Zero Carbon® Home

Zero Carbon, Zero Bills

How to cut your home's carbon footprint, heating bill and electricity bill to zero

By someone who has done it: David Green

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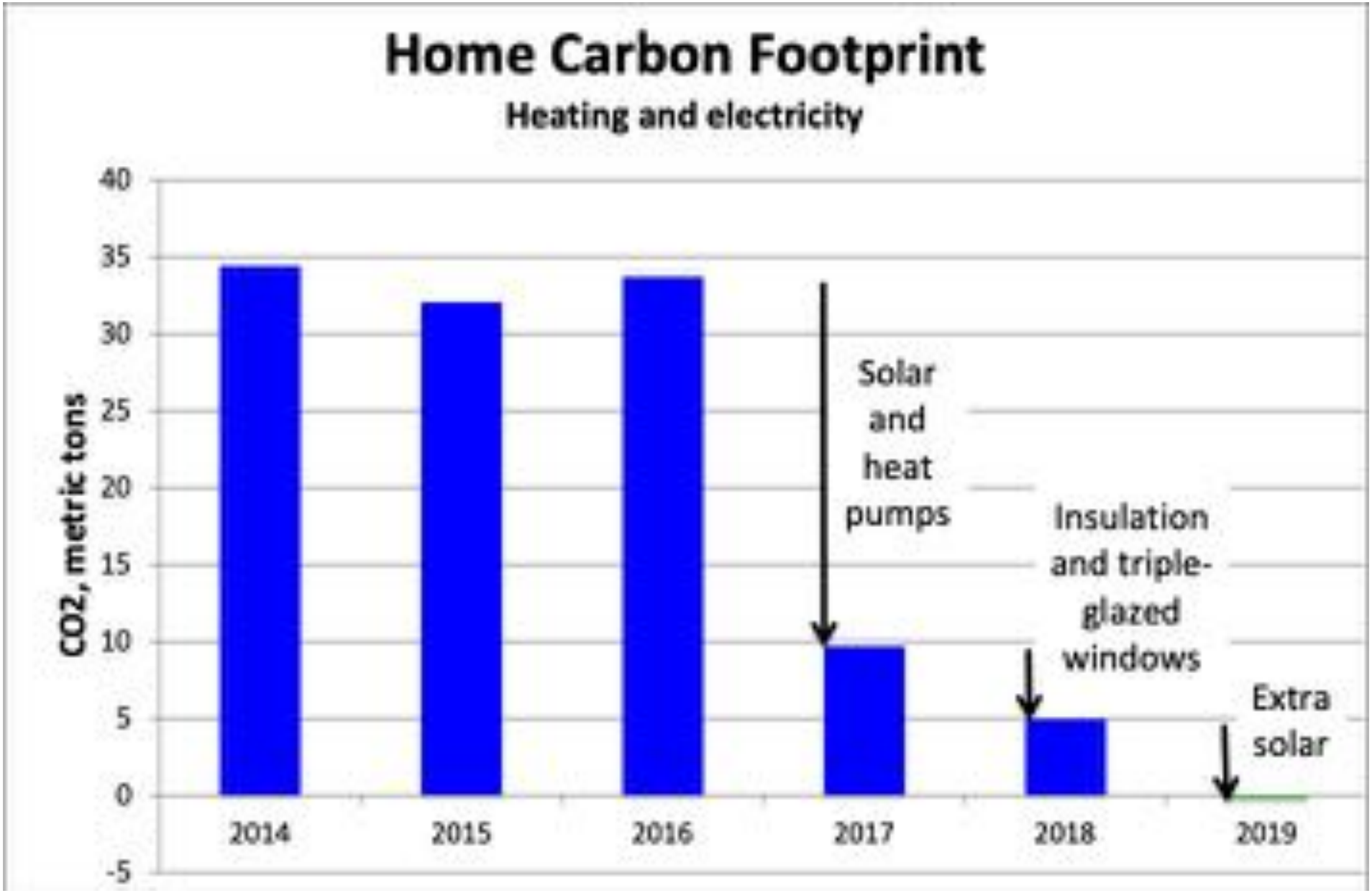

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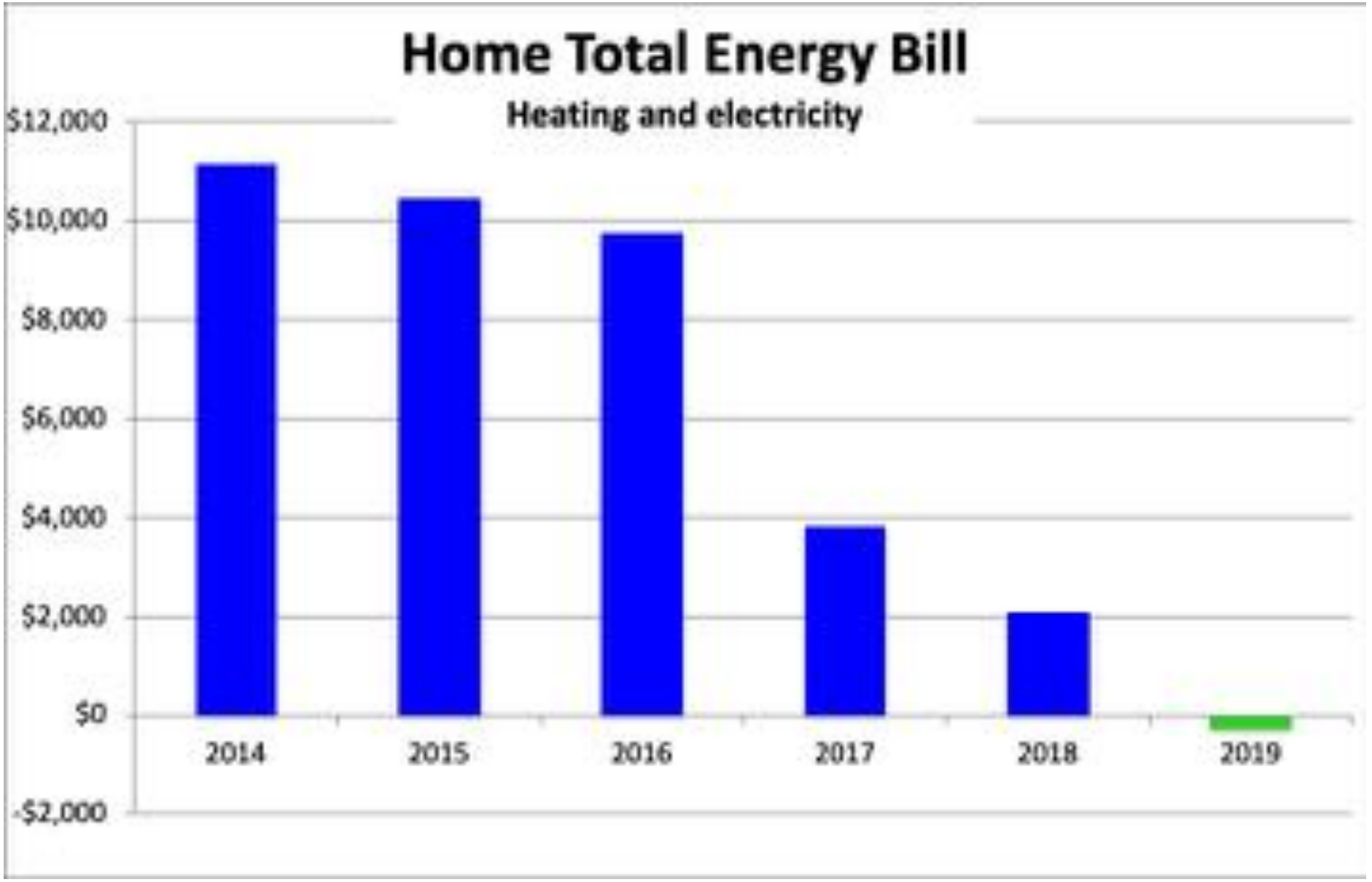

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About the author, David Green:

- *Holds a degree in physics from Oxford University (with honors)*
- *And an MBA from Harvard Business School (with distinction)*
- *Founded, and was CEO of, two biotechnology companies: Harvard Bioscience™ and BioStage™. He took both companies public.*
- *While at home recovering from a 2014 road accident he did the research on cutting his family's carbon footprint.*
- *His house and pool now have a zero-carbon footprints.*
- *He is saving over $11,000 a year on house bills and $3,000 on the pool*
- *He is the author of Zero Carbon® Home and Zero Carbon® Pool*
- *He does not work for, or get paid by, any supplier of equipment.*
- *He has no financial conflict of interest, other than selling the book for $25/$15. He consults to homeowners wanting to "go zero" but only gets paid on results – 1x the actual first-year energy bill savings*
- *His advice is based on his experience but neither he nor Zero Carbon LLC is giving investment, tax, legal or financial advice, nor providing any guarantee of results*
- *I'm not going to tell you to eat vegetarian, turn down your thermostat, wear a cardigan, bike to work, have fewer children or vote for Al Gore*
- *It is coincidence, or perhaps destiny, that our family name is Green.*

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Publications

- David Green's work on zero carbon houses has been publicized on global news media outlets including ABC, NBC, CBS and Fox.
- Has appeared on the front cover of Green Energy Times, in the Boston Herald and in Renewable Energy World, and
- On the websites of the U.S. Department of Energy, Zero Energy Project, Cool Effects and the Green Home Institute.

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How was the data gathered?

- Our house is a 2-story, 5,400 sf house built in 1974 with 4” cavity walls filled with fiberglass.
  - Before we “went zero”, it had no energy efficiency features
  - We live in Dover, Massachusetts with 5,800 HDD
- Each day for over 2 years I have measured the heating oil and electricity used by our home
  - I used this data to build an energy model of our home with over 80% R-squared daily. Full-year bills projected +/- 10%
  - I used the energy model to make financial projections of the changes to our home – cash-flow based NPV, IRR, payback
  - I measured the cut in energy and $ for each of the fab four
  - Similar method for our rental property and consulting clients

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Why now?

Because the technologies of insulation, heat pumps, solar panels and triple-glazed windows are now so good and the subsidies from government are so significant, you can, by following these examples, cut the carbon emissions from your home to zero, save thousands of dollars a year on heating and electricity bills, and make a good return on your investment.

We have done it.

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Fab Four

How did we cut our carbon footprint to zero? By installing the fab four:

- Heat pumps
- Insulation
- Triple-glazed windows
- Solar panels

Easy to remember the fab four because the Fab Four (The Beatles) had lots of HITS

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Fab Four

How did we go zero and make money?

- We installed the fab four
- We got all the tax breaks and subsidies

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HITS - Heat Pumps

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Results for Heat Pumps

Effect on	Impact
Carbon Footprint	Cut 47% (20 tons)
Money saved per year	$2,888
Investment (net)	$26,250
Years to pay for itself	9.1
Return on investment	9% (after tax)

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Our heat pumps replaced our AC units, but both heat and cool the house

Heat pumps heat with 4x the efficiency of a furnace or boiler and cool with the same efficiency as an AC unit

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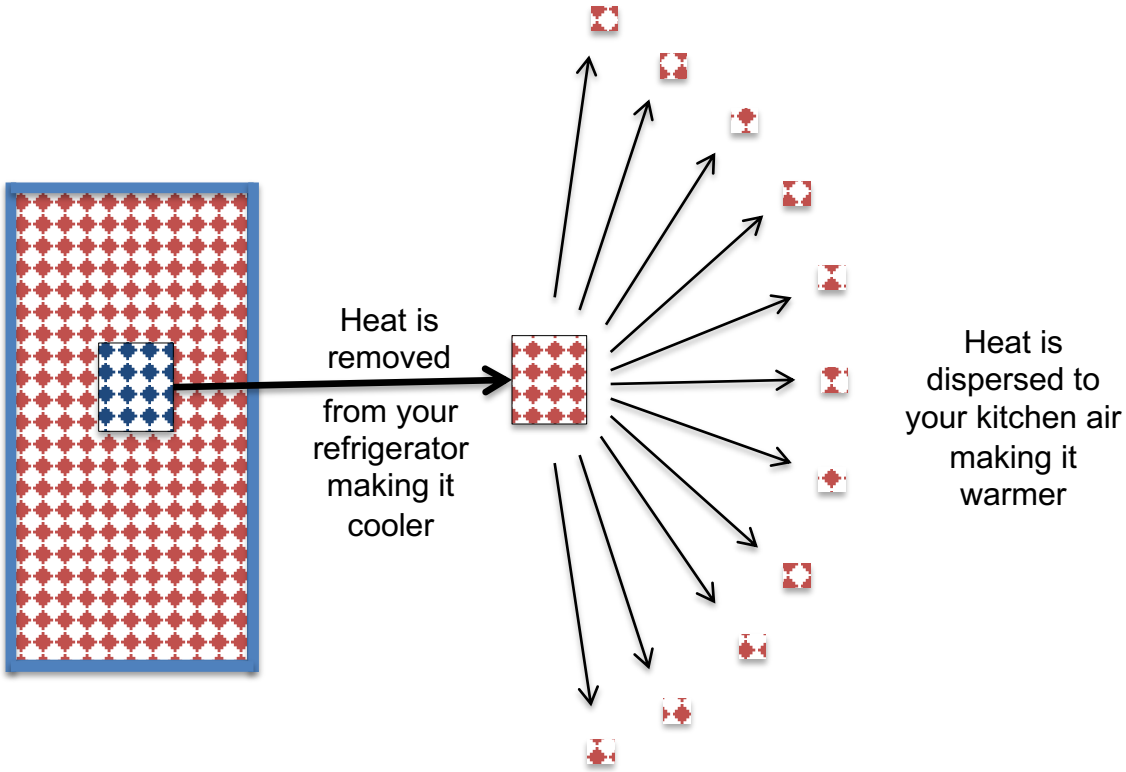
A heat pump cools your refrigerator by pumping the heat into the kitchen



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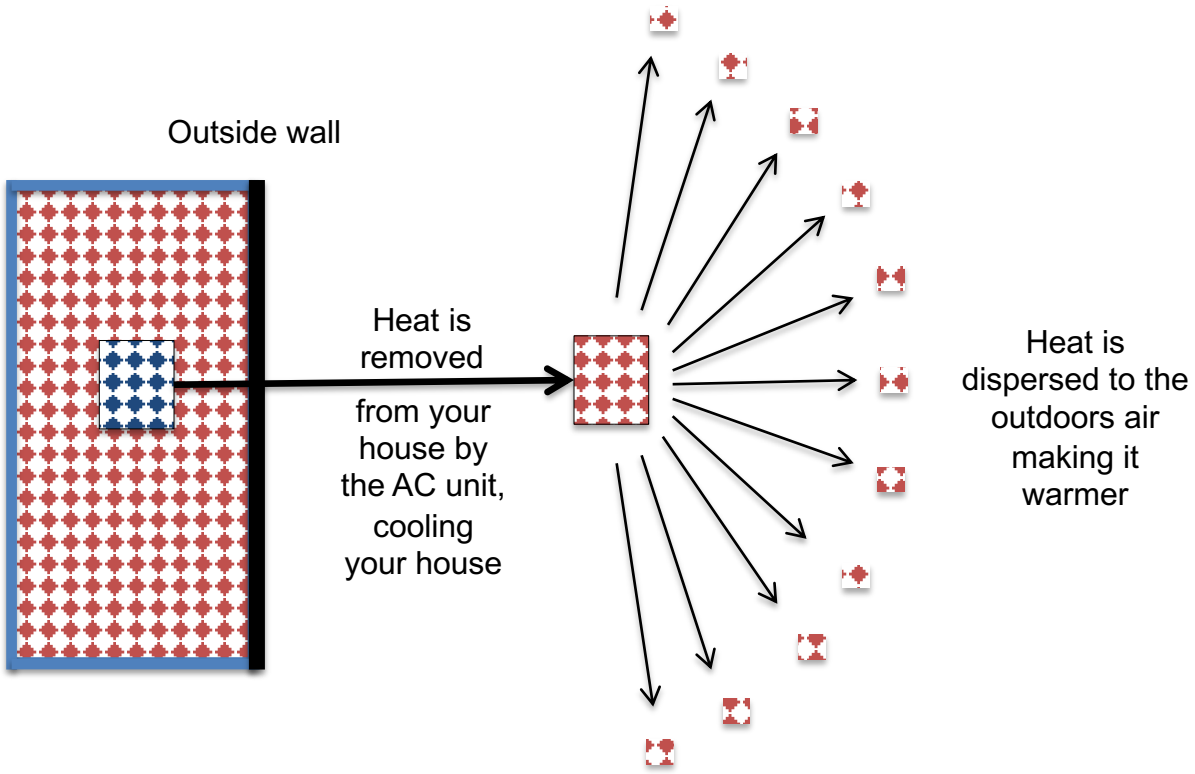
A heat pump cools your house in summer by pumping heat to the outside air



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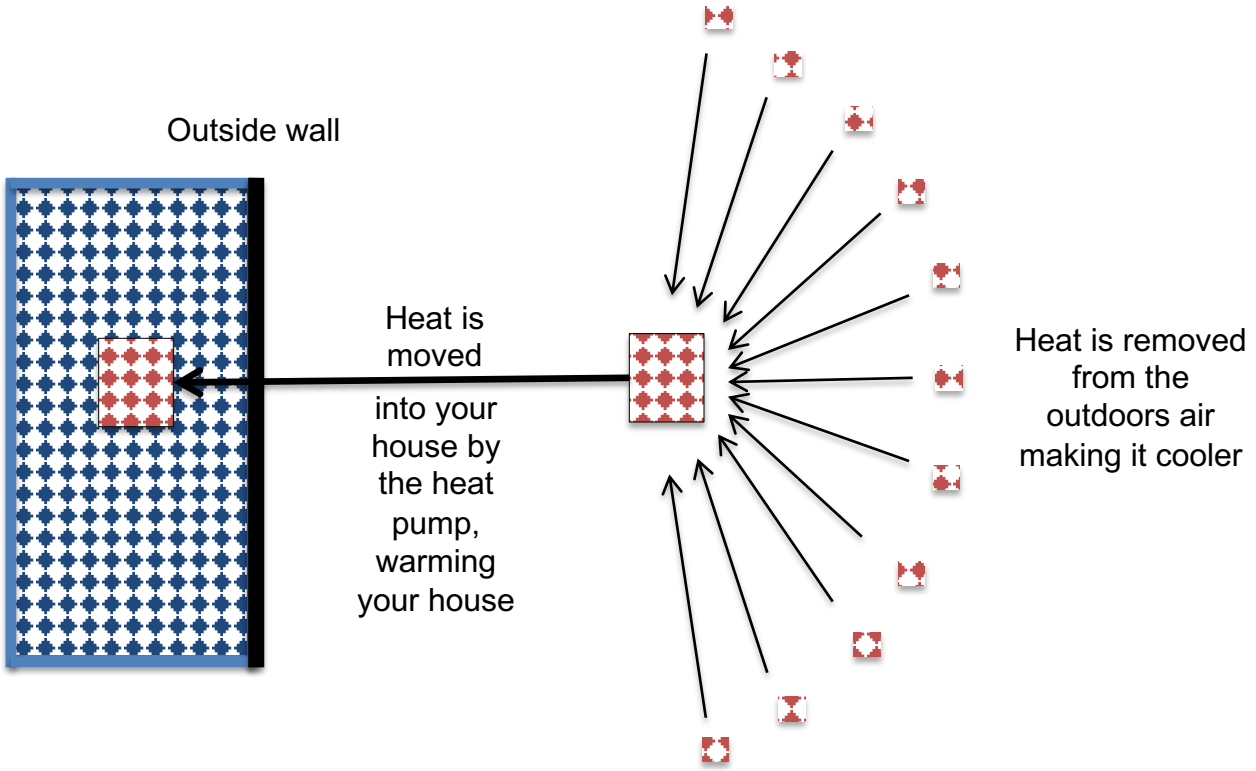
A heat pump warms your house in winter by pumping heat inside



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Heat pumps make the outside air even colder in winter

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Wall or Ceiling-Mounted Heat Pumps

(Aka Ductless Mini-Split Heat Pumps)

Outdoor
condenser unit

Indoor
ceiling-mounted unit

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HITS - Heat Pumps

- For details on which heat pumps we bought and why, the subsidies available and the zero-interest loan financing available please see Chapter 2 in Zero Carbon® Home
- I do not recommend geothermal (ground-sourced) heat pumps. They will cut your carbon footprint but they are far too expensive compared to air-sourced heat pumps
- Leave your furnace in place
- Any questions so far?

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HITS - Insulation

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Results for Insulation

Effect on	Impact
Carbon Footprint	Cut 16% (7 tons)
Money saved per year	$2,923
Investment (net)	$1,000
Years to pay for itself	0.3
Return on investment	100% (after tax)

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Insulation – three types

Blown in cellulose –
R3 per inch

Fiberglass –
R3 per inch

Sprayfoam –
R5 per inch

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Insulation: what we did

Our flat roof

10” fiberglass plus 4” ISO board – R50 total

Our basement ceiling

12” fiberglass – R38 total

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Insulation - MassSave

MassSave will pay 75% of the cost of insulation up to $2,000

Insulation is the lowest hanging ripest fruit in the garden. Pick it!

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HITS - Insulation

- For details on which type of insulation to put where in your house, occasions to insulate walls opportunistically, how much of it to install and where to get the subsidies see Chapter 1 in Zero Carbon® Home. Or www.dsireusa.org
- I do not recommend you take off your siding, thicken the walls with insulation and replace your siding. It will cut your carbon footprint but it is far too expensive compared to insulating your roof and basement.
- Any questions on insulation?

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HITS - Triple-Glazed Windows

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Results for Triple-Glazed Windows

Effect on	Impact
Carbon Footprint	Cut 5% (2 tons)
Money saved per year	$974
Investment (net)	$4,500
Years to pay for itself	4.6
Return on investment	19% (after tax)

Note: the investment and cost savings are the additional cost above that for double-glazed equivalents. I only recommend you install triple-glazed windows when you are replacing your windows for other reasons like they are rotting or leaking. Replacing windows, any windows, will not usually pay for themselves from the utility bill savings. Unless you use “fit-from-the-inside” triple-glazed windows.

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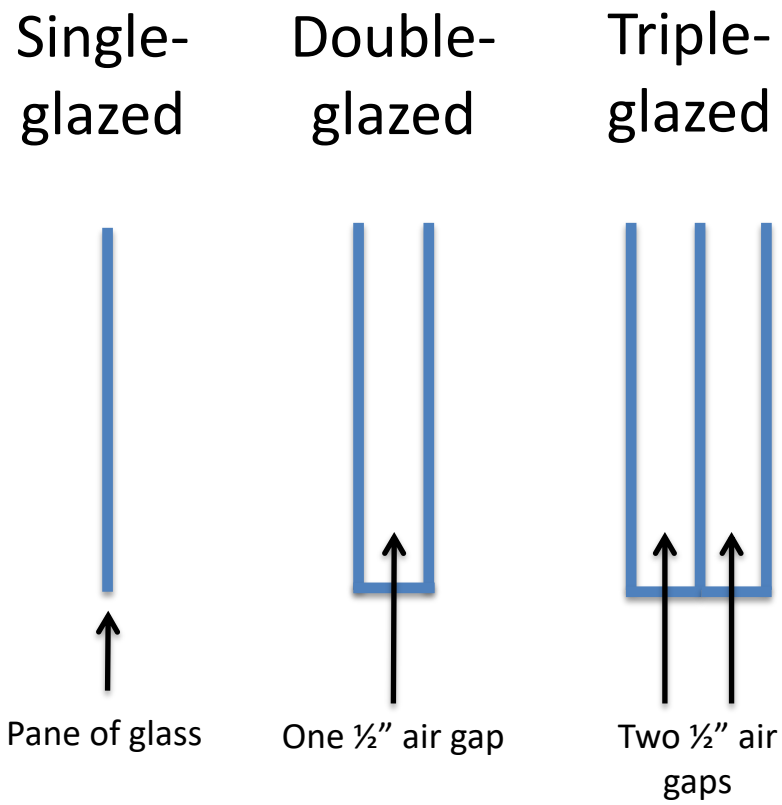
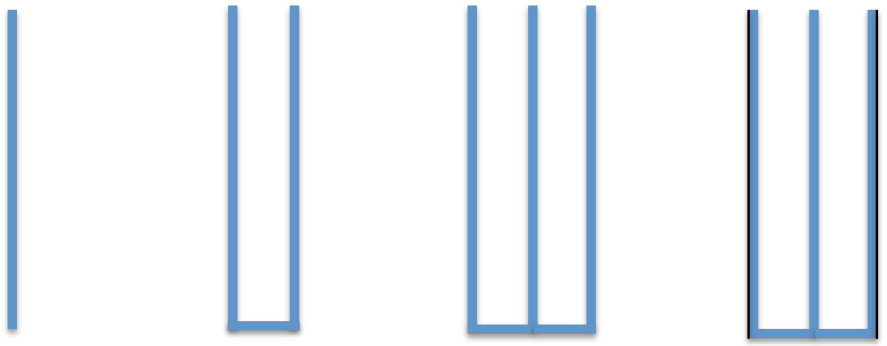
What is a Triple-Glazed Window?



It is the air that insulates, not the glass

A double-glazed window plus a storm is not a triple-glazed window!

Triple-Glazed Low-E Windows



Single-glazed R0.75

Double-glazed R 2

Triple-glazed R 3.3

Triple-glazed low-E R 4-6

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Triple-Glazed Windows – It's the Two Layers of Air That Insulate

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Plus those low-E coatings
that are a bit like an emergency space blanket

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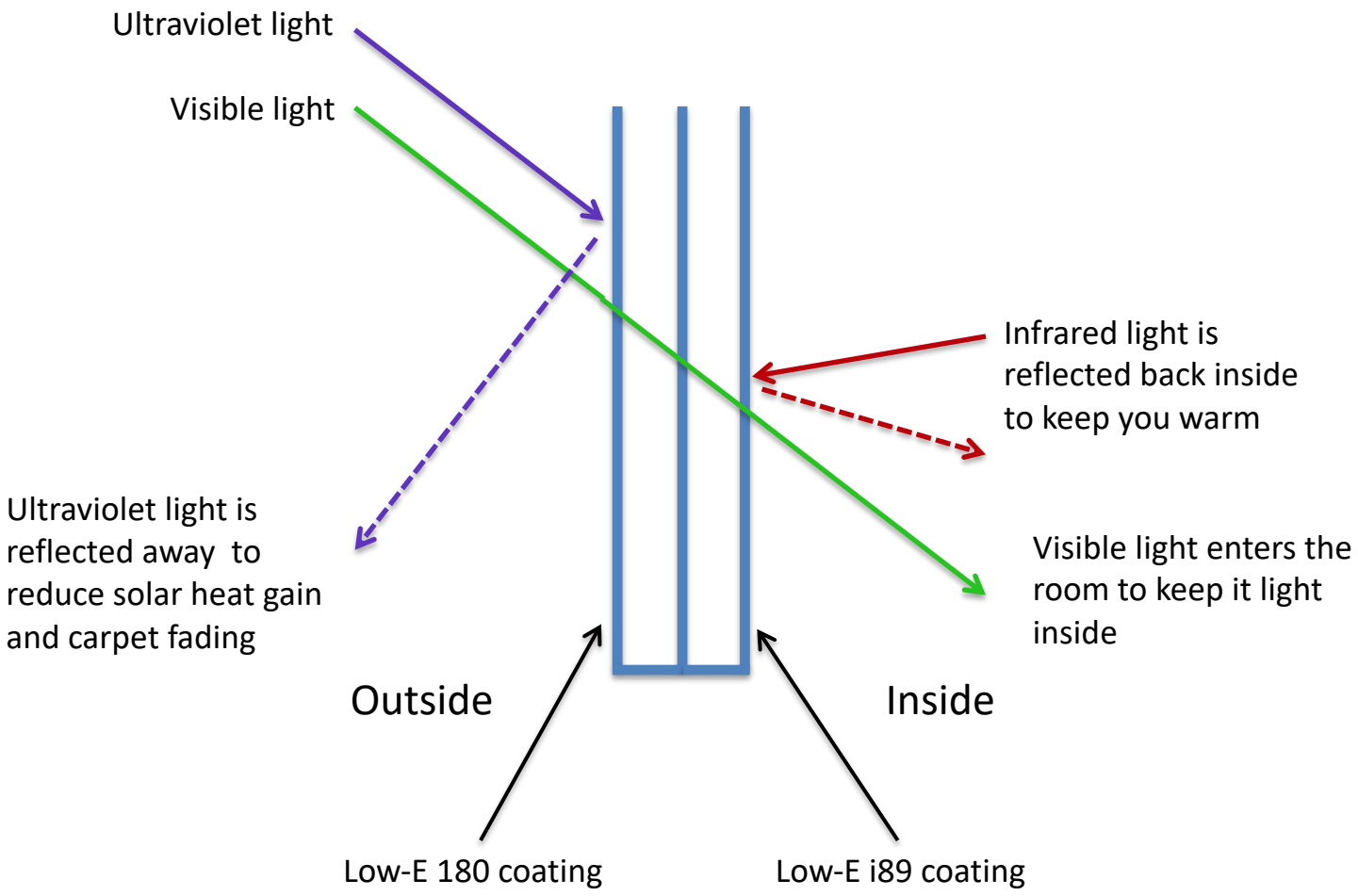
How Do Triple-Glazed Windows Work?



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HITS - Triple-Glazed Windows

Our 1970's double-glazed, metal framed windows with the gaps sealed with duct tape

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HITS - Triple-Glazed Windows

In addition to cutting our carbon footprint and saving us money, our new wood-framed, triple-glazed windows have transformed the look and feel of our house – and we can see the garden!

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Low cost triple-glazed windows – “fit-from-the-inside” window inserts

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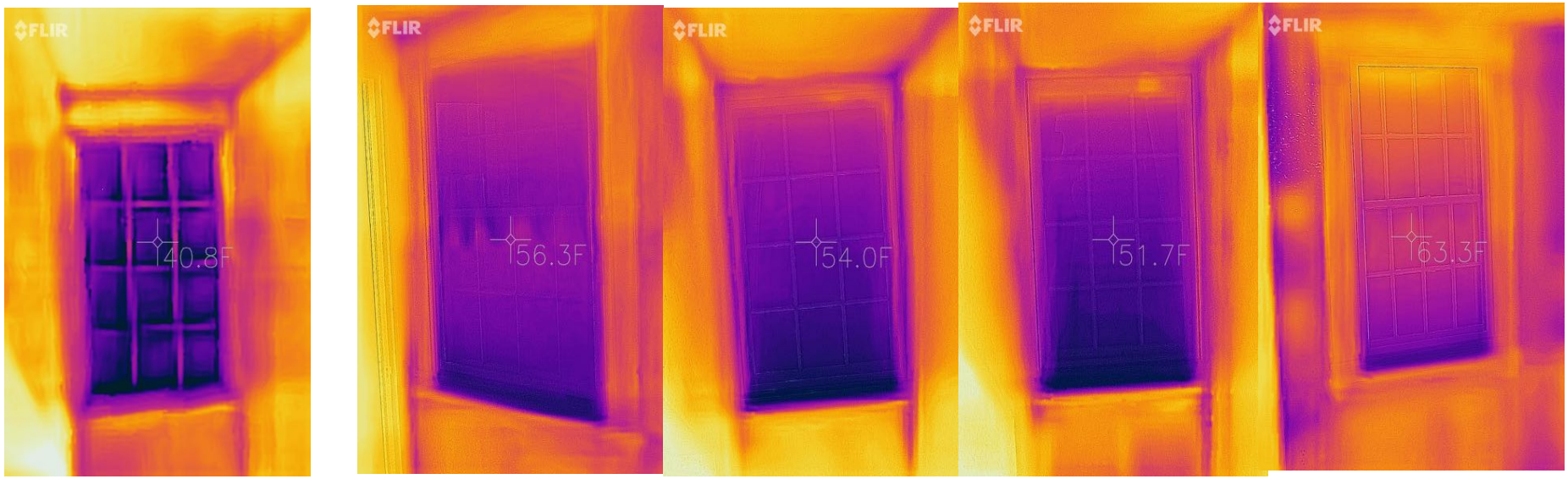
Window Inserts - Evaluation of R Value



Control - single pane

Alpina R1.4

Indow R0.8

Window Inserts R0.7

Innerglass R1.9

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Window Inserts - Payback

		Saving per R value per year	Savings per year from insert	Insert price delivered	Payback (years)	Insert price without delivery	Payback (years)
Alpina adds	1.4 R value	$21	$30.42	$163	5.4	$163	5.4
Indow adds	0.8 R value	$21	$16.47	$289	17.5	$289	17.5
Window Inserts adds	0.7 R value	$21	$14.42	$110	7.6	$75	5.2
Innerglass adds	1.9 R value	$21	$39.33	$431	11.0	$181	4.6

My personal preference among them is the Innerglass one:

- it has the highest R-value,
- it is reasonably priced
- I prefer the look of glass to that of clear plastic sheets.
- the glass is also easy to break in an emergency,
- no thick rubber gasket around the edge because its edges are spring loaded and you hold them in while fitting it.

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HITS - Triple-Glazed Windows

For details on how to:

- Shop for triple-glazed windows;
- Which types of glass I recommend for which locations;
- How to get zero-interest loans to purchase them. If not in MA visit www.dsireusa.org
- I do not recommend the stretchy film

Please see Chapter 4 in Zero Carbon® Home

Any questions on triple-glazed windows?

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HITS - Solar Panels

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Results for Solar Panels

Effect on	Impact
Carbon Footprint	Cut 32% (14 tons)
Money saved per year	$5,572
Investment (net)	$42,791
Years to pay for itself	7.2
Return on investment	13% (after tax)

In addition, the DOE/Appraisal Journal estimates (based on analysis of 49,000 houses with Census Bureau data over 5 years) that our house value has increased by $111,000 from installing the solar panels. PVValue/DCF estimate is $105,000. That is more than double our net investment in solar panels and more than our net investment in all the fab four.

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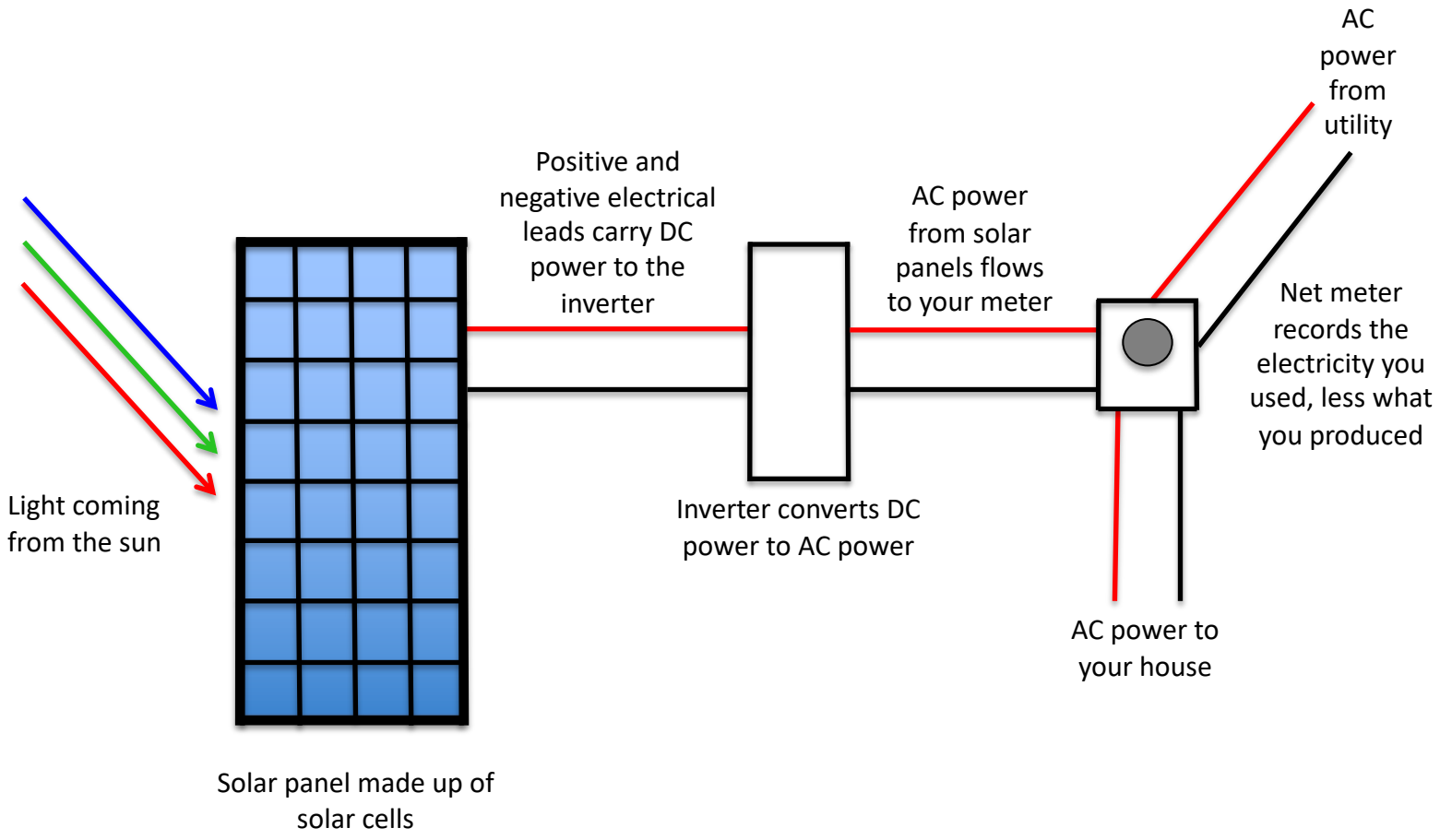
How solar panels work



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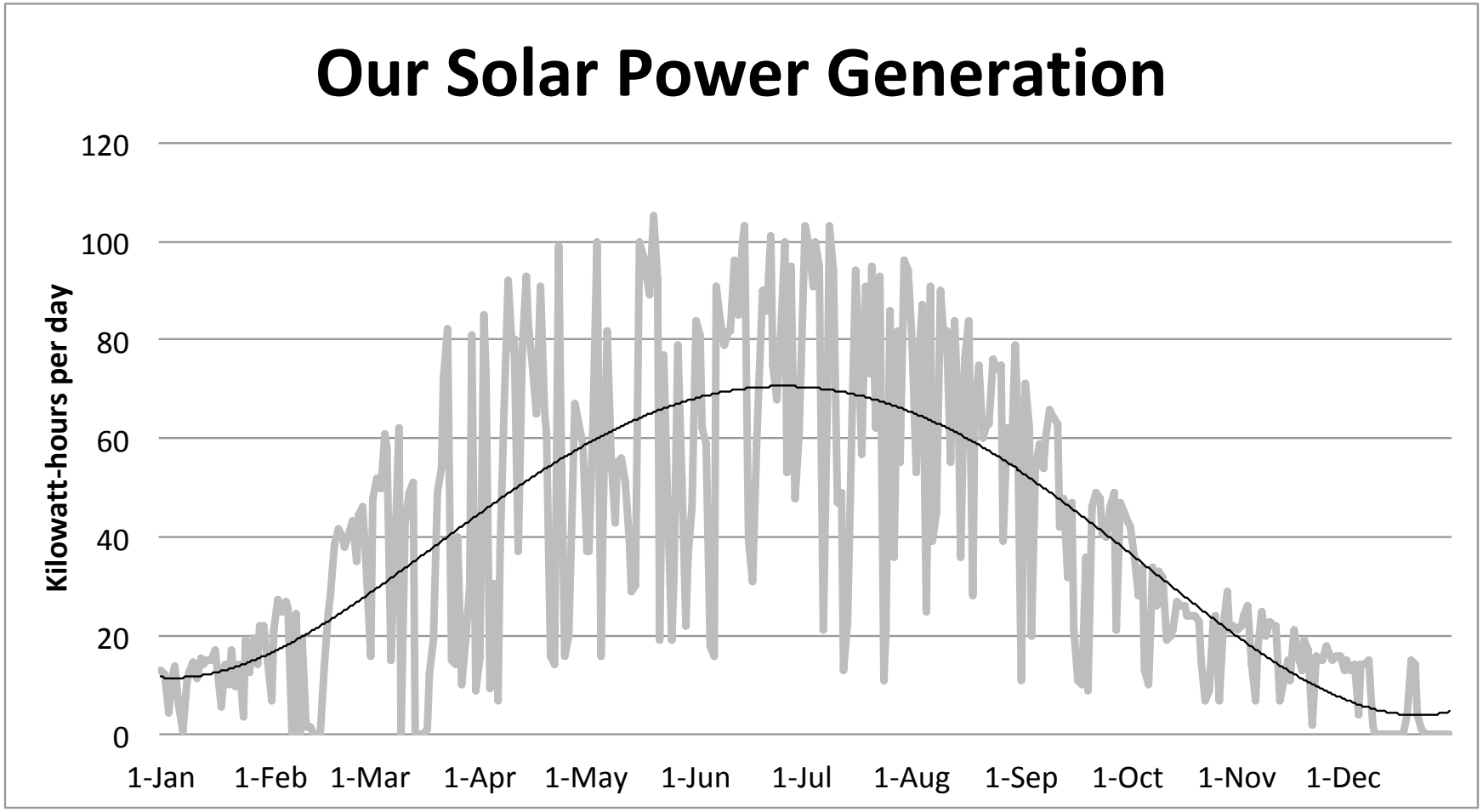
Solar power and net-metering – you will never be without power



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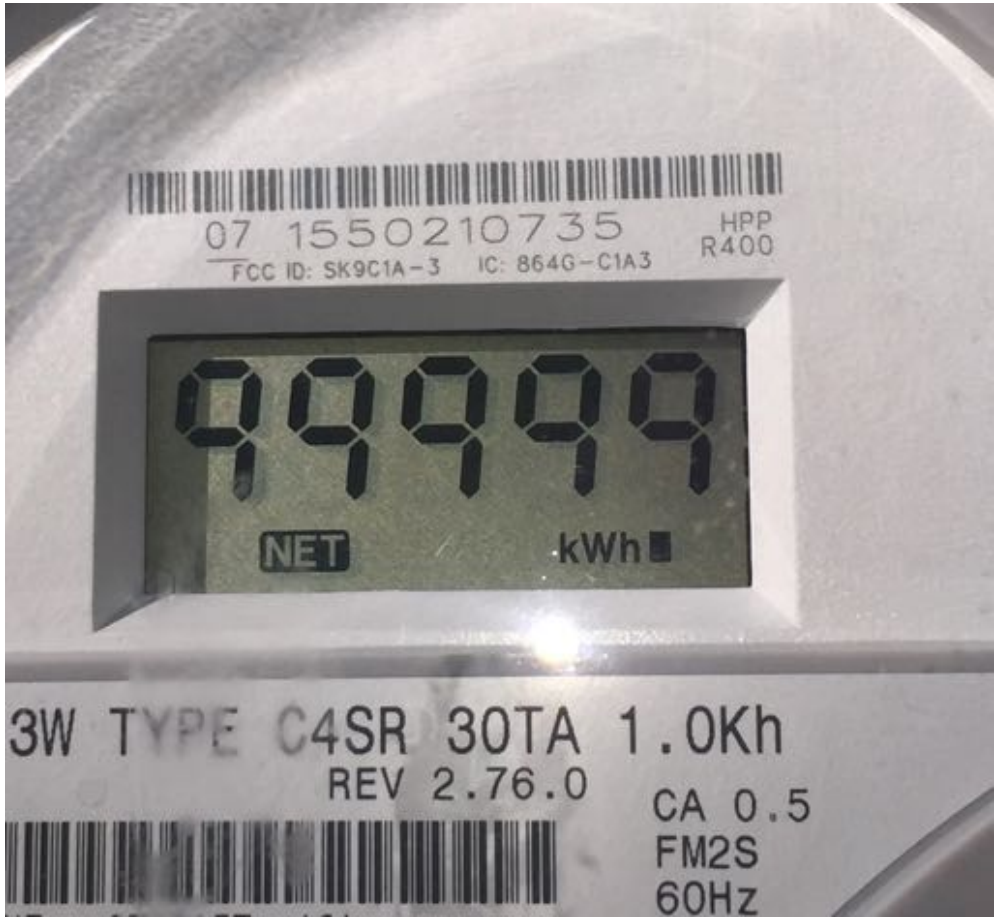
Our net meter on day one



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Gross and Net Cost of our 15.6kW Solar Panels (Dec. 2016)

Gross cost	$76,000
Federal tax credit	-$22,800
MA tax credit	-$1,000
Present value of MA SREC income	-$29,000
Net cost	$23,200
Cost per kWh	7c (ES 24c)
NPV	$23,000
IRR	12%
Breakeven	8 years

In addition the DOE estimates our house price has increased $71,000

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Gross and Net Cost of our 17.6kW Solar Panels (Mar. 2017)

Gross cost	$56,000
Federal tax credit	-$16,900
MA tax credit	-$1,000
Present value of MA SREC income	-$23,800
Net cost	$14,300
Cost per kWh	5c (ES 24c)
NPV	$29,000
IRR	14%
Breakeven	7 years

Recent bidding (under SMART) for one of my clients was 4-6c per kWh. What was good value in 2016 is even better value in 2020, despite increasing tariffs and declining subsidies!

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“Proper” Financial Evaluation of Solar Panels December 2016

	32x Certainteed 285W panel from Amergy	32x Sunpower 335W panel from Amergy	34x Sunpower 360W panel from NE Clean Energy	46x Sunpower 345W panel from NE Clean Energy	49x LG 315W Neon from MA Renewables
Financials					
25 yr. NPV @ 3% discount rate	$14,239	$15,878	$15,304	$38,437	$34,449
IRR	10%	9%	7%	12%	14%
Breakeven	9 years	9 years	10 years	8 years	7 years
Cost per kWh (after subsidies)	$0.07	$0.07	$0.10	$0.07	$0.03
Warranties (years)					
workmanship on installation	N/A	N/A	20	20	20
panel power production	N/A	N/A	25	25	20
panel workmanship	N/A	N/A			20
inverter	N/A	N/A	25	25	25
roof protection	N/A	N/A	20	20	20

Or use the EnergySage web site run by the DOE which compares bids for you

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Our first solar panel array

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HITS - Solar Panels

For details on how to:

- Perform the detailed technical and financial evaluation of both solar panel manufacturers and installers;
- Evaluate lease/loan/cash purchase options;
- Obtain subsidies and low-interest financing options. If not in MA visit www.dsireusa.org
- I do not recommend solar hot-water panels

Please see Chapter 4 in Zero Carbon® Home

Any questions on solar panels?

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The fab four – putting it all together

"All together now…"

from Yellow Submarine by the real Fab Four

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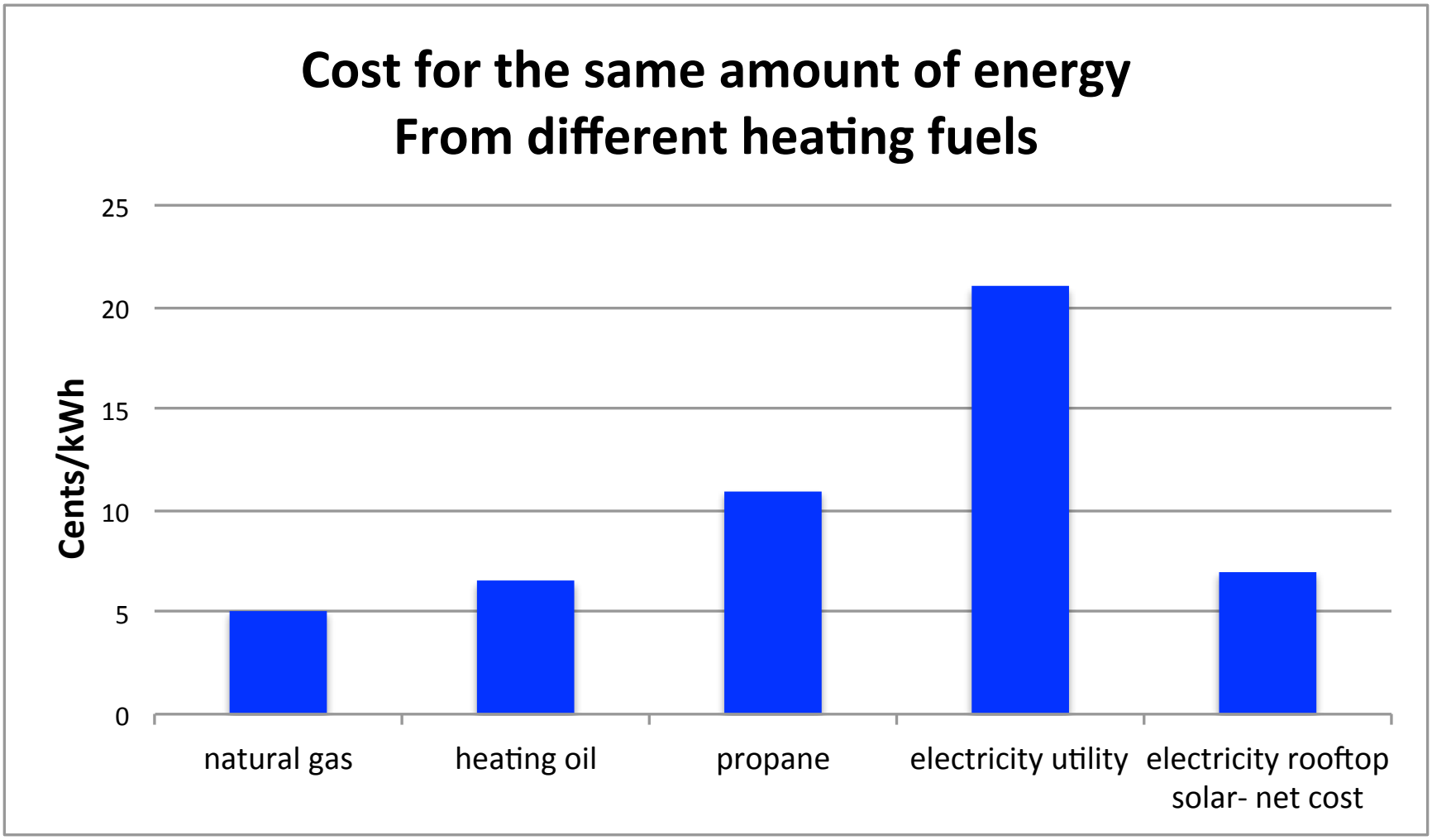

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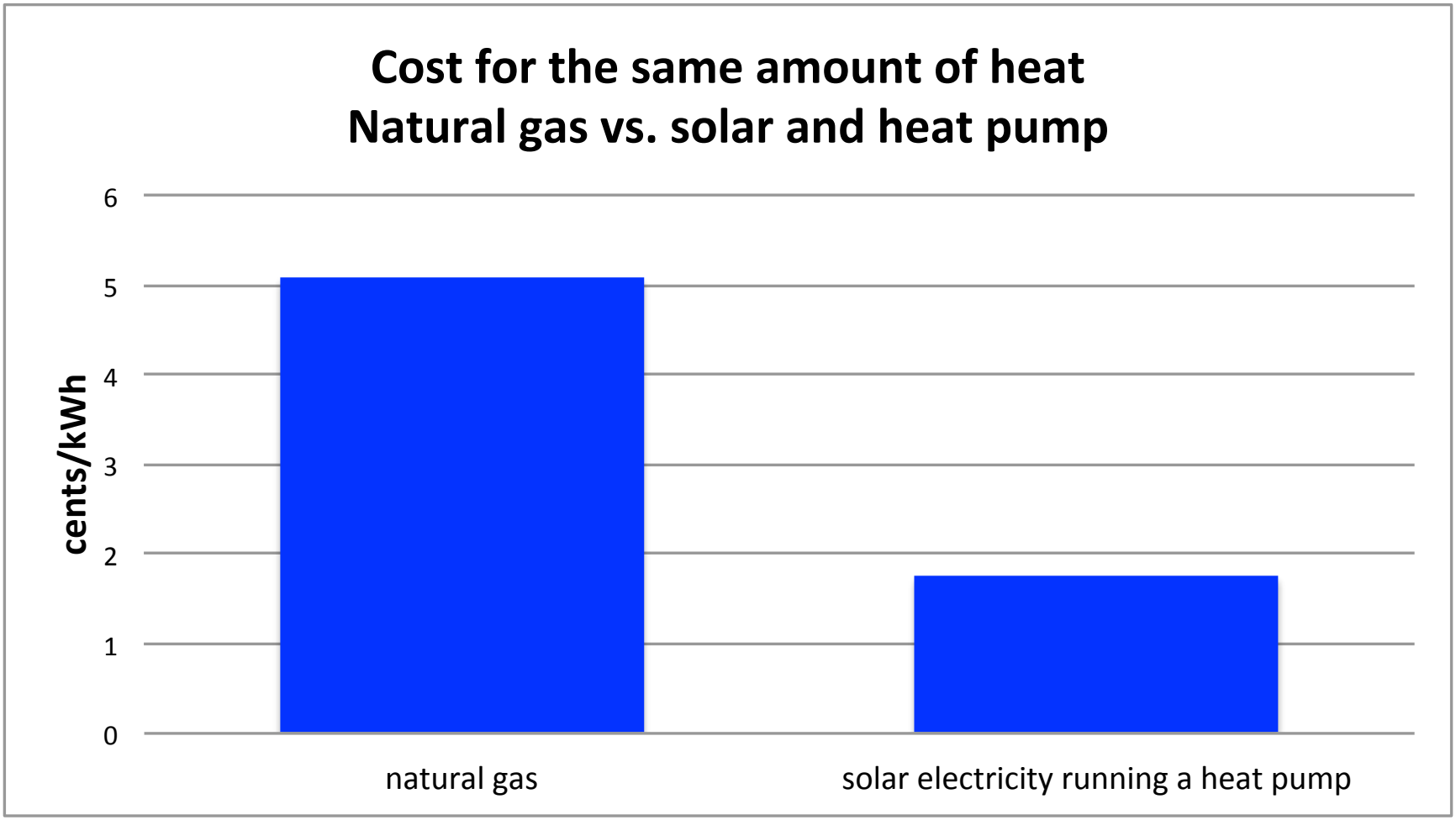

This is how we now heat our house – solar running heat pumps.
This is now the cheapest way to heat your house.

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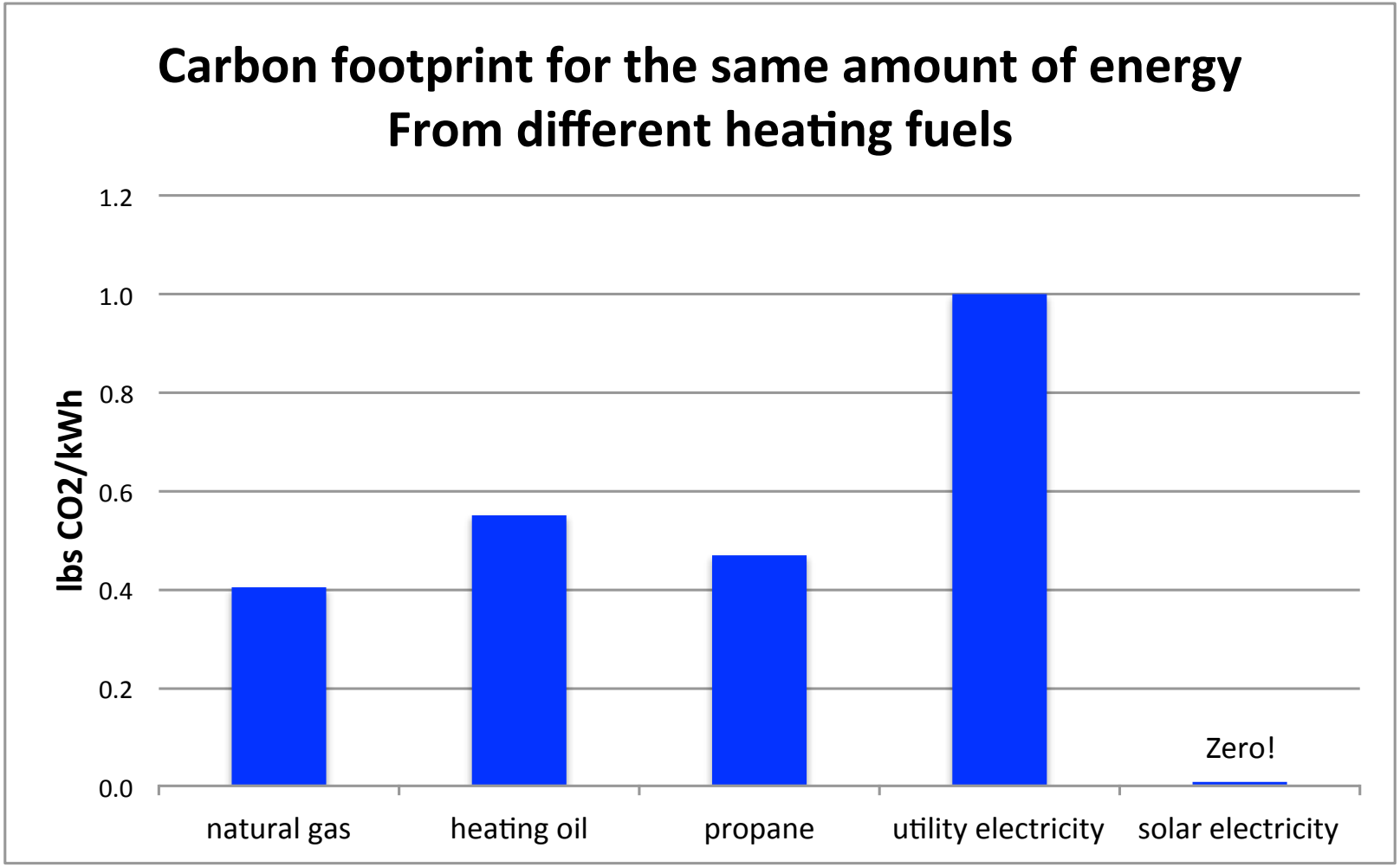

Solar running a heat pump is the cheapest way to heat your house AND it has a zero carbon footprint!

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The key to going zero

- Cut your house's energy use so much you can generate it all from solar panels on your roof
  - Cut it with insulation
  - Cut it with triple-glazed windows
  - Cut it with heat pumps
  - Generate it with solar panels

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Fab Four Summary

	Total money saved (per year)	Total carbon footprint reduction (CO_2 per year)
Heat pumps	$2,888	20 Tons
Insulation	$2,923	7 Tons
Solar panels	$5,572	14 Tons
Triple-glazed windows	$974	2 Tons
Total	$12,358	43 Tons

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Fab Four Financial Summary

	Total money invested (after subsidies and tax credits)	Years to pay for itself	Return on Investment (after tax)
Heat pumps	$26,250	9.1	9%
Insulation	$1,000	0.3	100%
Solar panels	$42,791	7.2	13%
Triple-glazed windows	$4,500	4.6	19%
Total	$74,541	5.9	15%

Based on the Appraisal Journal analysis of 49,000 houses in the USA this total utility bill saving has increased the price of our house by $250,000 (about 14%) or over 3x what we paid for the fab four after tax credits and subsidies

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Next steps

- If you are convinced that installing the fab four will dramatically cut your home's carbon footprint and will save you lots of money then please go ahead and share your story with me at dgreen@greenzerocarbon.com
- If you are intrigued but need more time and more details to decide what is best for you then please read Zero Carbon® Home at www.greenzerocarbonhome.com
- To get the free book, order the e-book from my website, apply the coupon MIPL at checkout
  - This is free and has a zero carbon footprint

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