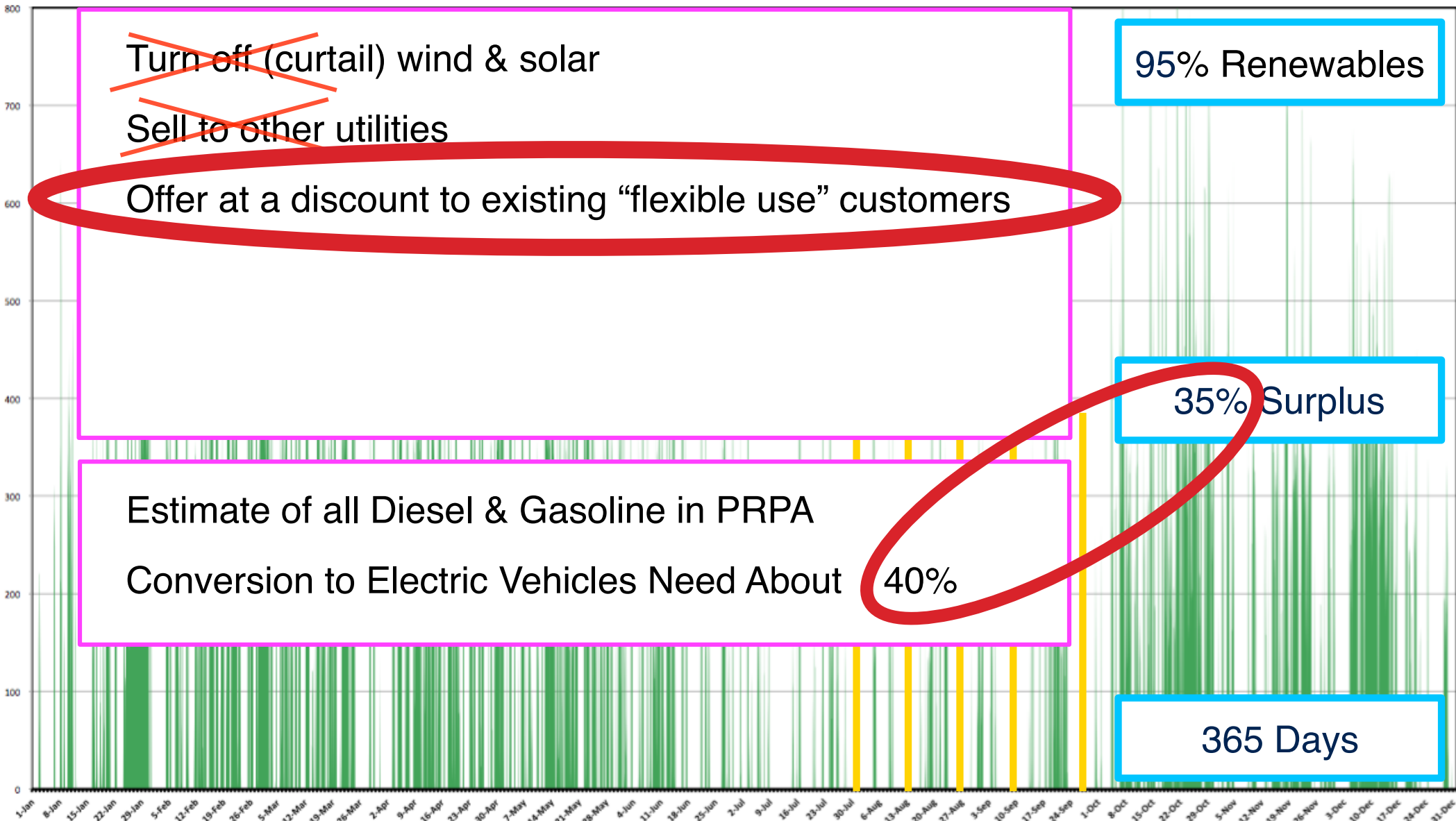
To better understand the effect of clustered EV adoption on the distribution system, Platte River is conducting an EV distributed charging study to evaluate vehicle energy consumption patterns and test smart charging technology. The study will be the first large-scale residential smart EV charging initiative in Colorado, serving Platte River's owner communities of Estes Park, Fort Collins, Longmont and Loveland. Data collection and analysis from up to 300 charging load monitoring and control devices will focus on:

What's in it for study participants?

Platte River is offering a \$200 rebate on smart Level 2 chargers through the Efficiency Works Store. The first 100 people to purchase a JuiceBox Pro 40 plug-in charging station will receive an additional \$154 instant manufacturer's rebate, discounting the smart device by more than 60 percent.

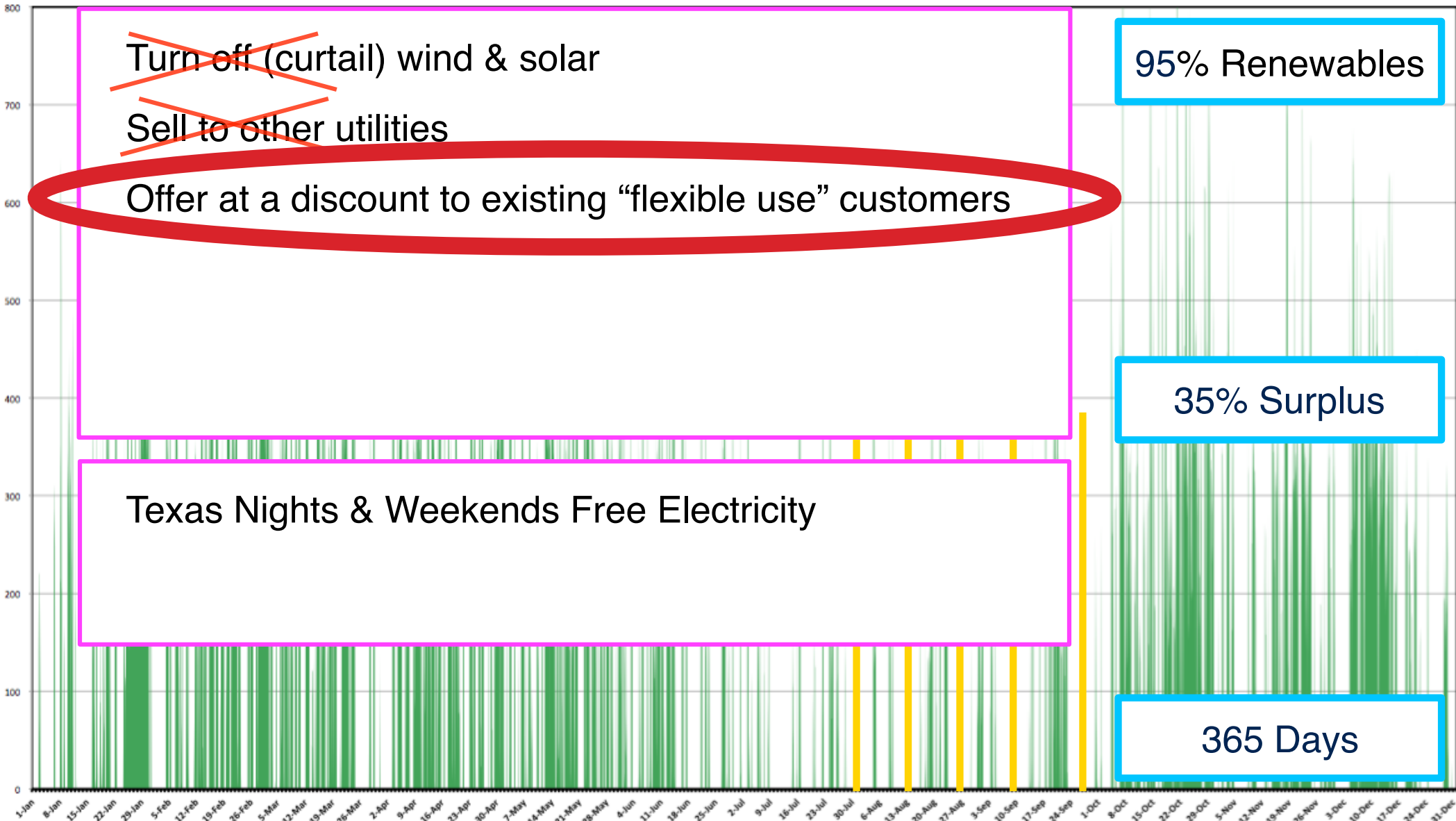
Just the Surplus

Reliable Cheap
100%



Just the Surplus

Reliable Cheap
100%



Ken's New Charger & App

*Reliable Cheap
100%*



9:11 AM

What would happen if we did this?

JuiceBox tracks several realtime markets.
Tell it how full you want to charge and how much you want to pay to get there.

Always "50% charged by 7 AM, 100% when cheap!"

Real-Time Market (\$/MWh), today
[SLAP_PG2-APND] PG Peninsula

12:00 AM 8:00 AM 4:00 PM

Day-Ahead Market (\$/MWh), today
[SLAP_PG2-APND] PG Peninsula

12:00 AM 8:00 AM 4:00 PM

75
50
25
0

Please check back soon

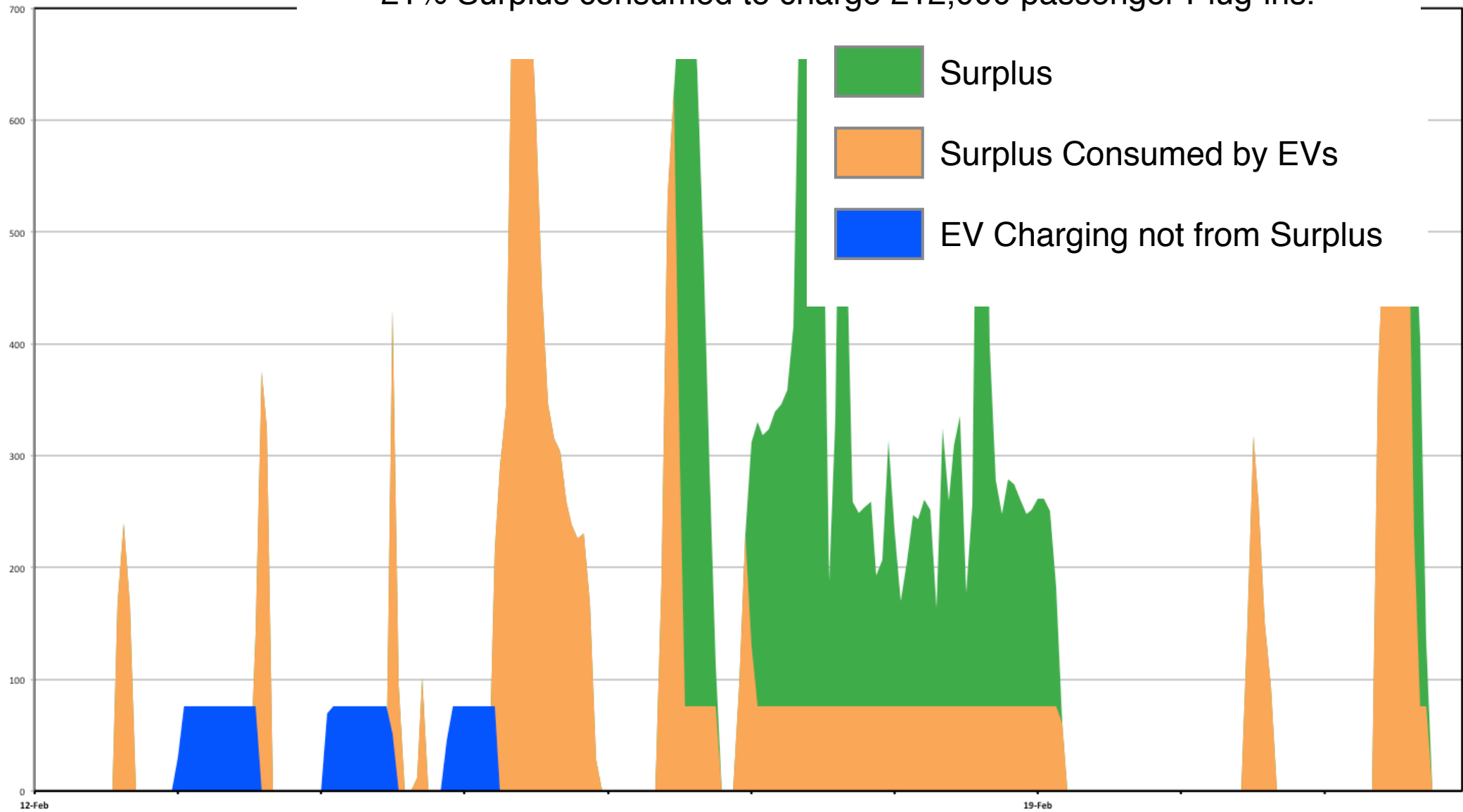
Unfortunately your utility company is not participating in our Rewards program at this time.

9:09 AM

Charging Grid News Rewards

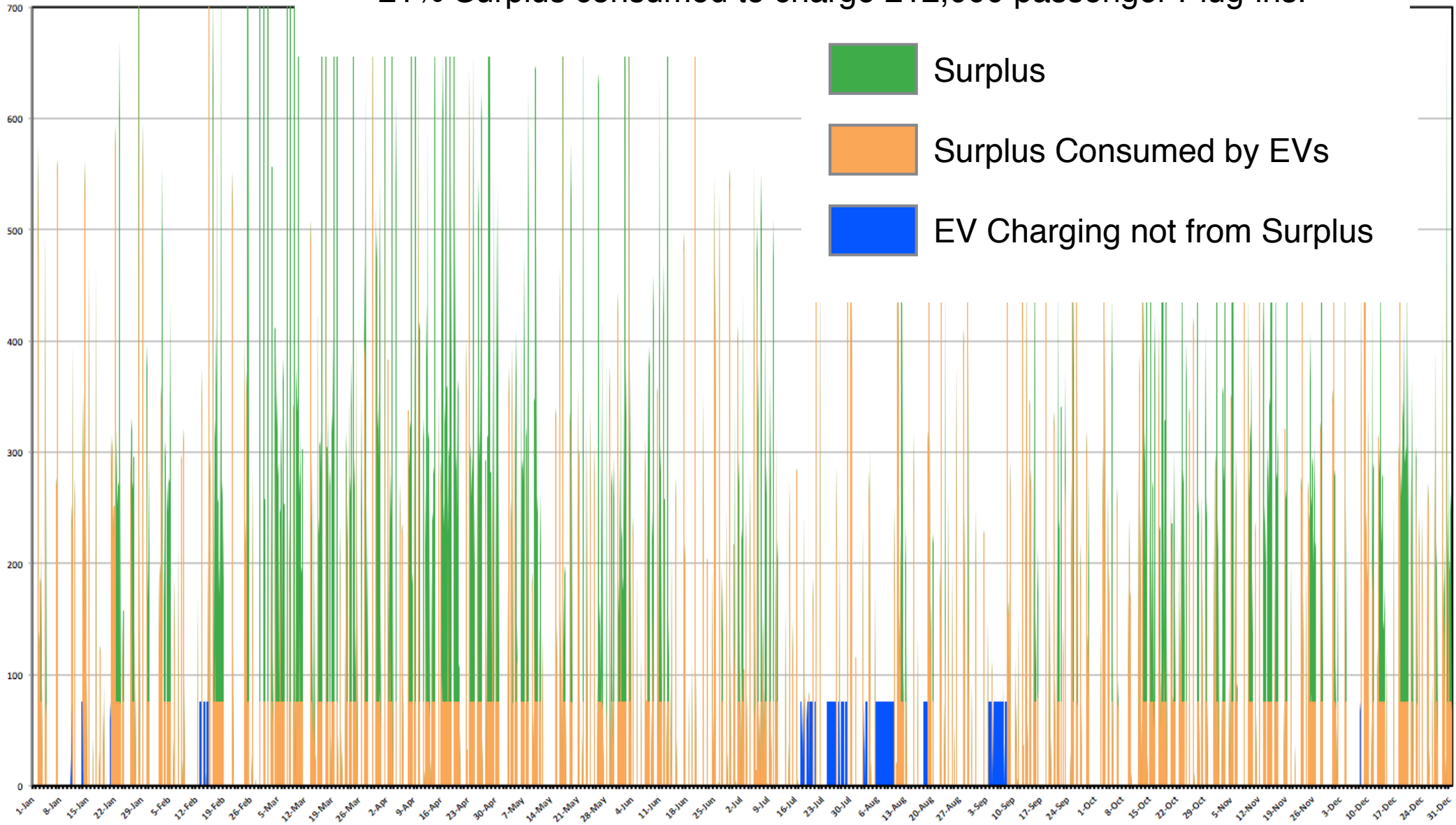
Rewarding Flexible Demand EV Charging on the Surplus.

10 days. 8760 hours. 95% Renewable, 14% Surplus,
21% Surplus consumed to charge 212,000 passenger Plug-ins.



Rewarding Flexible Demand EV Charging on the Surplus.

Entire Year. 8760 hours. 95% Renewable, 14% Surplus,
21% Surplus consumed to charge 212,000 passenger Plug-ins.



Rewarding Flexible Demand Beyond Charging Plug-ins.

A Reverse RFP - The Goal is Innovation

Bidders are offering to buy energy at a specific capacity. Reverse - high bids win.

Perhaps in 5 MW blocks of capacity.

Only when there is surplus.

New load so there is minimal cannibalization of existing load.

They must use power when directed to (with penalties?)

They must be located where there is adequate transmission & distribution.

Even with 10,000 Plug-Ins at 50% renewables, 1250 hours of surplus (14% of the year)

Examples:

Fixing nitrogen. Instead of using natural gas, make ammonia/fertilizer with surplus electricity.

Conversion of gas appliances to electric heat pumps.

Creation of green natural gas. Electricity to methane, inserted into existing nat gas distribution & storage system.

A close-up photograph of several fresh green zucchinis in a dark-colored basket. The zucchinis are vibrant green with some yellow at the stem ends. The background is slightly blurred, focusing on the vegetables in the foreground.

Reliable, ✓

Cheap, ✓

100% Renewables by 2030

A close-up photograph of several fresh green zucchinis in a dark-colored basket. The zucchinis are vibrant green with some yellow at the stem ends. The lighting is bright, creating highlights on the smooth skin of the vegetables.

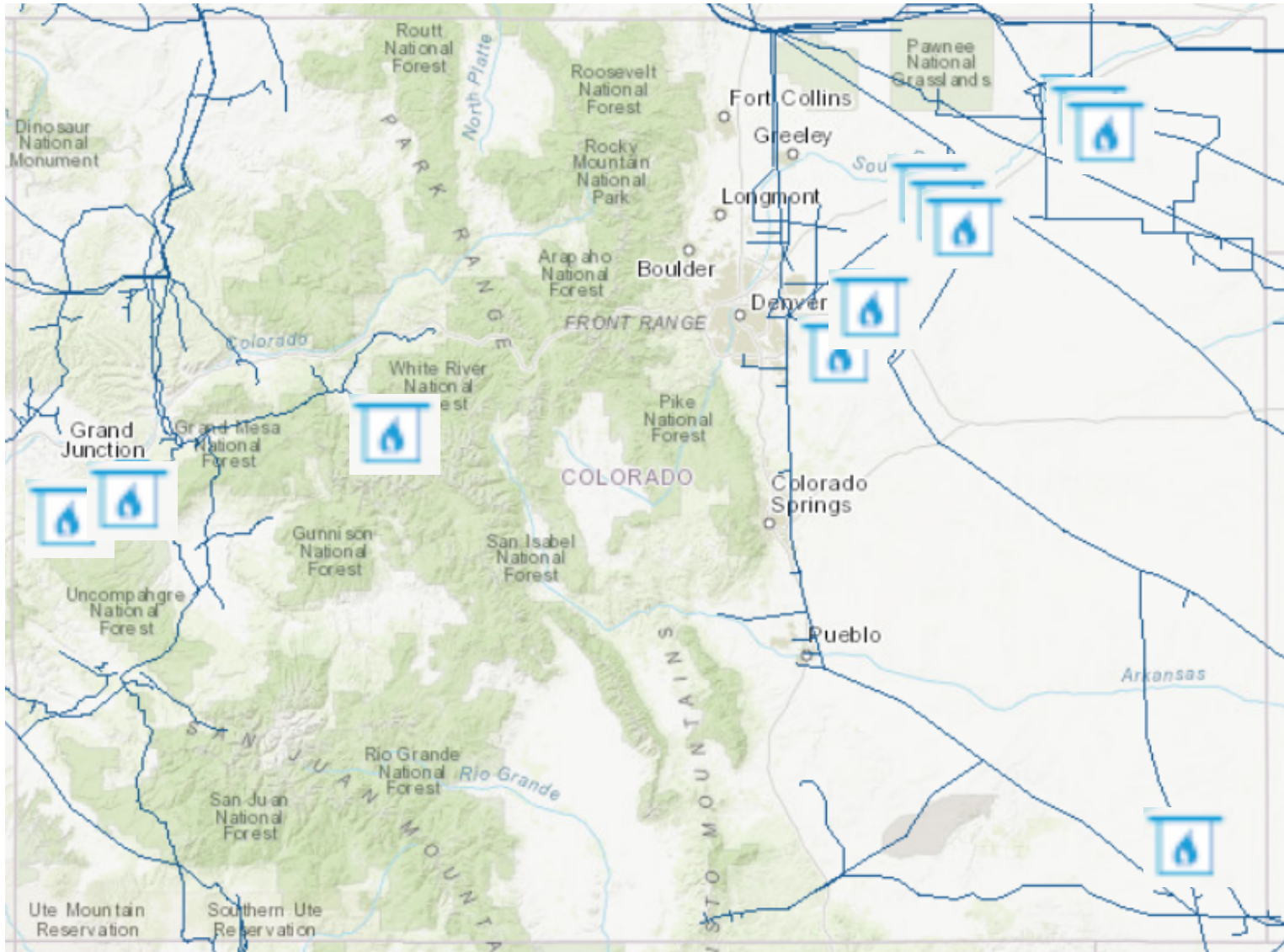
A few short items:

Reliable,

Cheap,

100% Renewables by 2030

As we use less and less...
What happens to natural gas pipeline and storage?



Source: EIA map <https://www.eia.gov/state/maps.php?v=Natural%20Gas>

How do we demonstrate for the public that savings from transportation electrification will more than cover increases in their electric bills?

Worst weather for Renewables: From 100 years of weather data...

What is the worst case no solar no wind number of days?

How likely is the wind to be blowing when we are having a cold snap?

How likely is the sun shining during heat waves?

Make a renewable fuel to use as storage.

Pros/cons/costs of making it from surplus electricity to burn in our existing natural gas turbines?

Liquid? Gas? Solid? Find something not a GHG itself? Make Biochar and sequester CO2?

With more and more wind & solar at about the same time...

Will surplus have any value to other utilities? What discounts are needed to get local customers to use surplus? Will Xcel ever have rewards for EV charging from the surplus?

**As we use less and less, what happens to natural gas distribution & storage costs?
... coal transport costs?**

Free public access to ALL utility data. All hourly generation, load, and cost data for generation, transmission, and distribution systems.

Can innovation and competition be maximized without it?

How can the public be assured of the most cost-effective solutions without it?



For ALL Colorado: Is There Enough Renewables?

PUBLIC VERSION Updated Attachment A

RFP Responses by Technology

Generation Technology	# of Bids	Bid MW	# of Projects	Project MW	Median Bid	
					Price or Equivalent	Pricing Units
Combustion Turbine/IC Engines	29	6,365	19	4,436	\$ 5.08	\$/kW-mo
Combustion Turbine with Battery Storage	7	804	3	476	6.21	\$/kW-mo
Gas-Fired Combined Cycles	3	873	3	873	█	\$/kW-mo
Stand-alone Battery Storage	28	2,144	24	1,945	10.53	\$/kW-mo
Compressed Air Energy Storage	1	317	1	317	█	\$/kW-mo
Wind	96	41,915	42	16,949	\$ 19.30	\$/MWh
Wind and Solar	5	2,601	4	2,151	19.96	\$/MWh
Wind with Battery Storage	11	5,700	5	2,700	20.63	\$/MWh
Solar (PV)	148	28,382	78	14,085	30.96	\$/MWh
Wind and Solar and Battery Storage	7	4,048	7	4,048	30.41	\$/MWh
Solar (PV) with Battery Storage	79	14,980	57	10,098	38.30	\$/MWh

Left 95% of bids on the table.

For ALL Colorado: Is There Enough Renewables?

PUBLIC VERSION Updated Attachment A

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Use Only “Wind” & “PV + storage” --> All Colorado: 95% Renewable. 60% Surplus.

20 to 25% of natural gas in the US is “associated” - produced from oil extraction. Suppose EVs do take a big whack out of oil sales. What happens to natural gas prices?

Big new investments in CCS, nuclear, transmission, or distribution may be doomed to being stranded and cause needless high costs to consumers as we rapidly change to renewables. And cheap storage is a threat to all of these as well. This is because the utilization rates will probably be much lower than optimistic projections.

The amount of space needed to sequester the billions of tons of CO₂ being discussed may be wildly above the amount of storage space available in depleted natural gas reservoirs - CO₂ may prove to be much tougher to store than the much smaller methane molecules. In addition, our history of burying our wastes has been checkered at best. And CO₂ needs to be sequestered for as much as a 1000 years. Making a renewable liquid like oil and sequestering that may be much more practical.

Our dependence on the electric system will be increasing rapidly with extreme heat. At the same time, the grid will become more difficult to make resilient in the face of extreme storms. Perhaps new transmission, and over time, old transmission needs to be buried to increase resiliency as well as make siting transmission easier. Our species is clever at reducing costs when forced to. Perhaps mandate a portion of transmission be underground.

100s of cities have taken the 100% pledge and yet have no practical way to get there because they have little control over their monopoly IOUs. Are there ways to make CCE - Community Choice Energy (AKA CCA) easier to accomplish?

***I skate to where the
puck is going to be,
not where it has been.***

- Wayne Gretzky



Barriers to 100% Clean Energy. Does Colorado Need Electricity Competition?

“Don’t Believe Everything You Think!”



This idea needs to be researched.



Ken Regelson

January 10, 2017

EnergyFreedomCO.org - Research & Education on Electricity Competition

Working to bring electricity competition
to Colorado.

A bunch of white papers.



Ken Regelson

January 10, 2017



— *Energy Freedom Colorado* —

Cheaper & cleaner electricity with competition & consumer choice

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[Stranded assets & securitization](#)

[RTO / ISO governance](#)

Example Choice States: [Illinois](#) | [Texas](#) | [Massachusetts](#)

GREENING THE GRID

through COMMUNITY CHOICE AGGREGATION

Shawn Marshall, LEAN Energy

Community Choice Aggregation is a local energy model and a shared-service model with investor-owned utilities that enables cities and counties to combine their electric load, offer customers lower rates and a choice of electricity provider, and lower greenhouse gas emissions.

LEAN Energy (Local Energy Aggregation Network) is devoted to accelerating the expansion and competitive success of the CCA model nationwide. LeanEnergyUS.org

EnergyFreedomCO.org

"Cheaper and cleaner electricity through competition and consumer choice"

Boulder, Colorado, March 4, 2019. Introduction by **Dan Greenberg**, Research Analyst.

Produced pro bono by Martin Voelker for Energy Freedom Colorado & the Colorado Renewable Energy Society cres-energy.org



Harnessing the Power of Communities

Just Announced...



First Regular Session | 72nd General Assembly

Colorado General Assembly

INTERIM COMMITTEE INTERIM COMMITTEE

Investor-owned Utility Review Interim Study Committee

(last bullet point)

- the role of community aggregated choice in the consumer price of energy.

Filling in With Gas

95% Renewable Hourly.

PRPA's Rawhide Station

PRPA Peak Load is 650 MW.

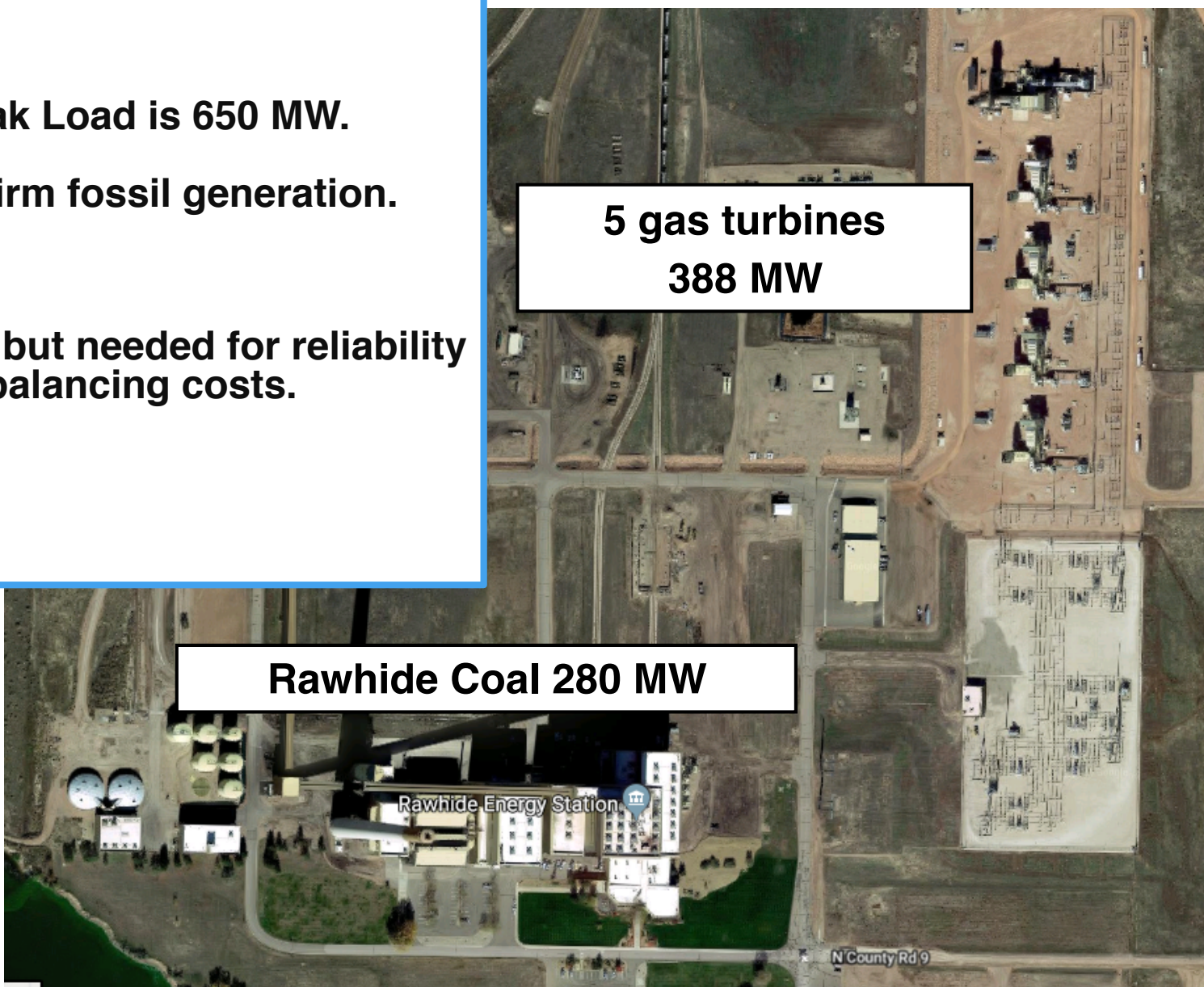
822 MW of firm fossil generation.

**Not “overbuilt” but needed for reliability
while balancing costs.**

**5 gas turbines
388 MW**

**Craig
Coal 154 MW**

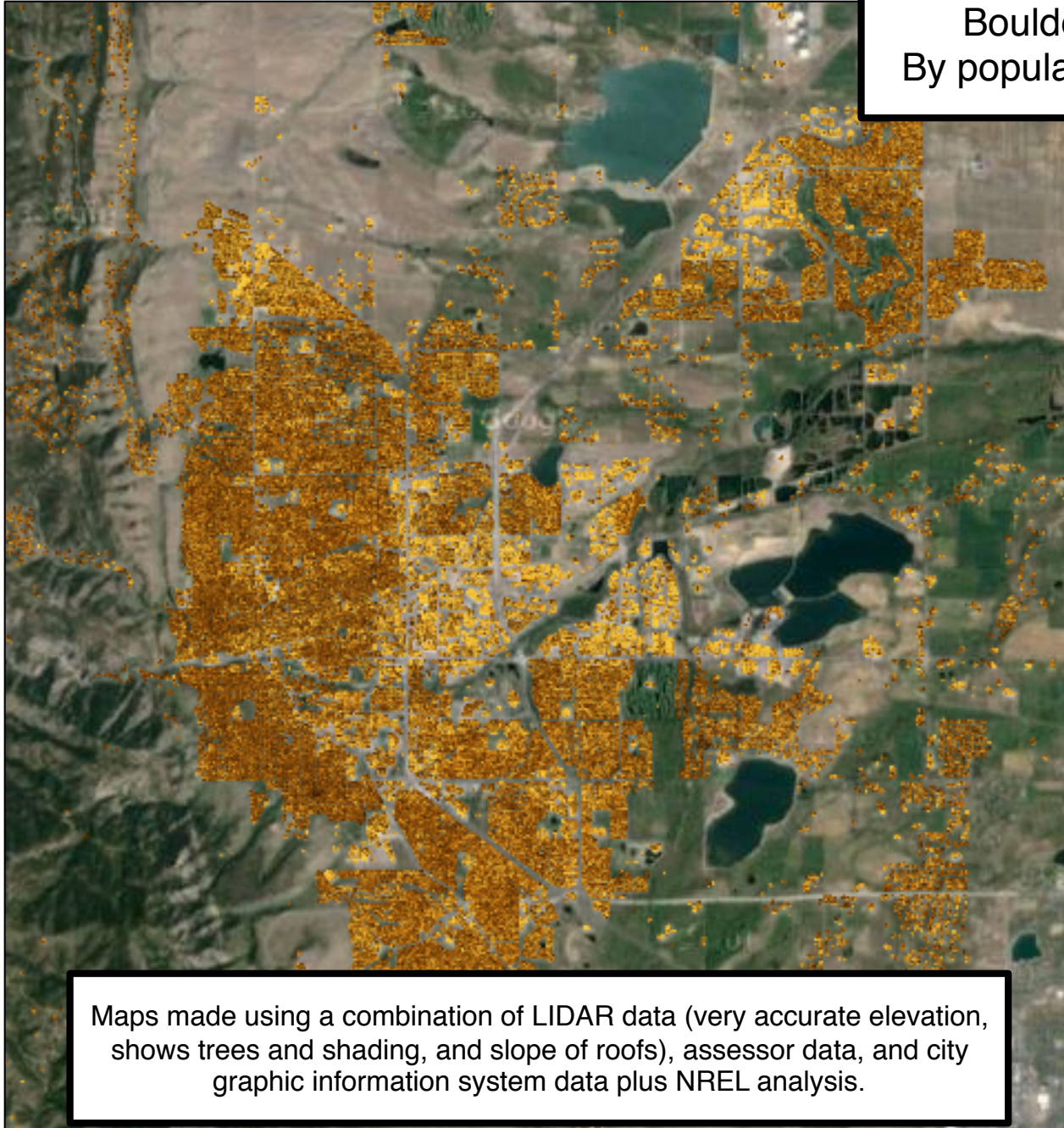
Rawhide Coal 280 MW



Q: How much rooftop high yield solar in the city of Boulder?

A: 630 MW. About 65% of Boulder's Total Annual Electricity Use.

Boulder is 4% of Colorado's population.
By population - **16 GW** rooftop solar statewide.



mapdwell.com

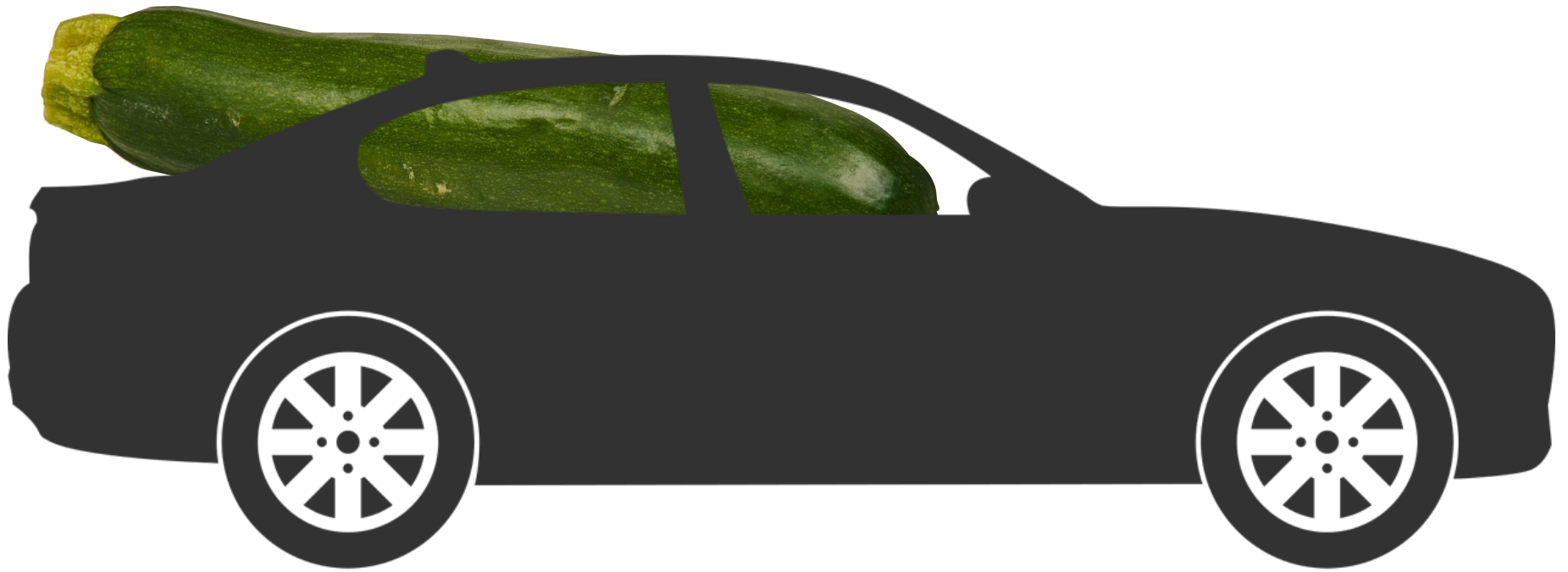



Maps made using a combination of LIDAR data (very accurate elevation, shows trees and shading, and slope of roofs), assessor data, and city graphic information system data plus NREL analysis.

Why do people lock their cars on summer nights in Paonia?



Why do people lock their cars on summer nights in Paonia?

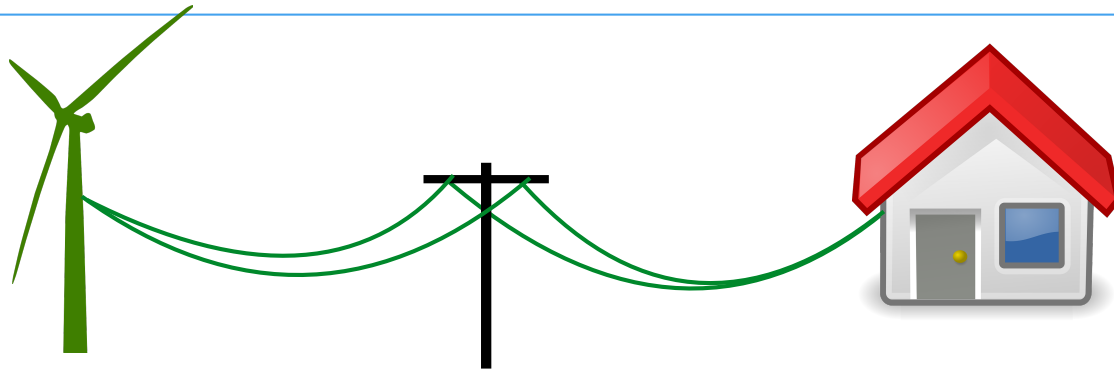


A close-up photograph of a large quantity of fresh green zucchinis. The zucchinis are piled together in a black plastic basket or container. They are vibrant green with some yellowing at the stems. The lighting is bright, highlighting the texture of the skin.

What do you
do with
Surplus
Zucchini?

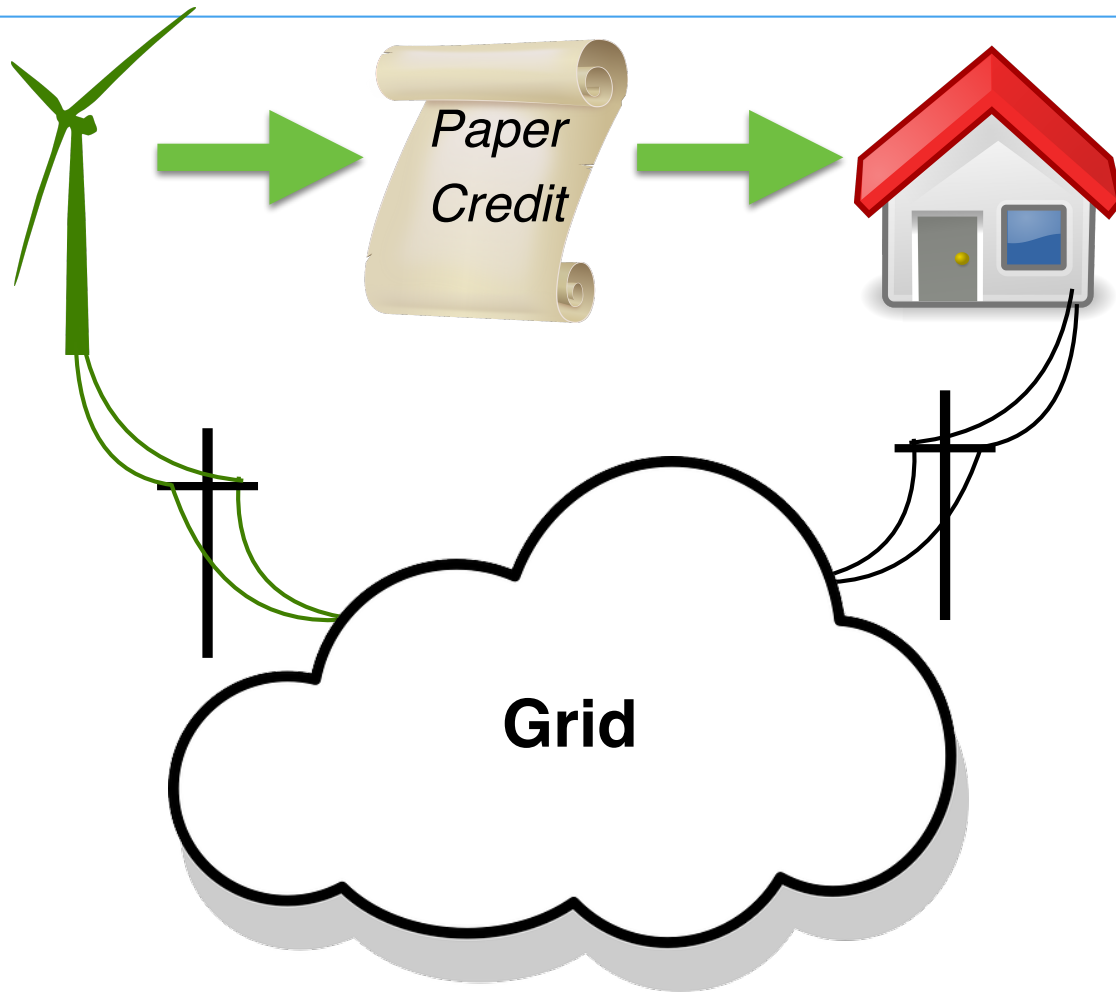
A Few Days a Year...

“Green Electricity” - Much Easier to Buy Than to Know What You Are Getting!



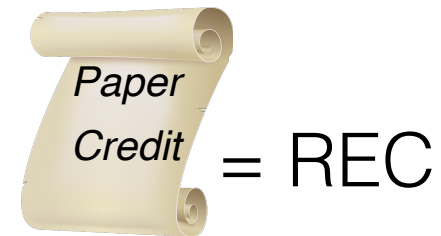
We think we are getting this.

“Green Electricity” - Much Easier to Buy Than to Know What You Are Getting!



Back in the old days when Renewables were more expensive than fossils.

Split the “greenness” from the electrons.



Renewable Energy Credit

If it seems too good to be true...

I skate to where the puck is going to be, not where it has been.

Electric planning traditionally incremental forward.

Let's do 20%, then when have 20% do 40%...

12 years is too short a time for that kind of planning.

Need to model and plan both forward to, and backward from 100%.

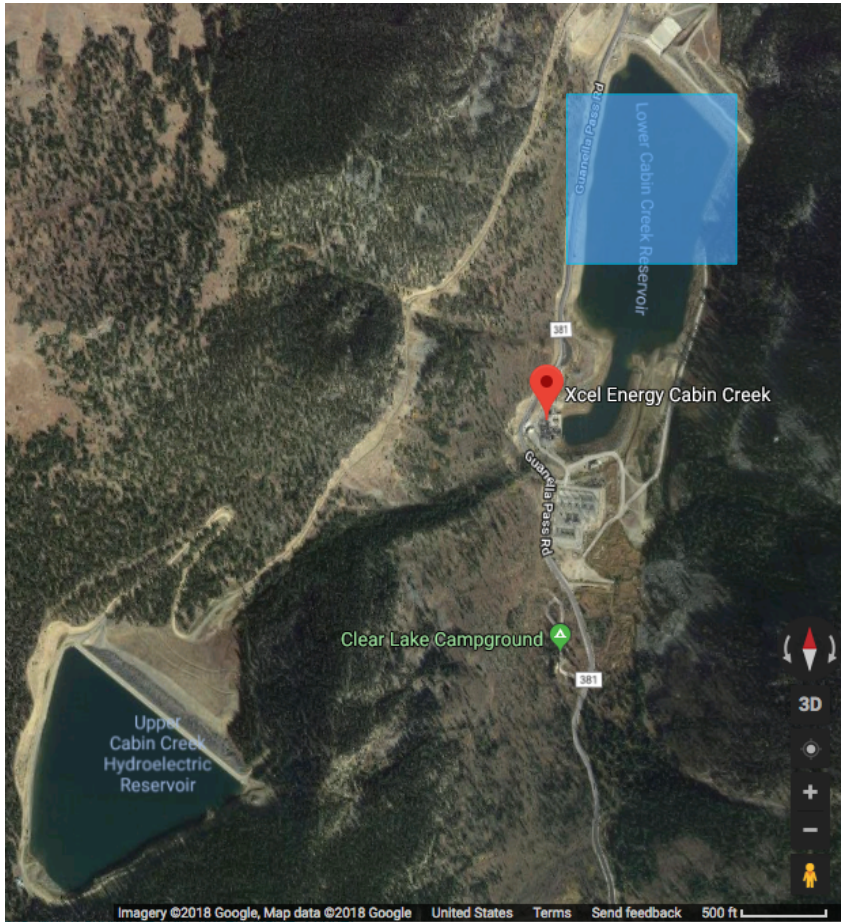
Preliminary rate design charges

2018 MONTHLY CHARGES	RECOVERY METHOD	PERIODS	RATE
Owner	Per percent owner community energy	Annual	\$8,451
Demand: transmission	Municipal Peak (SMD) 75% of annual SMD minimum	Annual	\$5.38
Demand: generation	System Coincident Peak 75% of annual CP minimum	Summer	\$5.28
		Non-Summer	\$3.96
Energy: dispatchable fixed costs	Per kWh for all energy supplied	Annual	\$0.01503
Energy: dispatchable variable costs	Per kWh for dispatchable energy supplied	Annual	\$0.01809
Energy: intermittent variable cost	Per kWh for intermittent energy supplied	Annual	\$0.03120
Intermittent energy settlement*	Per kWh adjustment	TBD Credit	
		TBD Debit	
Average Rate			\$0.06088

*Intermittent energy settlement pricing detail intended to be provided as additional settlement behind the invoice details. Intention is to highlight renewable “solar and wind” and increase transparency.



Storage Area



1300 MWh
27.5 mill sq ft
630 acres

5500

2000 MWh
23 acres
1000000 sq ft

5000

Show of hands

- How many people drove a car here?

Show of hands

How much did you pay per gallon?

- About \$3
- \$1

Show of hands

How much did you pay per gallon?

- About \$3
- \$1



Show of hands

How many would like to pay per gallon?

\$1

10 cents



Show of hands

How many approve of this ranking for electricity requirements?

Most Important

**Reliability
Keeping Lights On**

Second

Cost

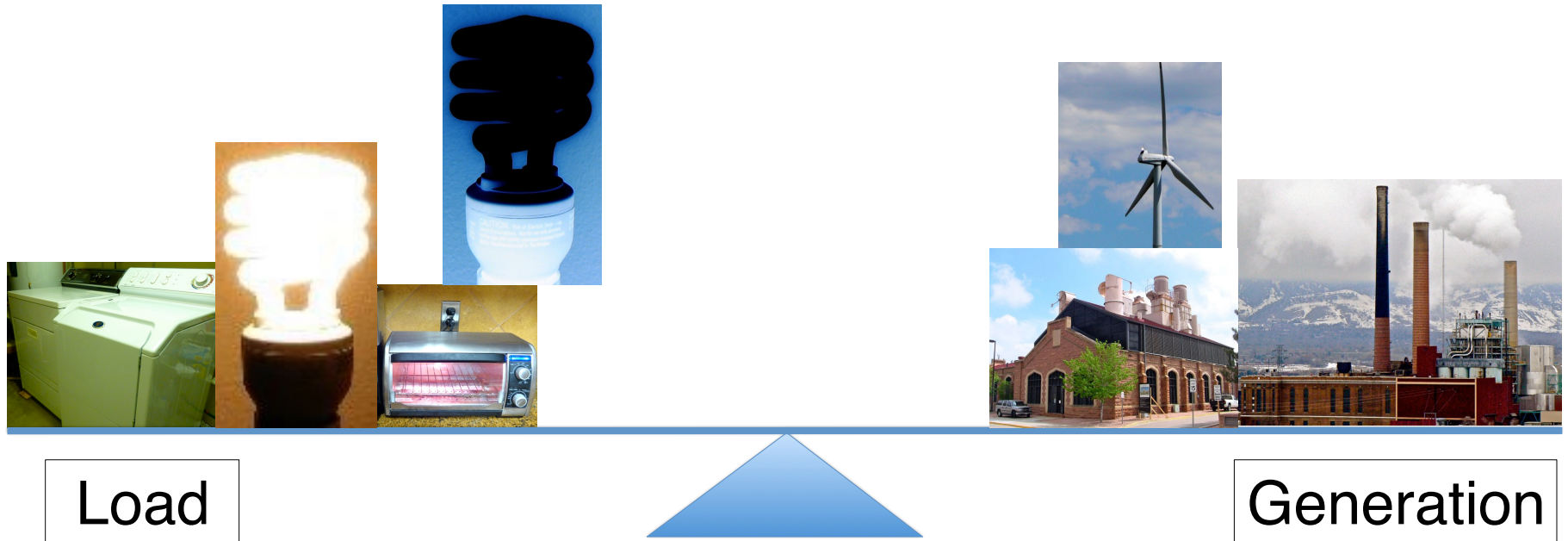
Third Most Important

Clean

Solar Wind & Hydro

Reliability

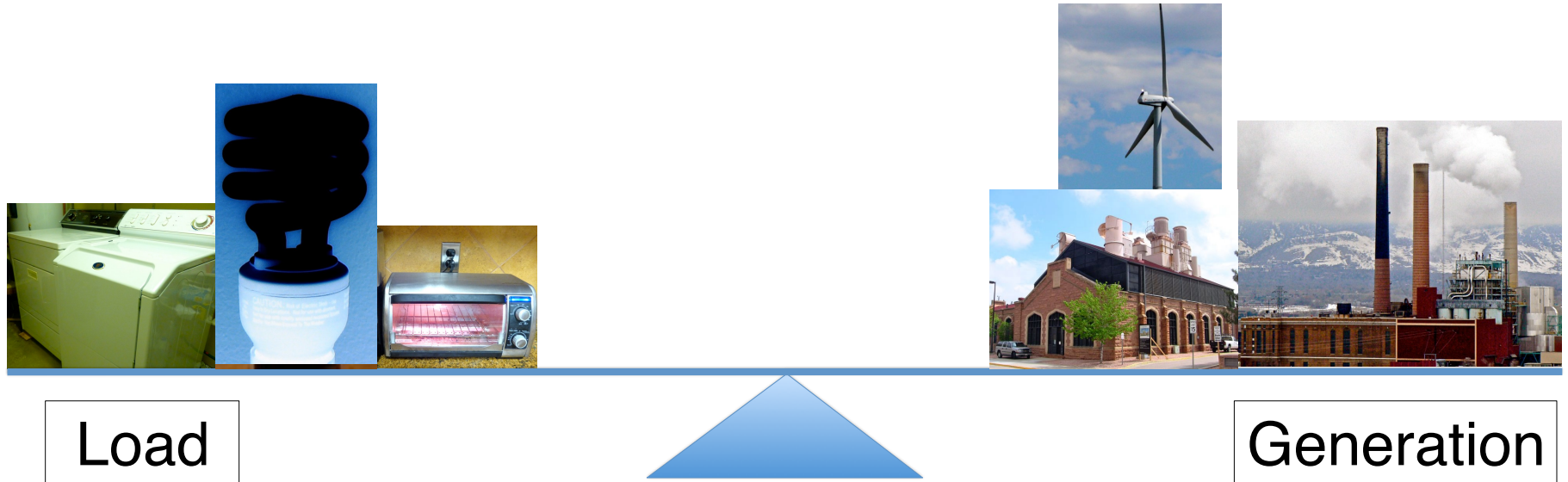
On the grid - Generation must **always** equal load.



Reliability

On the grid - Generation must **always** equal load.

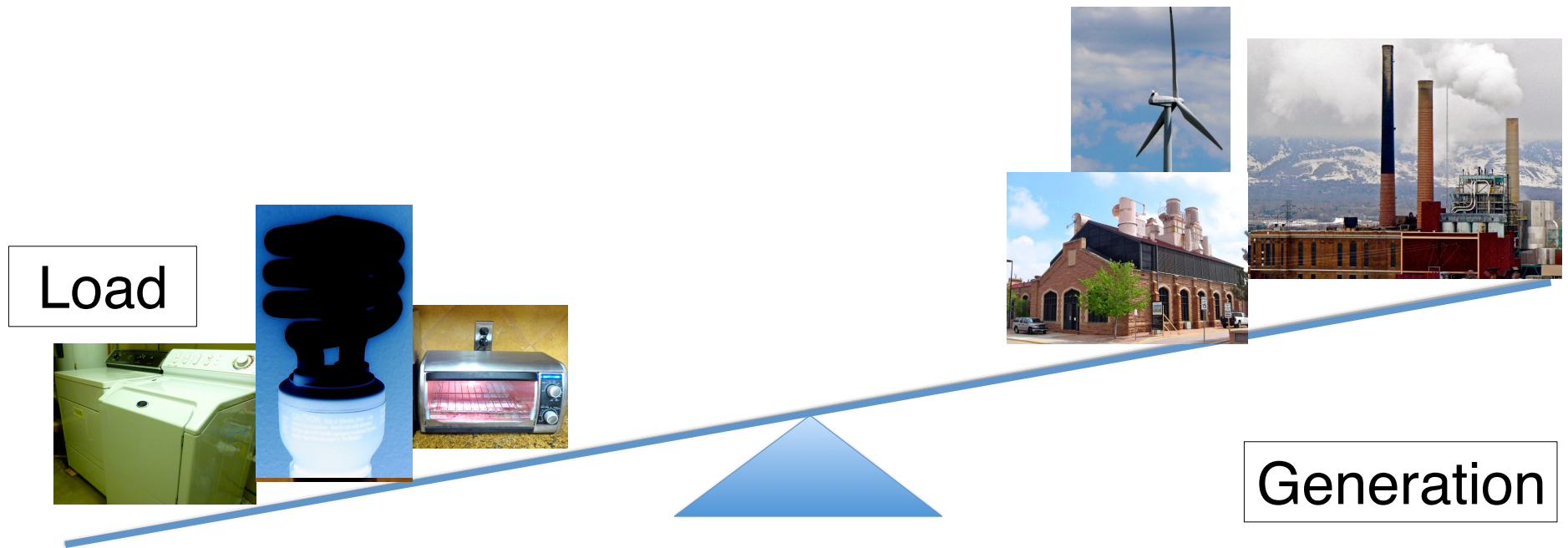
If out of balance either way - *the lights go out!*



Reliability

On the grid - Generation must **always** equal load.

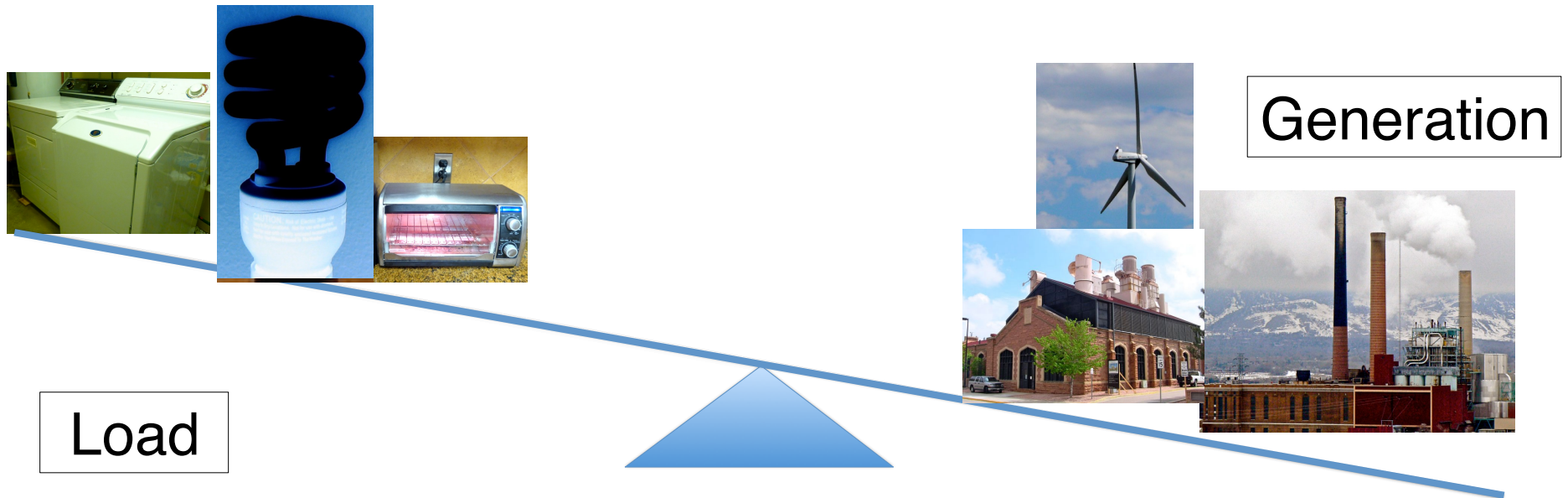
A blackout makes sense to us if not enough generation.



Reliability

On the grid - Generation must **always** equal load.

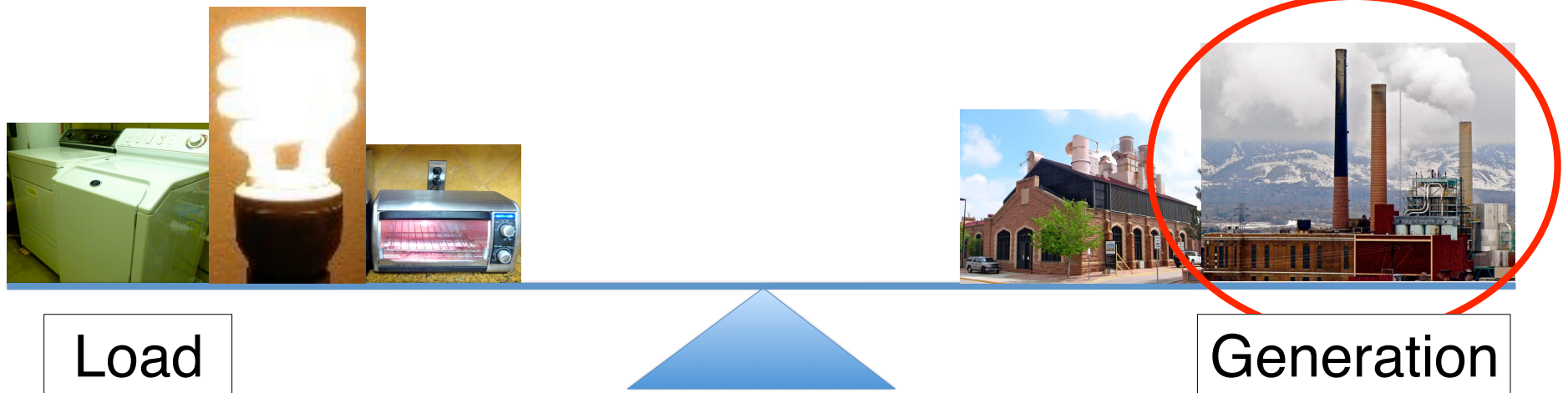
But if too much generation, the voltage goes up and utilities must take action or our lights would burn out.



Reliability

On the grid - Generation must **always** equal load.

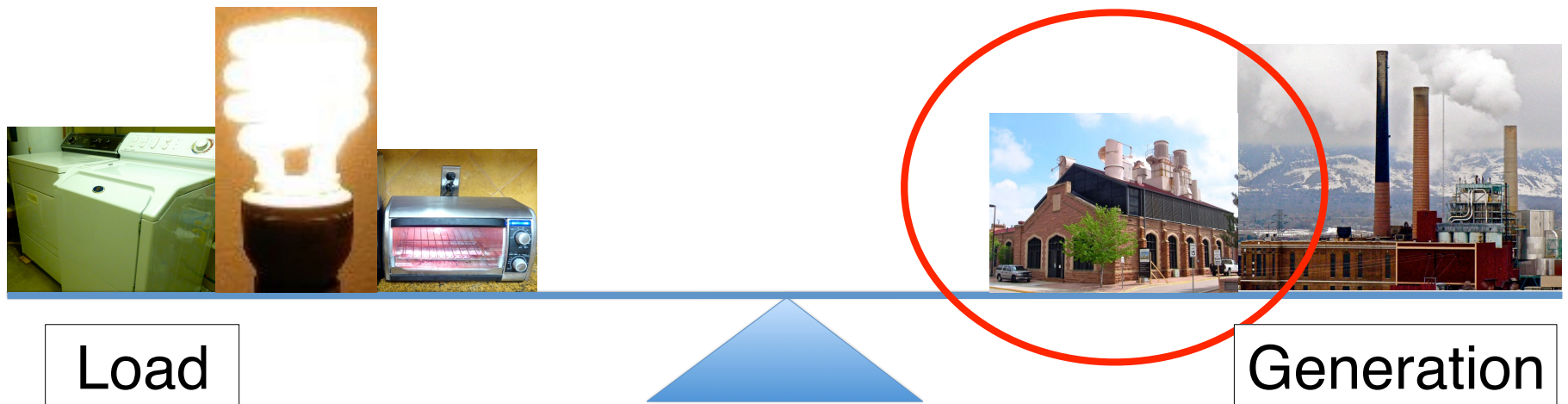
In the past, utilities “balanced” load & generation with a mix of static inflexible baseload & nimble flexible peaking generators.



Reliability

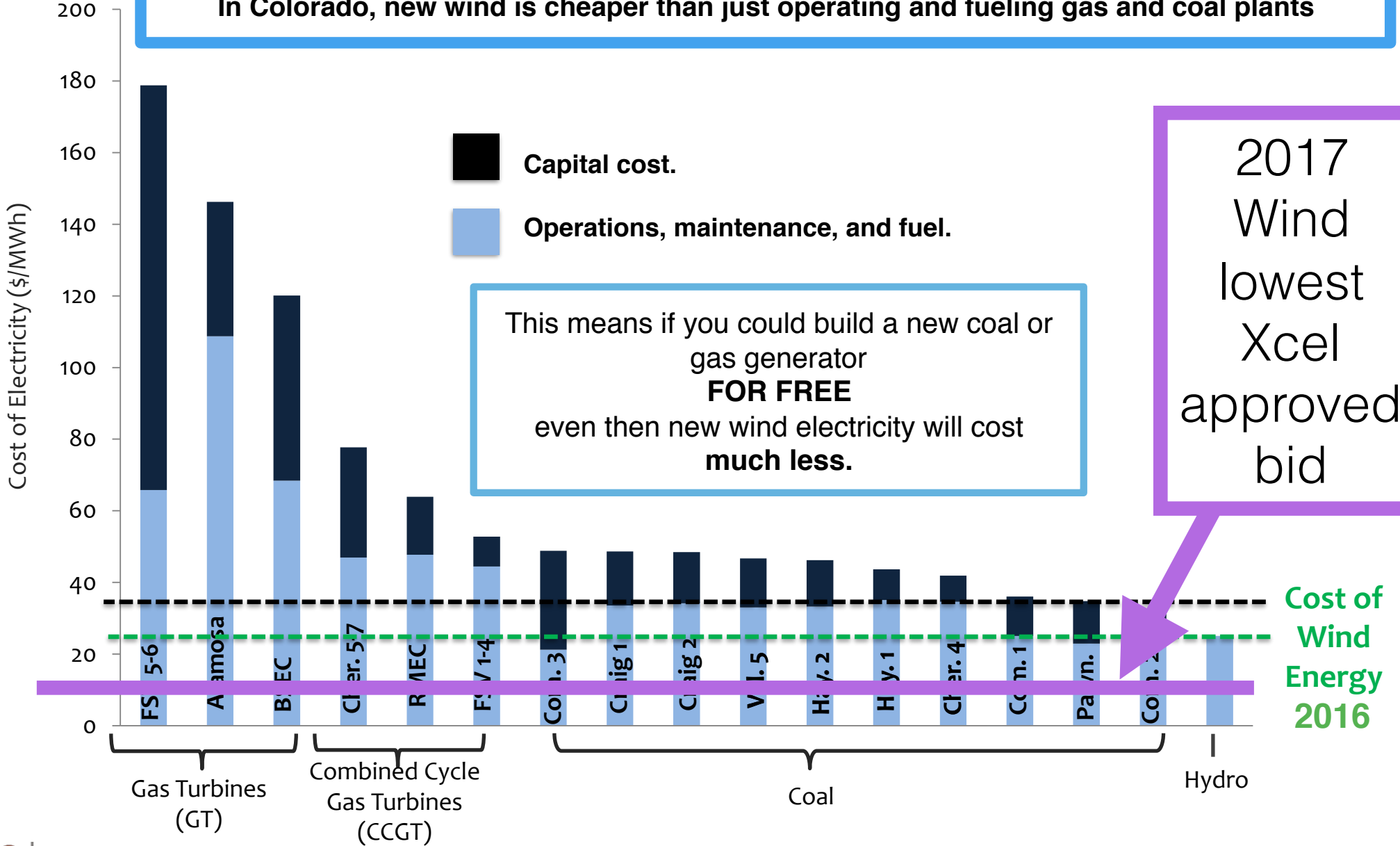
On the grid - Generation must **always** equal load.

In the past, utilities “balanced” load & generation with a mix of static inflexible baseload & nimble flexible peaking generators.



Comparing ALL of Xcel's Colorado Generation Fleet to Wind

In Colorado, new wind is cheaper than just operating and fueling gas and coal plants



2017 Wind lowest Xcel approved bid

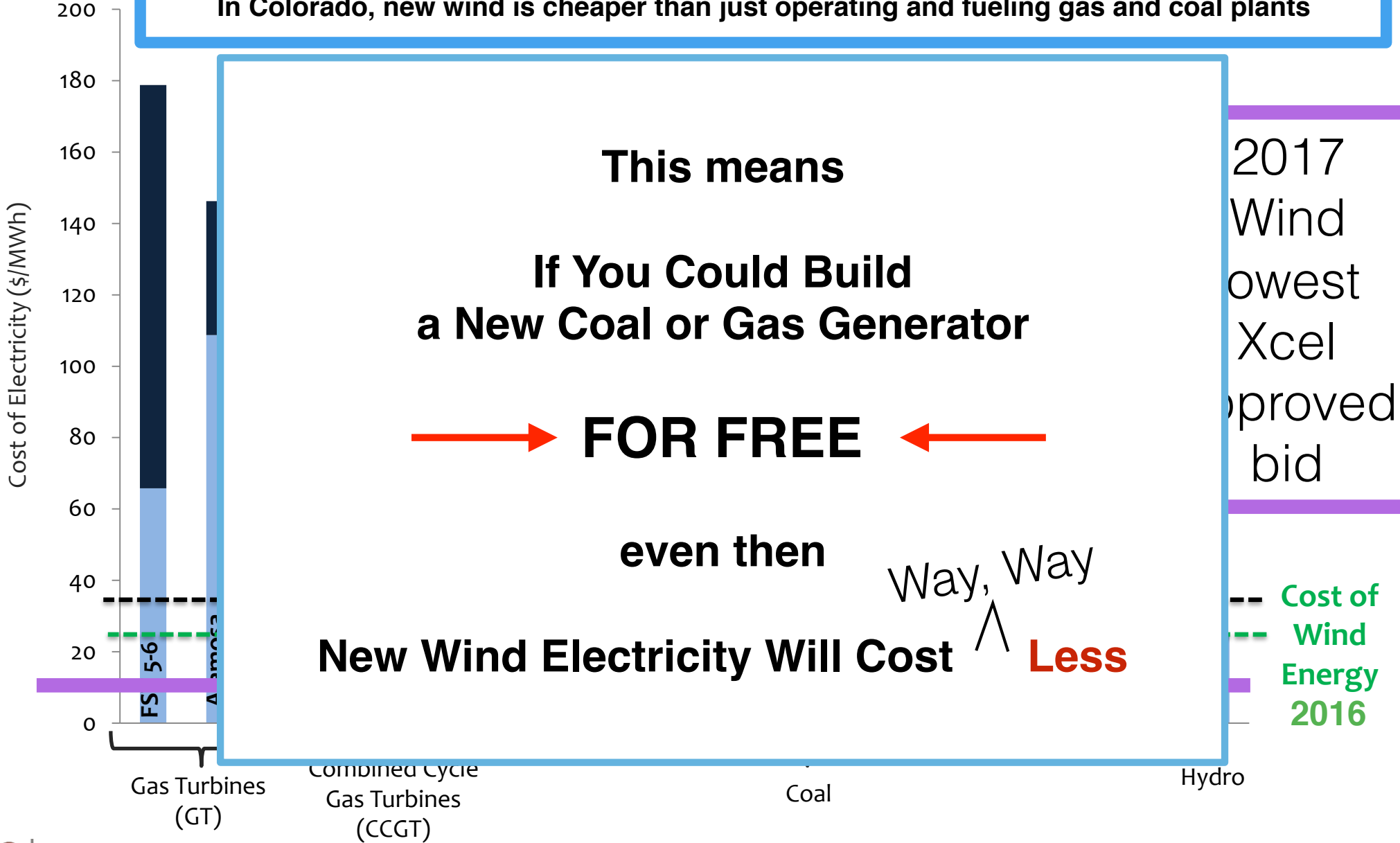
This means if you could build a new coal or gas generator **FOR FREE** even then new wind electricity will cost **much less.**

Cost of Wind Energy 2016

Source: Presentation to Boulder County Commissioners by Ron Lehr and Ron Binz. Data from Xcel energy. <http://bouldercountyco.suiteonemedia.com/GenFile.aspx?d=2158>

Comparing ALL of Xcel's Colorado Generation Fleet to Wind

In Colorado, new wind is cheaper than just operating and fueling gas and coal plants



Existing coal & gas generation contracts to expire in 2016. In 2011: “What is the cheapest electricity?”

Muni - owns distribution but no generation

Wind cheap but doesn't blow full blast all the time.

Contracted wind for half-speed wind.

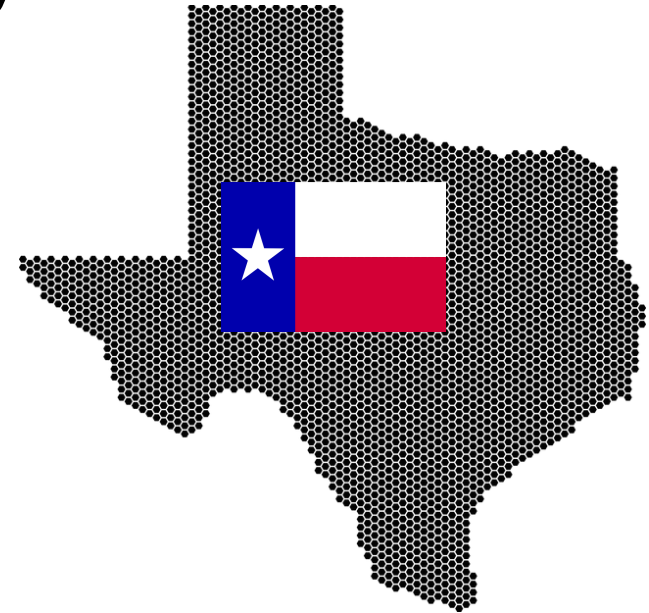
Contracted solar for half of full sun.

Most hours of the year covered.

200% Renewable! And 100% surplus electricity.

On the open market: Sell excess for thousands of hours per year.

Buy when needed for hundreds of hours.



 Open market: sell surplus and buy backup.

 **9 ¢ / kWh residential rate for next 20 years!**
(the average US residential rate is about 13 ¢ / kWh)

Electricity.

Reliable.

Cheap.

Clean.

2030.

Research Questions.

Ken Regelson

October, 2018

