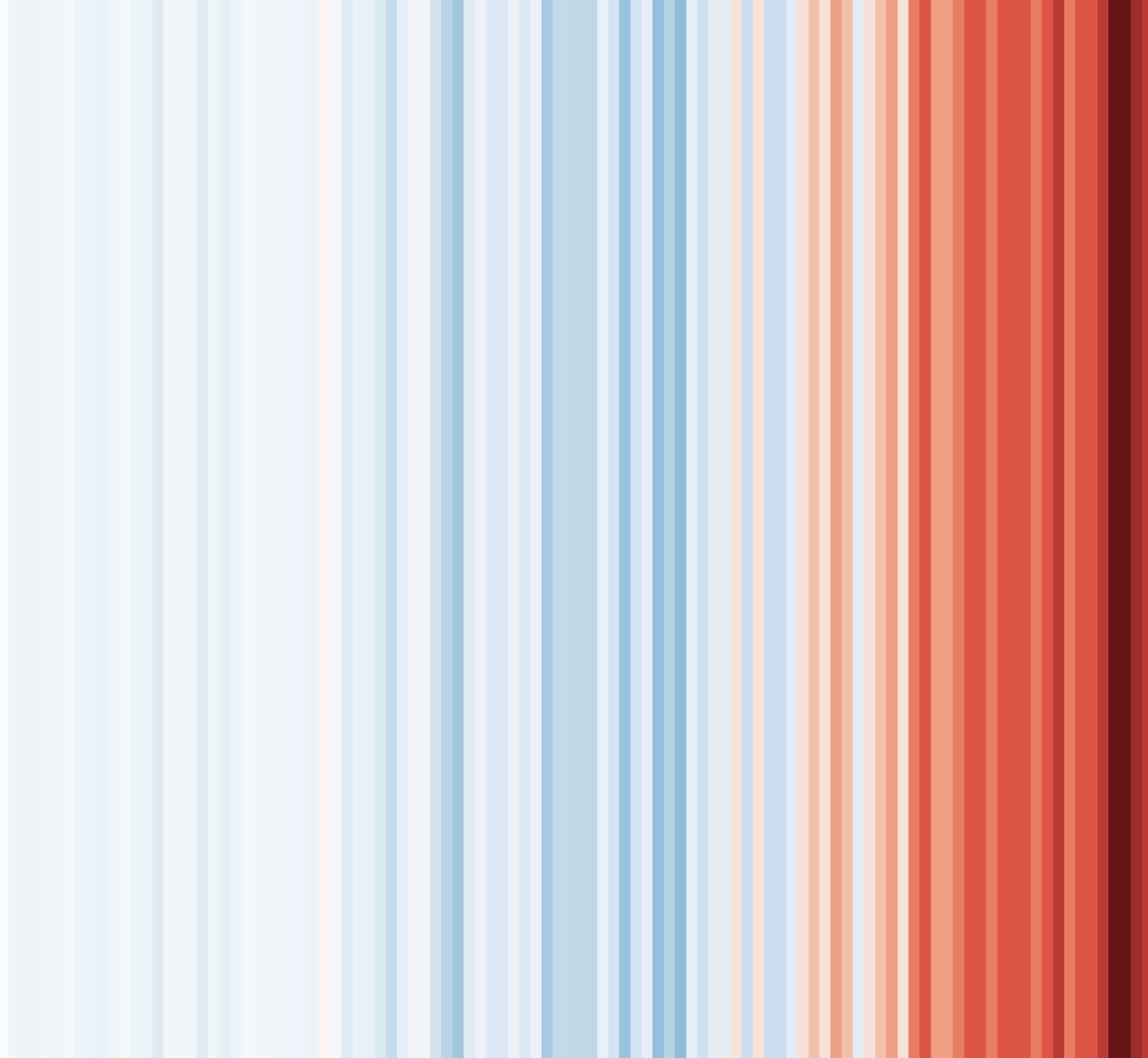
Rewiring America

A kitchen-table out and bottom-up solution to climate change

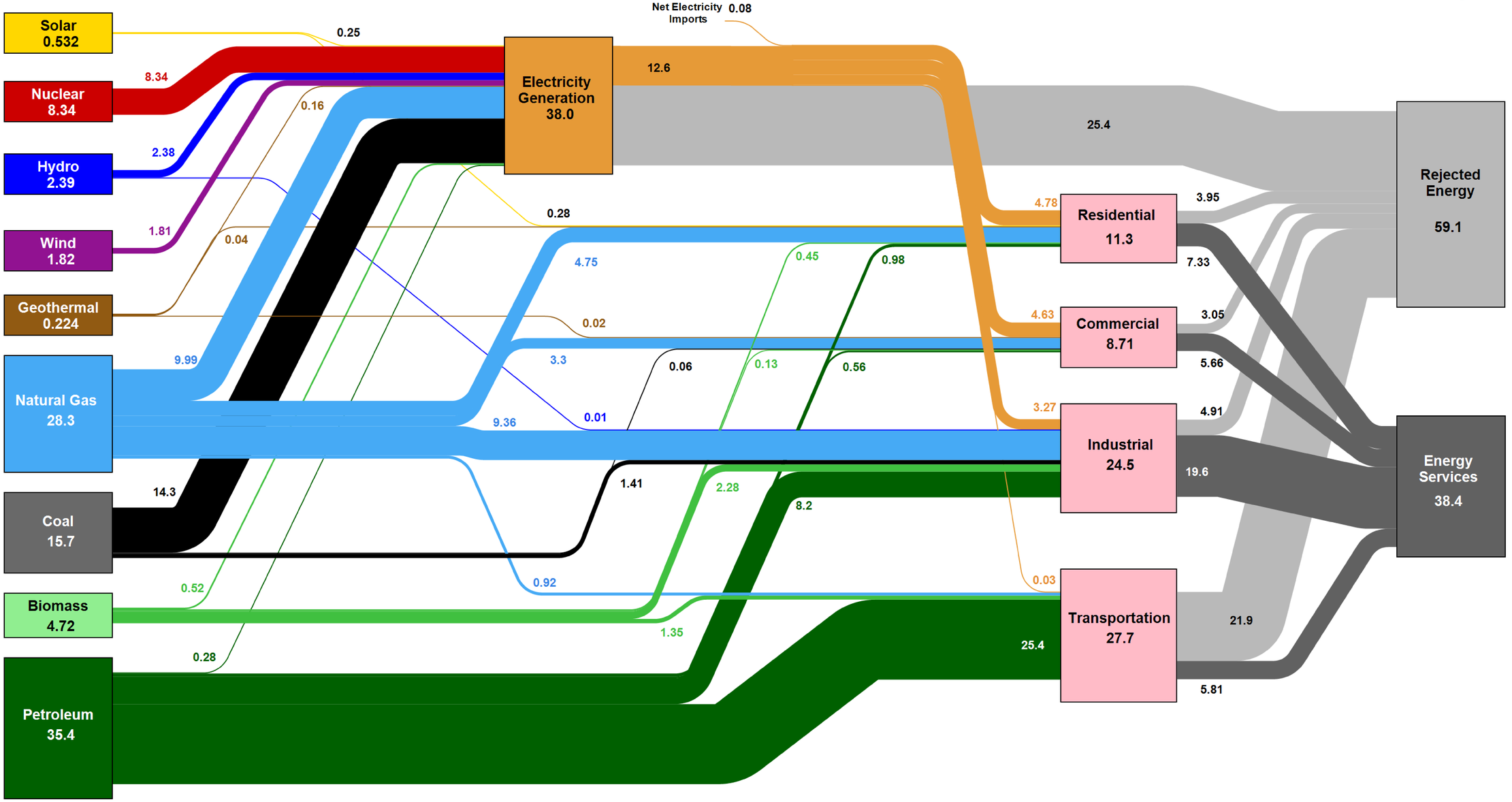
Our last shot at a good climate outcome:

Massive Electrification



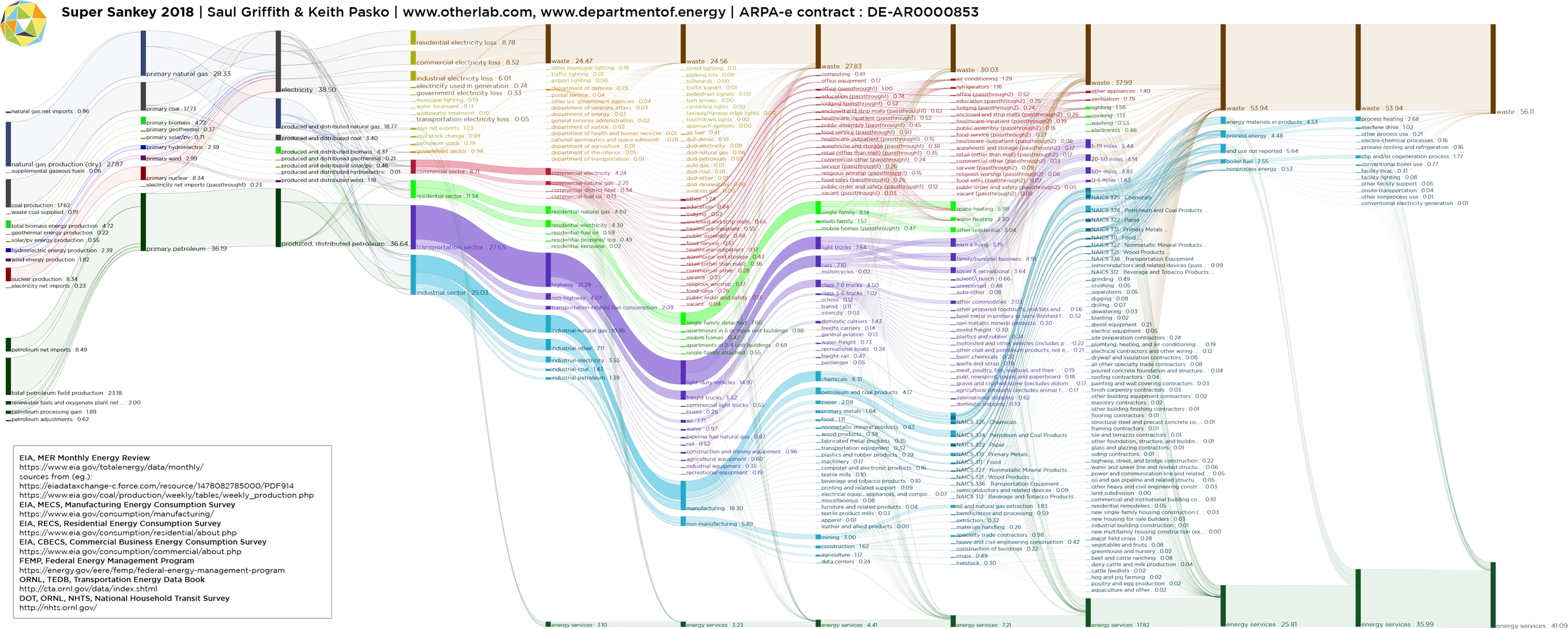
Estimated U.S. Energy Consumption in 2015: 97.5 Quads

Lawrence Livermore National Laboratory

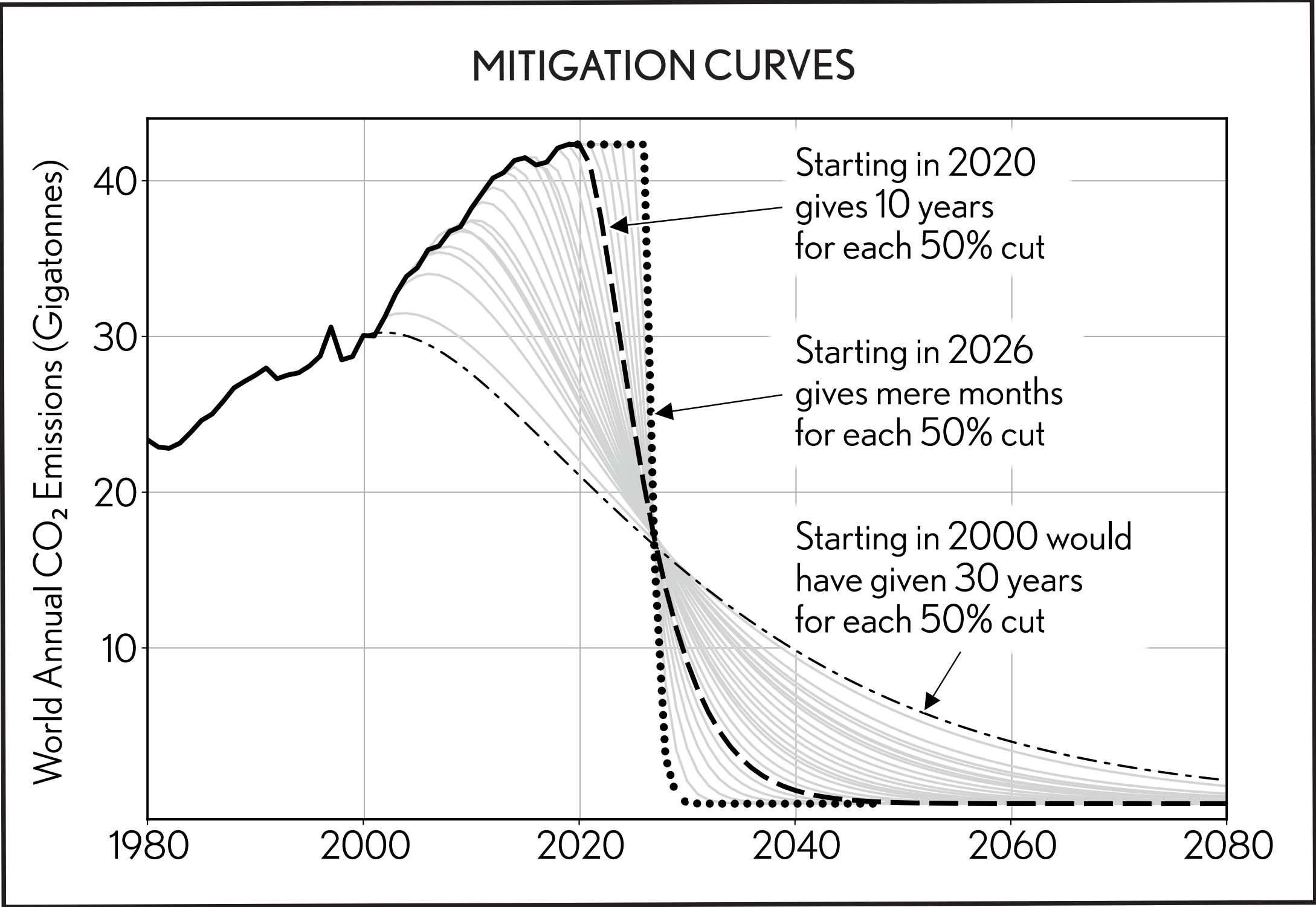


Source: LLNL March, 2016. Data is based on DOE/EIA MER (2015). If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail 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, 80% for the industrial sector, and 21% for the transportation sector. Totals may not equal sum of components due to independent Rounding. LLNL-MI-410527

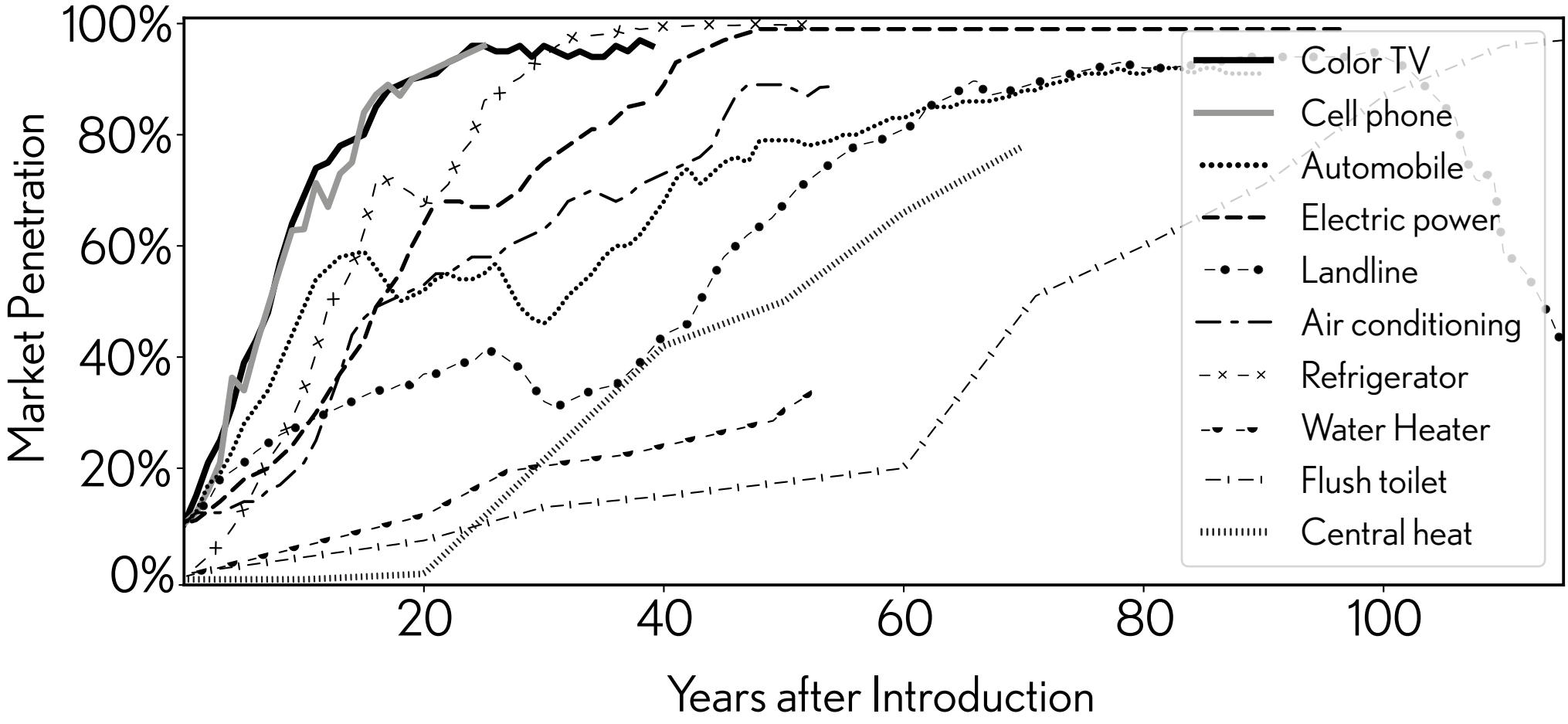
Super Sankey 2018 | Saul Griffith & Keith Pasko | www.otherlab.com, www.departmentof.energy | ARPA-e contract : DE-AR0000853



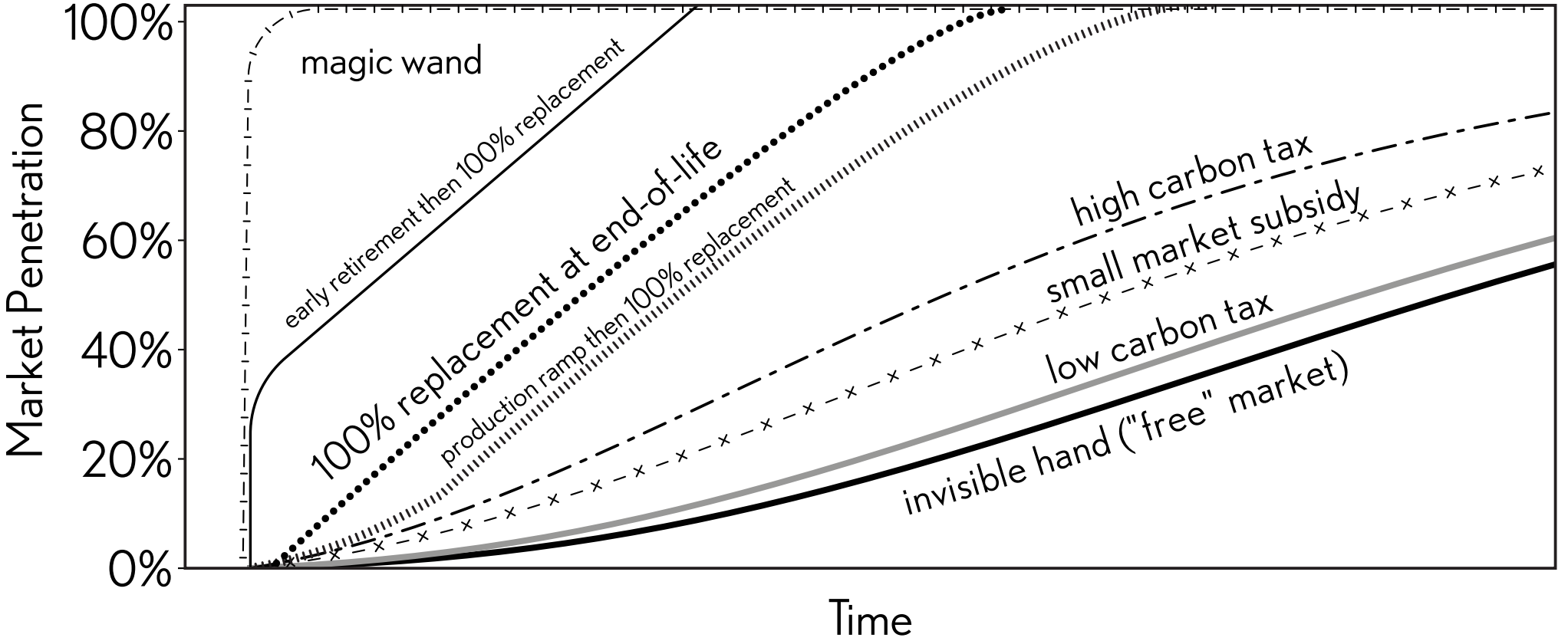
EIA, MER Monthly Energy Review
https://www.eia.gov/totalenergy/data/monthly/
sources from (eg.):
https://eiadataxchange-c.force.com/resource/1478082785000/PDF914
https://www.eia.gov/coal/production/weekly/tables/weekly_production.php
EIA, MECS, Manufacturing Energy Consumption Survey
https://www.eia.gov/consumption/manufacturing/
EIA, RECS, Residential Energy Consumption Survey
https://www.eia.gov/consumption/residential/about.php
EIA, CBECS, Commercial Business Energy Consumption Survey
https://www.eia.gov/consumption/commercial/about.php
FEMP, Federal Energy Management Program
https://energy.gov/eere/femp/federal-energy-management-program
ORNL, TEDB, Transportation Energy Data Book
http://cta.ornl.gov/data/index.shtml
DOT, ORNL, NHTS, National Household Transit Survey
http://nhts.ornl.gov/


MITIGATION CURVES
World Annual CO_2 Emissions (Gigatonnes)
40
30
20
10
1980
2000
2020
2040
2060
2080
Starting in 2020
gives 10 years
for each 50% cut
Starting in 2026
gives mere months
for each 50% cut
Starting in 2000 would
have given 30 years
for each 50% cut

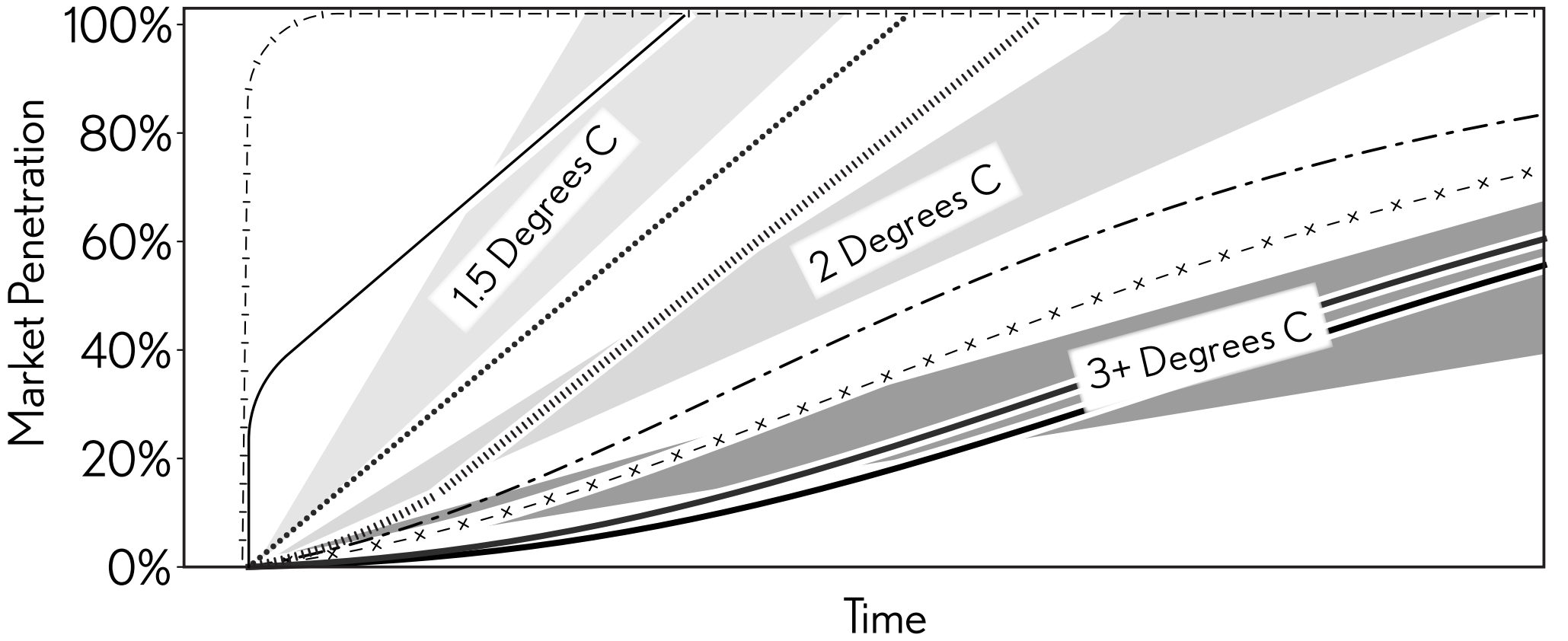
TECHNOLOGY ADOPTION RATES HISTORICALLY



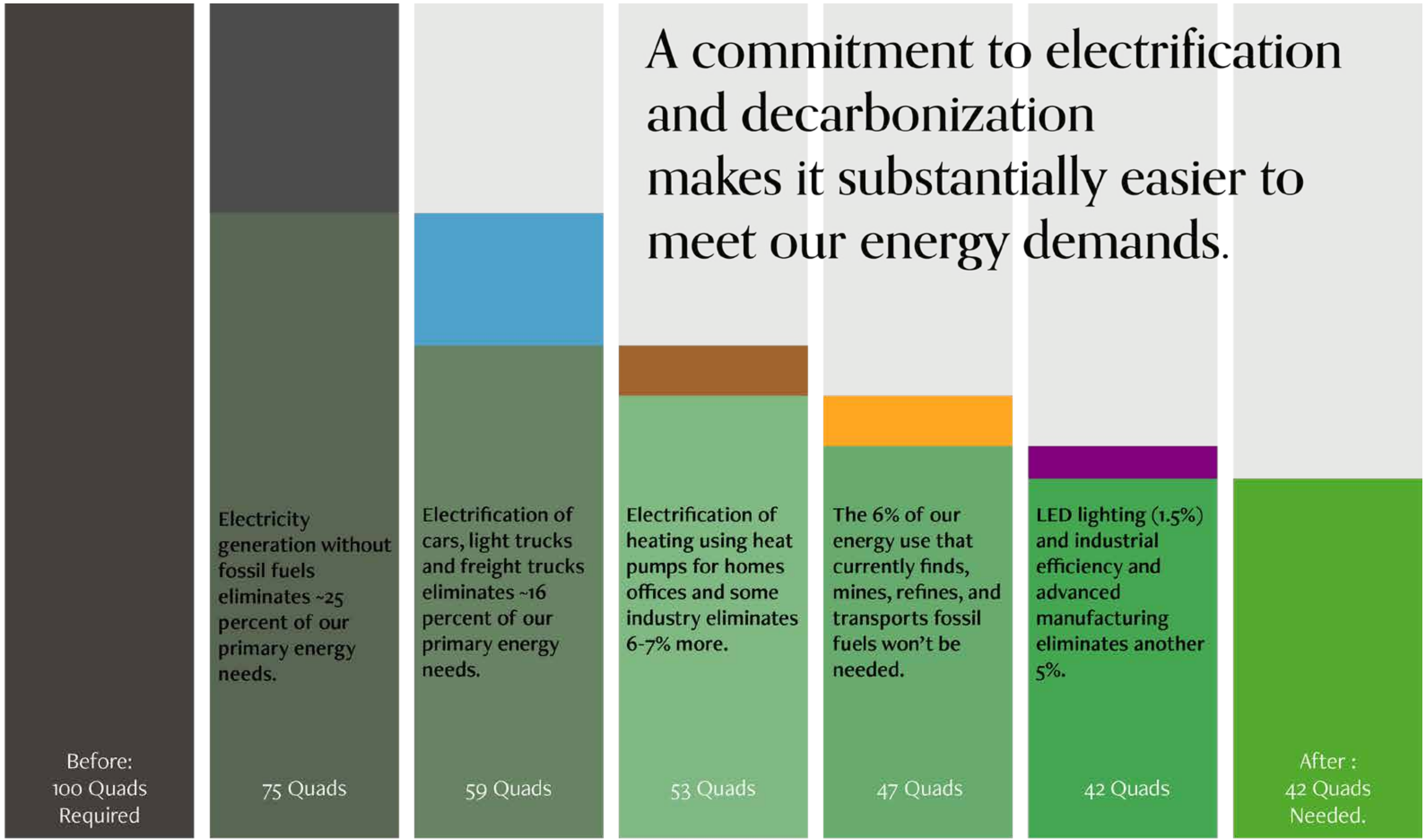
THEORETICAL ADOPTION RATES



THEORETICAL ADOPTION RATES VS. CLIMATE OUTCOMES



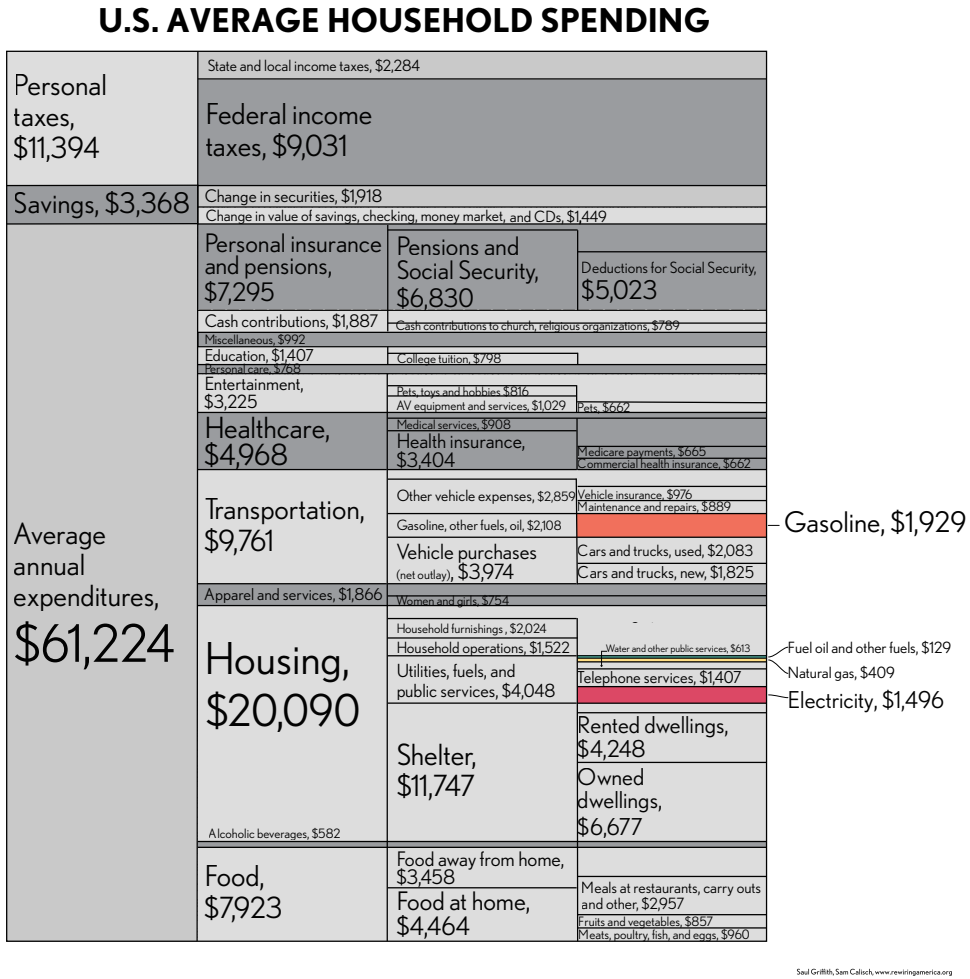
A commitment to electrification and decarbonization makes it substantially easier to meet our energy demands.



Household Expenditures

Our direct uses of energy and fossil fuels — gasoline, electricity, natural gas, propane, and heating oil — are shown at right in context with our other expenditures.[4]

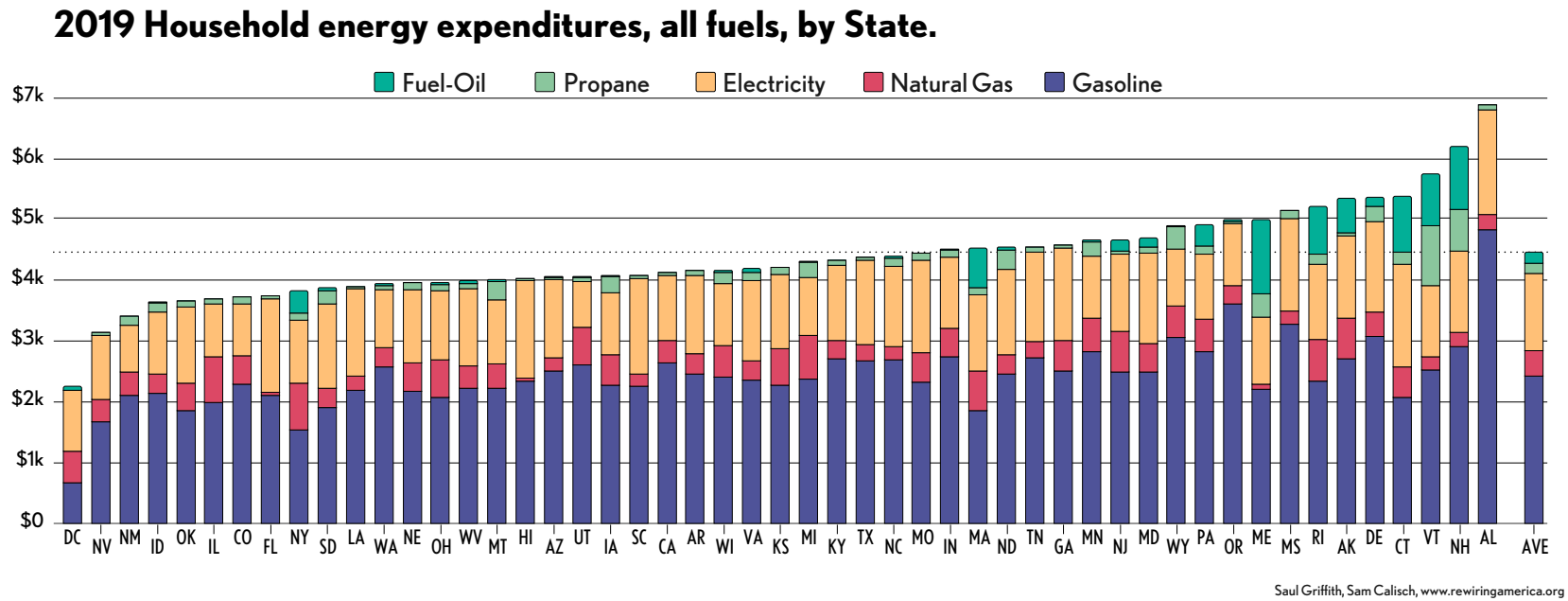
We spend more on electricity ($1,496) than we do on education ($1,407). We spend more on natural gas ($409) than dental services ($315). And we spend more on gasoline ($1,929) than we do on meat, poultry, fish, eggs, fruit and vegetables combined ($1,817).



[4] Data from Bureau of Labor Statistics, Consumer Expenditure Survey

Existing Energy Costs per Household

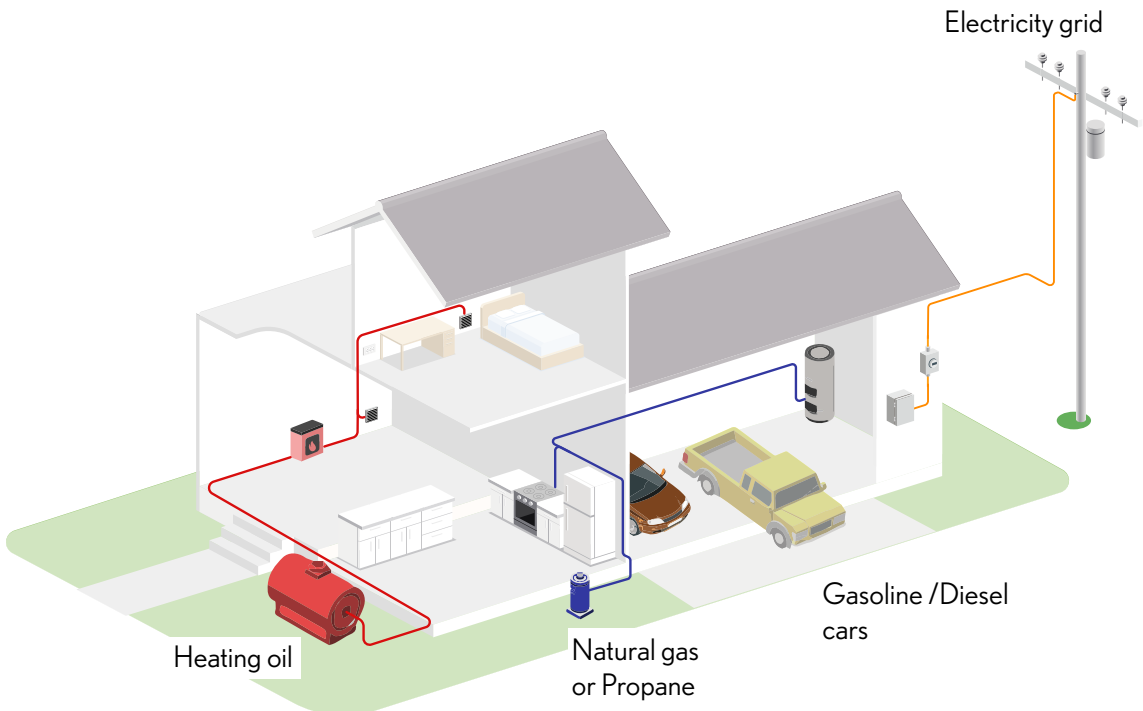
The average household spends around $4,470 annually on energy. (Data from SEDS, NHTS, RECS).



In New England, the mid-Atlantic, and colder northern states, we use substantial amounts of energy heating. Hot places like Hawaii use significant energy in air conditioning. In rural places like Alabama, people tend to drive a lot and buy more gasoline.

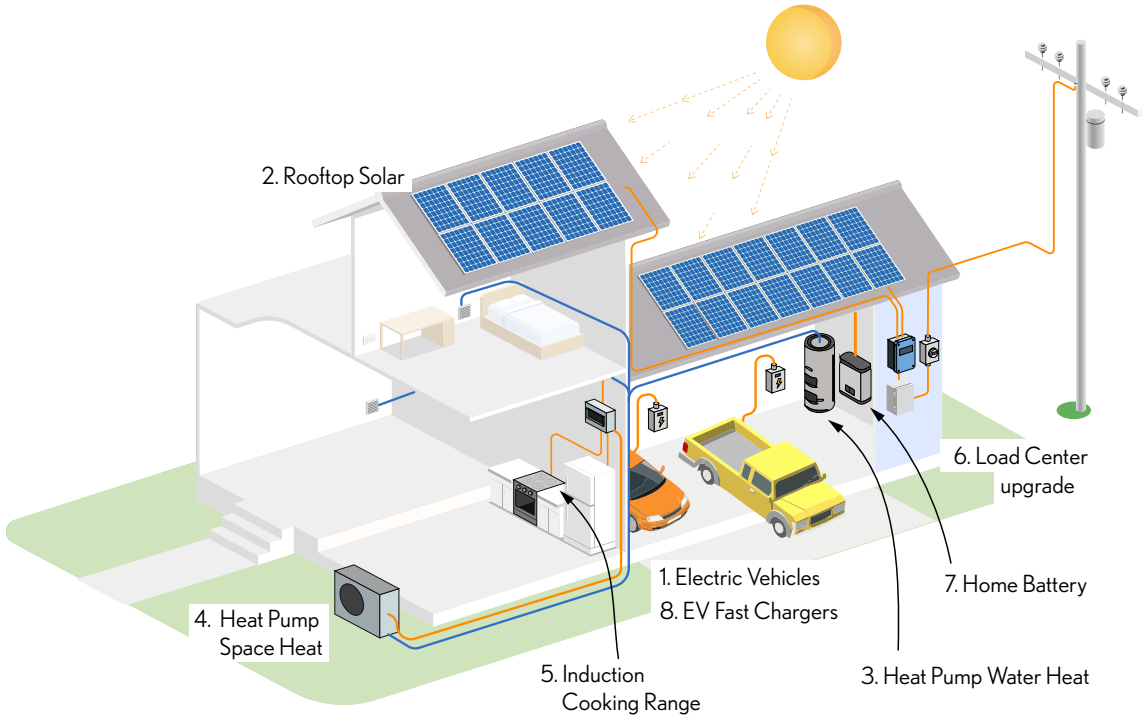
Households today

This is a picture of the fuel–burning infrastructure used to power households today: Gasoline or diesel power most cars. Natural gas, fuel oil, or propane heat most homes. Natural gas is frequently used for cooking. Electricity lights up every home.



Household decarbonization infrastructure upgrade

What does this electrification upgrade infrastructure look like?



These are electric versions of the ∼ half–dozen pieces of "life infrastructure" that we buy every 10 or so years. These are the critical household purchasing decisions climate–wise, and they are all currently capital–intensive, with high up–front costs.[3]

[3] Air conditioning is also a critical piece of household infrastructure. As it is already electric, it is not included in this analysis apart from the savings caused by lower electricity costs.

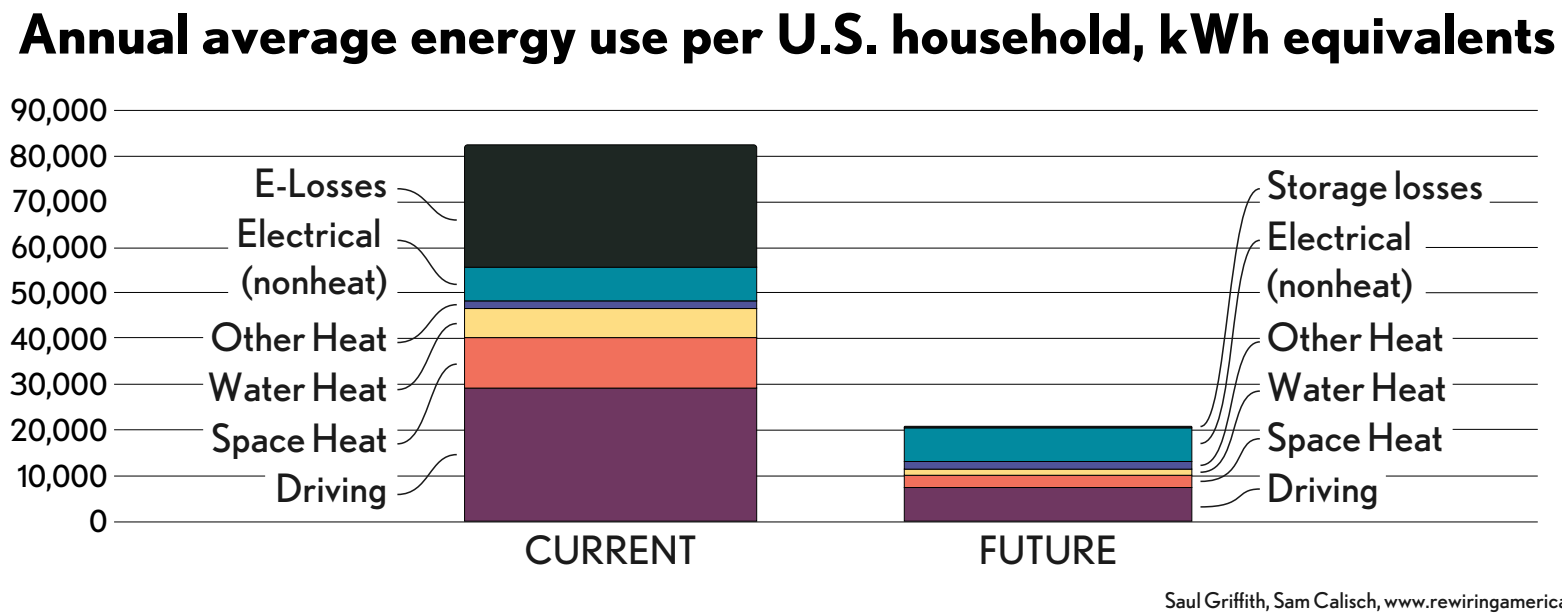
Current households vs. electrified

The electrified U.S. household uses substantially less energy than current homes.

One area of enormous savings is the elimination of thermoelectric losses in electricity generation, assuming we will provide our future loads with renewables.

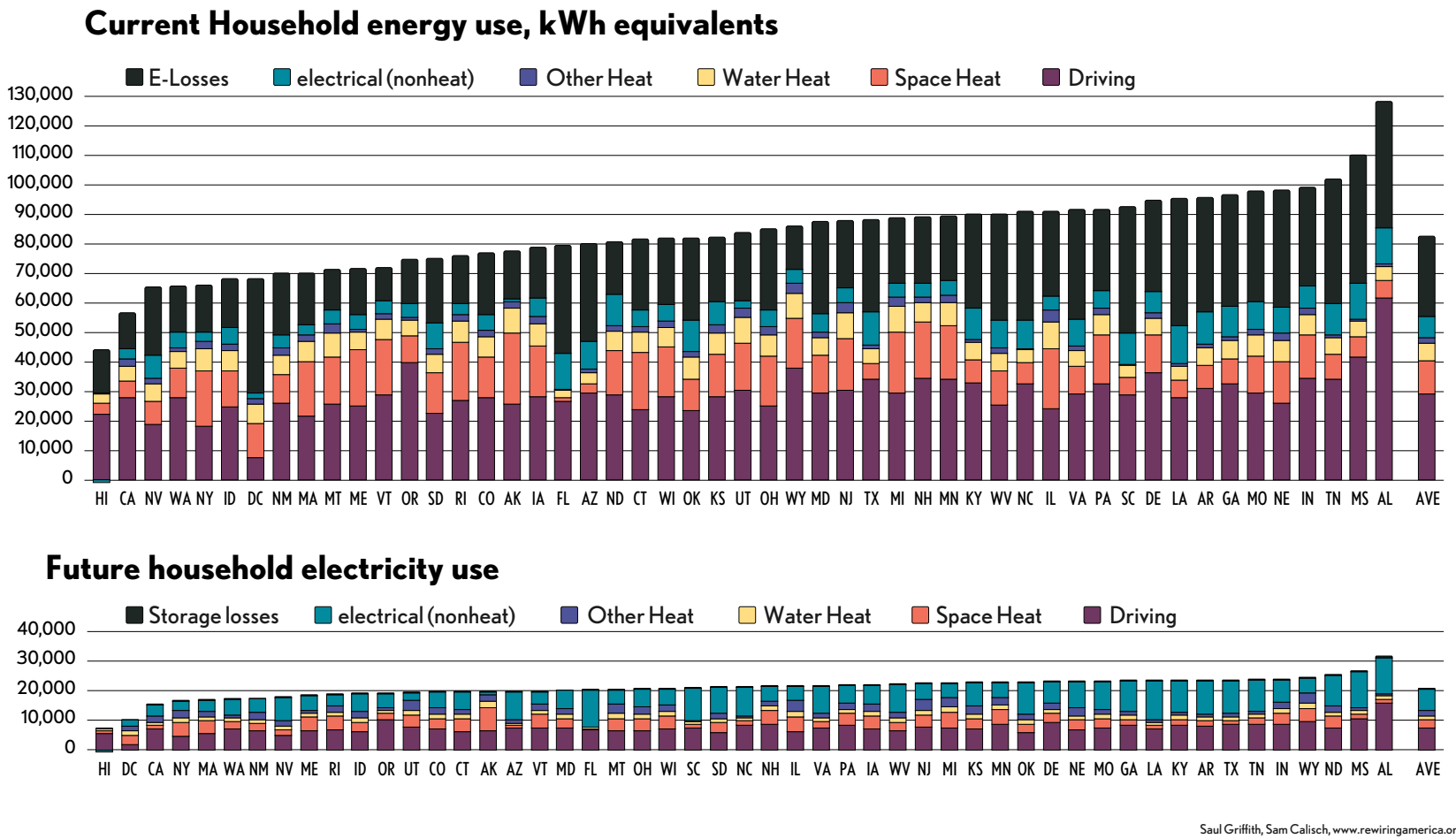
The efficiency of electric cars over internal combustion engine (ICE) vehicles also generates substantial savings.

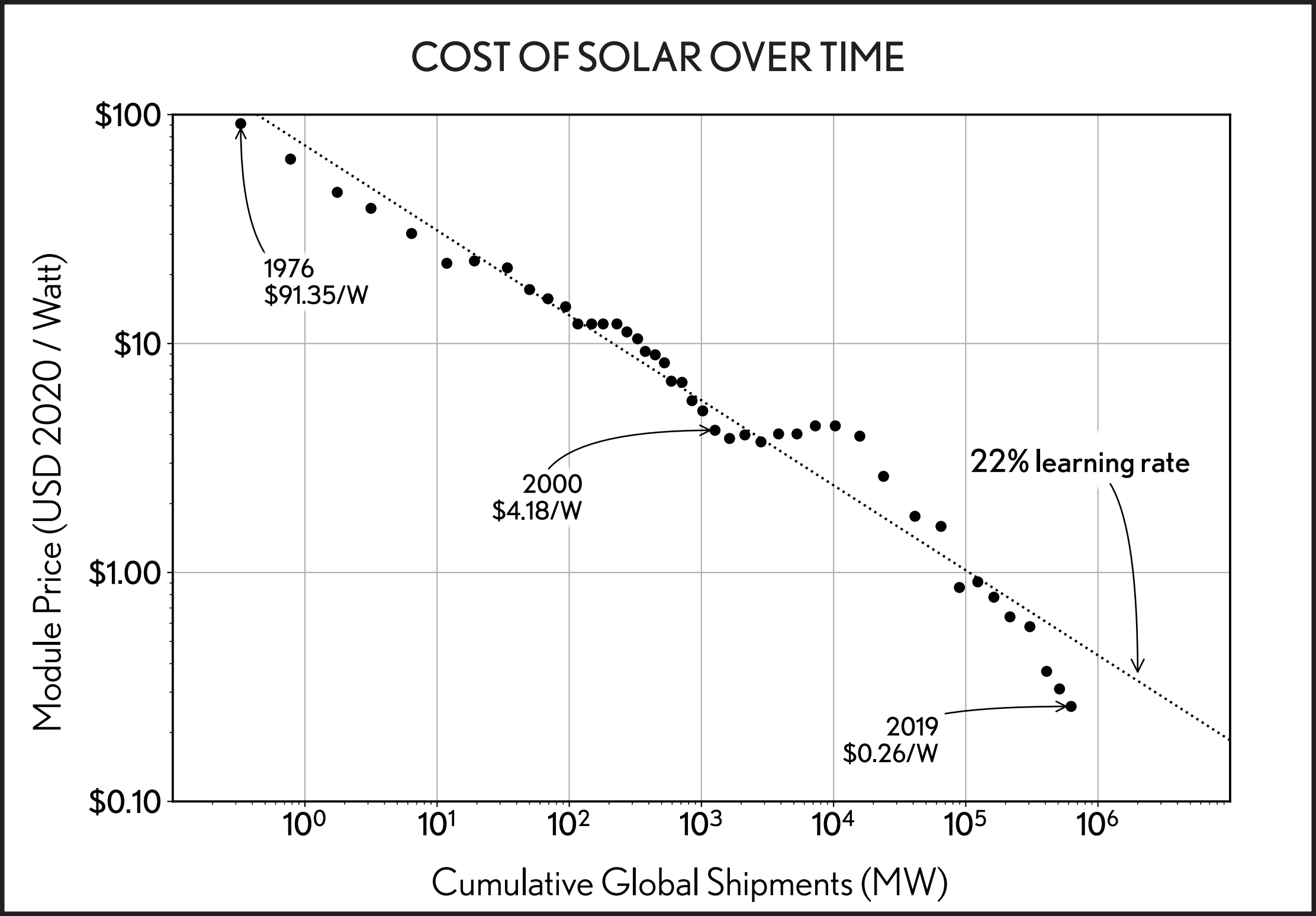
Similarly, we show the substantial savings derived from the high efficiency of heat pumps for space and water heating.



Current and future household energy consumption, by state

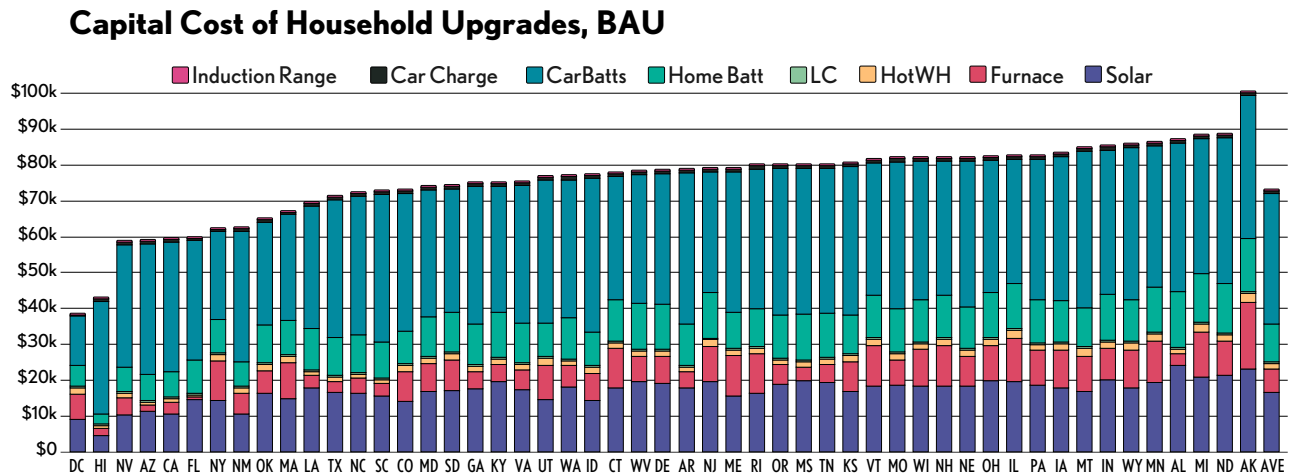
We see some variation state–to–state, but going electric saves significant energy across the board.

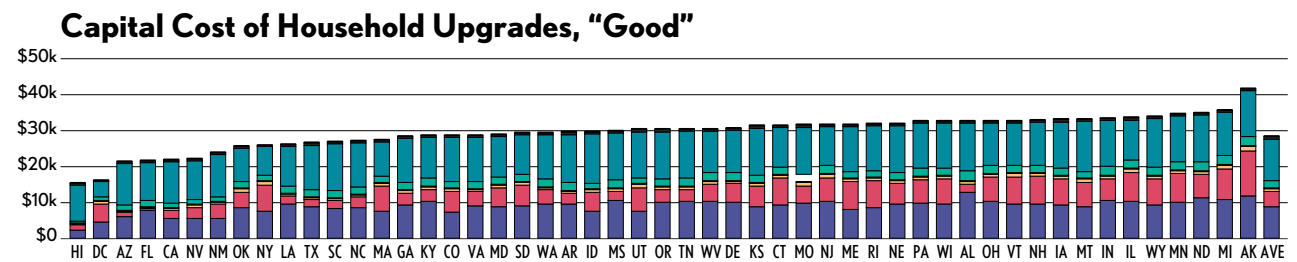


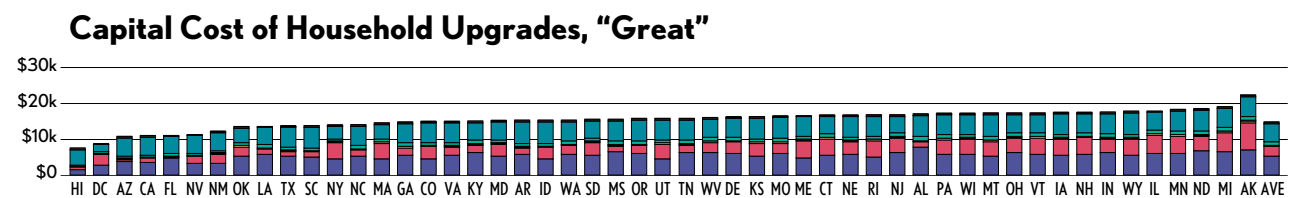

COST OF SOLAR OVER TIME
$100
$10
$1.00
$0.10
Module Price (USD 2020 / Watt)
1976
$91.35/W
2000
$4.18/W
22% learning rate
2019
$0.26/W
10^0
10^1
10^2
10^3
10^4
10^5
10^6
Cumulative Global Shipments (MW)

Modeled capital cost reductions

The industrial scale just mentioned, as well as regulatory optimization (such as the Australian rooftop solar experience), drive the large capital cost reductions of the Good and Great scenarios.







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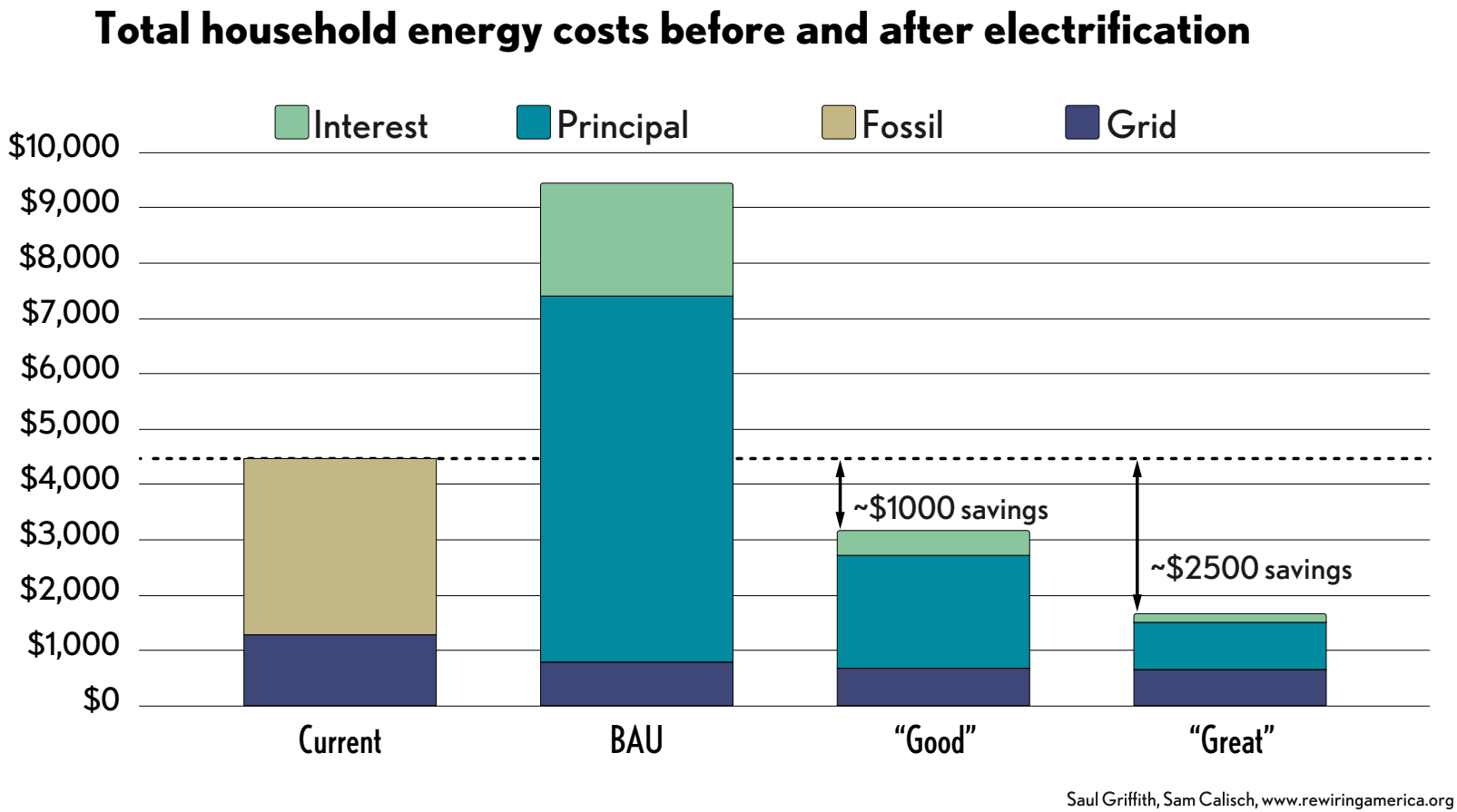
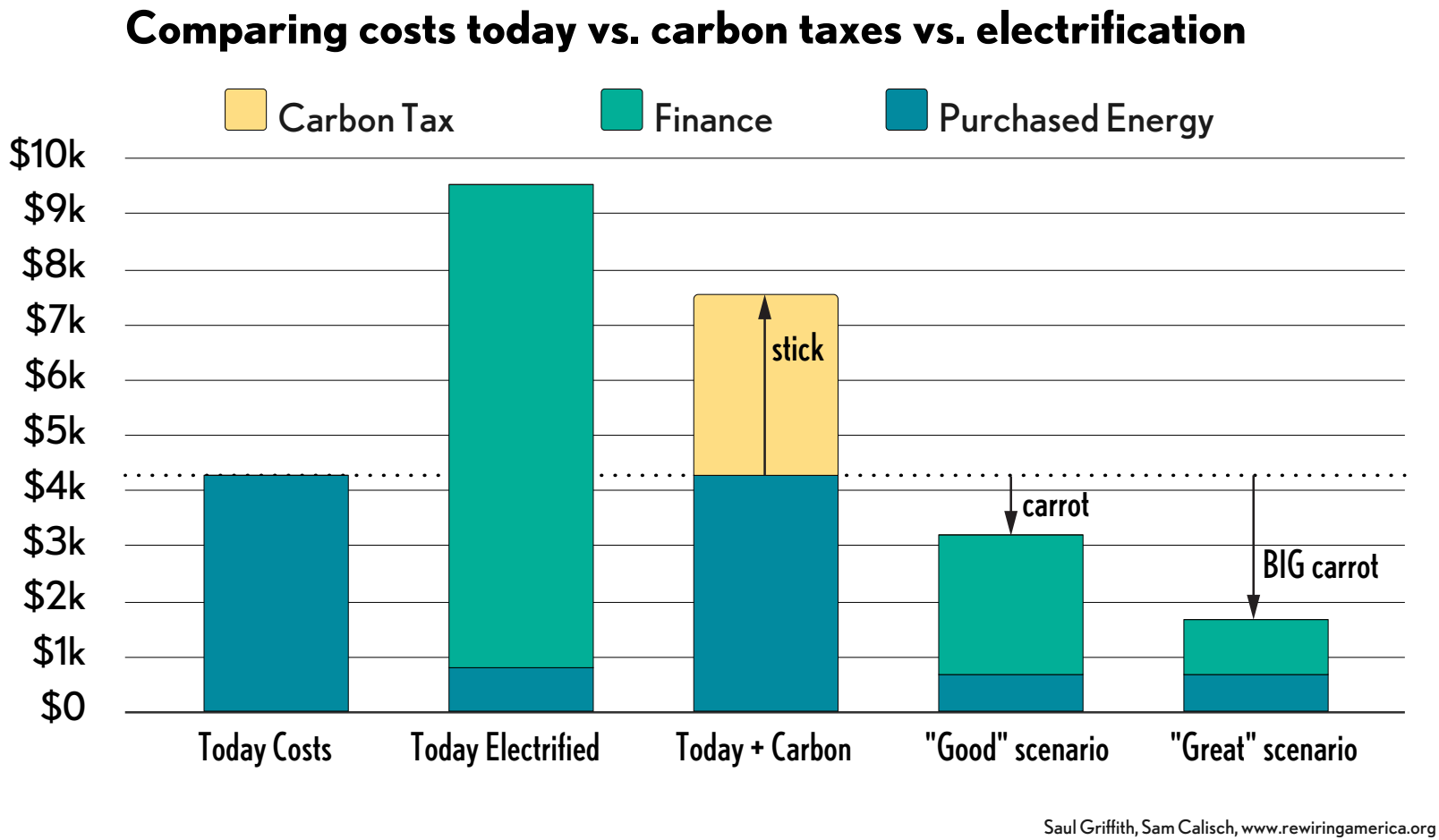
Energy costs: Fuels today vs. financing tomorrow



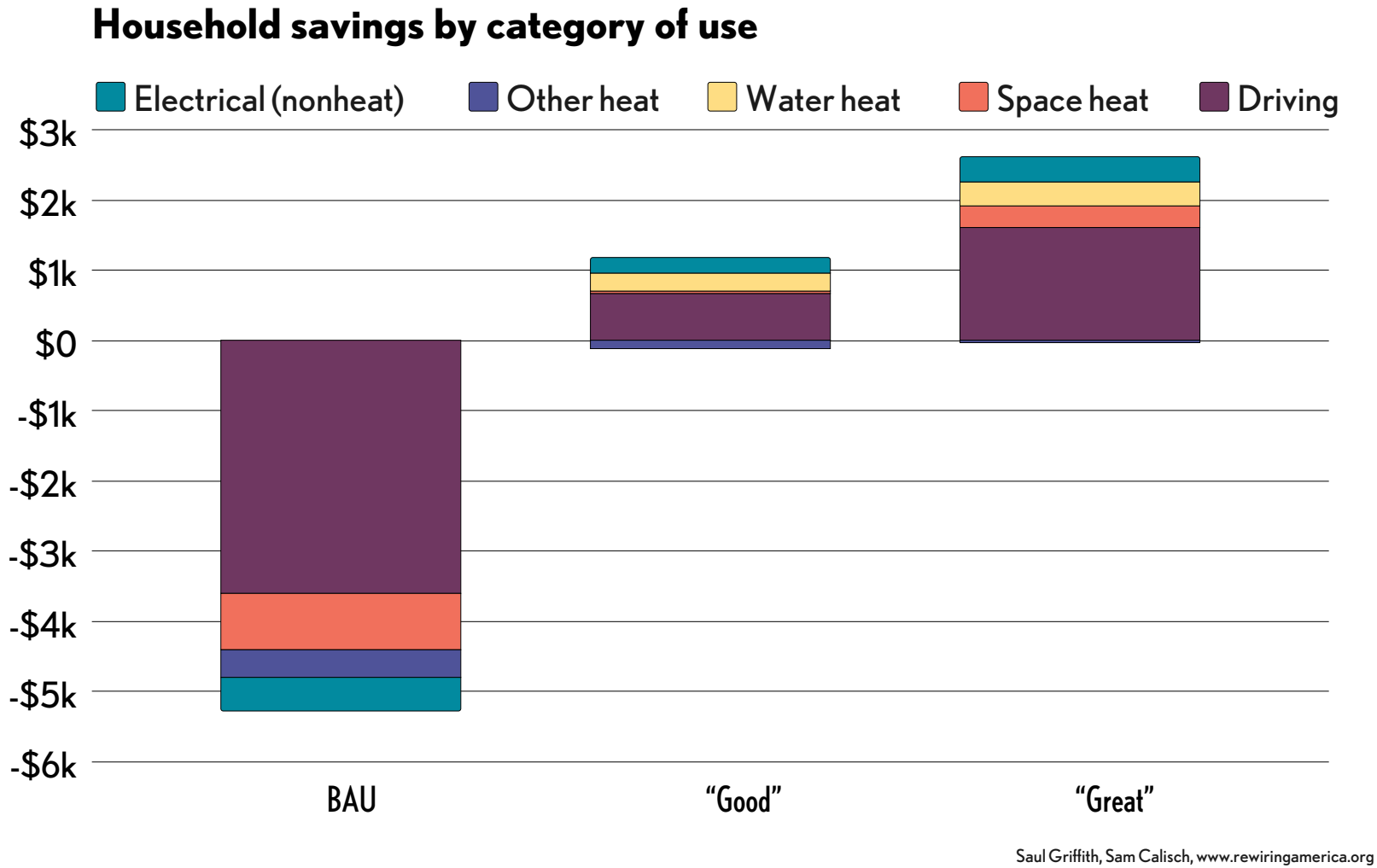
Electrification and decarbonization costs today



We can compare this approach to the commonly-proposed carbon tax mechanism, seeing that while a carbon tax acts as a "stick" for households, electrification can be a (big) "carrot."

Savings by category

Savings can be assigned to the category of energy use. The biggest savings are derived from driving and heating.

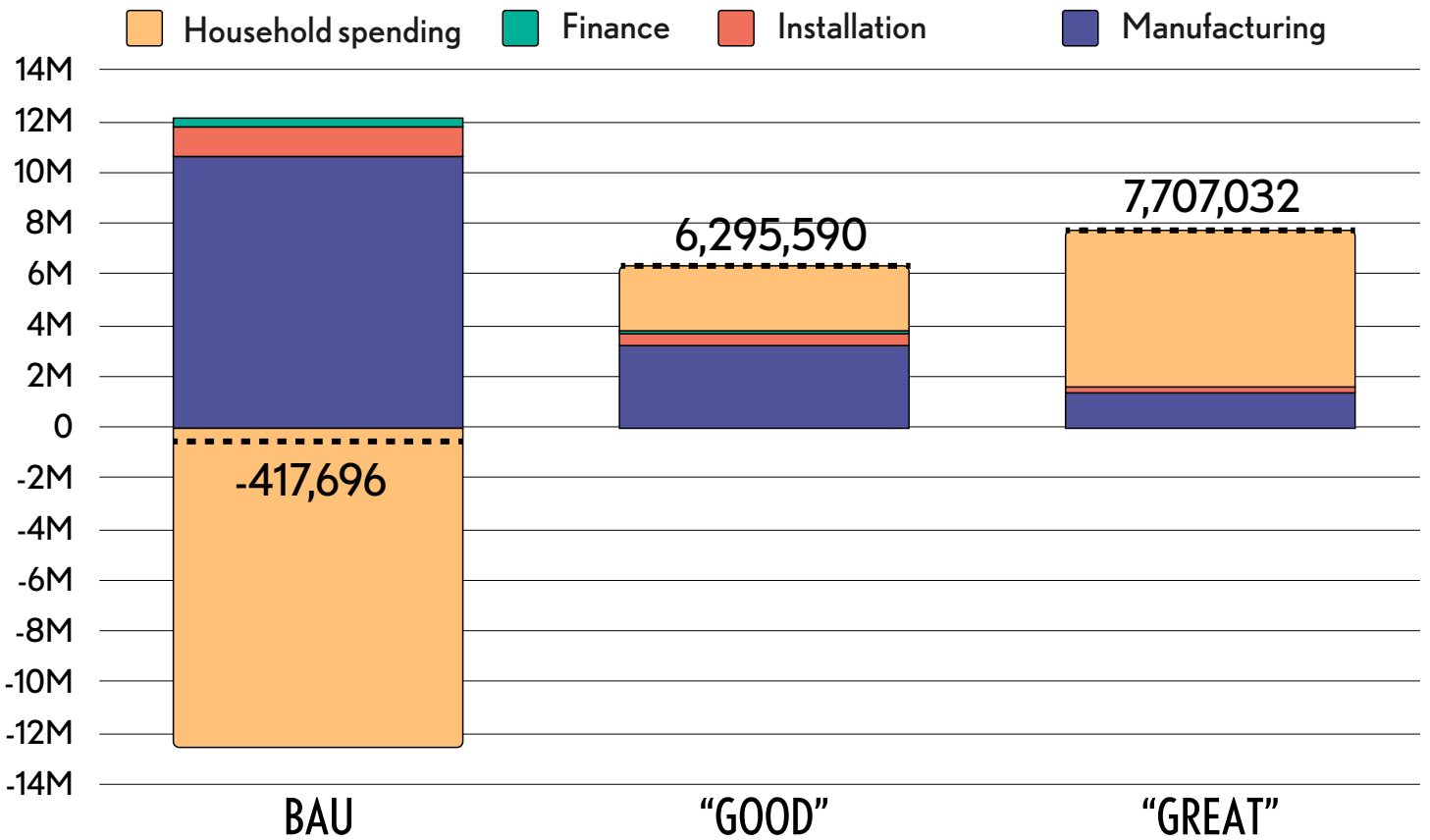


Annual savings by household, by state

What is the effect of this stimulus on jobs?

As many as 25 million jobs will be created in the U.S. by an aggressive climate plan.[12] The household transformation outlined here will create more than 7.7 million of those new jobs.[13]

Net-Jobs created, by category, 3 scenarios.



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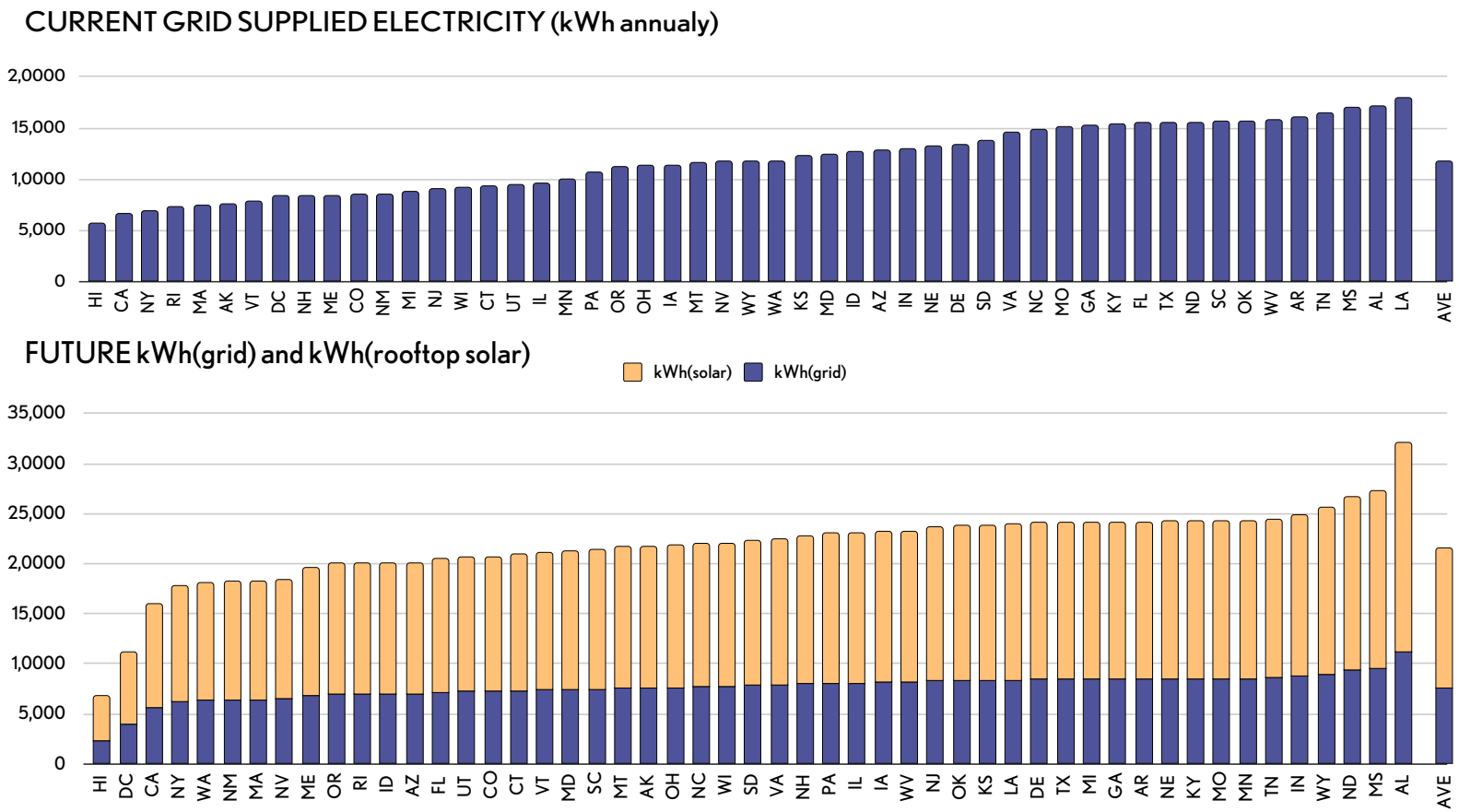
[12] We have analyzed this previously in the Rewiring America Jobs Report.

[13] We use data from Implan to analyze the number of net new jobs created.

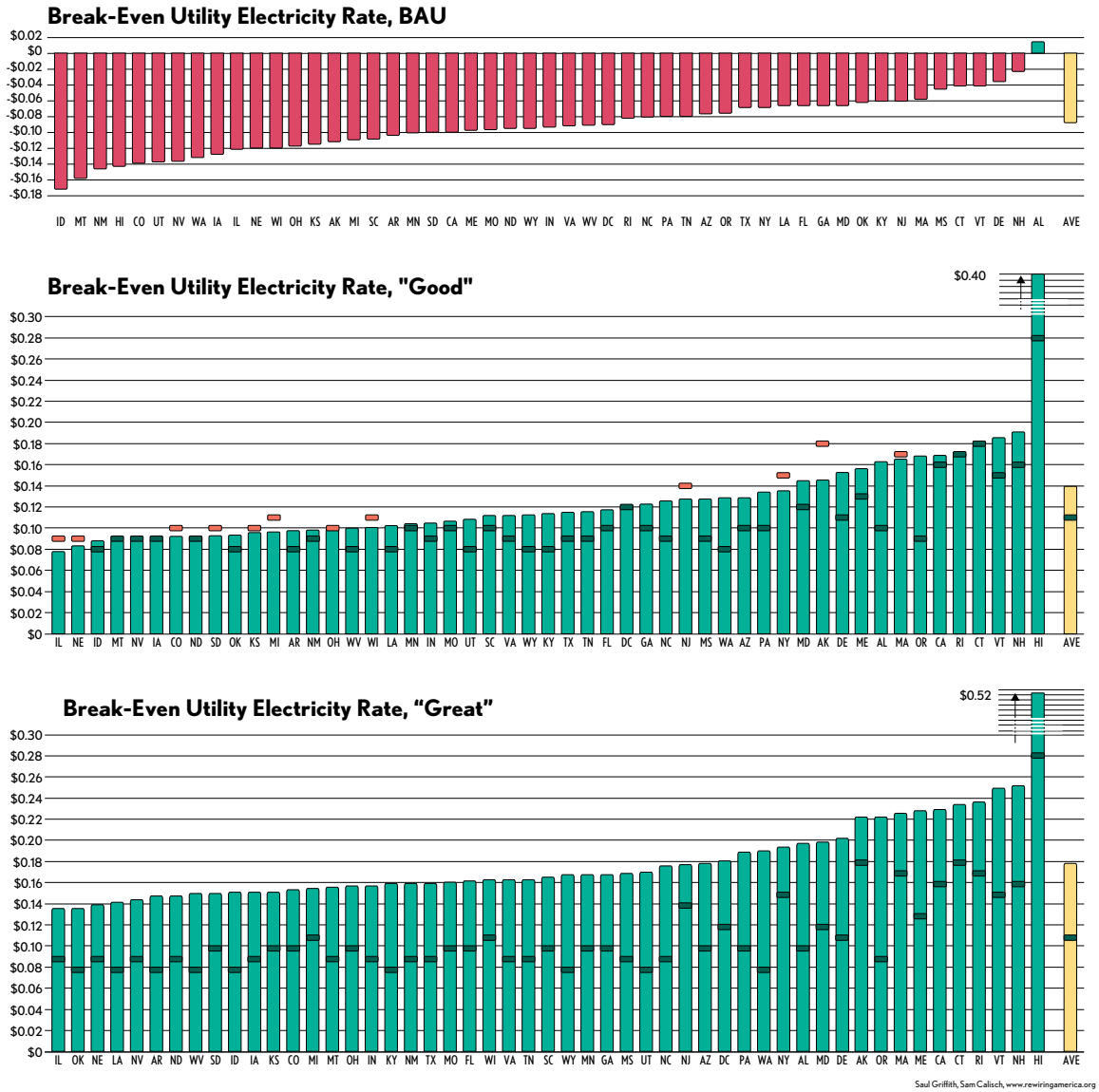
Rooftop solar and the grid

This electrification program will install ~1100 GW of rooftop solar, which is within the total rooftop potential of the U.S.[14].

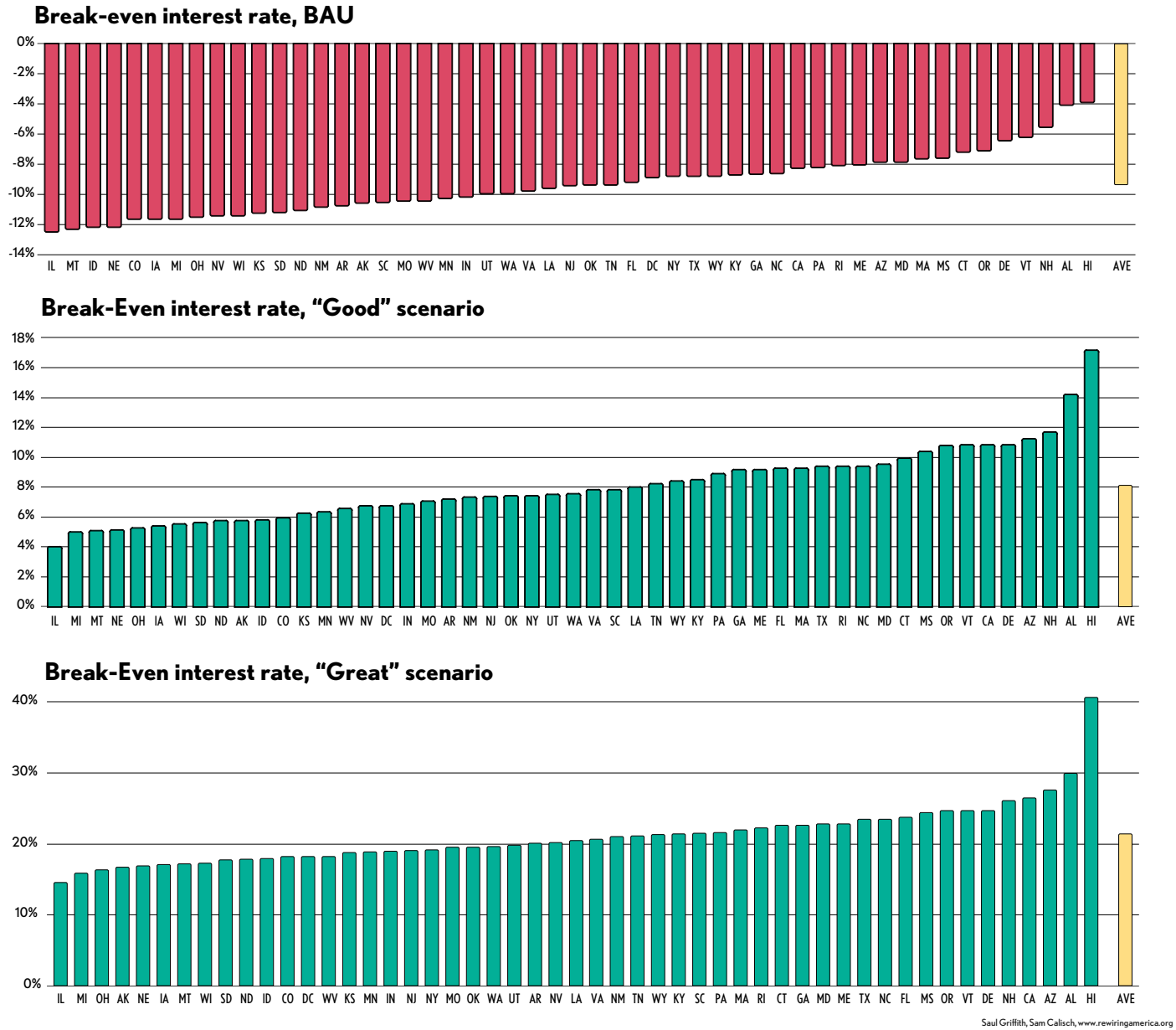


[14] NREL's 2016 report, Rooftop Solar Photovoltaic Technical Potential in the United States, finds over 1100GW potential even using a very conservative 16% module efficiency.

Can we do it through grid–delivered electricity alone?

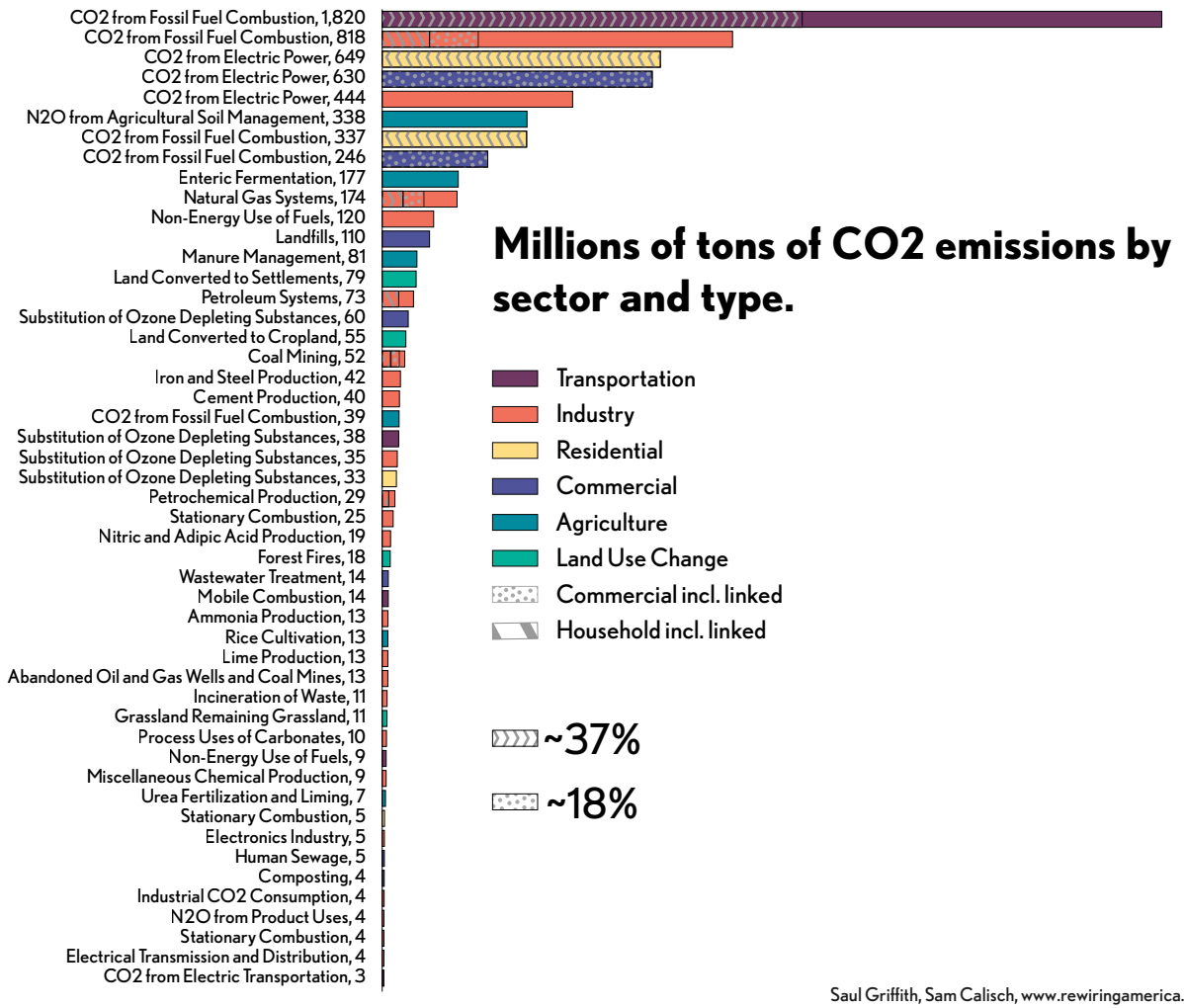


What interest rates are required?

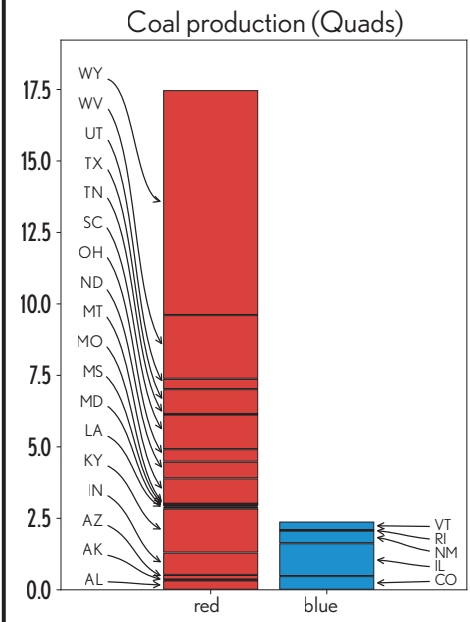


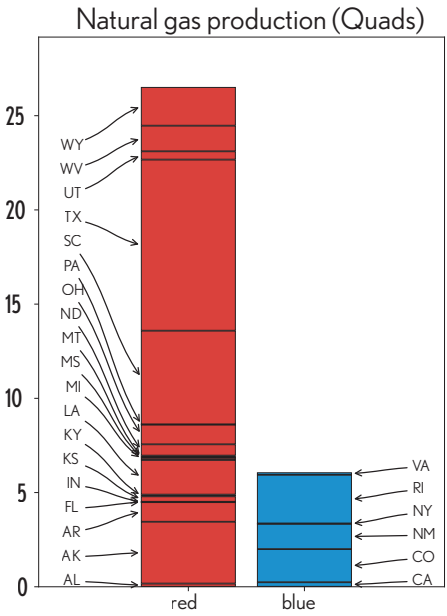
Greenhouse Gas Emissions of households (and commercial businesses)

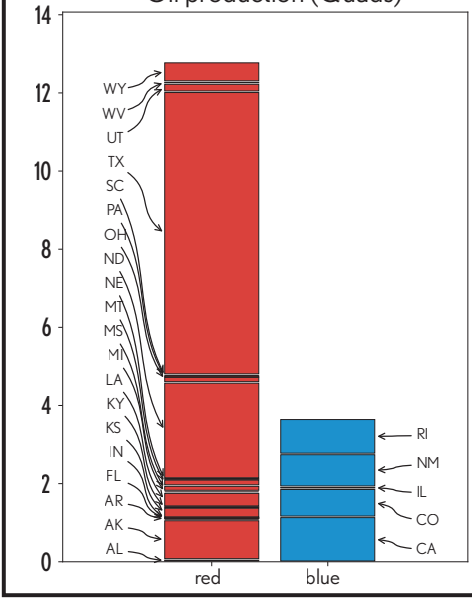
Figure 1: Greenhouse gas emissions in households, including personal vehicles, residential energy consumption, and industrial energy consumption associated with delivering fuels to households.

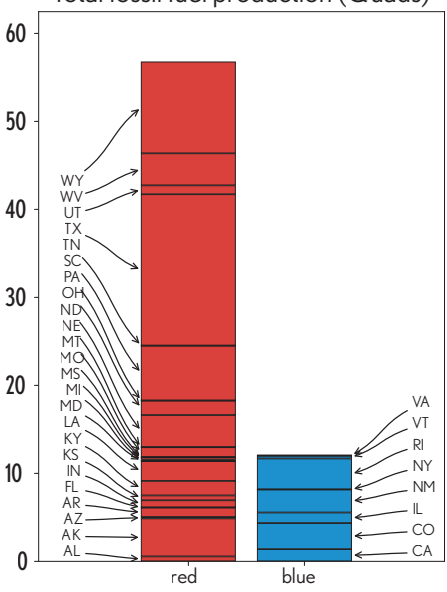


All U.S. Fossil Production, 2015 by 2016 election preference

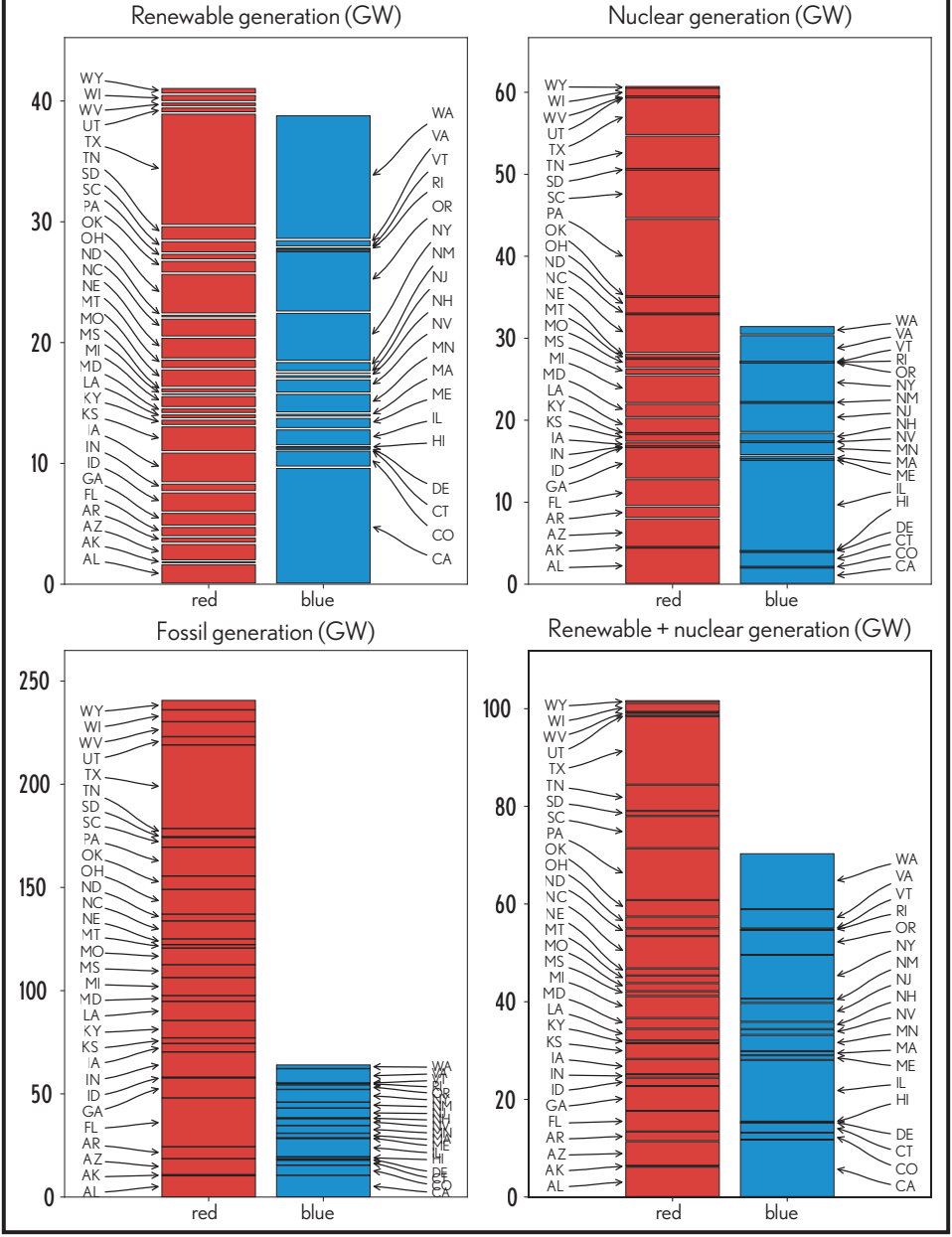








All U.S. electricity generation, 2018 by 2016 election preference



U.S. land area (million square miles) by 2016 electoral preference