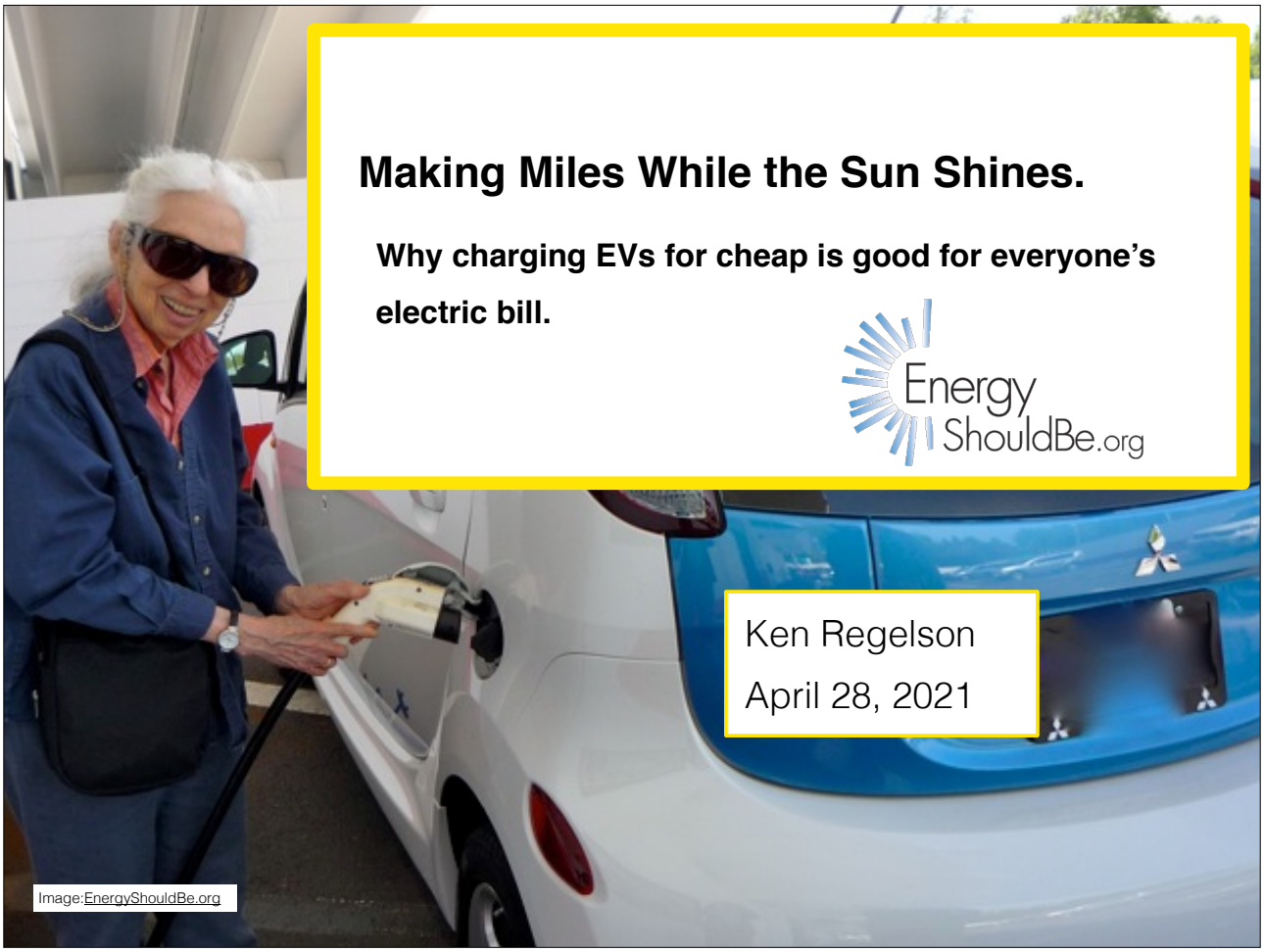

Making Miles While the Sun Shines.

Why charging EVs for cheap is good for everyone's electric bill.

Energy ShouldBe.org

Ken Regelson

April 28, 2021

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

- Wayne Gretzky

Don't Believe Everything You Think.

Energy ShouldBe.org

Drive a rapid transition to a reliable, reasonable cost, renewable energy future based on data driven actions.

Gretzky Image: Kris Krüg [CC BY-SA 2.0 (https://creativecommons.org/licenses/by-sa/2.0)]
source: https://commons.wikimedia.org/wiki/File:Wayne_Gretzky_2006-02-18_Turin_001.jpg

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

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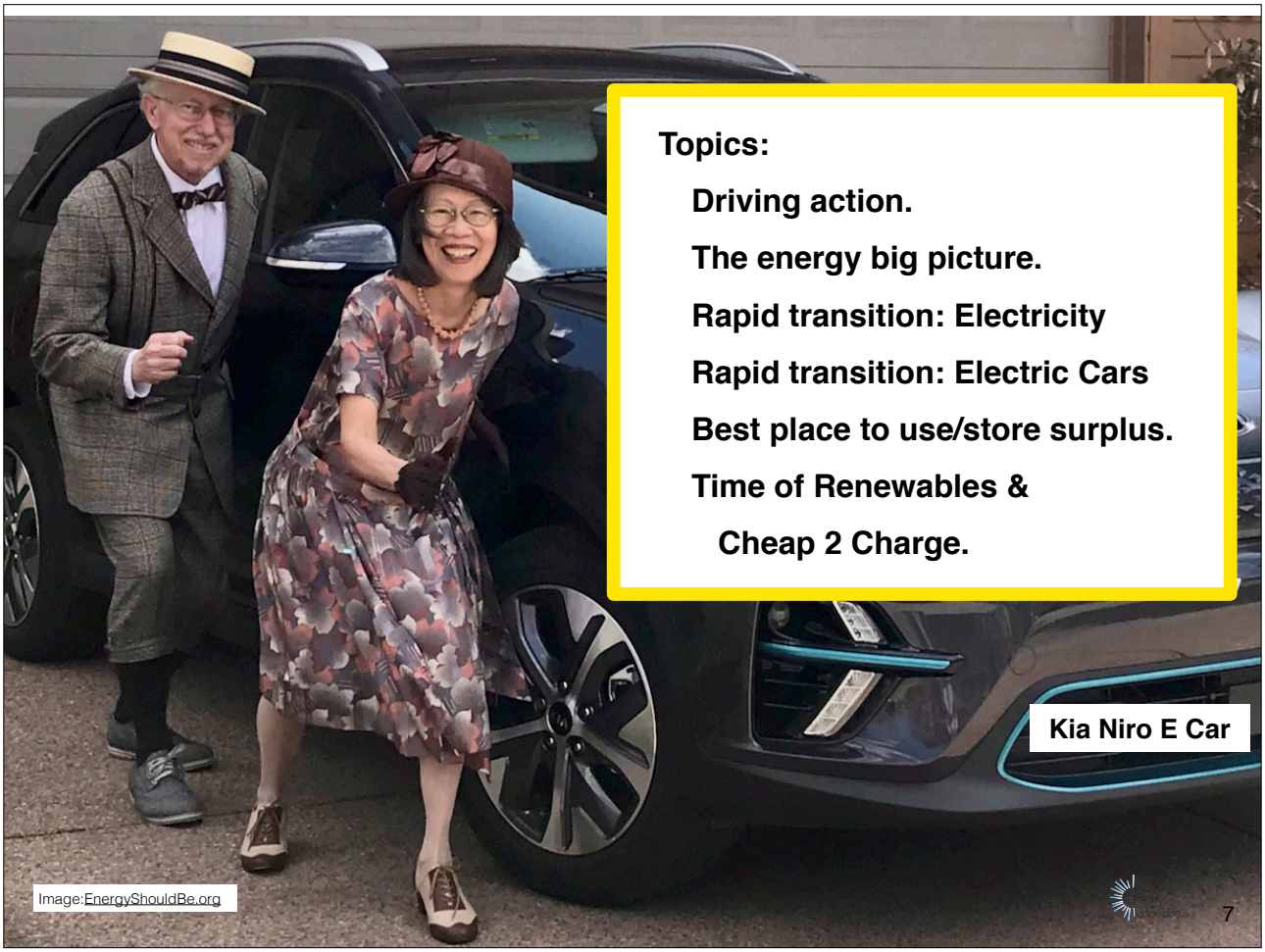
Energy ShouldBe.org

I like my data to be actionable!

Gretzky Image: Kris Krüg [CC BY-SA 2.0 (https://creativecommons.org/licenses/by-sa/2.0)]
source: https://commons.wikimedia.org/wiki/File:Wayne_Gretzky_2006-02-18_Turin_001.jpg



Topics:

- **Driving action.**
- **The energy big picture.**
- **Rapid transition: Electricity**
- **Rapid transition: Electric Cars**
- **Best place to use/store surplus.**
- **Time of Renewables &**
  - **Cheap 2 Charge.**

Kia Niro E Car

Image:EnergyShouldBe.org

Driving Action

Tesla Model Y

Image:EnergyShouldBe.org

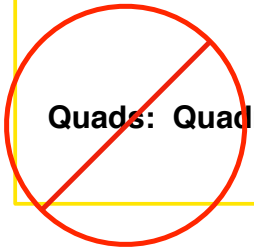
Ford 2019 Electric Car Poll

**“three in four
say they’d prefer to date
an electric vehicle owner. “**

Poll: https://media.ford.com/content/fordmedia/fna/us/en/news/2020/02/13/spark-a-new-romance-with-all-electric-mustang-mach-e.html
Image: EnergyShouldBe.org

What drives people to action?

Fear	Climate Change
$s	Cost
Fun	Competition
Hope	
Stories	True and Useful
Humor	



Quads: Quadrillion BTUs of Energy?

Which argument is most likely to lead to action?

Gasoline vs Electric Cars

Light Duty Transportation

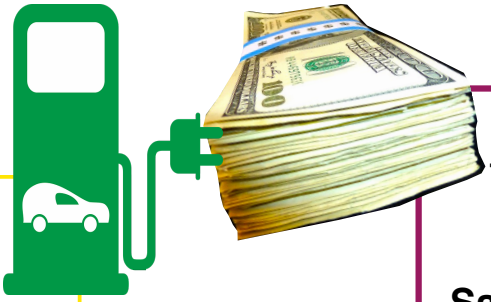
Fuel Cost

gasoline	$0.10 / mile	$3 / gallon / 30 MPG
electricity	$0.034 / mile	$0.12 / kWh / 3.5 miles / kWh

BTU

gasoline	120,000 BTU / gallon / 30 MPG =	4,000 BTU / mile
electricity	3,214 BTU / kWh / 3.5 miles/kWh =	920 BTU / mile

Plug-In For Savings!



Light Duty Transportation

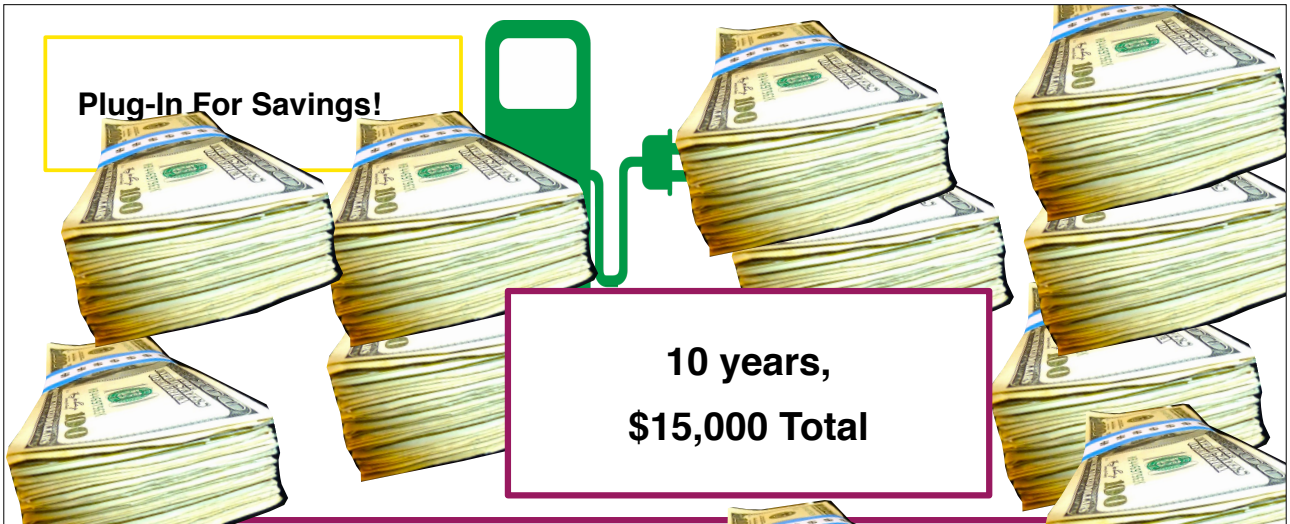
Fuel Cost

gasoline	$0.10 / mile
electricity	$0.034 / mile

15,000 miles,
$1,000 Fuel Savings Per Year

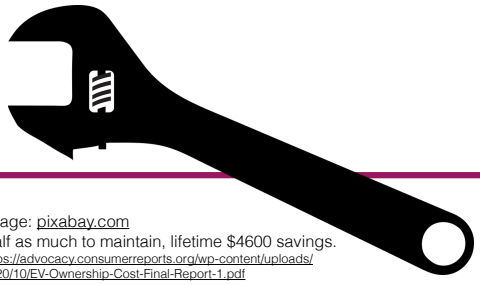
Image: pixabay.com
Half as much to maintain, lifetime $4600 savings.
https://advocacy.consumerreports.org/wp-content/uploads/2020/10/EV-Ownership-Cost-Final-Report-1.pdf

Plug-In For Savings!



10 years,
$15,000 Total

Life of Car Maintenance
$4,600 Savings



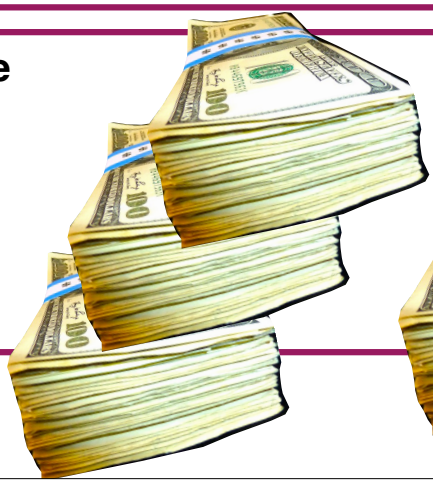


Image: pixabay.com
Half as much to maintain, lifetime $4600 savings.
https://advocacy.consumerreports.org/wp-content/uploads/2020/10/EV-Ownership-Cost-Final-Report-1.pdf

The Energy Big Picture

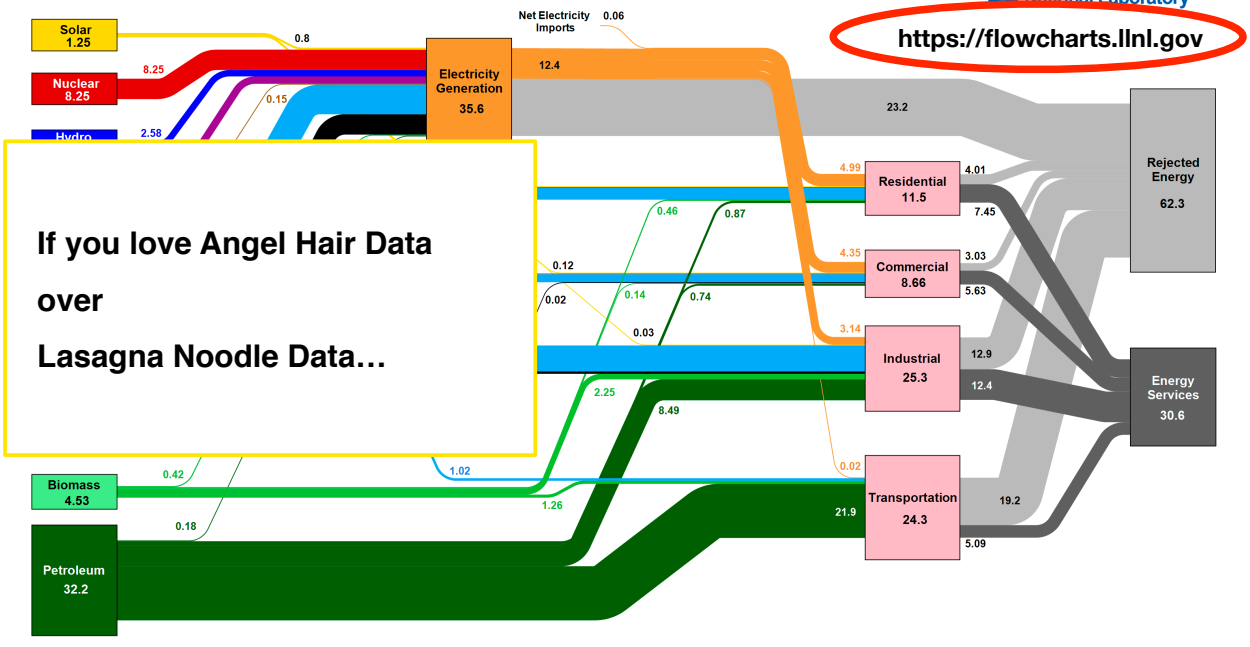
Plug-In Chevy Volt

Image:EnergyShouldBe.org

Estimated U.S. Energy Consumption in 2020: 92.9 Quads

Lawrence Livermore National Laboratory

https://flowcharts.llnl.gov



If you love Angel Hair Data

over

Lasagna Noodle Data…

Source: LLNL March, 2021. Data is based on DOE/EIA MER (2020). If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports consumption of renewable resources (i.e., hydro, wind, geothermal and solar) for electricity in BTU-equivalent values by assuming a typical fossil fuel plant heat rate. The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 65% for the residential sector, 65% for the commercial sector, 21% for the transportation sector and 49% for the industrial sector, which was updated in 2017 to reflect DOE's analysis of manufacturing. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

Image: Lawrence Livermore National Laboratory and the US Department of Energy
https://flowcharts.llnl.gov

Very Detailed Energy Sankey
http://energyliteracy.com

Estimated U.S. Energy Consumption in 2020: 92.9 Quads

Lawrence Livermore National Laboratory

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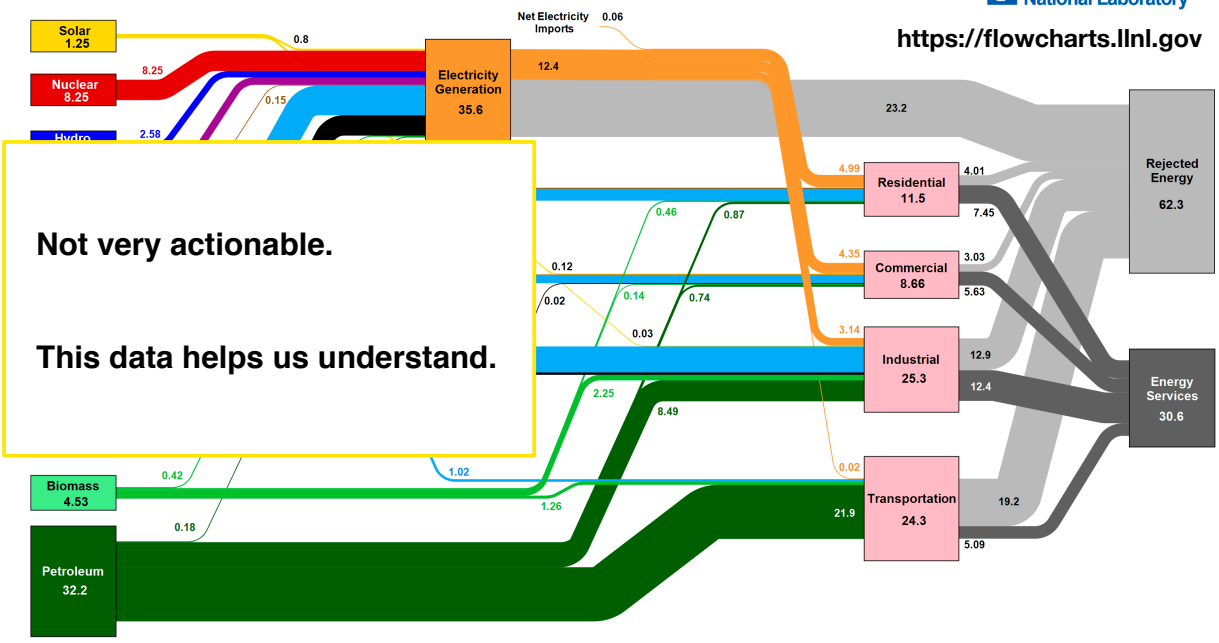


Not very actionable.

This data helps us understand.

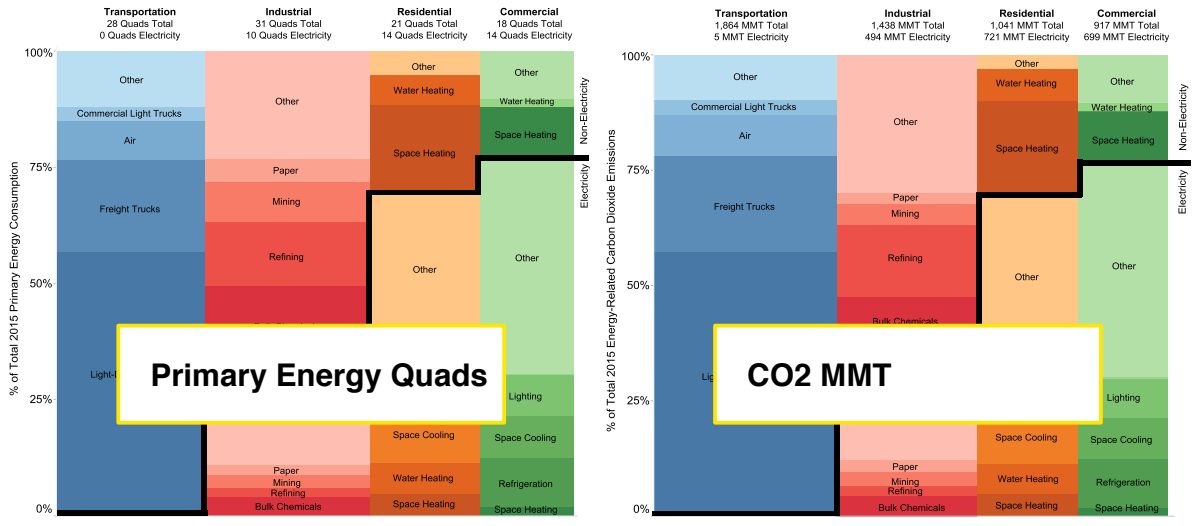
Source: LLNL March, 2021. Data is based on DOE/EIA MER (2020). If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports consumption of renewable resources (i.e., hydro, wind, geothermal and solar) for electricity in BTU-equivalent values by assuming a typical fossil fuel plant heat rate. The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 65% for the residential sector, 65% for the commercial sector, 21% for the transportation sector and 49% for the industrial sector, which was updated in 2017 to reflect DOE's analysis of manufacturing. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

Image: Lawrence Livermore National Laboratory and the US Department of Energy
https://flowcharts.llnl.gov

Very Detailed Energy Sankey
http://energyliteracy.com

Energy I ShouldBe.org

Subsector primary energy consumption and energy-related carbon dioxide emissions 2015



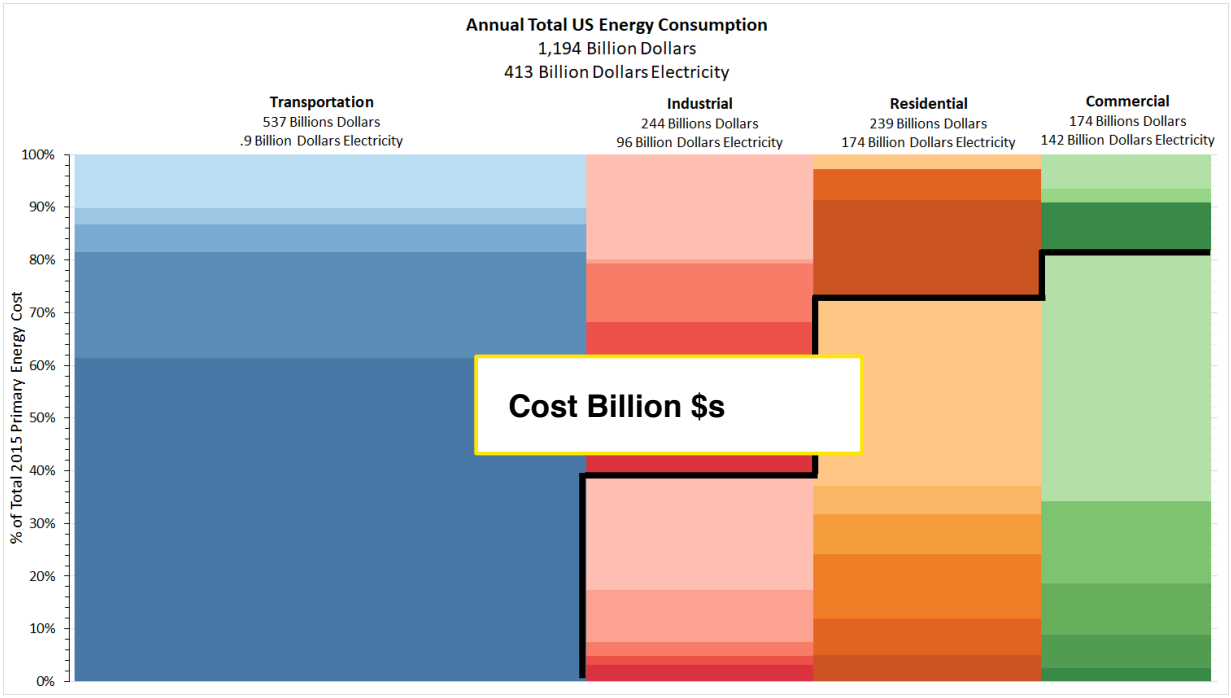
Primary Energy Quads

CO2 MMT

The Money???

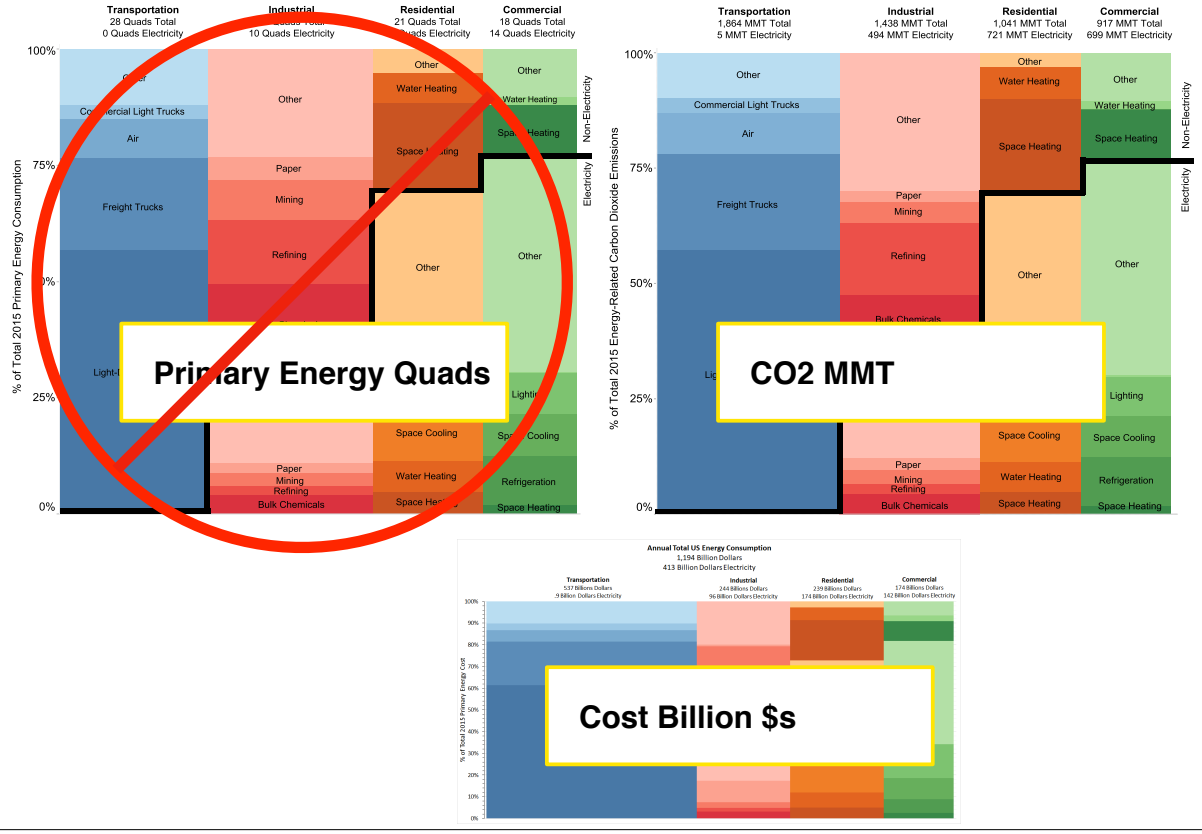
Source NREL. https://www.nrel.gov/docs/fy18osti/70485.pdf page 18. Based on 2015 data from EIA.

$ draft



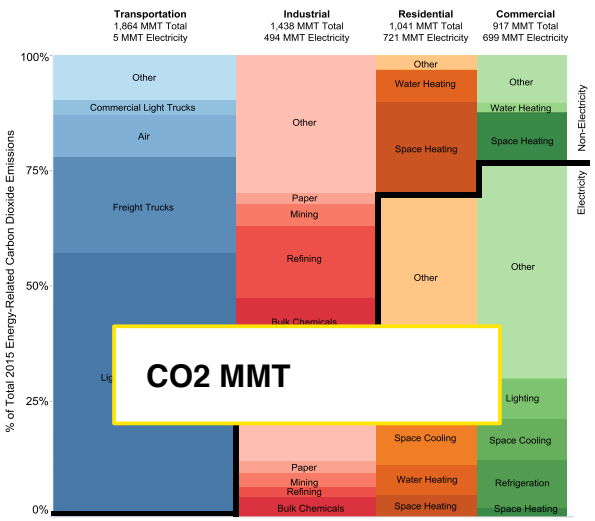
Draft from EnergyShouldBe.org based on 2015 EIA data

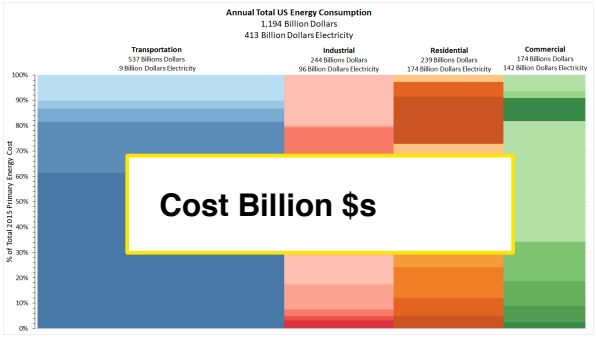
Subsector primary energy consumption and energy-related carbon dioxide emissions 2015



Subsector primary energy consumption and energy-related carbon dioxide emissions 2015

Actionable.
Interesting data.
Hard for most to understand.

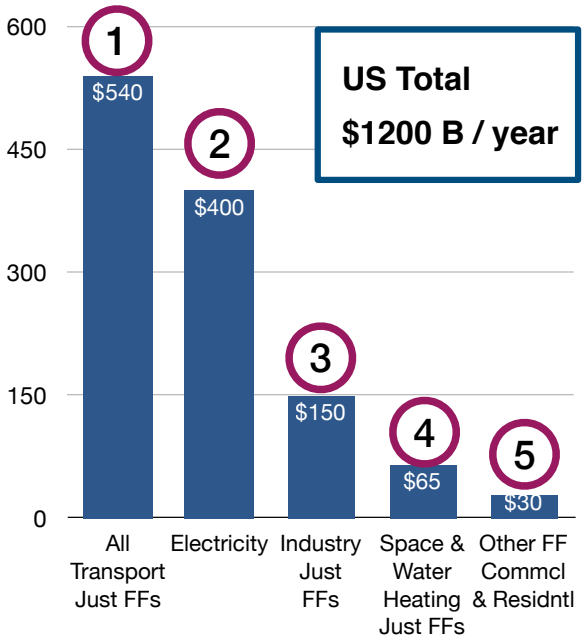


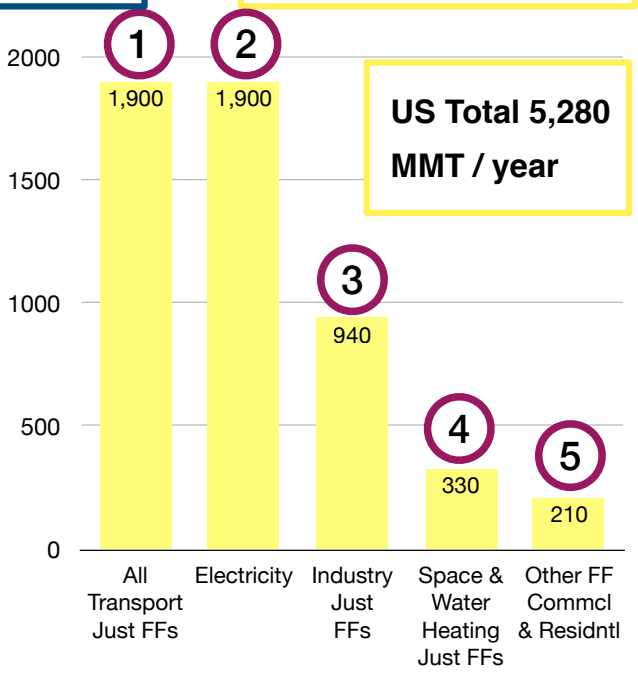


US Energy Cost Billion $ Per Year

2015

US - GHGs Million MT CO2*e*





Images: EnergyShouldBe.org

Data analysis EnergyShouldBe.org based on EIA 2015 US data. Space heating includes water heating.

Actions Now to 2035

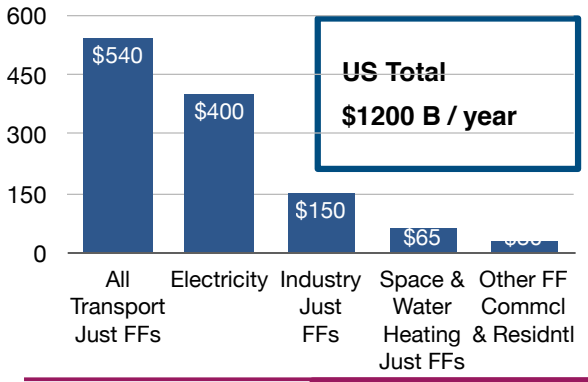
1. **Electrify 80% of transportation.**

2. **90% Renewable Electricity**
3. **50% electrification of industry (FF).**
   Hydrogen generated onsite?
4. **50% electrification of heating (FF).**
   Heat pumps.

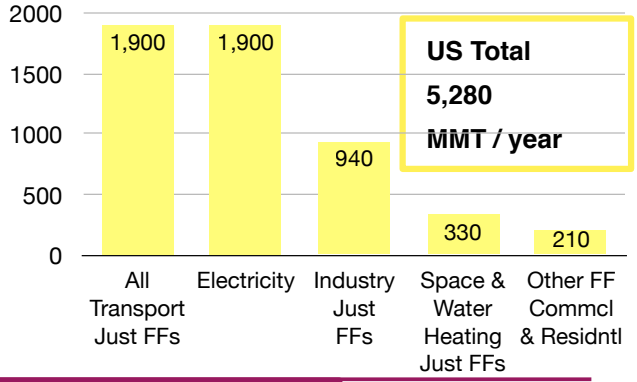
US Energy Cost
Billion $ Per Year

2015

US Energy GHGs
Million MT CO2*e*



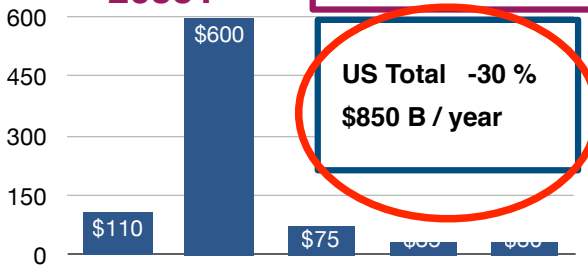
US Total
$1200 B / year



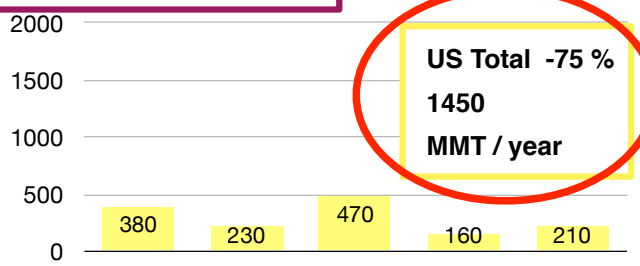
US Total
5,280
MMT / year

2035?

90% Renewable Electricity. 80% EVs. Electrify 50% of industry and Heating.



US Total -30 %
$850 B / year



US Total -75 %
1450
MMT / year

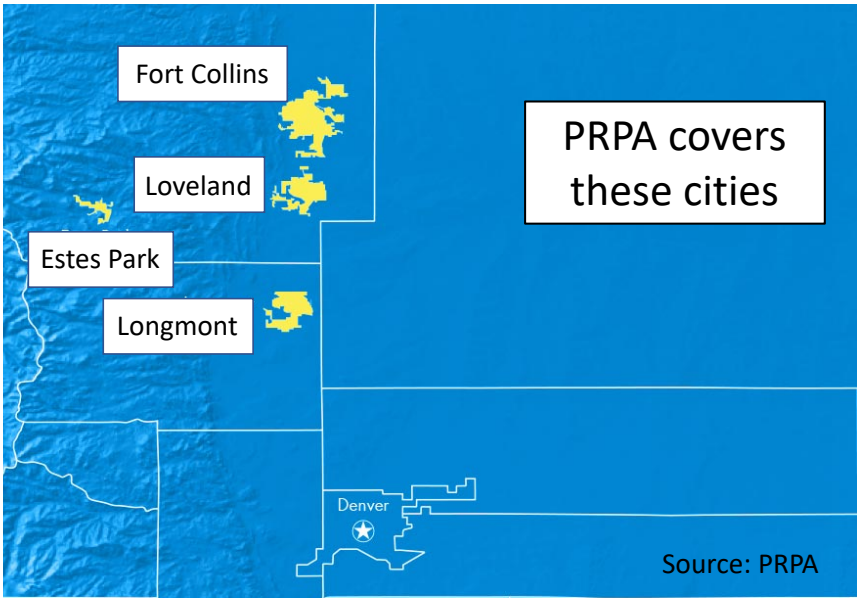
Images: EnergyShouldBe.org Data analysis EnergyShouldBe.org based on EIA 2015 US data.

Rapid Transition: Electricity

Chevy Bolt All-Electric

Image:EnergyShouldBe.org

Platte River Power Authority (PRPA) is a leader in transitioning to renewable electricity

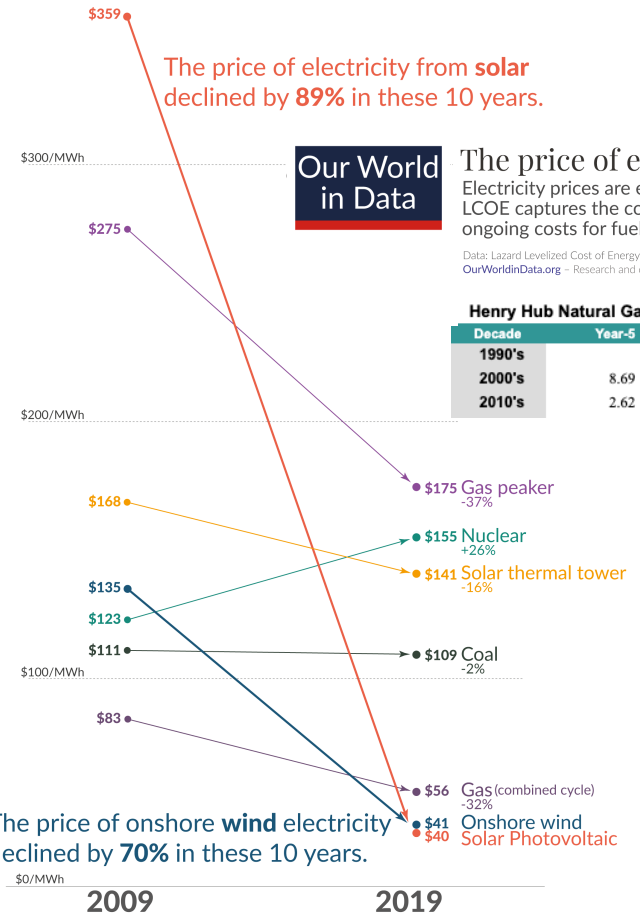


PRPA - Lowest cost & highest reliability in Colorado.

In 2014, ~ 20% renewables.
If you told them 50% by 2020…
In 2020, 50% renewables. ✓

Cost of Wind & Solar WENT DOWN.

3 Pillars
- **Reliability**
- **Cost**
- **Environment**



Our World in Data

The price of electricity from new power plants

Electricity prices are expressed in 'levelized costs of energy' (LCOE). LCOE captures the cost of building the power plant itself as well as the ongoing costs for fuel and operating the power plant over its lifetime.

Data: Lazard Levelized Cost of Energy Analysis, Version 13.0
OurWorldInData.org – Research and data to make progress against the world's largest problems.

Henry Hub Natural Gas Spot Price (Dollars per Million Btu)

Decade	Year-5	Year-6	Year-7	Year-8	Year-9
1990's			2.49	2.09	
2000's	8.69	6.73	6.97	8.86	3.94
2010's	2.62	2.52	2.99	3.15	2.56

https://ourworldindata.org/cheap-renewables-growth
https://www.eia.gov/dnav/ng/hist/rngwhhdA.htm

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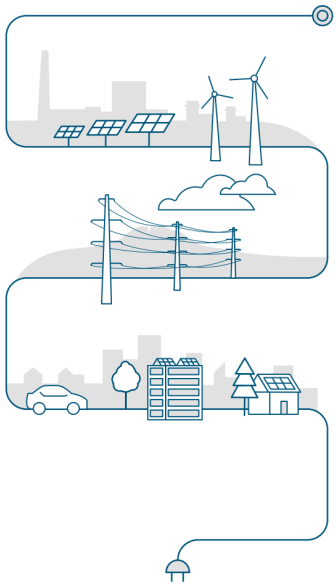
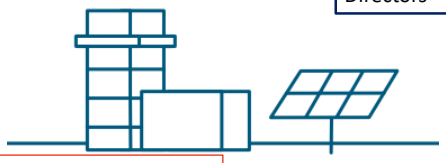


2020 Integrated Resource Plan

Approved by PRPA Board of Directors



Portfolio 2: zero coal

3 Pillars
- **Reliability**
- **Cost**
- **Environment**

85% Renewables, 90% carbon reduction, by 2030!

Includes big storage.

Source: PRPA 2020 IRP https://www.prpa.org/wp-content/uploads/2020/10/IRP_10.8_spread.pdf

Platte River Power Authority

North Colorado
85% Renewable Electricity by 2030

2035Report.com UC Berkeley

Every US State

"90% clean,
carbon-free electricity nationwide by 2035,
dependably,
at no extra cost to consumers,
and without new fossil fuel plants."

Xcel Energy Colorado

90% carbon free 2030. ERP just released 4/2021.

Etc.

Platte River Power Authority

North Colorado
85% Renewable Electricity by 2030

2035Report.com UC Berkeley

2 Weeks ago: 2035Report.com 2nd report.

" with the right policy, it is technically and economically feasible for all new car and truck sales to be electric by 2035…

… would prevent 150,000 premature deaths and avoid $1.3 trillion in environmental and health costs through 2050

… would save consumers $2.7 trillion by 2050, …
and would support a net increase of over 2 million jobs in 2035

Etc.

Platte River Power Authority

North Colorado
85% Renewable Electricity by 2030

2035Report.com

Every US State 90%
Renewable Electricity by 2035

And

Every new car & truck sold
by 2035 Electric.

Xcel Energy Colorado

90% carbon free 2030. ERP just released 4/2021.

Etc.

Why?

Solar and wind electricity are now cheaper than operations, maintenance and fuel of many fossil fuel generators.

Why?

These Make the Same Amount of Electricity per year

Competition and Mass Production always means costs go down!

1

425

13,000,000

Number of wind turbine and solar panel calculations by EnergyShouldBe.org from common data sources for Colorado.

These Make the Same Amount of Electricity per year

Competition and Mass Production always means costs go down!

1

425

13,000,000

Billions

of batteries for Electric Vehicles

In 2015 in California, new battery storage beat gas generation for peaking needs.

Number of wind turbine and solar panel calculations by EnergyShouldBe.org from common data sources for Colorado.

The world's best solar power schemes (bids) now offer the "cheapest…electricity in history"

…cheaper than coal and gas in most major countries. … International Energy Agency…

https://www.carbonbrief.org/solar-is-now-cheapest-electricity-in-history-confirms-iea

90% Renewable Electricity is in rapid transition.

Need to Scale to Everyone.

Get close to 100%.

Surplus - Cost Issue

Dark Calms - Reliability and Cost

Intern Kirya Miller's 7 minute summary:
Youtube: Alternatives to Natural Gas Generation for Platte River Power Authority

Actions Now to 2035

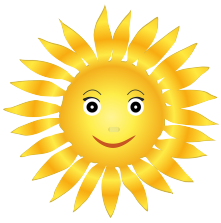
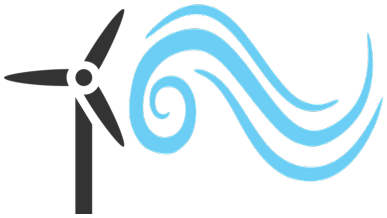
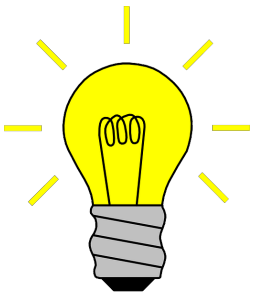
1. **Electrify 80% of transportation.**
2. **90% Renewable Electricity**
3. **50% electrification of industry (FF). Hydrogen generated onsite?**
4. **50% electrification of heating (FF). Heat pumps.**

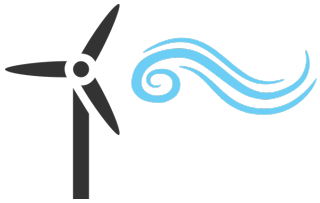
How much energy does a heat pump use if a heat pump pumps when it's cold?

Interns Will Balan & Kirya Miller's work on-going:
Air vs. Ground Source Heat Pump Impact on the Grid in Cold Climates

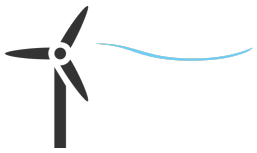
How much energy does a heat pump use if a heat pump pumps when it's cold?

Above 30% of electricity from wind and solar there will be surplus. Why?

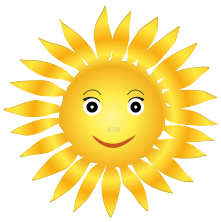
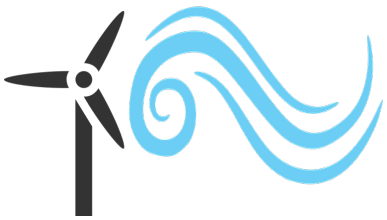




Blackout = no electricity use!

Images pixabay.com

Above 30% of electricity from wind and solar there will be surplus. Why?

When there is lots of solar and/or lots of wind, and little use of electricity there will be surplus!

Selling the surplus, even for cheap, keeps rates low.

We will get back to "Surplus"

Images pixabay.com

Rapid Transition: Electric Cars

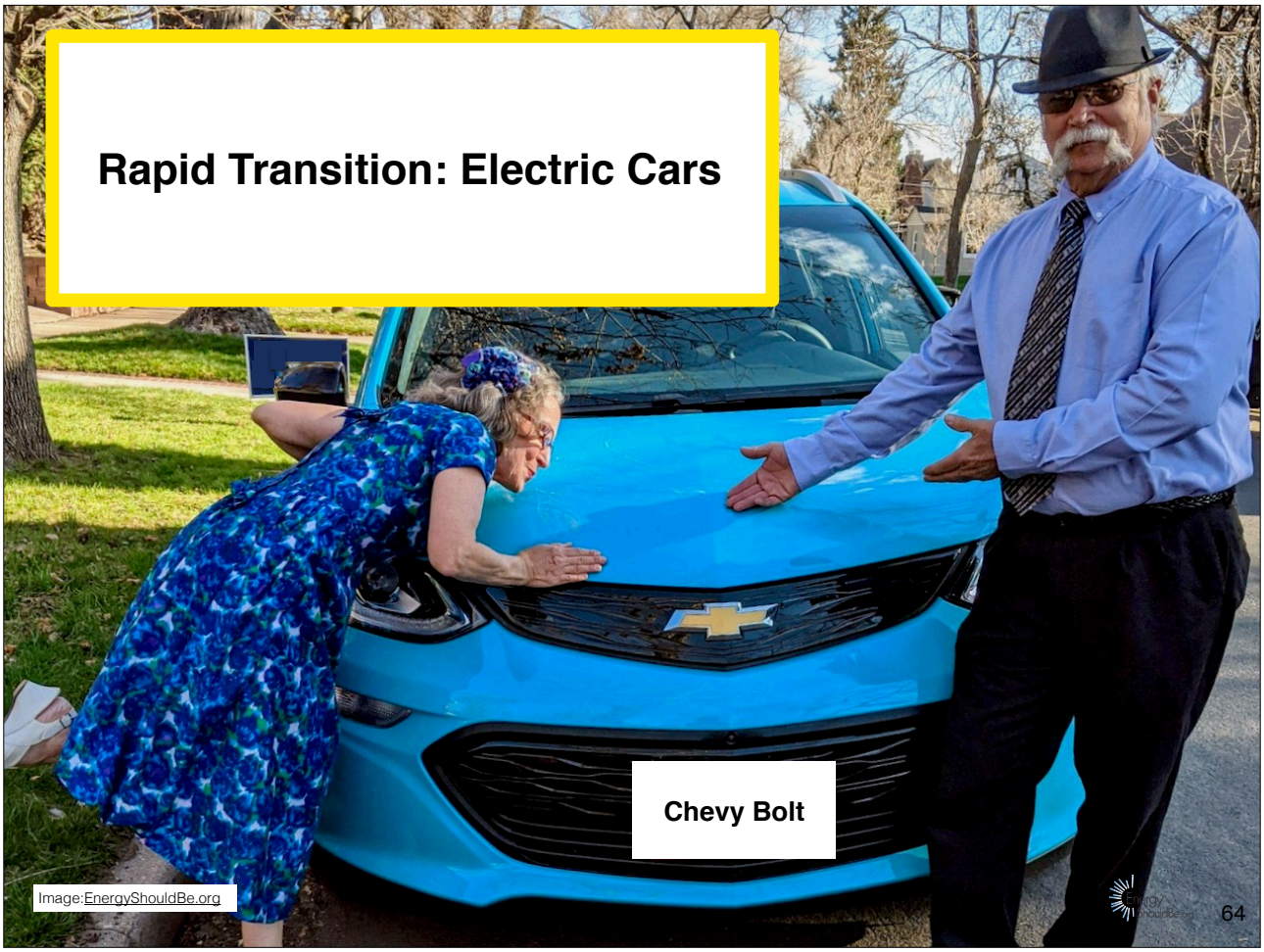


Image:EnergyShouldBe.org

Plug-In For Savings!

10 years,

$15,000 Total

Life of Car Maintenance

$4,600 Savings

Image: pixabay.com

Half as much to maintain, lifetime $4600 savings.

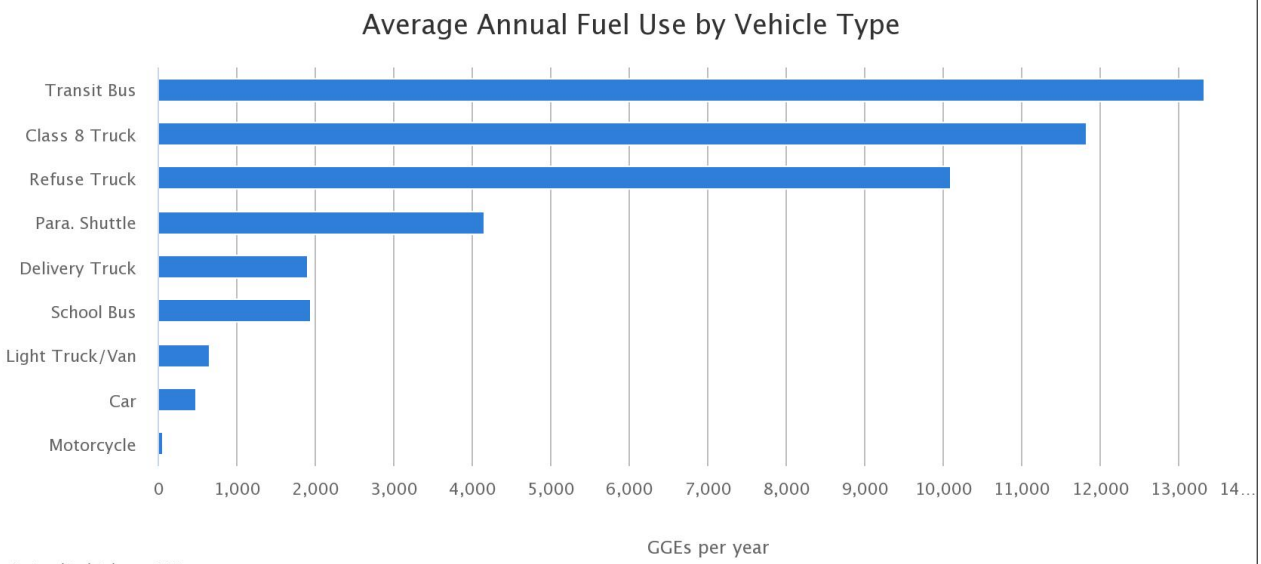
https://advocacy.consumerreports.org/wp-content/uploads/2020/10/EV-Ownership-Cost-Final-Report-1.pdf

What is important for a Rapid Transition to Electric Transportation?

Fuel Used.

Miles Driven.

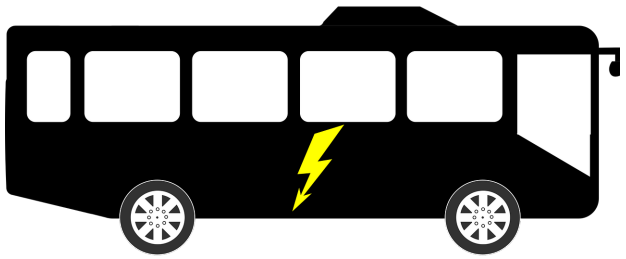
# of vehicles converted.

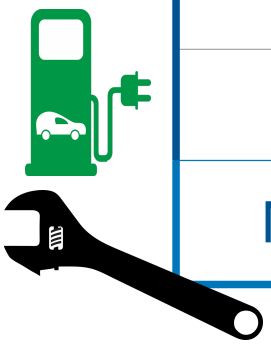


GGE Gasoline Gallon Equivalents https://afdc.energy.gov/data/10308

Electric Transit Bus $avings per Year From Fossil Fuels

34,000
miles per year



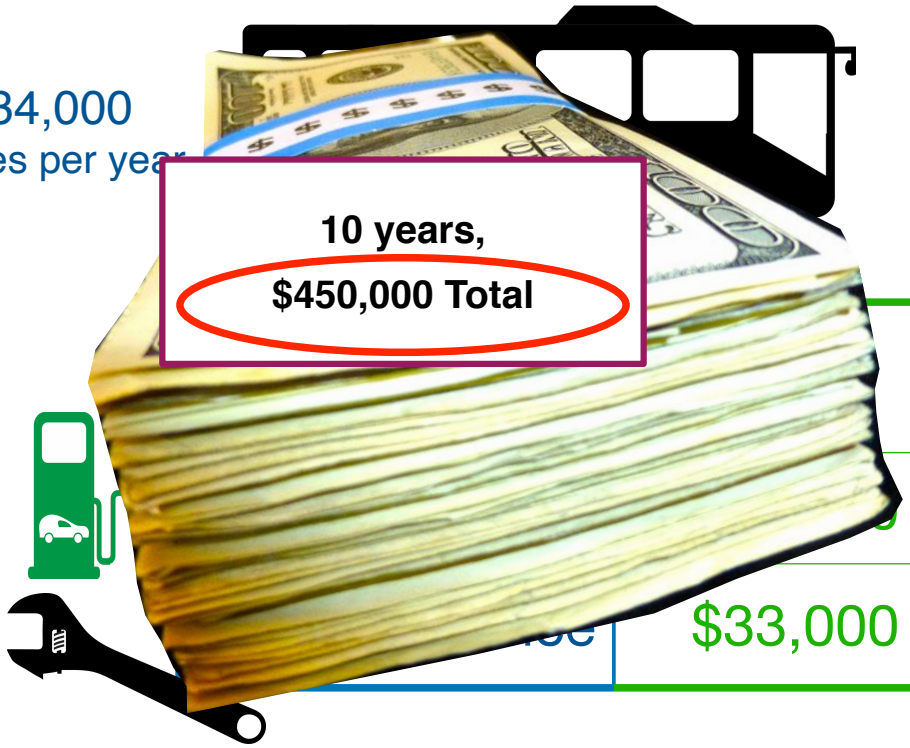


Diesel vs. Electricity	$avings per year
Fuel	$11,500
Maintenance	$33,000

Images: pixabay.com
46¢, 13¢ from http://swenergy.org/new-xcel-energy-rate-could-speed-rtd's-purchase-of-electric-buses- using Xcel's proposed rate for 13¢. 34,000 miles per year from https://afdc.energy.gov/data/10309

Electric Transit Bus $avings per Year From Fossil Fuels

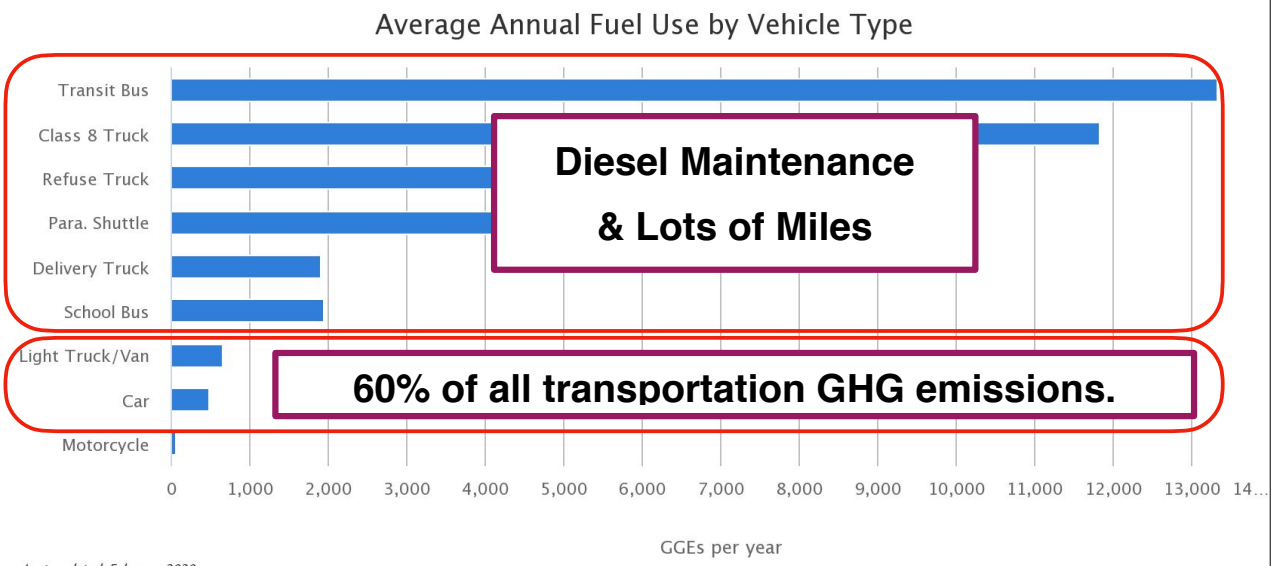
34,000
miles per year



10 years,
$450,000 Total

$33,000

Images: pixabay.com
46¢, 13¢ from http://swenergy.org/new-xcel-energy-rate-could-speed-rtd's-purchase-of-electric-buses- using Xcel's proposed rate for 13¢. 34,000 miles per year from https://afdc.energy.gov/data/10309



GGE Gasoline Gallon Equivalents https://afdc.energy.gov/data/10308

Actions Now to 2035

1. **Electrify 80% of transportation. Start with light duty, high mileage, and high energy use vehicles.**
2. **90% Renewable Electricity**
3. **50% electrification of industry (FF). Hydrogen generated onsite?**
4. **50% electrification of heating (FF). Heat pumps.**

Platte River Power Authority

North Colorado

85% Renewable Electricity by 2030

2035Report.com UC Berkeley

2 Weeks ago: 2035Report.com 2nd report.

" with the right policy, it is technically and economically feasible for all new car and truck sales to be electric by 2035…

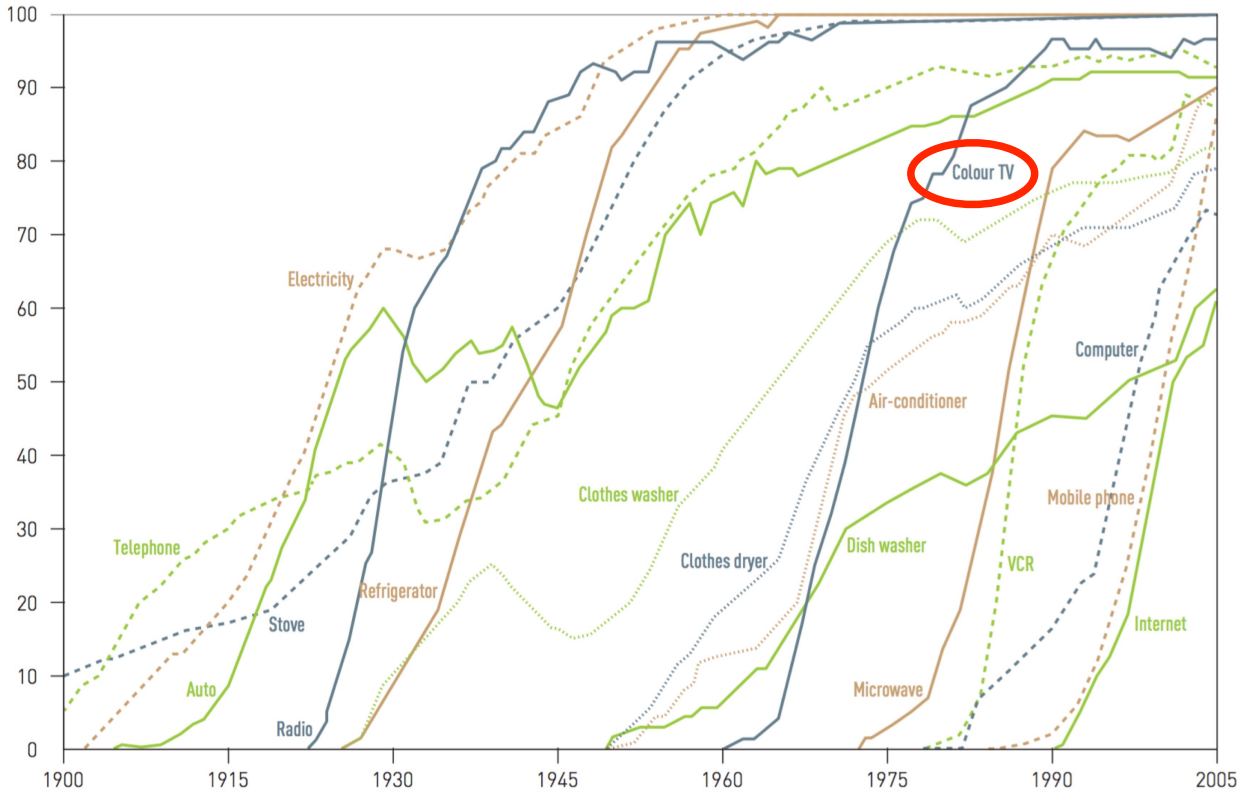
… would prevent 150,000 premature deaths and avoid $1.3 trillion in environmental and health costs through 2050

… would save consumers $2.7 trillion by 2050, …

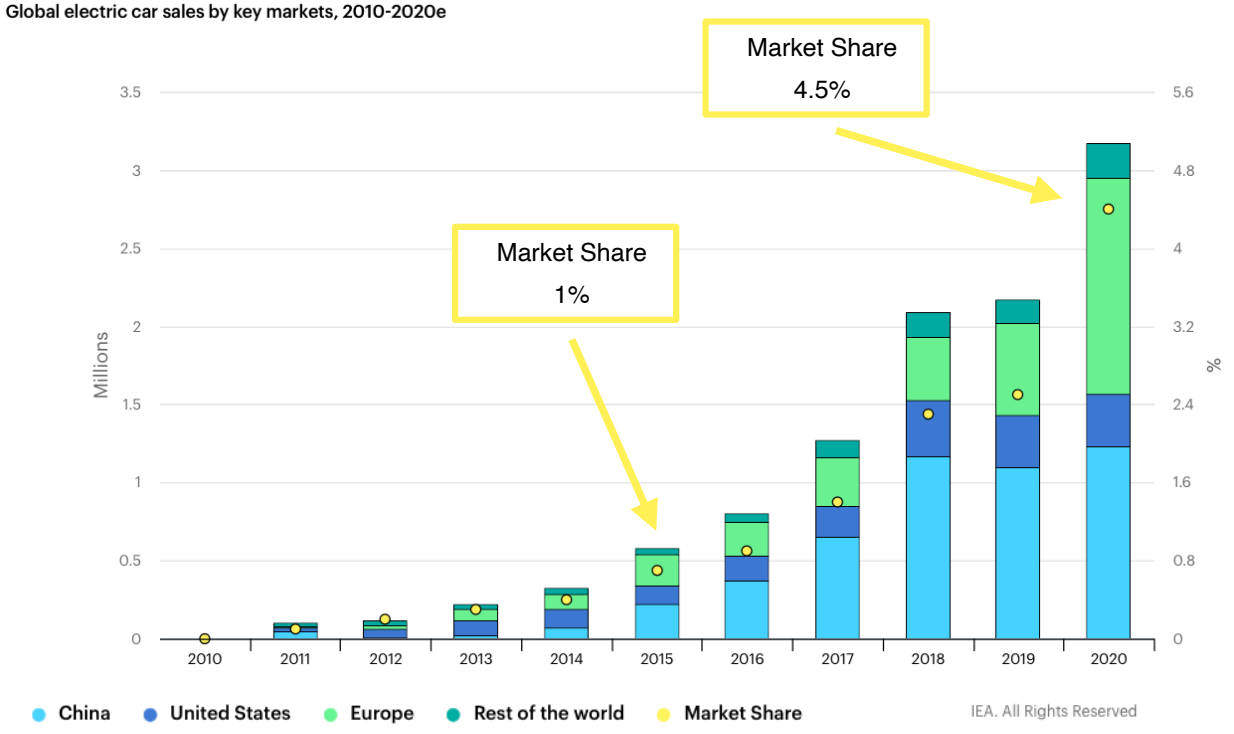
and would support a net increase of over 2 million jobs in 2035

Etc.

It is Common for Innovative Technologies to Grow Fast.



Source: Innovative product adoption chart New York Times, 2008 (page 18 in PDF): http://apo.org.au/files/Resource/vicgov_electric-vehicle-trial-mid-term_2013.pdf



Source:IEA, Global electric car sales by key markets, 2010-2020e, IEA, Paris https://www.iea.org/data-and-statistics/charts/global-electric-car-sales-by-key-markets-2010-2020e

Energy ShouldBe.org

The dribble of EV and plug-in launches has turned into an avalanche of news about accelerated EV timelines and emissions-reduction goals.

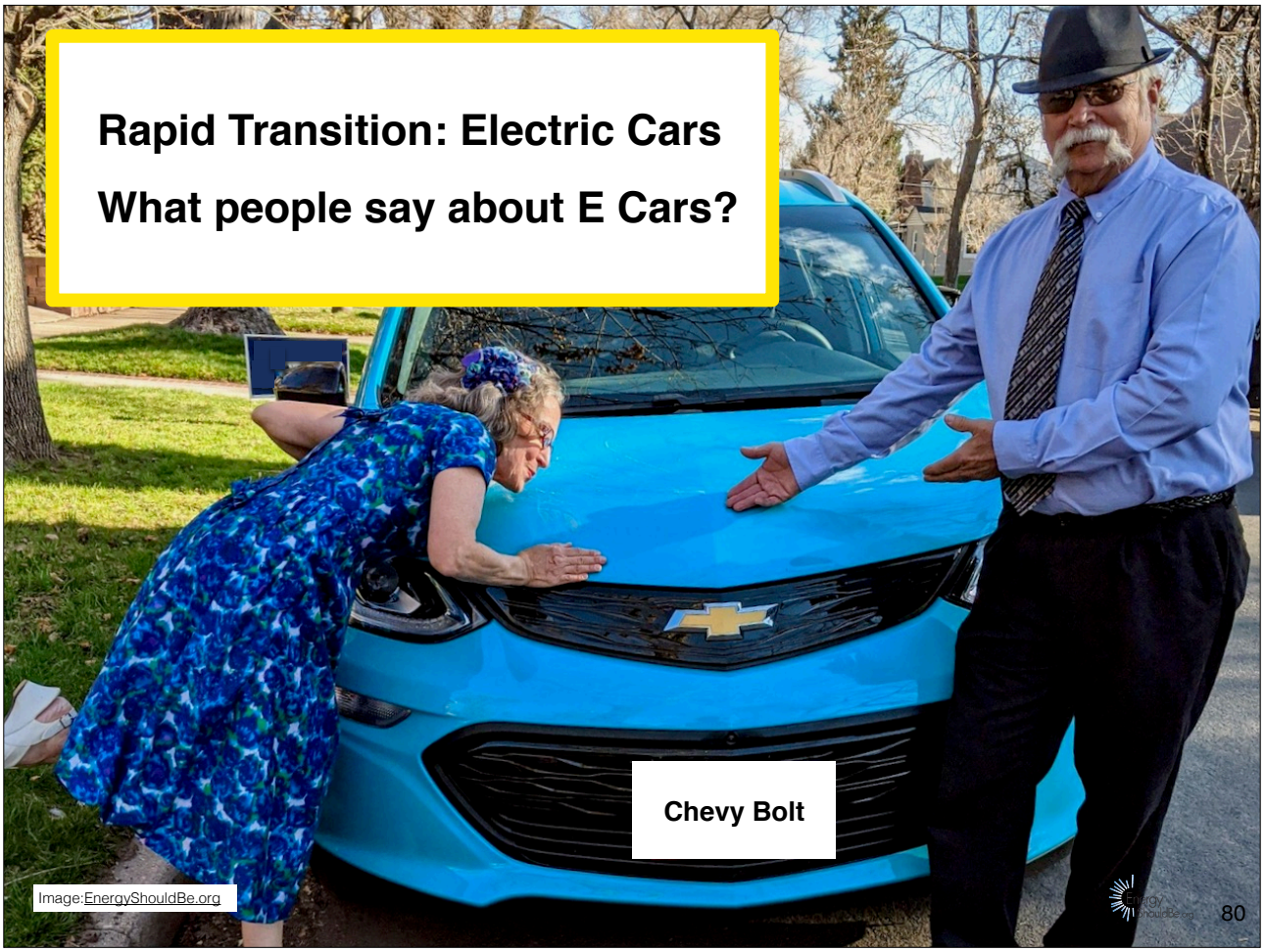
- Car & Driver 2/20/21

An electric trickle is turning into a flood: As many as 100 new E.V. models are coming to showrooms by 2025. Heavyweights including Volkswagen, General Motors and Ford are floating promises of all-electric lineups within a decade.

- New York Times 4/22/21

https://www.caranddriver.com/news/g35562831/ev-plans-automakers-timeline/
https://www.nytimes.com/2021/04/22/business/electric-suvs-ford-volkswagen-volvo.html

Energy ShouldBe.org



AAA Polled 1,100 Electric Car Owners

For the 60% of households with two or more cars where one car is electric:

An amazing

90% of driving is on electricity!

This means, 9 out of 10 times people prefer to take their EVs.

Poll: https://newsroom.aaa.com/2020/01/aaa-owning-an-electric-vehicle-is-the-cure-for-most-consumer-concerns/ 87% of driving on electric car in multi-car households.
2/3's of households that have any cars have 2 or more cars: https://transportgeography.org/?page_id=5143

Energy ShouldBe.org

AAA Polled 1,100 Electric Car Owners

electric car owners:

- Most never run out of charge.
- 75% of charging at home.
- **96% say "my next car will plug-in."**

Poll: https://newsroom.aaa.com/2020/01/aaa-owning-an-electric-vehicle-is-the-cure-for-most-consumer-concerns/ 87% of driving on electric car in multi-car households.
2/3's of households that have any cars have 2 or more cars: https://transportgeography.org/?page_id=5143

Energy ShouldBe.org

Image:EnergyShouldBe.org

Shhhh. Don't disturb the cat!

Energy ShouldBe.org

Images:EnergyShouldBe.org

"Our Best Car So Far"

Energy ShouldBe.org

Rapid Transition: Electric Cars

Range & Recharging

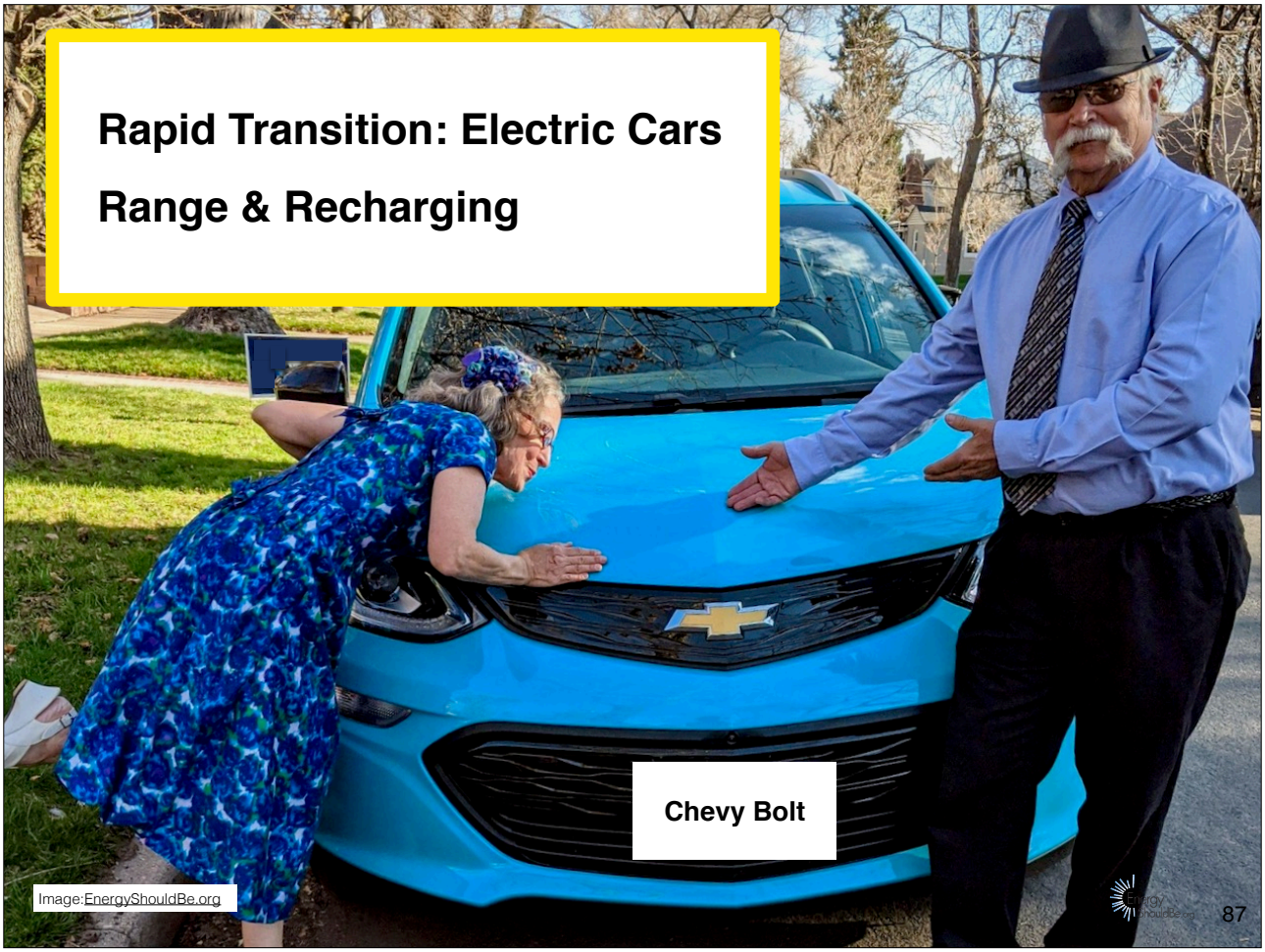
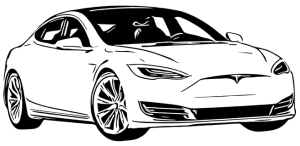


Image:EnergyShouldBe.org

2015 Two Practical Electric Cars



Tesla Model S

2015 Leaf
80 miles
realistic range

2019 Five Practical Electric Cars

All at least
240 miles
realistic range

Nissan Leaf

2021 Ford Mustang Mach-E, VW ID4 and Volvo Recharge, Hyundai, Kia, Toyota, Subaru, Porsche, Audi, etc

Images: EnergyShouldBe.org
Tesla drawing and Kona image: pixabay.com

Range Rapidly Rising

Energy ShouldBe.org

240 miles roundtrip Denver to Pueblo or Vail

2020: Range of 370 miles on sale.

500 miles coming soon.

All car makers plan Electric Cars & Trucks. Most have stopped development of combustion engines.

Ford says its electric F-150 pickup will be:
"**cheaper** to own, …
faster, and
more powerful
than any truck we've ever made."

2019 Five Practical Electric Cars

All at least
240 miles
realistic range

Nissan Leaf

2021 Ford Mustang Mach-E, VW ID4 and Volvo Recharge, Hyundai, Kia, Toyota, Subaru, etc

Images: EnergyShouldBe.org
Tesla drawing and Kona image: pixabay.com
Ford quote

Range Rapidly Rising

Energy ShouldBe.org

Fast Recharging: Cannonball Run

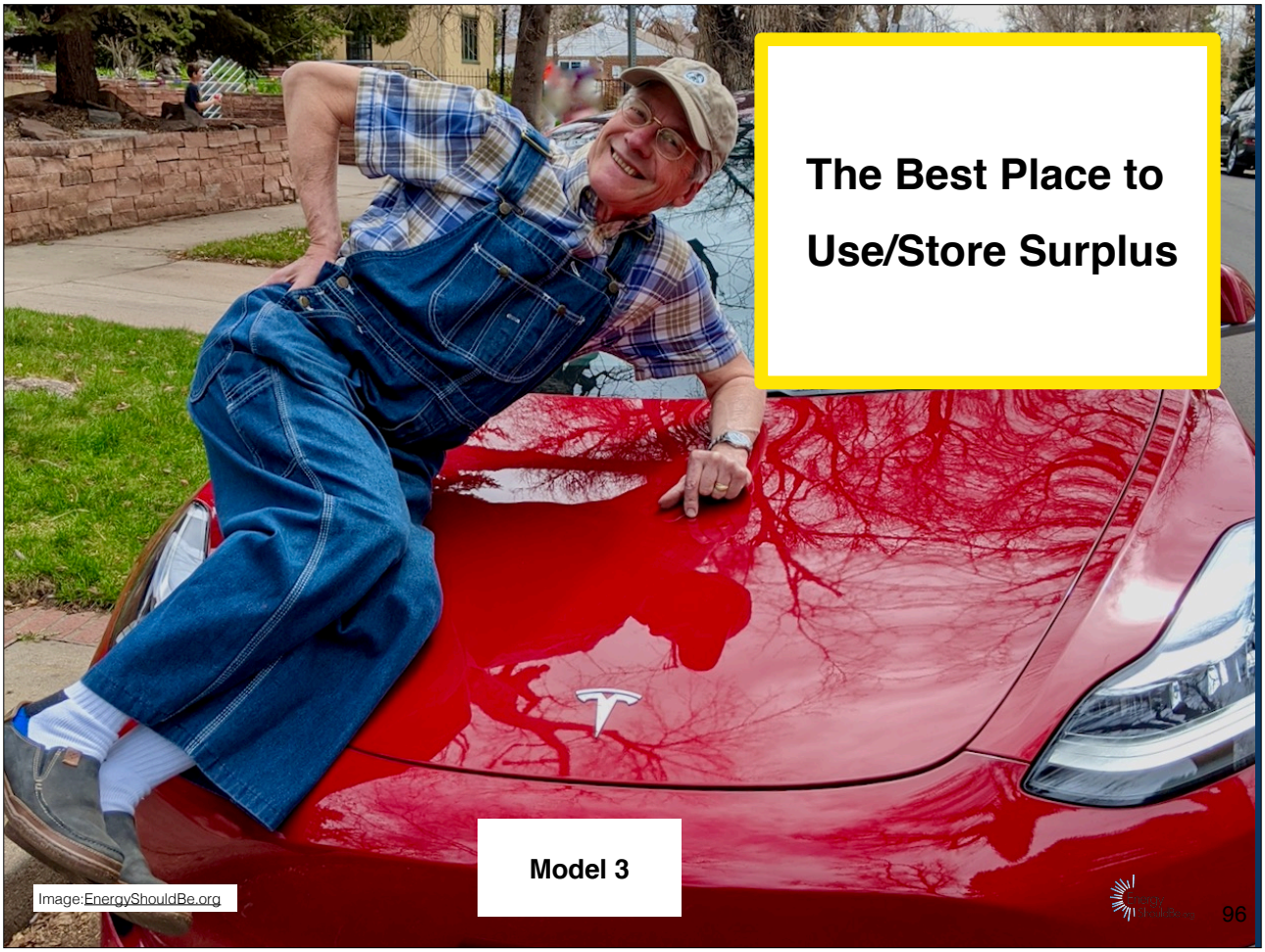
Tesla: Record right now 45 hours total time.

Fast recharging varies with the car, it's internal charging, battery size, and charger capability.

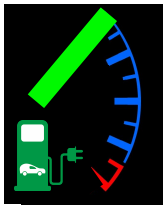
And most people will do medium or slow charging at home and work most of the time.

2 minute video by Ken on charging.

Images: EnergyShouldBe.org
Tesla drawing and Kona
image: pixabay.com
Ford quote

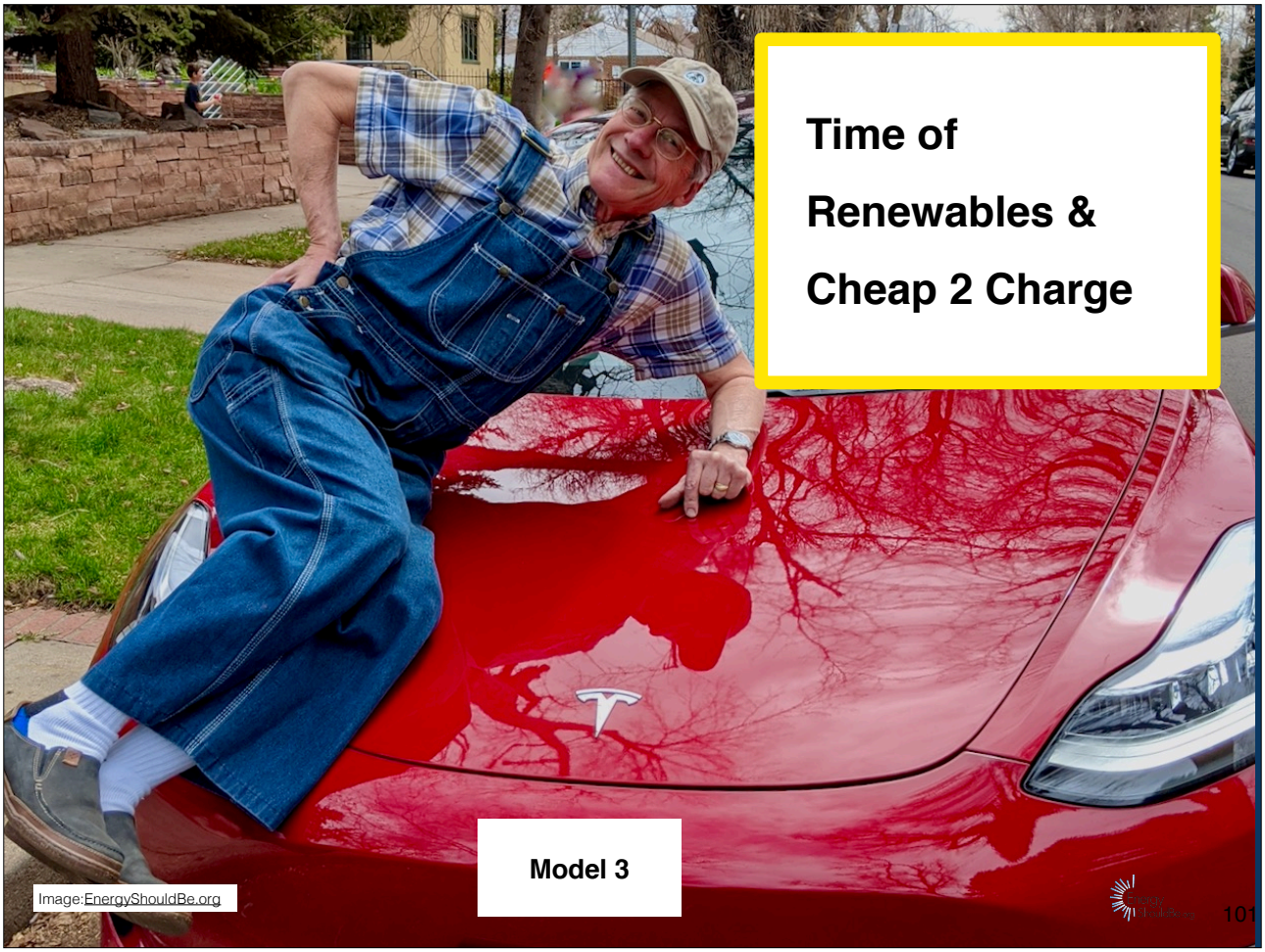


Best Choice to Use the Surplus. Storage & Impact. Just PRPA.



How Used Storage lasts…	Energy Use per day per car…	Impact per year
Electric car 4 days.	30 miles about 9 kWh/day	270,000 vehicles. Roughly **30%** of total electricity use all transportation - commercial and residential.
Hot water heater. 1 - 2 days.	3 people 6/kWh/day for electric resistance. Heat pumps use less - about half to a third.	110,000 homes. Roughly **8%** of total electricity use.
Pre heat/cool home or business. A few hours.	TBD	TBD

Images: pixabay.com



Time of Renewables - TOR

Manage Electricity Use to Maximize Sun/Wind/Hydro

Demand Management has mostly been about reducing demand.

TOR is demand shifting to maximize renewables, minimize fossil fuel generation.

24 Hours PRPA 85% Renewable

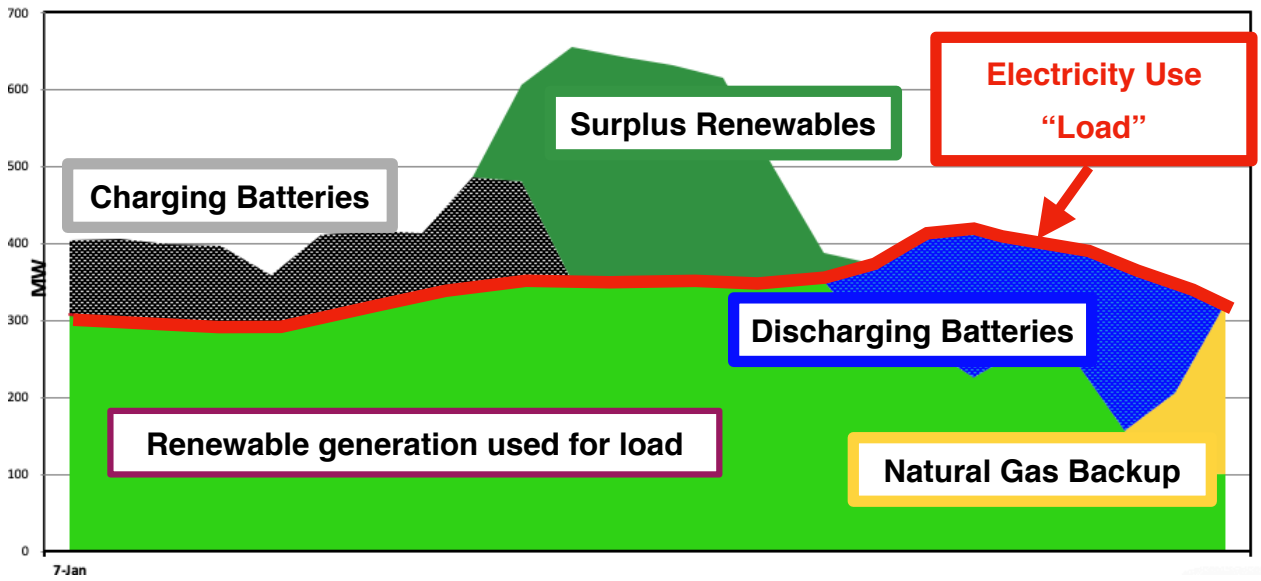


Chart: EnergySHouldBe.org

TOR Using Electric Cars

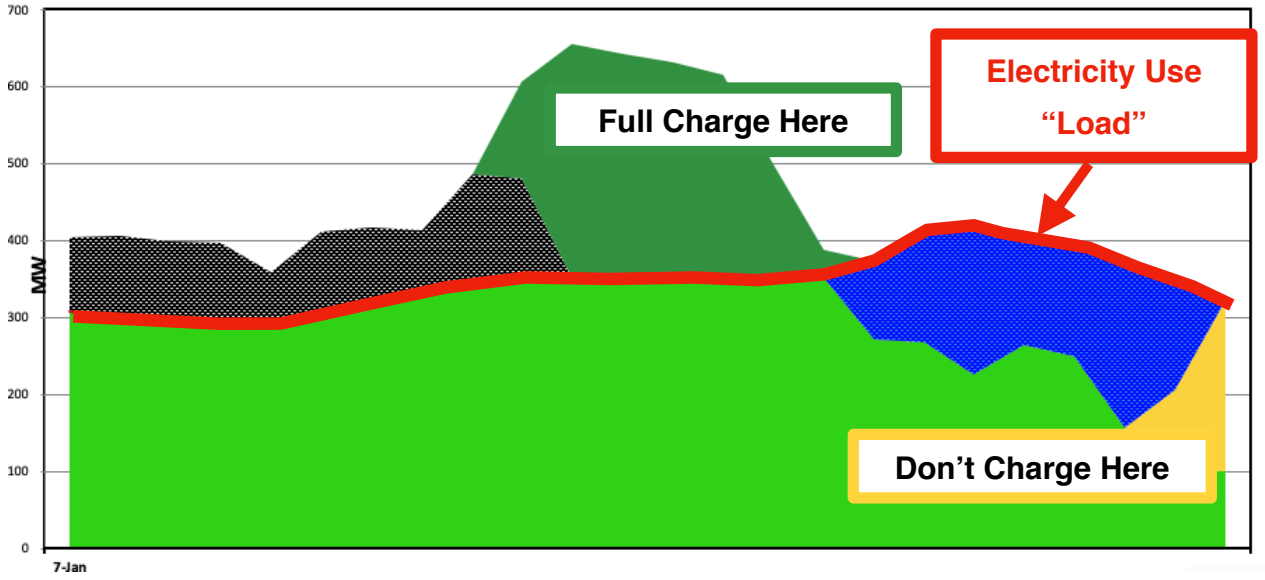
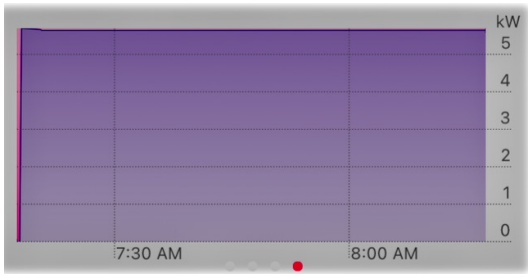


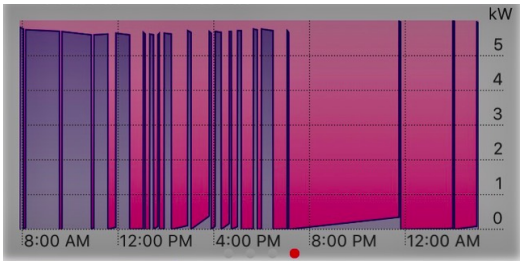
Chart: EnergySHouldBe.org

TOR: ENEL X JuicePoints

"Get paid to charge smarter"



Normal Charging



JuicePoints Charging

https://evcharging.enelx.com/juicepoints

images: Screen shots from ENEL X phone App by EnergyShouldBe.org

TOR: Zap Map - Free Charging on Surplus

…free electricity when Britain is generating an abundance of solar and wind power.

(Electric car charging)… customers will be alerted to a four-hour 'flash' window when charging their vehicle will come at no extra cost.

- Fleet News 4/13/21

https://www.fleetnews.co.uk/news/latest-fleet-news/electric-fleet-news/2021/04/13/electric-vehicle-drivers-can-charge-for-free-thanks-to-new-tariff

TOR: 24/7 Renewable Electricity

Google **google 24/7 renewable**

Google **biden 24/7 renewable**

Not renewables over a year generated anyplace.

Renewables every hour generated regionally. Requires TOR thinking. Use when renewables are.

2019 Five Practical Electric Cars

All at least 240 miles realistic range

Nissan Leaf

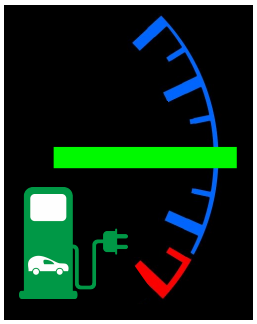
2021 Ford Mustang Mach-E, VW ID4 and Volvo Recharge, Hyundai, Kia, Toyota, Subaru, Porsche, Audi, etc

Images: EnergyShouldBe.org
Tesla drawing and Kona image: pixabay.com

Ecar Charging Modeling Assumptions

240 miles of Range

Always Wake to 120 Miles (50%)



Can override for a full charge.

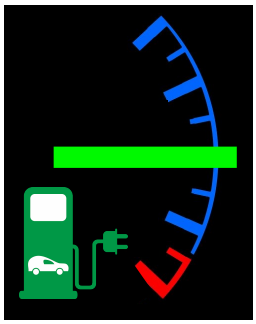
average 30 miles per day

Images: pixabay.com

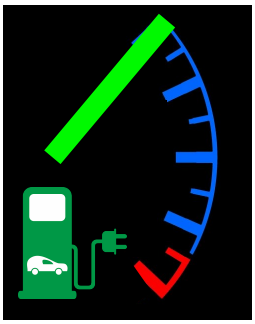
Ecar Charging Modeling Assumptions
"Cheap 2 Charge from Surplus" Program

240 miles of Range

***Always* Wake to**
120 Miles (50%)



Cheap 2 Charge
"Fill Er Up!"
240 Miles (100%)



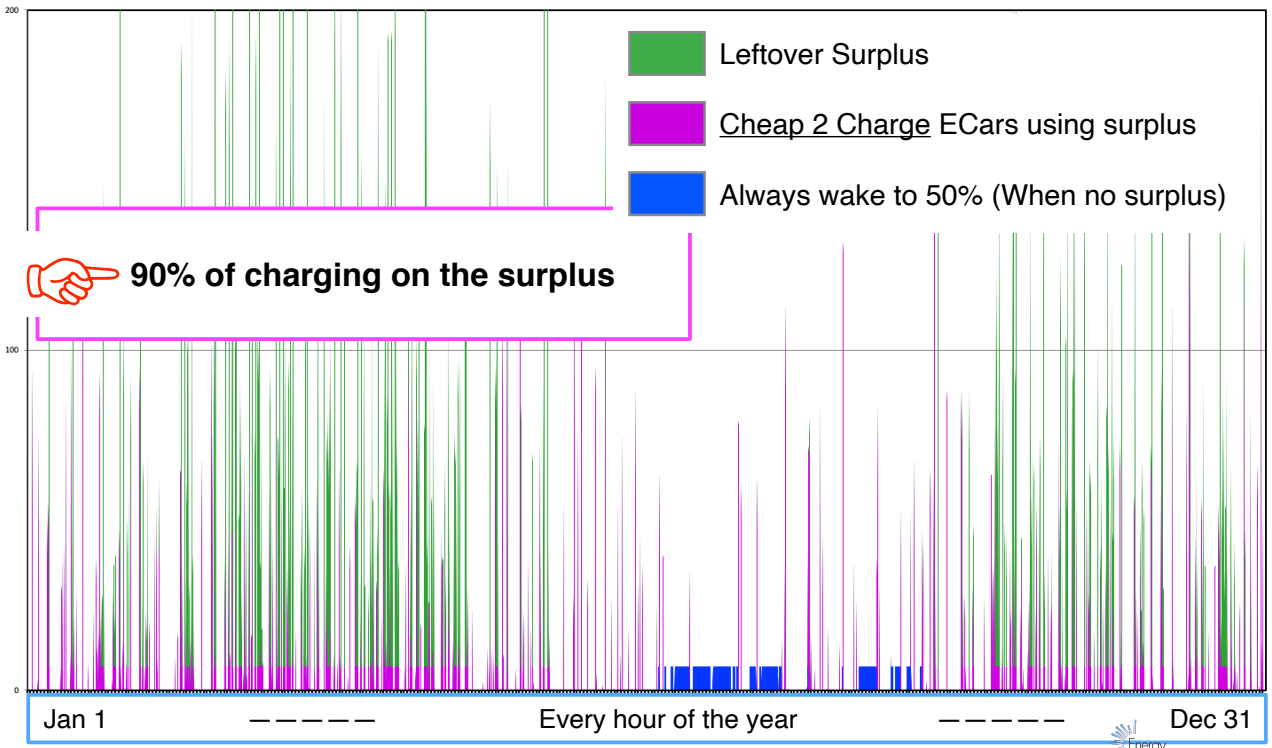
Can override for a full charge.

average 30 miles per day

Images: pixabay.com

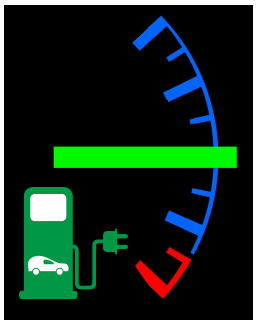
Rewarding Flexible Use of Surplus Electricity

Wind & solar PRPA 2023. **60% Renewable. 20,000 Plug-ins.**

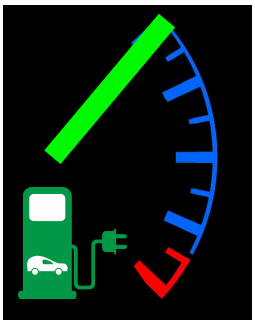


Electric Car Charging Modeling Assumptions
"Cheap 2 Charge from Surplus" Program

***Always* Wake to**
120 Miles (50%)



Cheap 2 Charge
"Fill Er Up!"
240 Miles (100%)



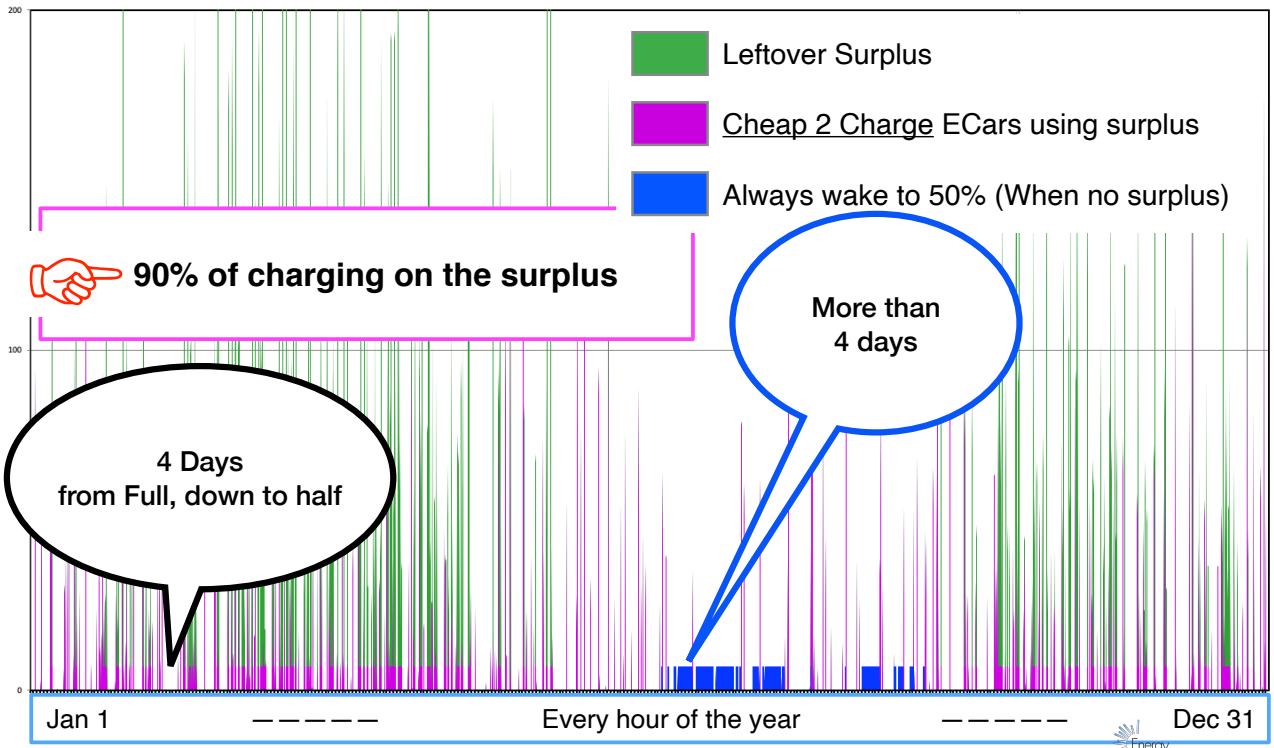
120 miles of additional range when full

4 days from Full to Half at 30 miles driven per day

Images: pixabay.com

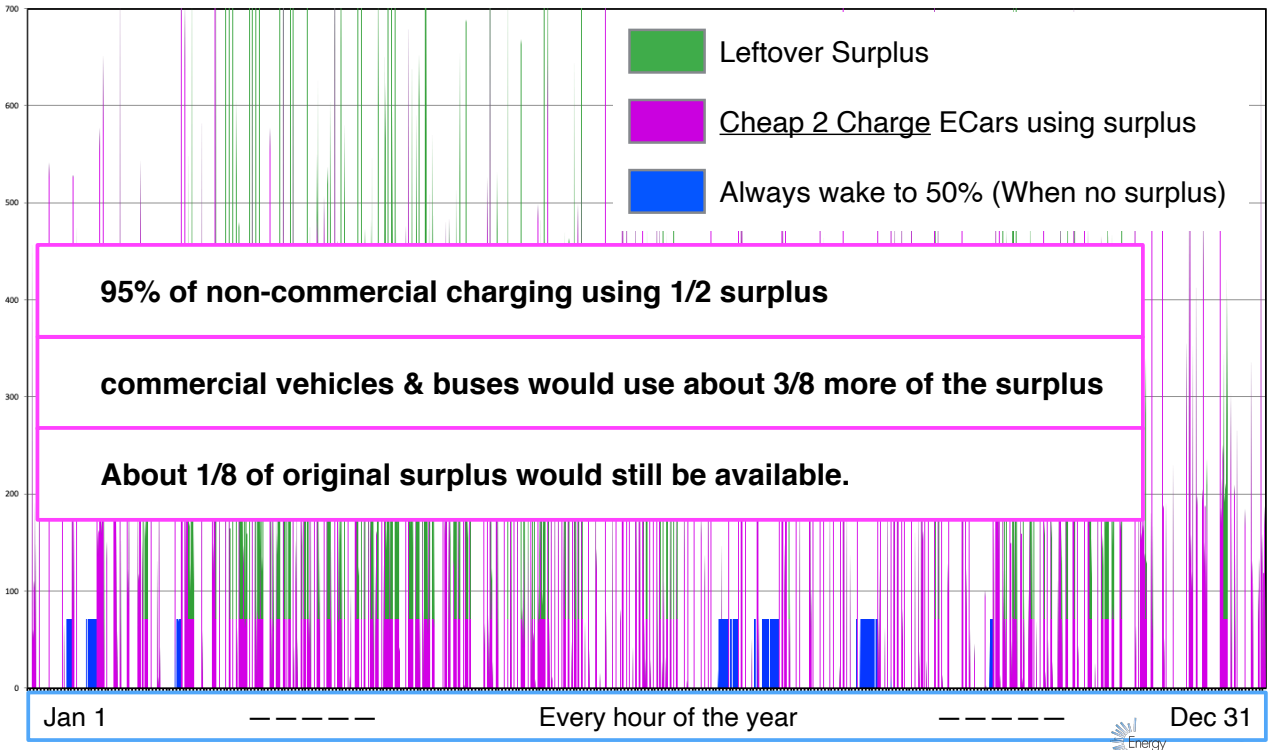
Rewarding Flexible Use of Surplus Electricity

Wind & solar PRPA 2023. **60% Renewable. 20,000 Plug-ins.**



Rewarding Flexible Use of Surplus Electricity

Wind & solar PRPA 2030. **95% Renewable. 200,000 Plug-ins.**

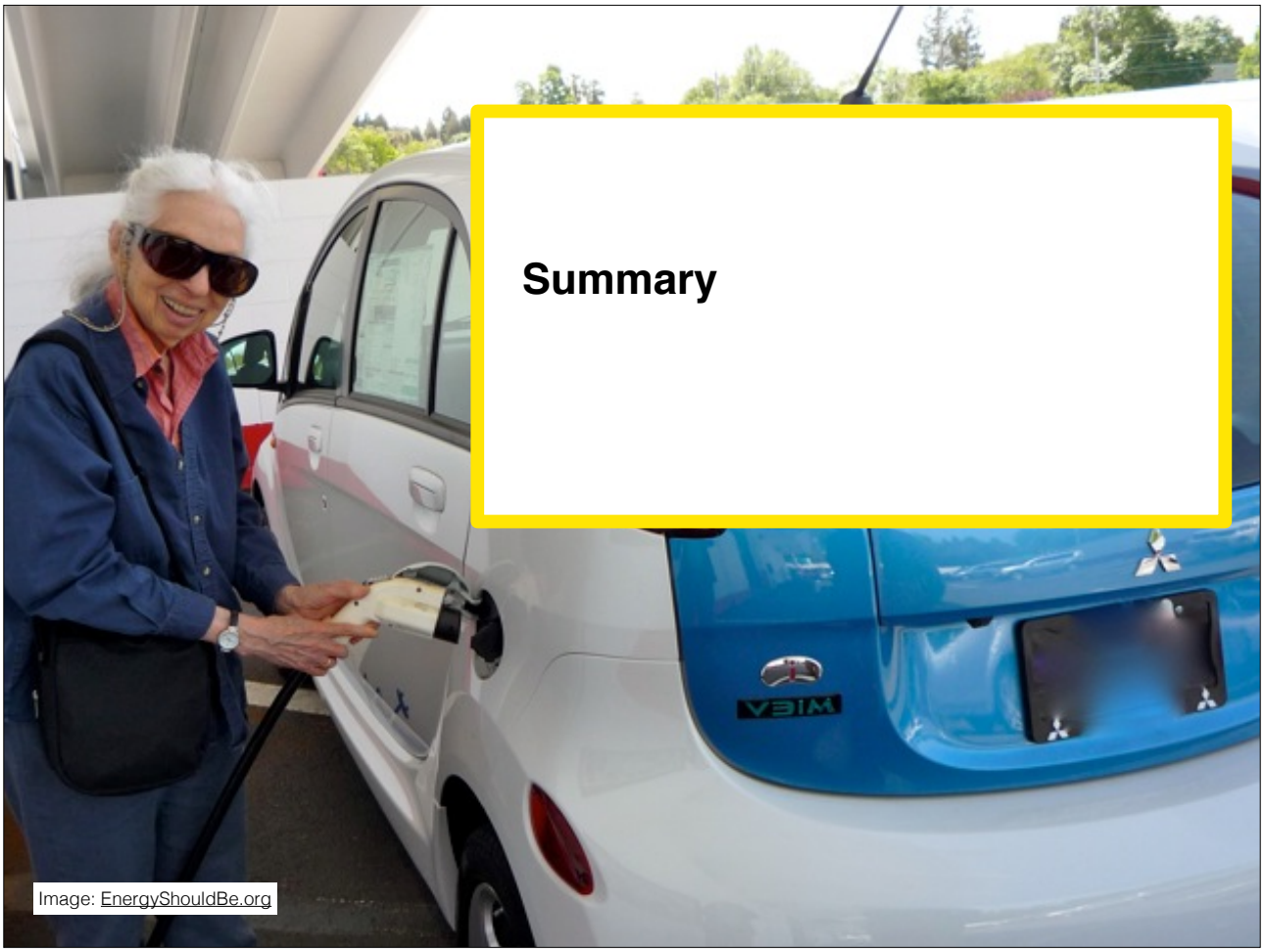


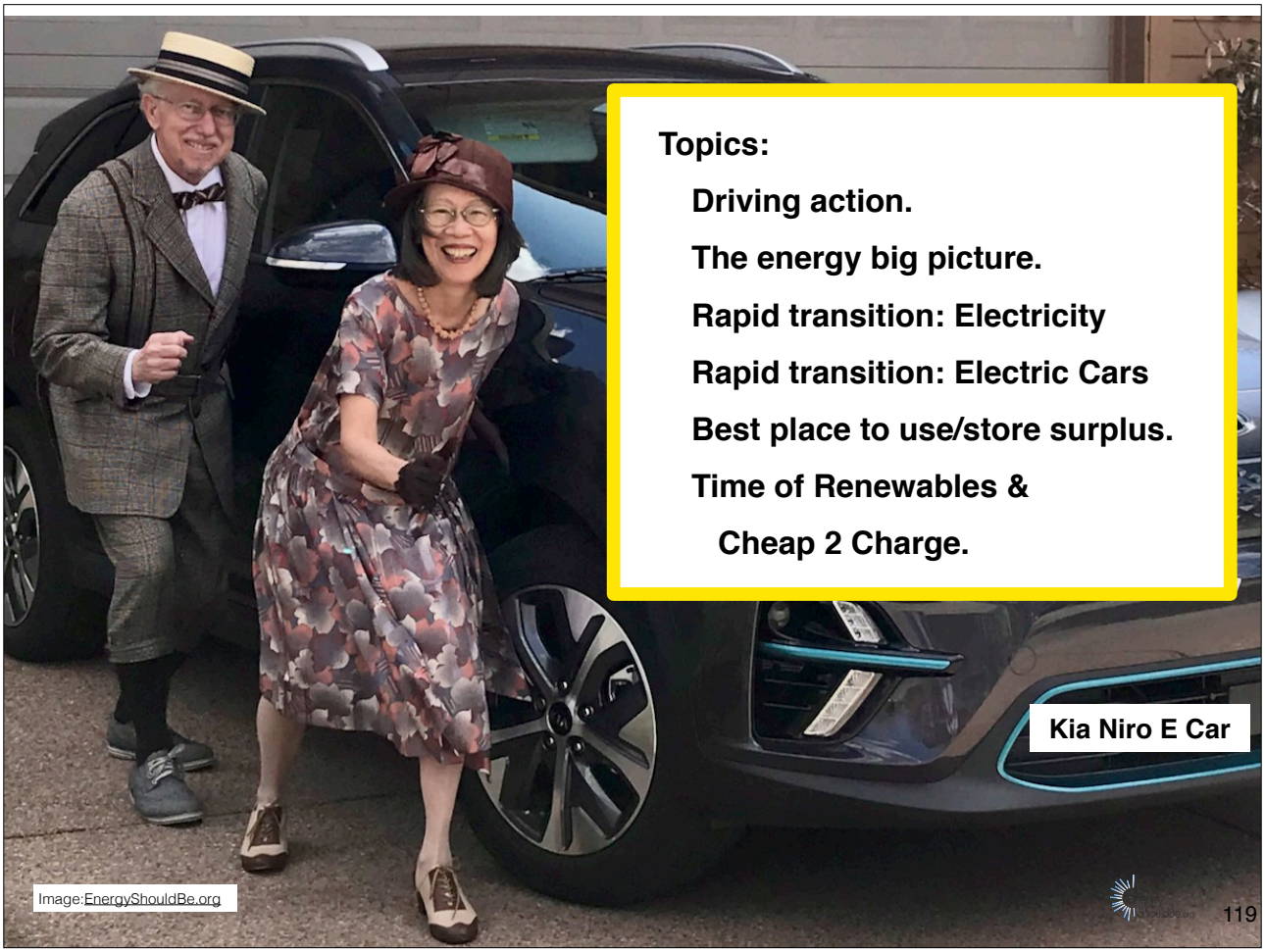
Do Ecar chargers exist today that allow charging when the sun is shining or wind blowing?

When surplus electricity?

Cheap 2 Charge?

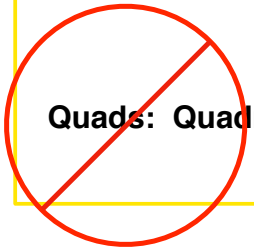
- ☐ Yes
- ☑ Almost
- ☐ No


Summary
Image: EnergyShouldBe.org


Topics:
Driving action.
The energy big picture.
Rapid transition: Electricity
Rapid transition: Electric Cars
Best place to use/store surplus.
Time of Renewables &
Cheap 2 Charge.
Kia Niro E Car
Image:EnergyShouldBe.org

What drives people to action?

Fear	Climate Change
$s	Cost
Fun	Competition
Hope	
Stories	True and Useful
Humor	



Quads: Quadrillion BTUs of Energy?

Which argument is most likely to lead to action?

Gasoline vs Electric Cars

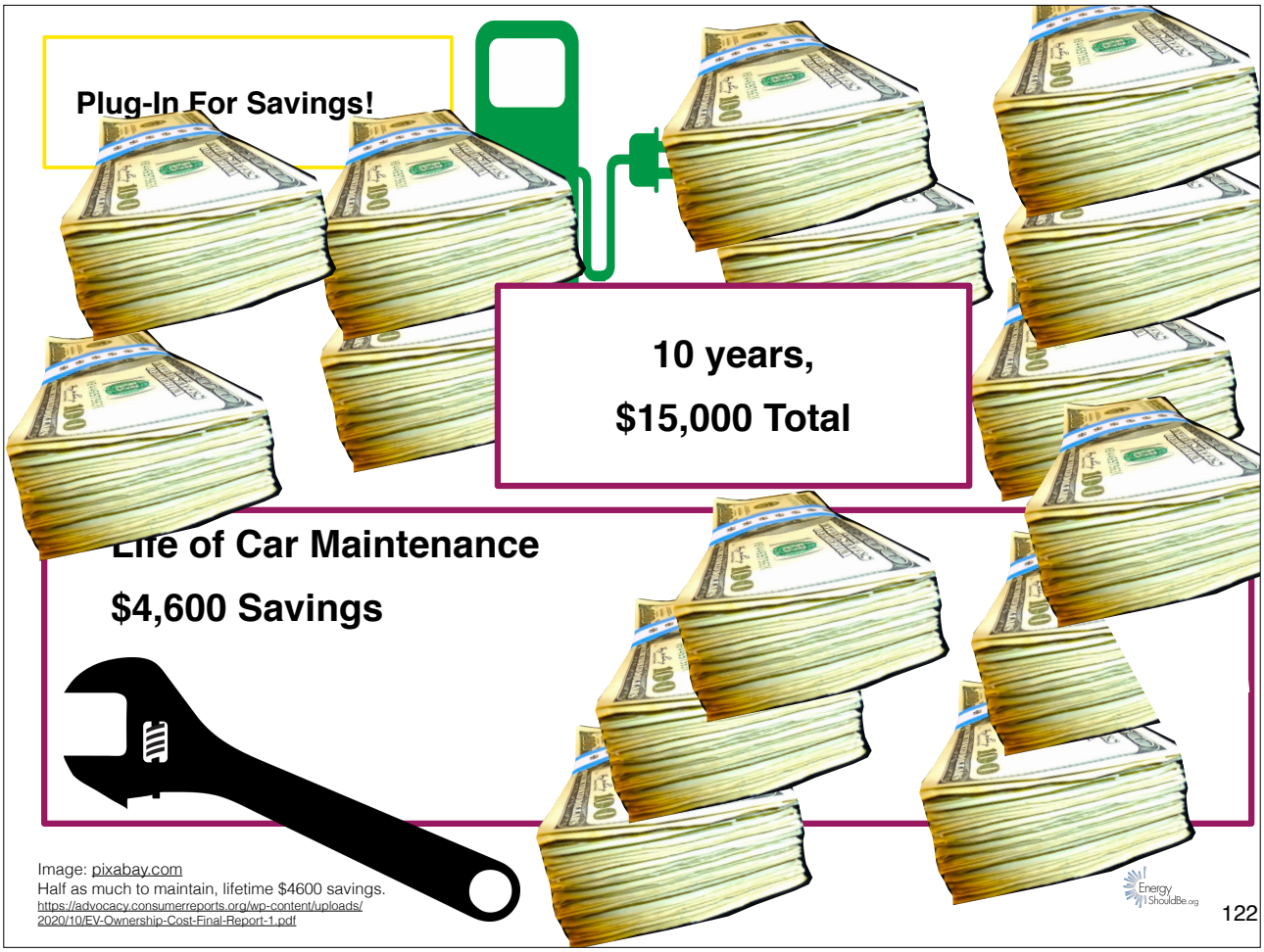
Light Duty Transportation

Fuel Cost

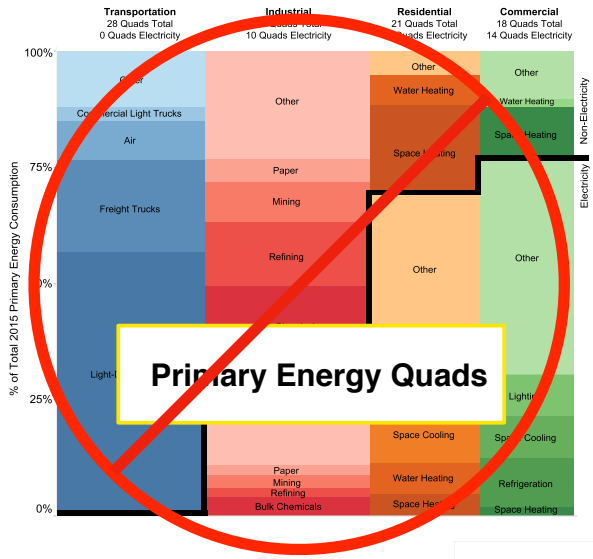
gasoline	**$0.10 / mile**	**$3 / gallon / 30 MPG**
electricity	**$0.034 / mile**	**$0.12 / kWh / 3.5 miles / kWh**

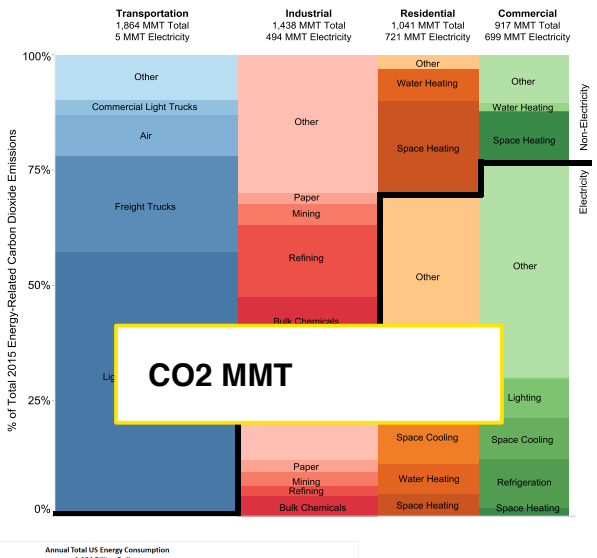
BTU

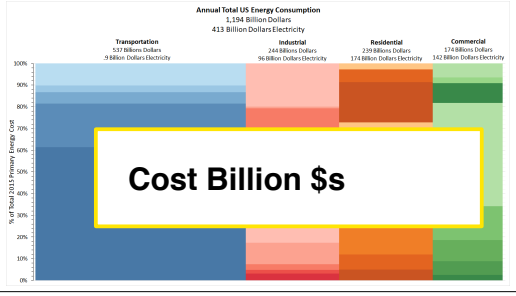
gasoline	120,000 BTU / gallon / 30 MPG =	**4,000 BTU / mile**
electricity	3,214 BTU / kWh / 3.5 miles/kWh =	**920 BTU / mile**

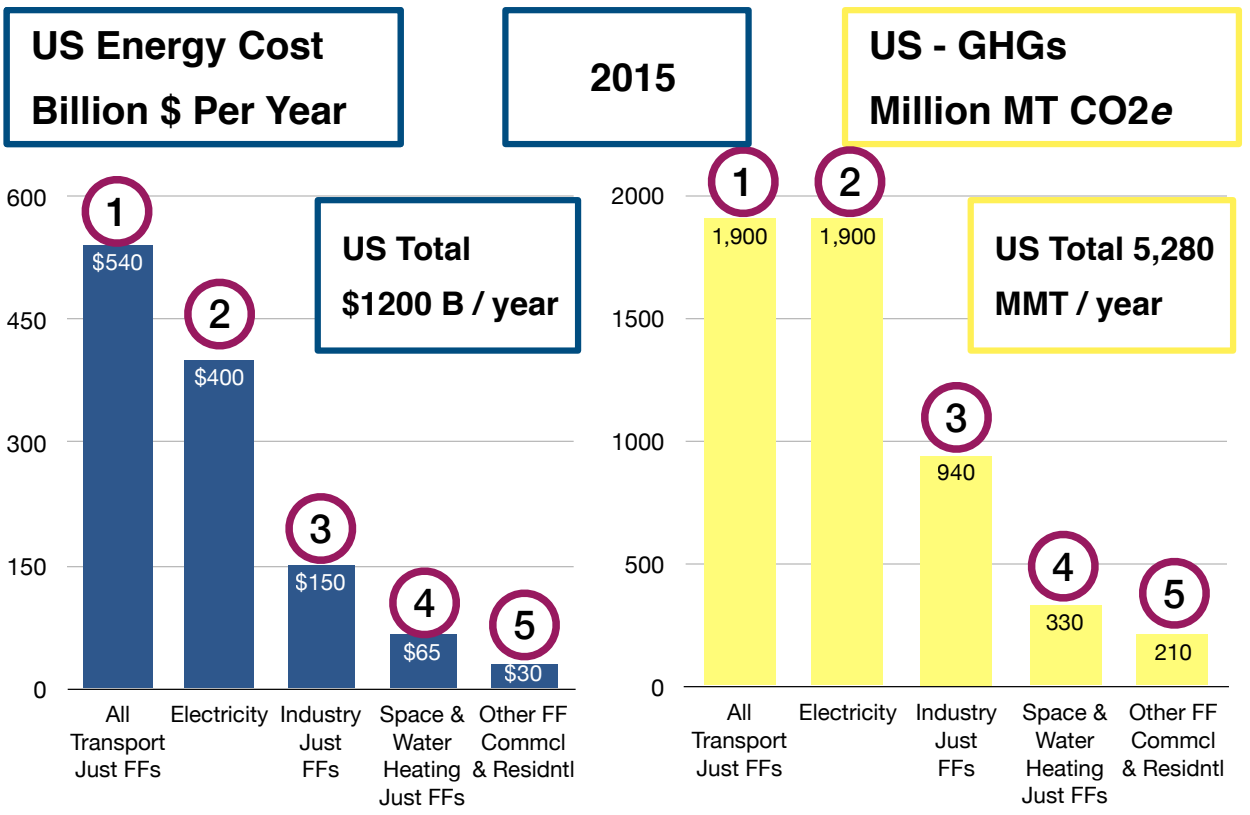


Subsector primary energy consumption and energy-related carbon dioxide emissions 2015









Images: EnergyShouldBe.org

Data analysis EnergyShouldBe.org based on EIA 2015 US data. Space heating includes water heating.

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Actions Now to 2035

1. **Electrify 80% of transportation.**
2. **90% Renewable Electricity**
3. **50% electrification of industry (FF). Hydrogen generated onsite?**
4. **50% electrification of heating (FF). Heat pumps.**

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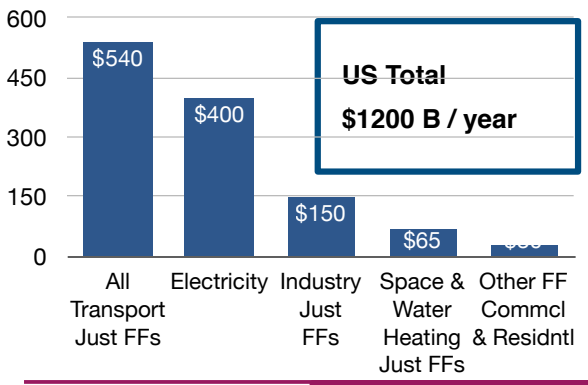
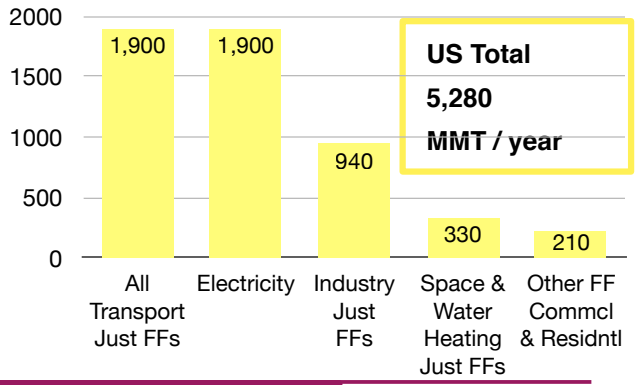
US Energy Cost
Billion $ Per Year

2015

US Energy GHGs
Million MT CO2*e*



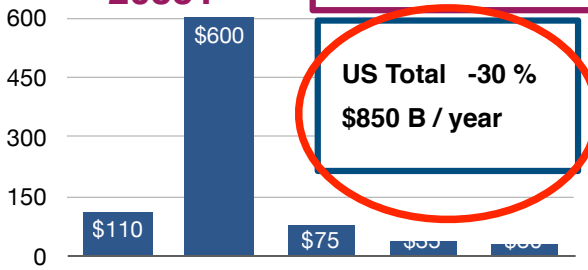
US Total!
$1200 B / year



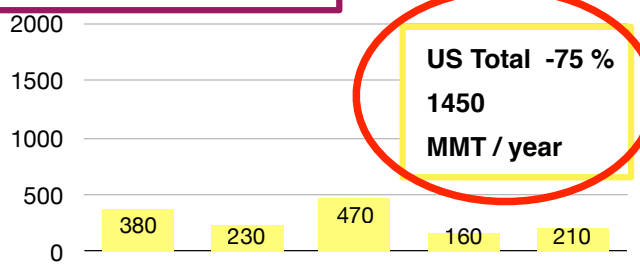
US Total
5,280
MMT / year

2035?

90% Renewable Electricity. 80% EVs. Electrify 50% of industry and Heating.



US Total -30 %
$850 B / year



US Total -75 %
1450
MMT / year

Images: EnergyShouldBe.org Data analysis EnergyShouldBe.org based on EIA 2015 US data.

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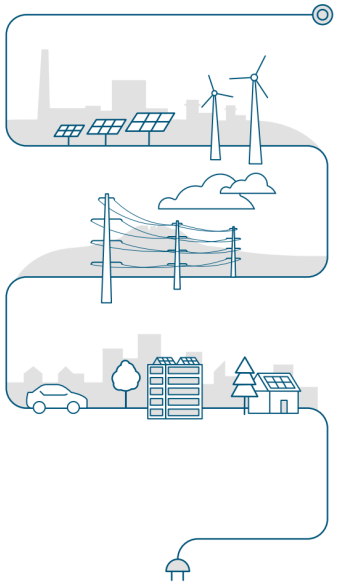
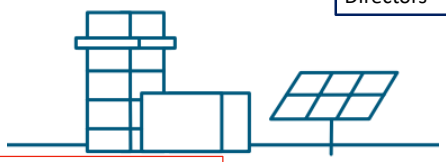
PRPA - Lowest cost & highest reliability in Colorado.

In 2014, ~ 20% renewables.
If you told them 50% by 2020…
In 2020, 50% renewables.

Approved by PRPA Board of Directors





Portfolio 2: zero coal

85% Renewables, 90% carbon reduction, by 2030!

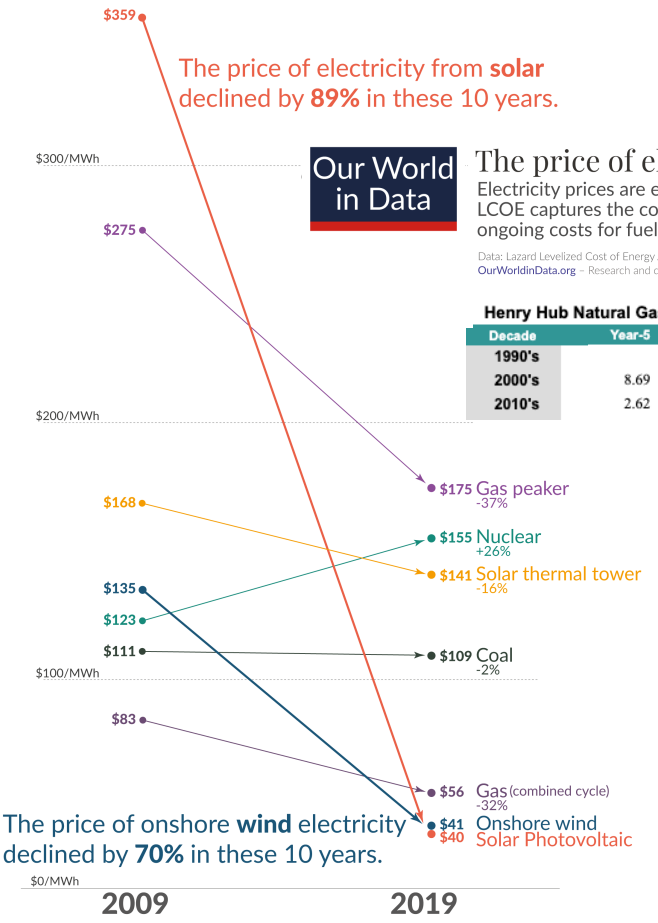
Includes big storage.

3 Pillars
Reliability
Cost
Environment

2020 Integrated Resource Plan

Source: PRPA 2020 IRP https://www.prpa.org/wp-content/uploads/2020/10/IRP_10.8_spread.pdf

127



Our World in Data

The price of electricity from new power plants

Electricity prices are expressed in 'levelized costs of energy' (LCOE). LCOE captures the cost of building the power plant itself as well as the ongoing costs for fuel and operating the power plant over its lifetime.

Data: Lazard Levelized Cost of Energy Analysis, Version 13.0
OurWorldinData.org – Research and data to make progress against the world's largest problems.

Henry Hub Natural Gas Spot Price (Dollars per Million Btu)

Decade	Year-5	Year-6	Year-7	Year-8	Year-9
1990's			2.49	2.09	2.27
2000's	8.69	6.73	6.97	8.86	3.94
2010's	2.62	2.52	2.99	3.15	2.56

https://ourworldindata.org/cheap-renewables-growth
https://www.eia.gov/dnav/ng/hist/rngwhhdA.htm

Platte River Power Authority

North Colorado
85% Renewable Electricity by 2030

2035Report.com

Every US State 90%
Renewable Electricity by 2035

And

Every new car & truck sold
by 2035 Electric.

Xcel Energy Colorado

90% carbon free 2030. ERP just released 4/2021.

Etc.

Why?

Solar and wind electricity are now cheaper than operations, maintenance and fuel of many fossil fuel generators.

Why?

These Make the Same Amount of Electricity per year

Competition and Mass Production always means costs go down!

1

425

13,000,000

Billions of batteries for Electric Vehicles

In 2015 in California, new battery storage beat gas generation for peaking needs.

Number of wind turbine and solar panel calculations by EnergyShouldBe.org from common data sources for Colorado.

90% Renewable Electricity is in rapid transition.

Need to Scale to Everyone.

Get close to 100%.

Surplus - Cost Issue

Dark Calms - Reliability and Cost

Intern Kirya Miller's 7 minute summary:
Youtube: Alternatives to Natural Gas Generation for Platte River Power Authority

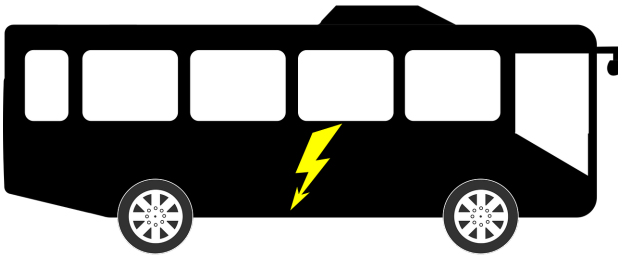
Interns Will Balan & Kirya Miller's work on-going:

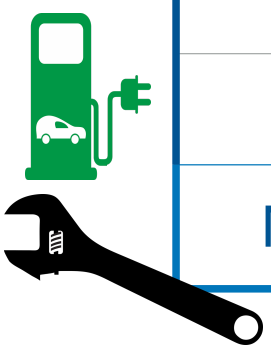
Air vs. Ground Source Heat Pump Impact on the Grid in Cold Climates

How much energy does a heat pump use if a heat pump pumps when it's cold?

Electric Transit Bus $avings per Year From Fossil Fuels

34,000
miles per year

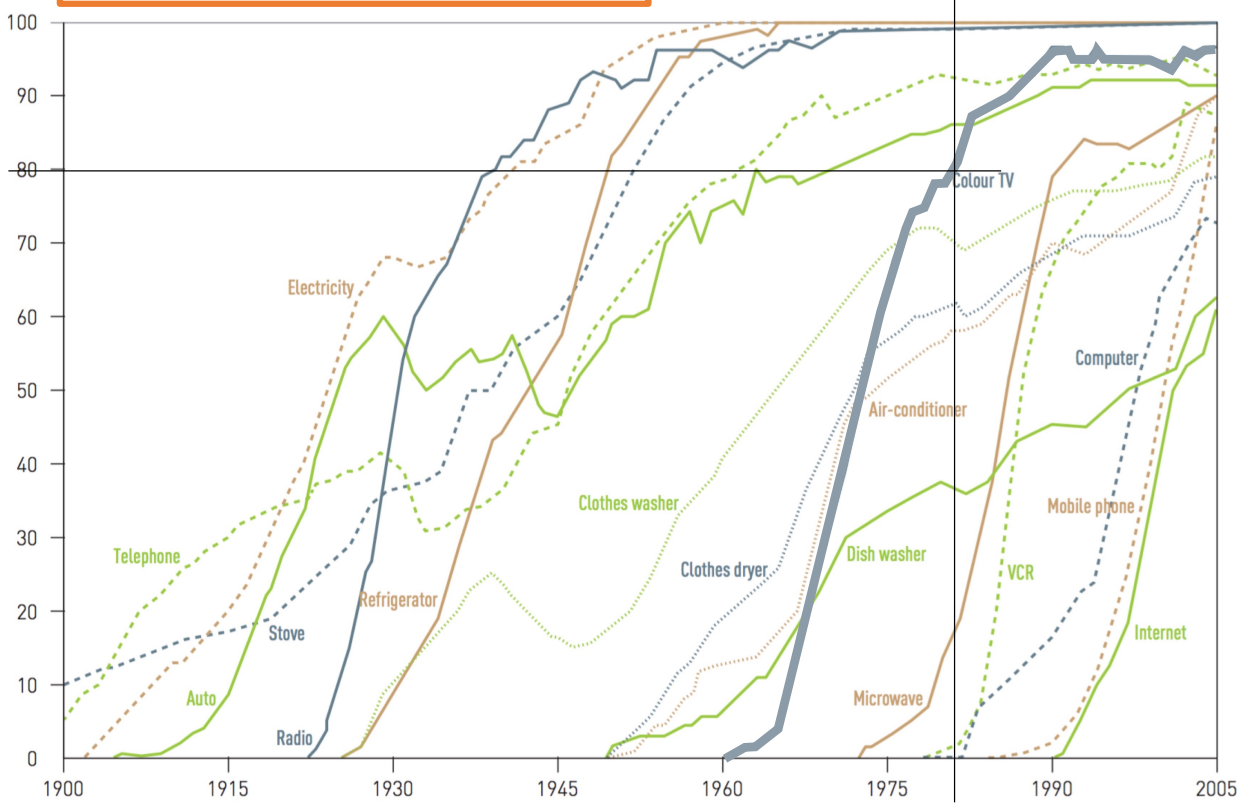




Diesel vs. Electricity	$avings per year
Fuel	$11,500
Maintenance	$33,000

Images: pixabay.com
46¢, 13¢ from http://swenergy.org/new-xcel-energy-rate-could-speed-rtd's-purchase-of-electric-buses- using Xcel's proposed rate for 13¢. 34,000 miles per year from https://afdc.energy.gov/data/10309

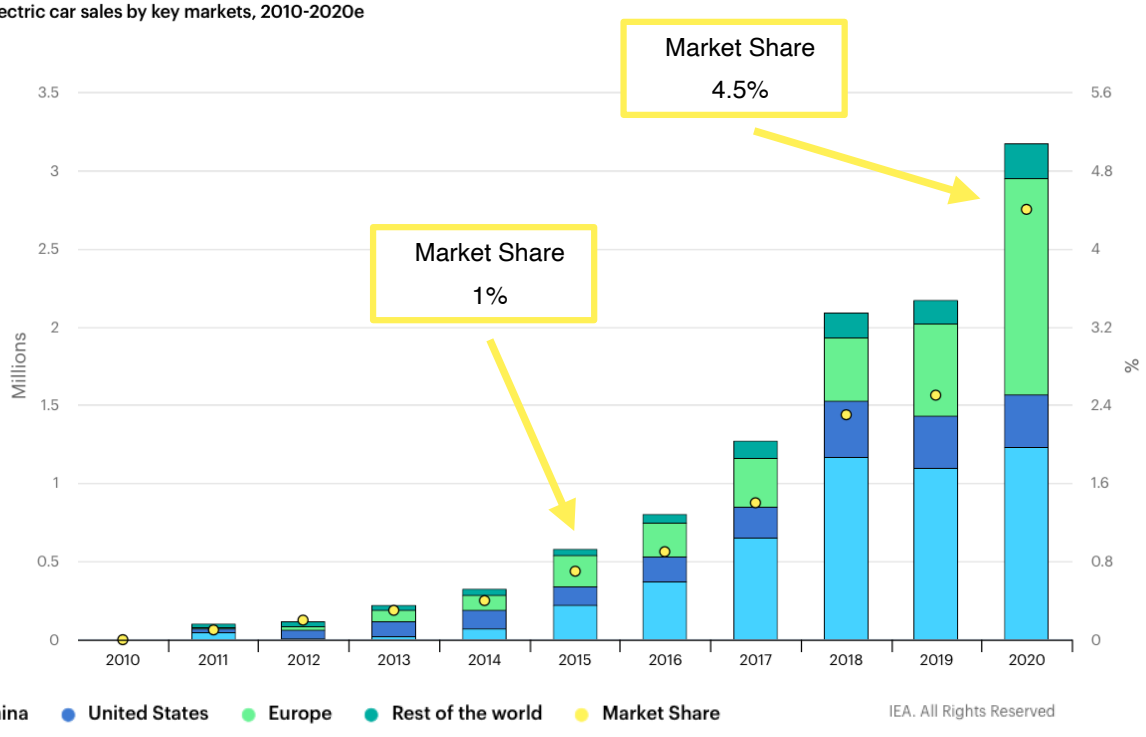
It is Common for Innovative Technologies to Grow Fast.



Source: Innovative product adoption chart New York Times, 2008 (page 18 in PDF): http://apo.org.au/files/Resource/vicgov_electric-vehicle-trial-mid-term_2013.pdf

Energy ShouldBe.org

Global electric car sales by key markets, 2010-2020e



Source:IEA, Global electric car sales by key markets, 2010-2020e, IEA, Paris https://www.iea.org/data-and-statistics/charts/global-electric-car-sales-by-key-markets-2010-2020e

Energy ShouldBe.org

AAA Polled 1,100 Electric Car Owners

For the 60% of households with two or more cars where one car is electric:

An amazing

90% of driving is on electricity!

This means, 9 out of 10 times people prefer to take their EVs.

Poll: https://newsroom.aaa.com/2020/01/aaa-owning-an-electric-vehicle-is-the-cure-for-most-consumer-concerns/ 87% of driving on electric car in multi-car households.
2/3's of households that have any cars have 2 or more cars: https://transportgeography.org/?page_id=5143

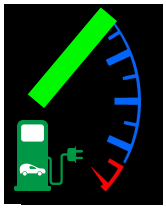
Energy ShouldBe.org

Image:EnergyShouldBe.org

Shhhh. Don't disturb the cat!

Energy ShouldBe.org

Best Choice to Use the Surplus. Storage & Impact. Just PRPA.



How Used Storage lasts…	Energy Use per day per car…	Impact per year
Electric car 4 days.	30 miles about 9 kWh/day	270,000 vehicles. Roughly **30%** of total electricity use all transportation - commercial and residential.
Hot water heater. 1 - 2 days.	3 people 6/kWh/day for electric resistance. Heat pumps use less - about half to a third.	110,000 homes. Roughly **8%** of total electricity use.
Pre heat/cool home or business. A few hours.	TBD	TBD

Images: pixabay.com

TOR Using Electric Cars

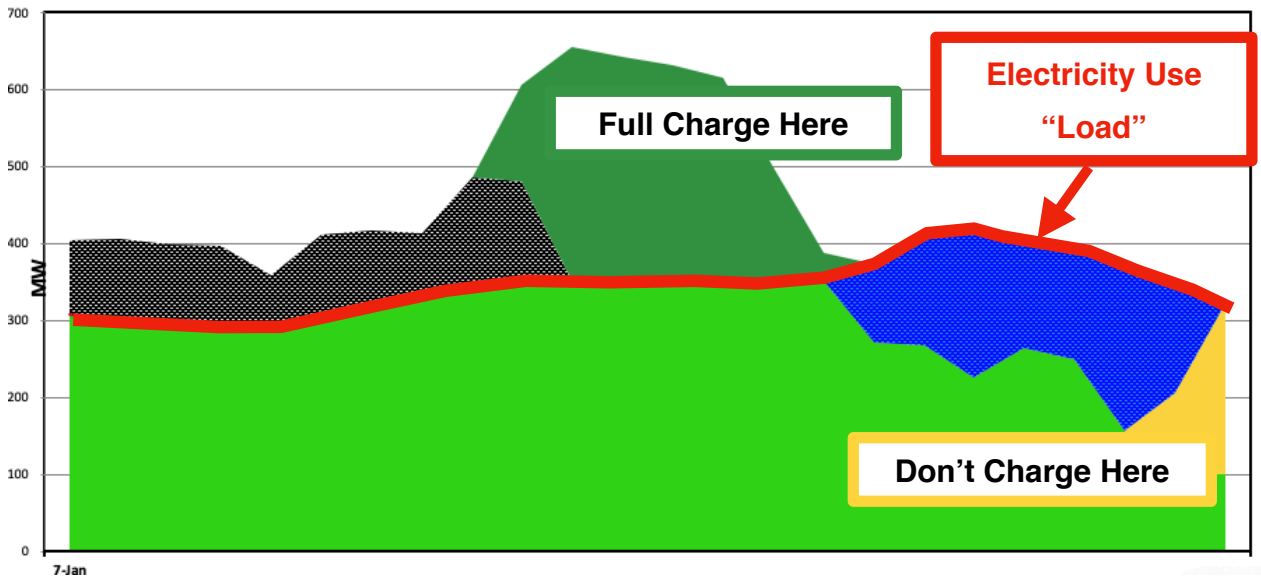
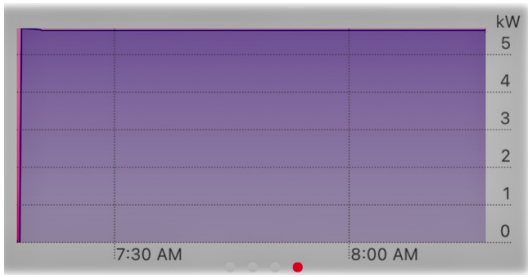


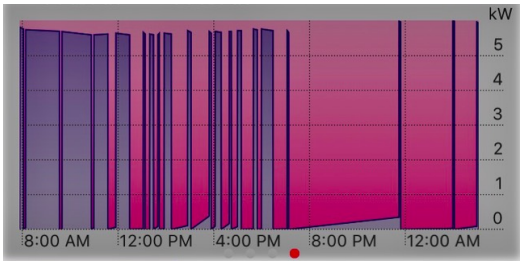
Chart: EnergySHouldBe.org

TOR: ENEL X JuicePoints

"Get paid to charge smarter"



Normal Charging



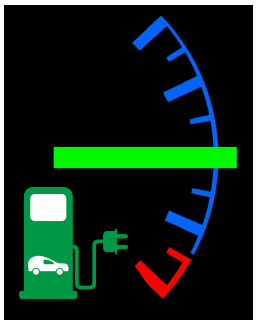
JuicePoints Charging

https://evcharging.enelx.com/juicepoints

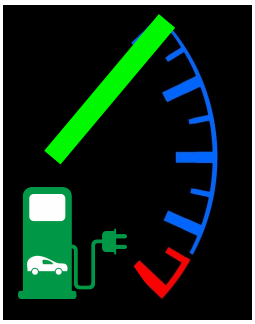
images: Screen shots from ENEL X phone App by EnergyShouldBe.org

Electric Car Charging Modeling Assumptions
"Cheap 2 Charge from Surplus" Program

***Always* Wake to**
120 Miles (50%)



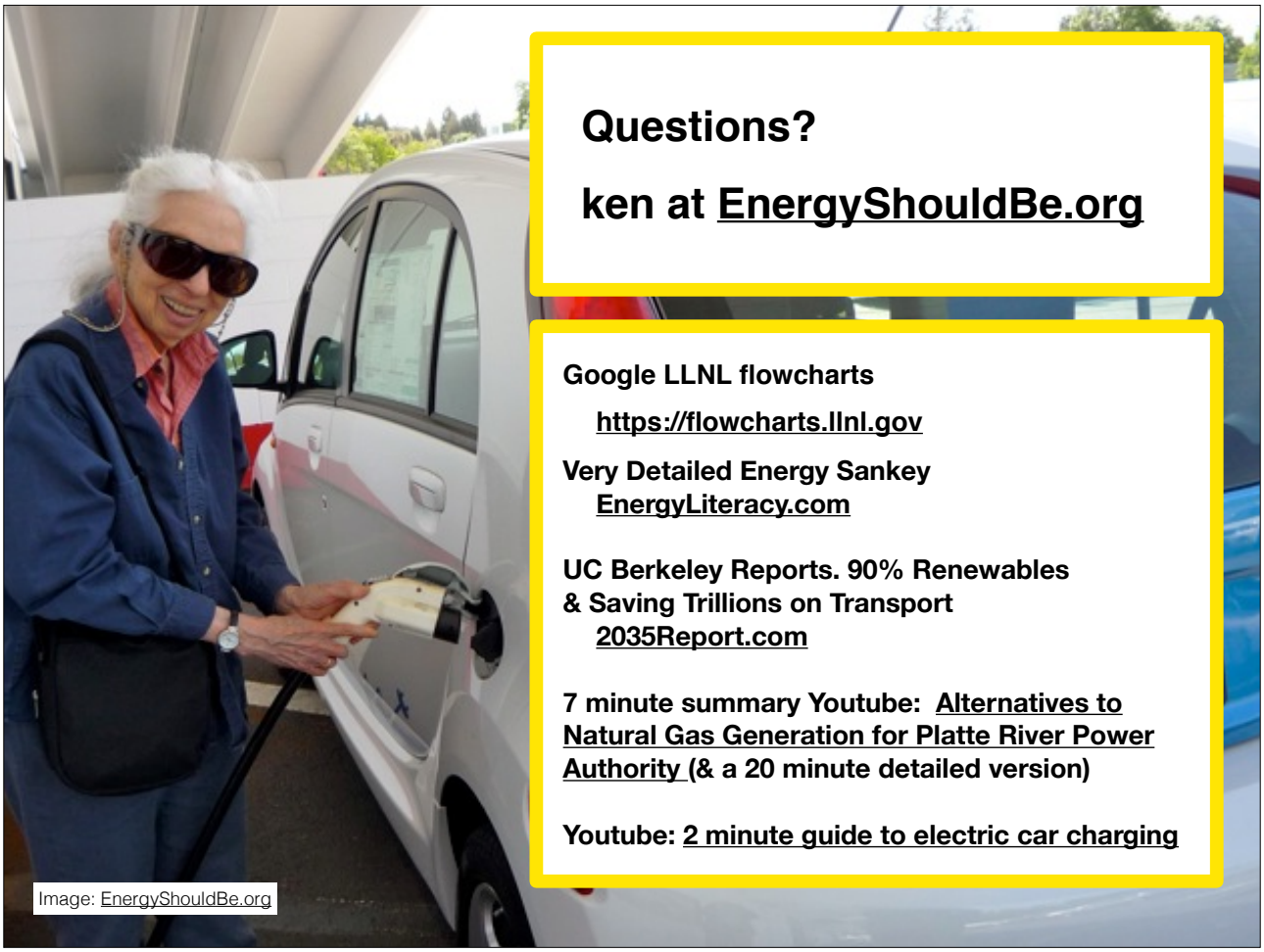
Cheap 2 Charge
"Fill Er Up!"
240 Miles (100%)



120 miles of additional range when full

4 days from Full to Half at 30 miles driven per day

Images: pixabay.com



Questions?

ken at EnergyShouldBe.org

Google LLNL flowcharts

https://flowcharts.llnl.gov

Very Detailed Energy Sankey
EnergyLiteracy.com

UC Berkeley Reports. 90% Renewables & Saving Trillions on Transport
2035Report.com

7 minute summary Youtube: Alternatives to Natural Gas Generation for Platte River Power Authority (& a 20 minute detailed version)

Youtube: 2 minute guide to electric car charging

Wind Dumped/Curtailed/Tossed by Xcel Colorado But We Pay For.

"The Company (Xcel Colorado) … with … curtailment volumes … that it expects 950,756 MWh of potential wind energy to not be delivered in 2021. This is the equivalent energy of a 362 MW wind farm operating at 30% capacity factor. "

- PUC Staff Witness Joseph McCabe,
TEP docket 20A-0204E

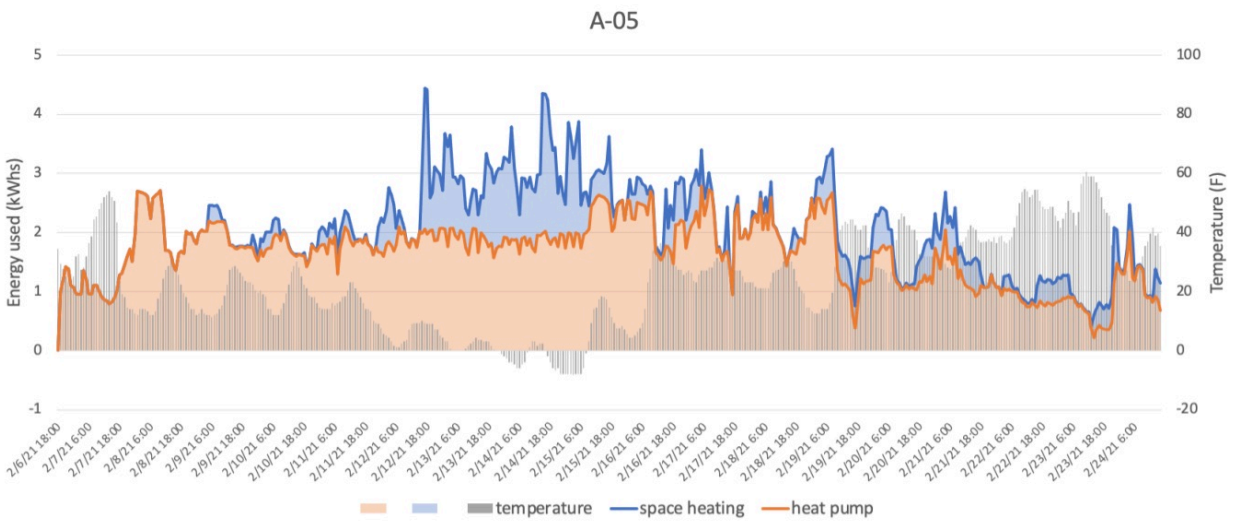
950,756 MWh is enough electricity to charge 300,000 electric cars 30 miles per day for an entire year.

- simple math by EnergyShouldBe.org

950,756 MWh * $40 / MWh = $43 M / year. If Production Tax Credit must be paid back as well, about $24 M / year more.

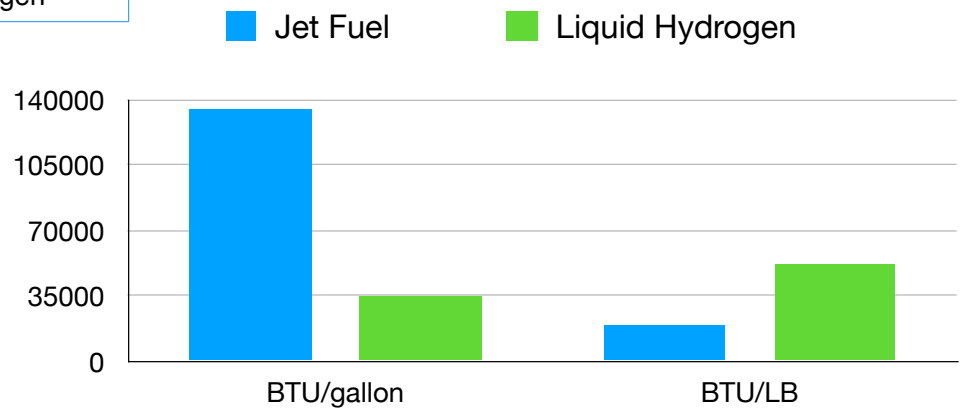
- simple math by EnergyShouldBe.org
$40/MWh from PSCo 2020 10-K

Hourly Building Data



February Cold Snap. Air Source Heat Pump.

Hydrogen



Round Trip Efficiency - kWh in to kWh out

Battery Storage and Pumped Hydro	**80%**
Hydrolysis to Fuel Cell Stack - ignoring transport & storage	**30-40%**

A friend recently pointed me to this article about a major manufacturer dropping hydrogen trucks in favor of battery trucks.
https://newatlas.com/automotive/scania-ditches-hydrogen/

By mass, H2 is great stuff. By volume, not so much. What happens to the design of an airplane, ship, etc if you need 4 X the volume or drop range to 1/4? Ships don't care much about mass. Airplanes do. Does the weight savings compensate for the additional volume needed? And this is raw BTUs, not useful work.

Raw BTUs to useful work in an internal combustion engine is quite inefficient. Turbines (like jet engines) are more efficient. Fuel cells are much more efficient still - about 2X internal combustion.

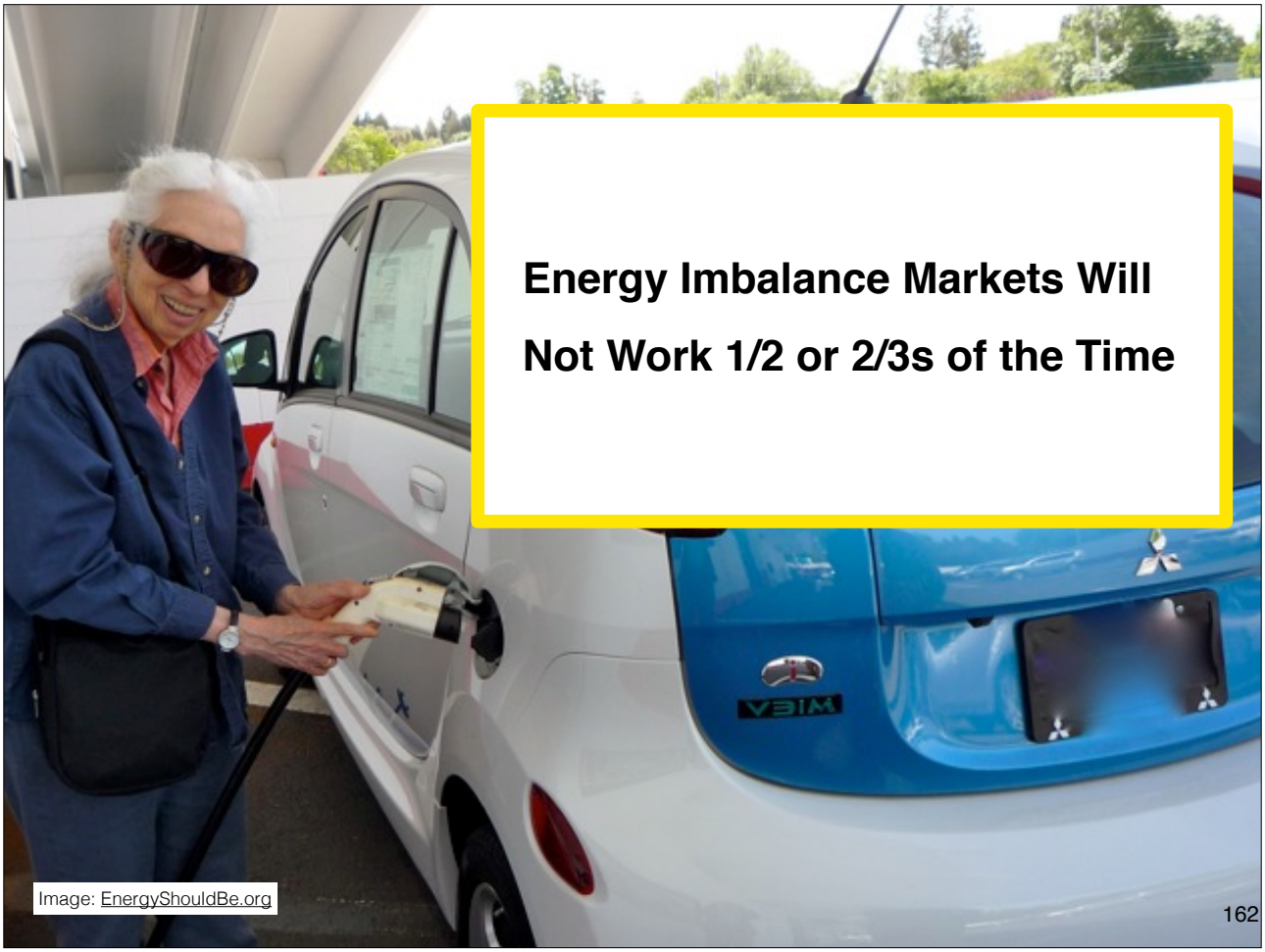
Finally, there are liquid fuel oxidizing fuel cells (e.g., methanol). Just not as many nor, I think, as efficient as hydrogen fuel cells, at least for now.

Storage vs. Transmission

Battery Storage is being mass produced.

Transmission is not enough volume to mass produce.

Historically, mass produced competitors win.



Surplus is a COST problem > 50% Renewables

$25 - $50 Million
rate increase
if the surplus isn't sold.

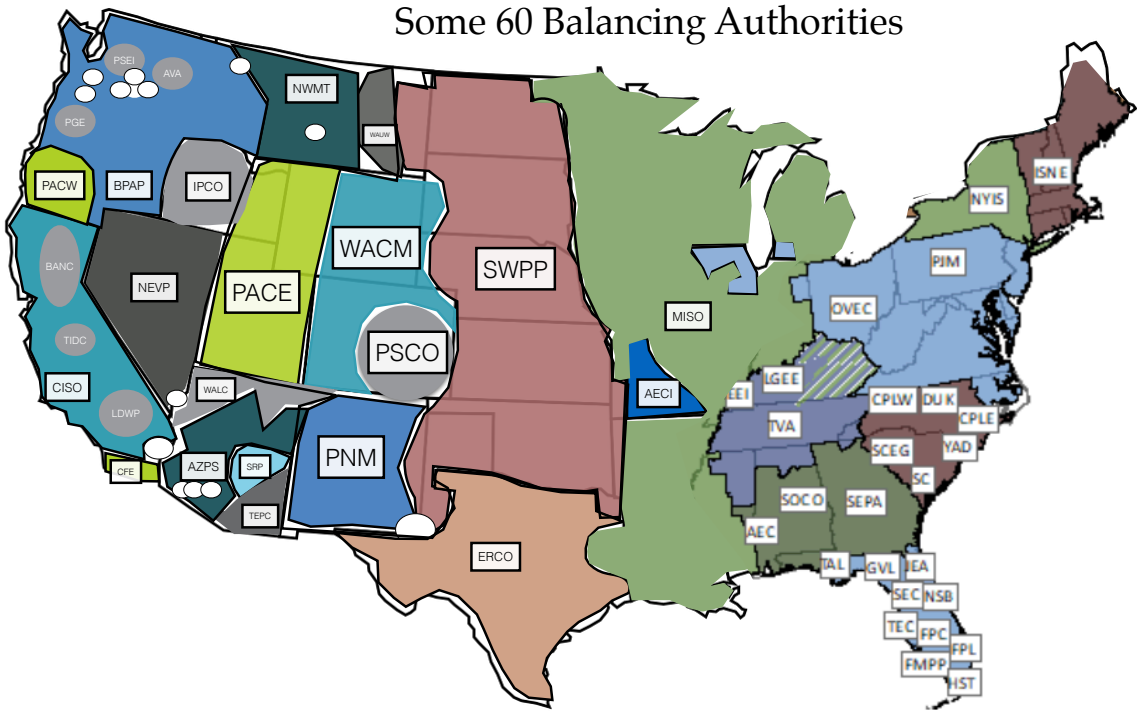
Or, can sell it for cheap and save everyone's rates!

"Sell for cheap" to who??

- Other utilities.
  Energy Imbalance Market
- Existing customers.

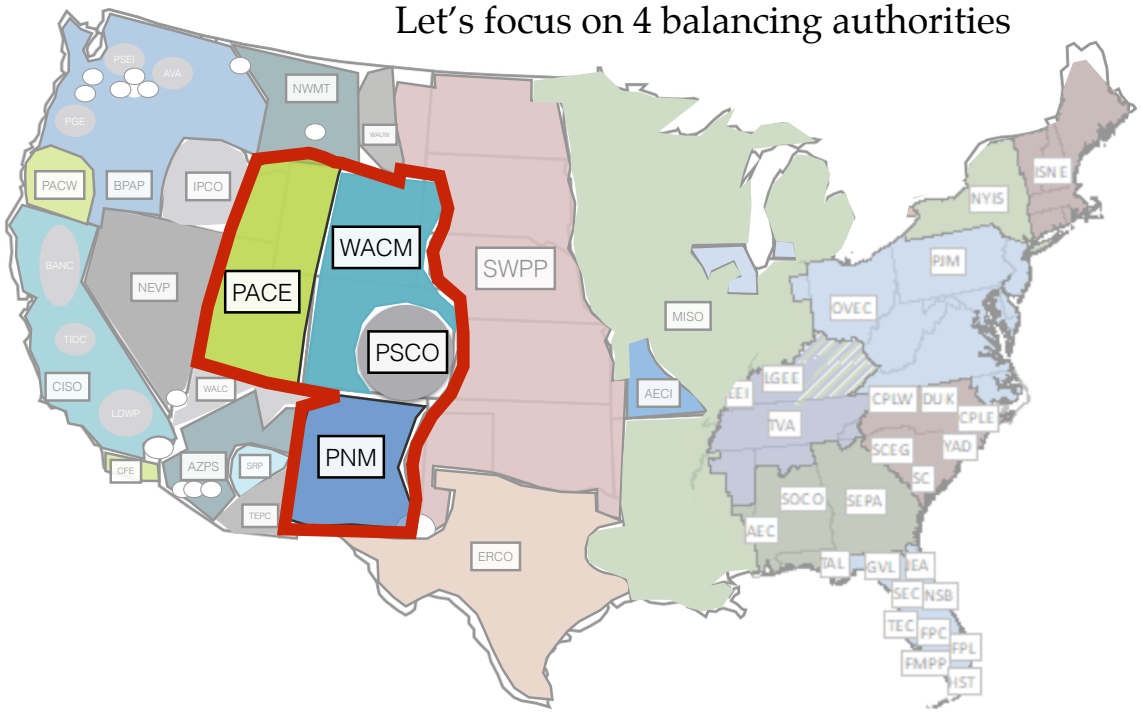
Will EIM Work to Sell Surplus?

Some 60 Balancing Authorities



Will EIM Work to Sell Surplus?

Let's focus on 4 balancing authorities



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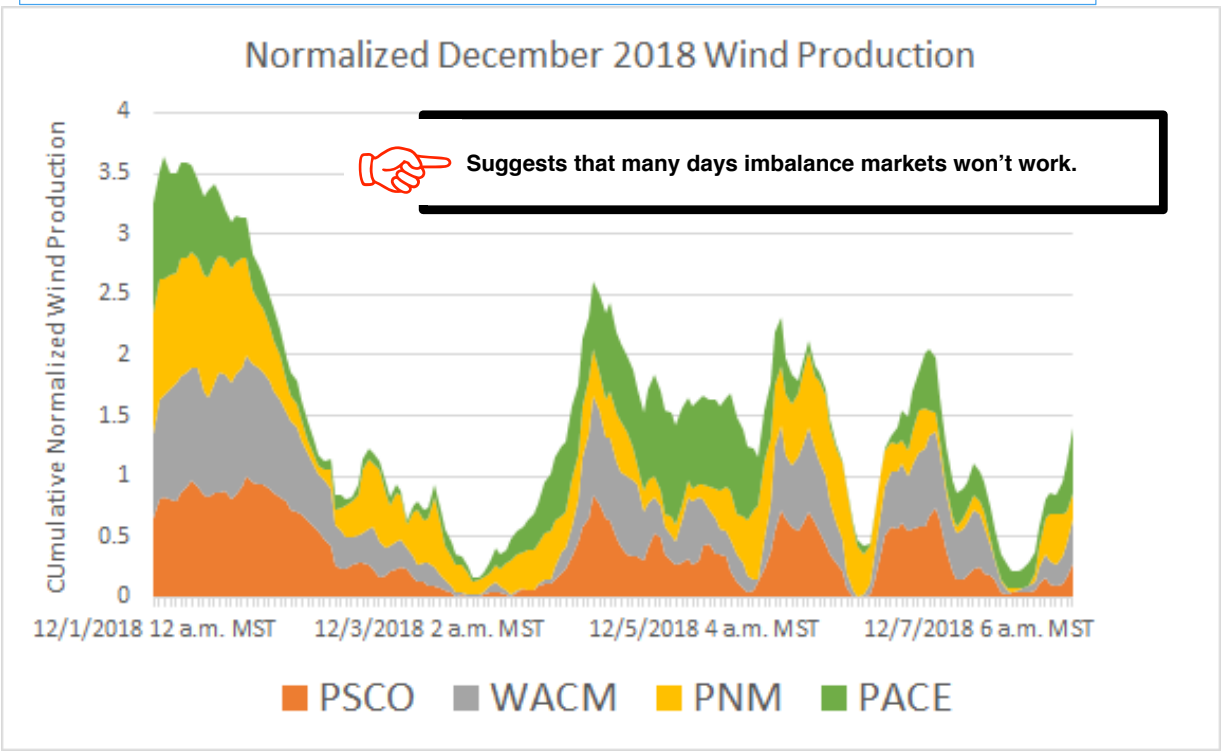
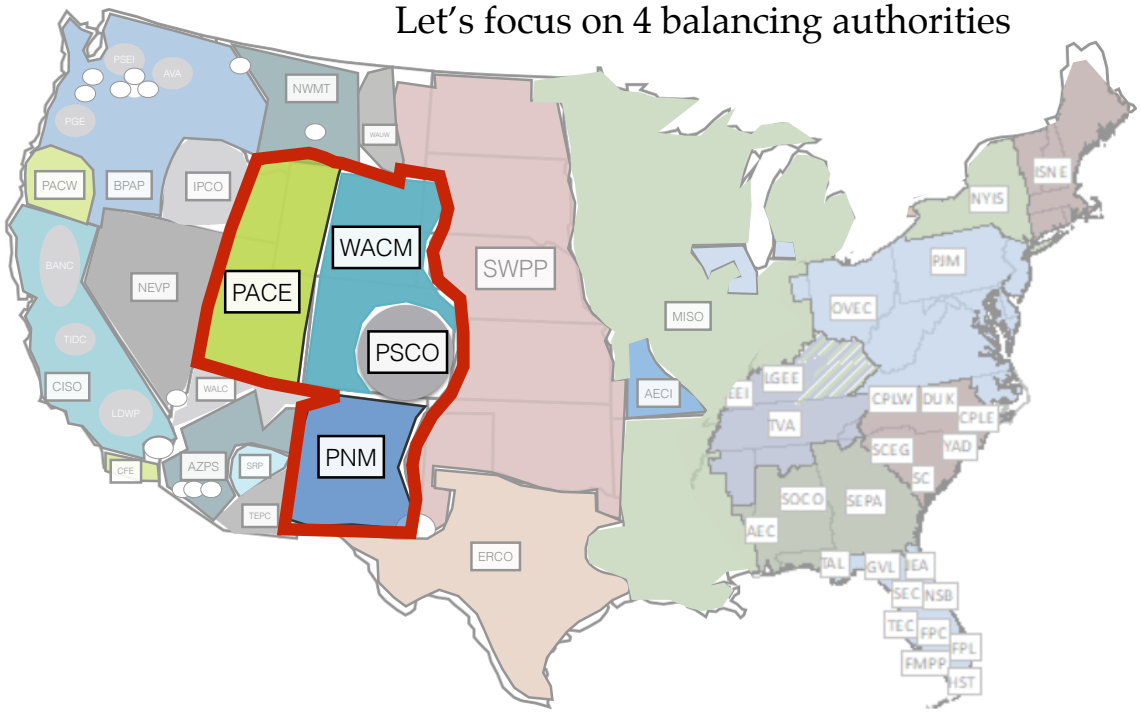
7 Days. Just Wind. 4 Neighboring Balancing Authorities



Will EIM Work to Sell Surplus?

Let's focus on 4 balancing authorities



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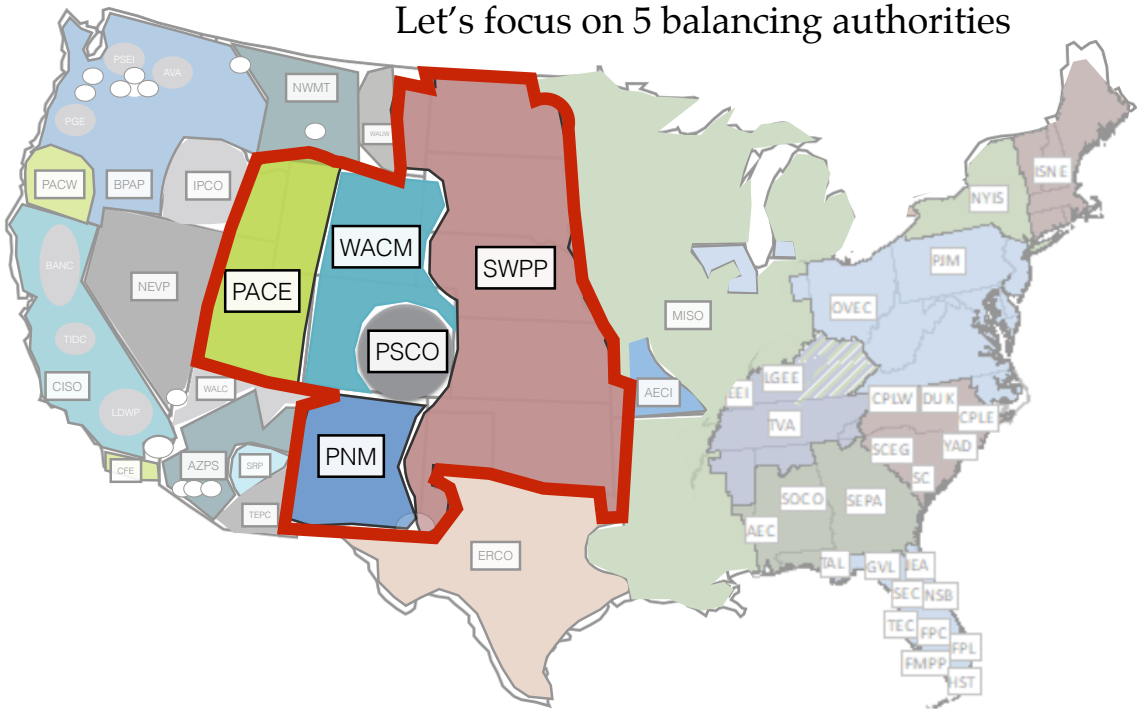
Will EIM Work to Sell Surplus?

Let's focus on 5 balancing authorities



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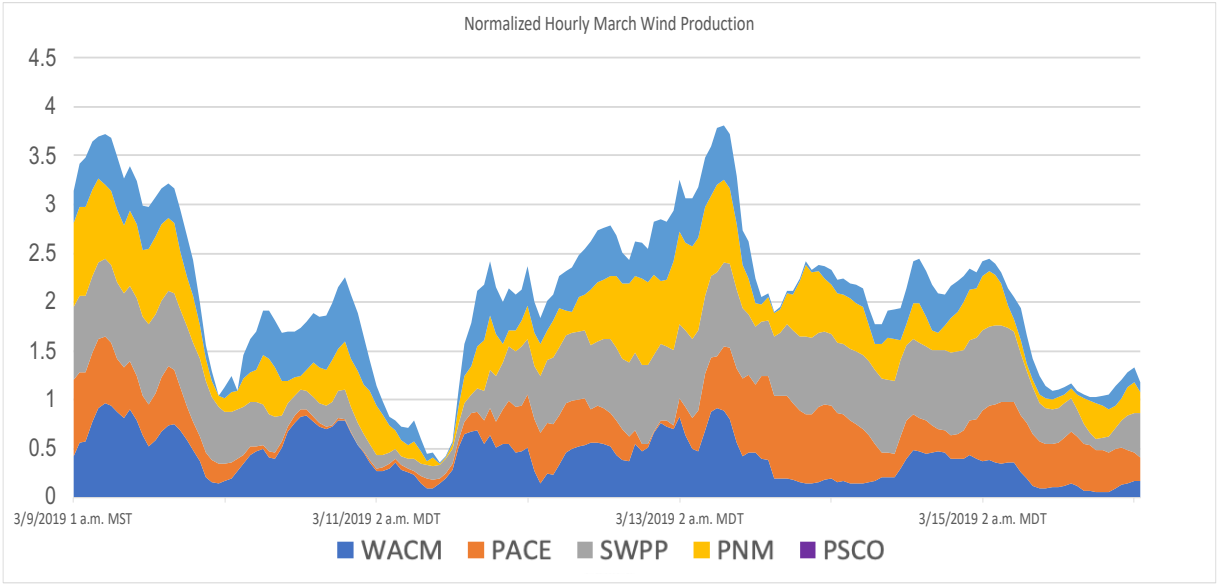
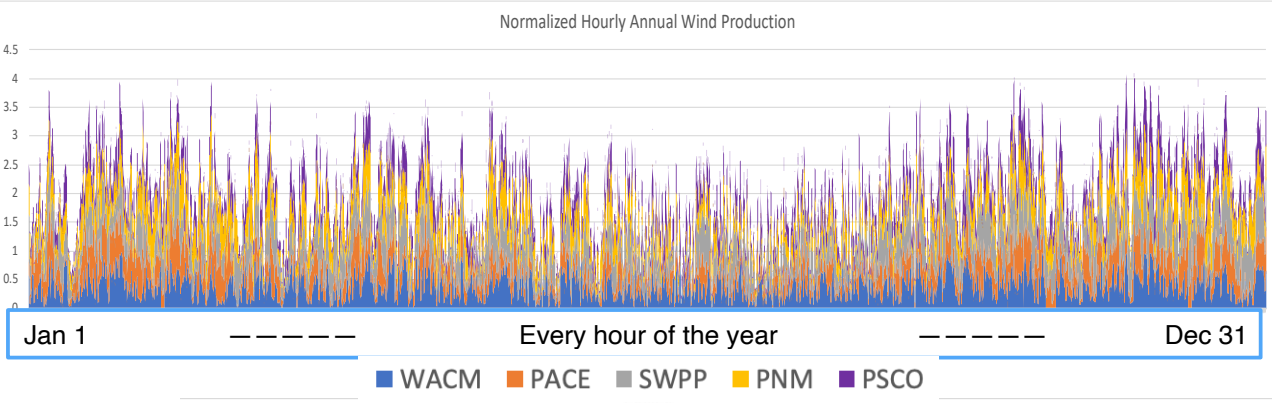
7 Days. Just Wind. 5 Neighboring Balancing Authorities

Suggests that many days imbalance markets won't work.



Entire Year. Just Wind. 5 Neighboring Balancing Authorities

Suggests that many days imbalance markets won't work.



Surplus is a COST problem > 30% Variable Wind & Solar

Or, can sell it for cheap and save everyone's rates!

"Sell for cheap" to who??

- Other utilities.
  Energy Imbalance Market
- Existing customers.

Which one? Probably "Do Both!"
And.
Be extremely skeptical of high cost projects to implement either.
(e.g. New Transmission)

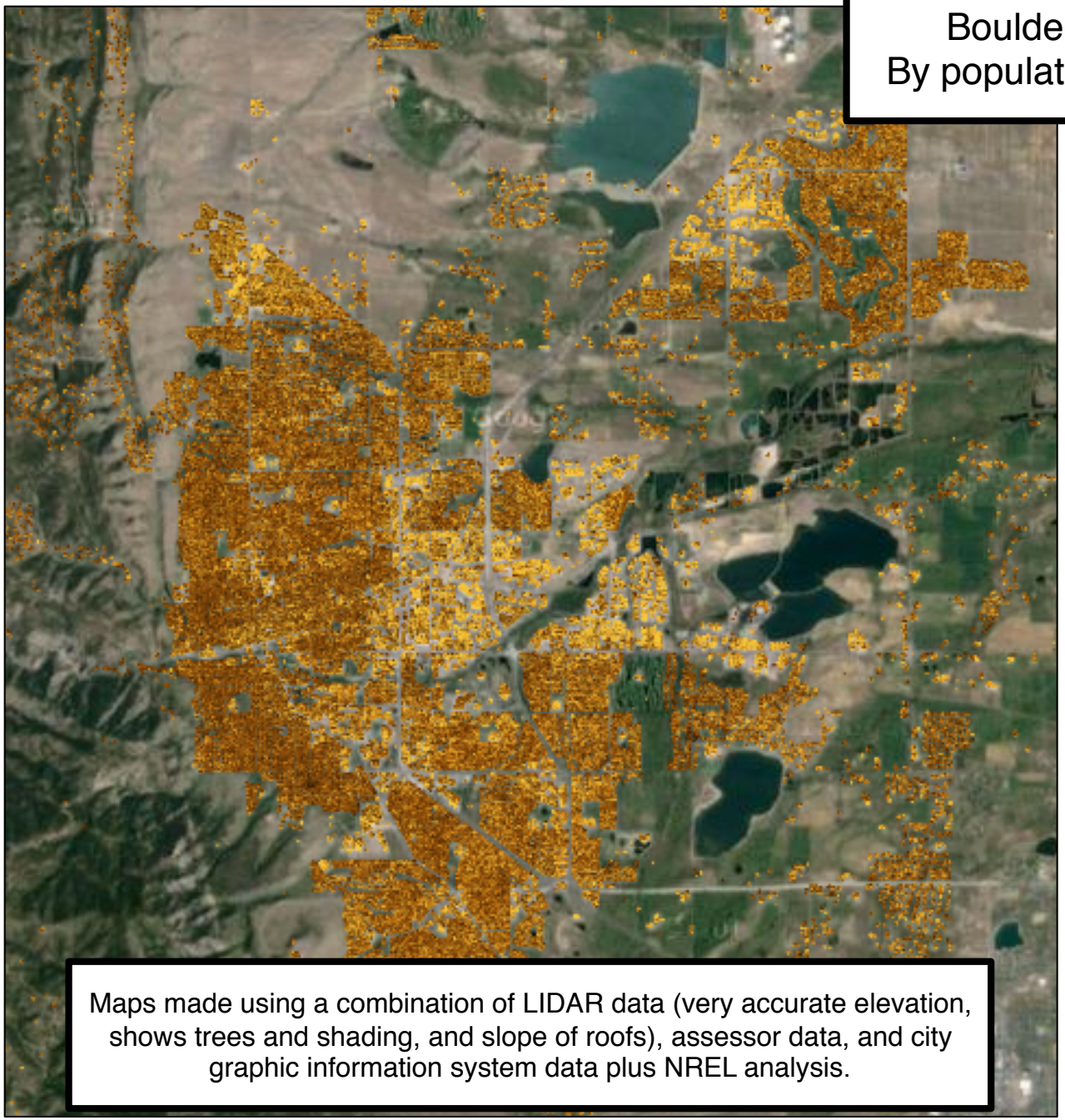
Q: How much rooftop high yield solar in the city of Boulder?

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

Energy ShouldBe.org



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.