1 Energy is everything. Nothing is accomplished without it.

2 Civilization is 90-95 percent reliant on a limited supply of fossil energy.

3 Every year the civilized consume as much fossilized bioenergy as is contained in all the forests covering the fifty United States.

4 At our current rate of energy consumption there are less than 100 years of remaining proved fossil reserves. New discoveries are declining and harder to access. When supplies are falling, without new extraction technologies, an increasing amount of energy is needed to extract the energy. New technology requires growth. Growth requires growing resources. The planet is limited.

5 If an animal continues to expend more energy gathering food than is contained in the food, it will soon die. When energy *out* exceeds energy *in*, a system loses energy.

6 The U.S. military budget is greater than the U.S. oil budget. When war is added to the cost of oil and gas extraction we may already consume more energy to retrieve these fuels, refine them, and deliver them than the energy contained in the fuel.

7 'Renewable energy' does not mean sustainably acquired energy. 'Renewable energy' only means that the energy capture rate is lower than the replenishment rate of an essentially inexhaustible energy source, i.e. the sun.

8 Current high-tech renewables are incapable of sustaining civilization. Civilization has relied on an endless growth strategy from the start. No energy source can sustain endless growth.

9 Solar module makers do not power the construction of their products with their own products possibly because their products are not sustainable.

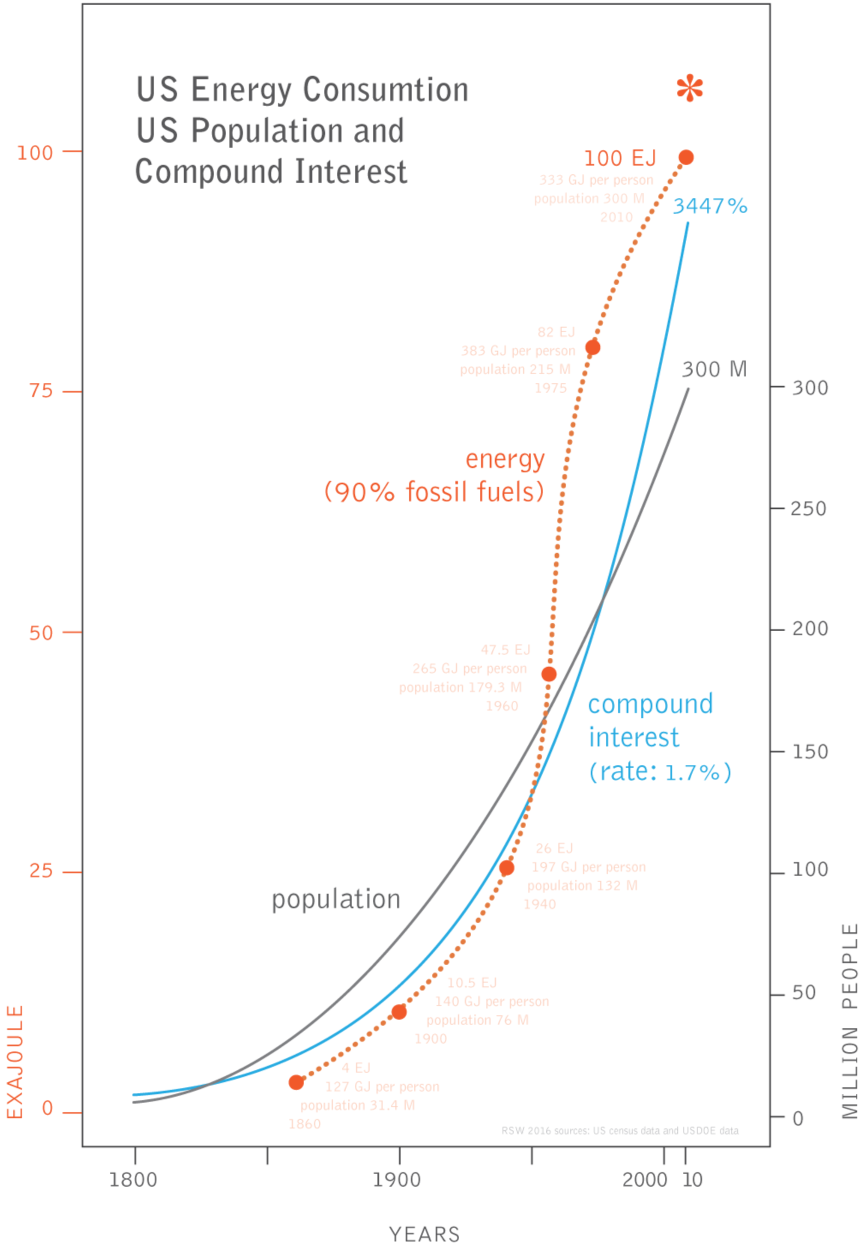
10 In an all electric future, synthetic graphite electrodes for melting steel and glass will have to come from vegetable matter—requiring an equivalent or more than current yields of certain agricultural crops.

11 Nukes are not the new 'green.' They are useful but dangerous. All nuclear power plants are permitted to emit limited amounts of dispersible radiocative material that accumulate in our immediate environment and continue to be dangerous for thousands of years.

12 Human ignorance about sexual reproduction is the pride of both theocrats and industrialists. Growing congregations and markets make them both rich.

13 Nuclear fusion cannot solve human reproduction and deforestation issues.

R S Wilson 2016 (ed 2019.06.19)

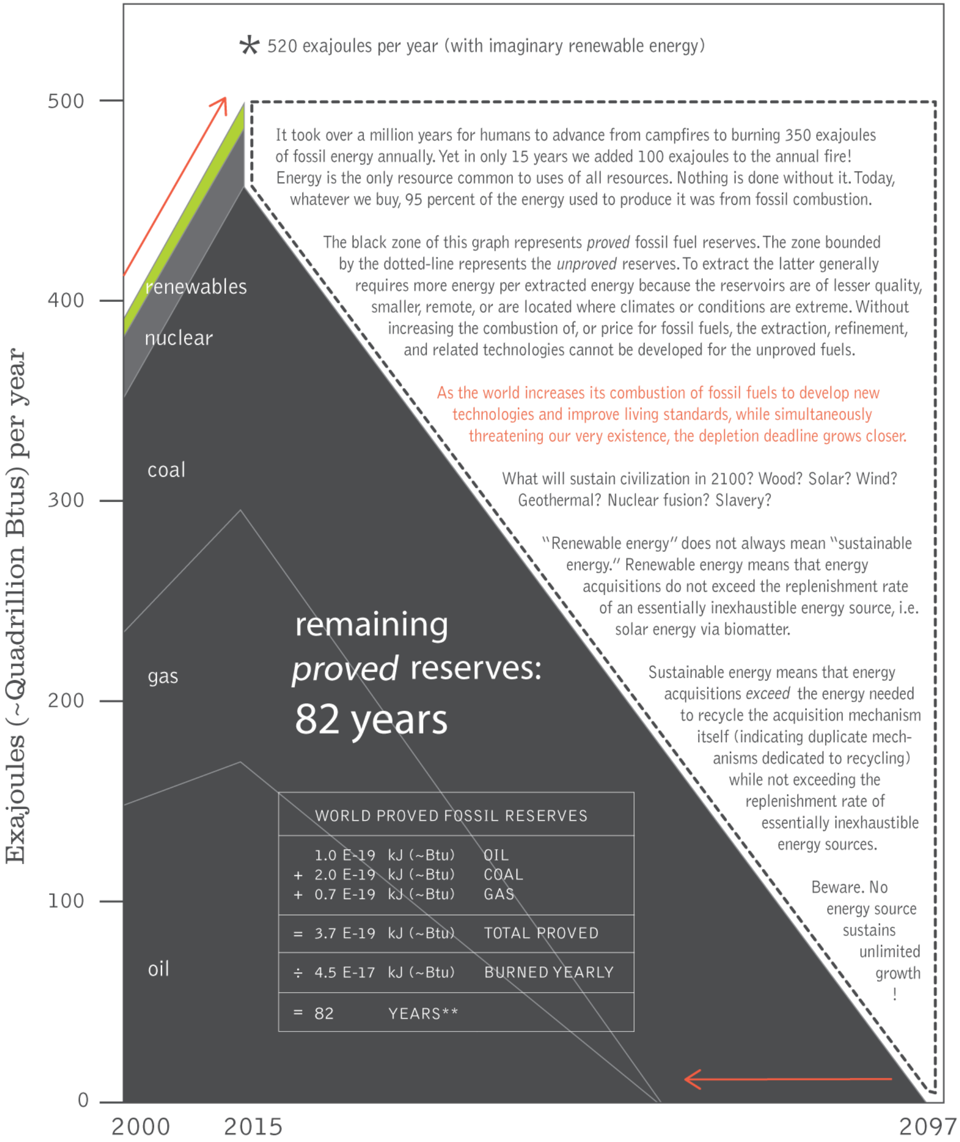


US Energy Consumtion
US Population and
Compound Interest

RSW 2016 sources: US census data and USDOE data

* US purchasing power on approximately 2 trillion of imports with higher energy-per-dollar ratios will set real US energy consumption higher.

World's Annual Consumption of Proved Fossil Fuel Reserves (exajoules/year & years)



* 520 exajoules per year (with imaginary renewable energy)

It took over a million years for humans to advance from campfires to burning 350 exajoules of fossil energy annually. Yet in only 15 years we added 100 exajoules to the annual fire! Energy is the only resource common to uses of all resources. Nothing is done without it. Today, whatever we buy, 95 percent of the energy used to produce it was from fossil combustion.

The black zone of this graph represents *proved* fossil fuel reserves. The zone bounded by the dotted-line represents the *unproved* reserves. To extract the latter generally requires more energy per extracted energy because the reservoirs are of lesser quality, smaller, remote, or are located where climates or conditions are extreme. Without increasing the combustion of, or price for fossil fuels, the extraction, refinement, and related technologies cannot be developed for the unproved fuels.

As the world increases its combustion of fossil fuels to develop new technologies and improve living standards, while simultaneously threatening our very existence, the depletion deadline grows closer.

What will sustain civilization in 2100? Wood? Solar? Wind? Geothermal? Nuclear fusion? Slavery?

"Renewable energy" does not always mean "sustainable energy." Renewable energy means that energy acquisitions do not exceed the replenishment rate of an essentially inexhaustible energy source, i.e. solar energy via biomatter.

Sustainable energy means that energy acquisitions *exceed* the energy needed to recycle the acquisition mechanism itself (indicating duplicate mechanisms dedicated to recycling) while not exceeding the replenishment rate of essentially inexhaustible energy sources.

Beware. No energy source sustains unlimited growth !

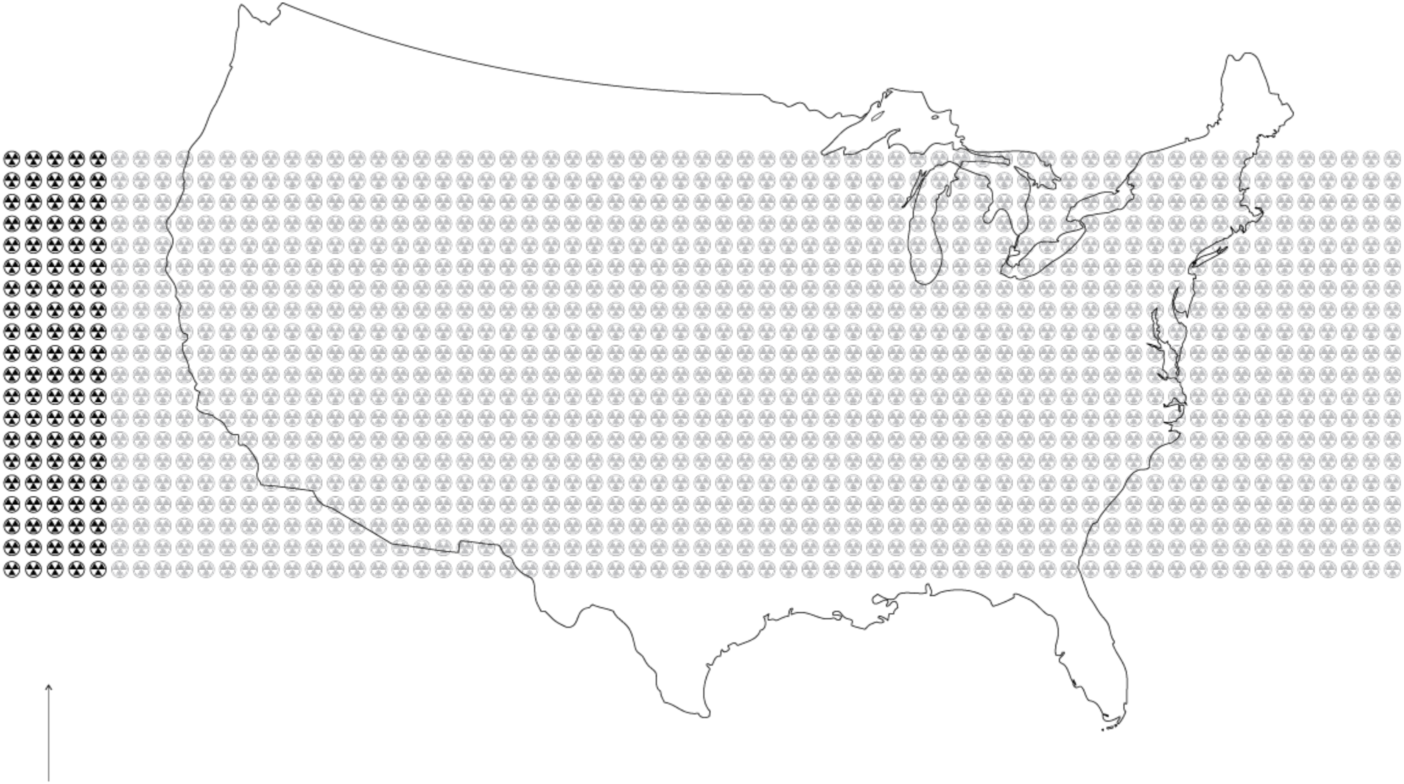
remaining *proved* reserves: 82 years

WORLD PROVED FOSSIL RESERVES

	1.0 E-19	kJ (~Btu)	OIL
+	2.0 E-19	kJ (~Btu)	COAL
+	0.7 E-19	kJ (~Btu)	GAS
=	3.7 E-19	kJ (~Btu)	TOTAL PROVED
÷	4.5 E-17	kJ (~Btu)	BURNED YEARLY
=	82	YEARS**	

* This graph shows captured renewable energy, not imaginary renewable energy. It corrects the U.S. Energy Information Administration and British Petroleum data that use a fossil fuel equivalent to inflate by 250% the performance of renewable energy. Because burning fuels to generate electricity wastes about 60% of the fuel as unrecovered heat, the EIA and BP make the fossil adjustment to show how much fossil energy might have been burned to generate the electricity captured by renewable systems. But such adjustments misrepresent facts, make it more difficult to see how much fossil-energy goes into the manufacture of renewable systems, and assume that other measures to reduce fossil fuel consumption are not available. (see table 1.3 EIA energy annual 2011)

**BP data suggests 69 years



2011 (104) More than 1200 nuclear power plants would be required if all U.S. energy demand was supplied by nuclear power. Don’t discount increases in accidents, legally permitted leakage of dispersible radioactive material, and health care.

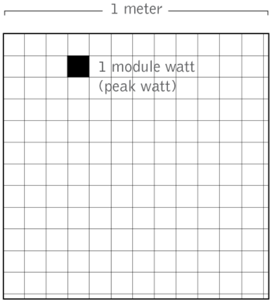
rs wilson 2014

Why doesn’t sunlight melt the desert sand?

Why doesn’t sunlight melt the windshield of a car?

Why doesn’t sunlight melt the glass and silicon of a solar module?

An automated solar module factory, operating 24 hours every day of the year, produces its modules by consuming fossil fuels and hydropower at a rate at least one billion times greater than what the modules themselves can generate without energy storage. An annual average of 6 hours peak sunlight per day, with storage, reduces the factor to ¼ billion, but does not include the energy consumed to make the means of storage and delivery (e.g. batteries and transmission lines). The 4.4 petajoules* consumed to make 1.1 billion module watts** (top right), were reported by a global manufacturer in 2016.



This diagram represents one square meter of module with 15 percent efficiency under standard test conditions. The black square represents a single module watt (peak watt; symbol Wp)—one of 150 total module watts, each occupying an area about 8 centimeters by 8 centimeters.

The average amount of sunlight striking a one square meter plane perpendicular to the sun throughout each day (tracked) in the U.S. is about 1825 kWh per year.

The standard test condition (STC) simulates bright sunlight, which is approximately 1000 watts per square meter.

The energy to manufacture one module watt:

≈ 4.4 petajoules per year*
÷ 3.6 megajoules per kilowatt hour
= 1.2 billion kilowatt hours per year
÷ 1.1 billion module watts made per year**
= 1.1 kilowatt hours to make one module watt

The rate at which the module watts are made:

≈ 1.1 billion module watts per year
÷ 31,536,000 seconds per year
= 35 module watts produced every second

The rate of energy consumed to manufacture 35 module watts per second:

≈ 4.4 petajoules per year
÷ 31,536,000 seconds per year
= 140 megawatts (per second)

Each module watt, made in 1/35 of a second, required:

≈ 140 megawatts
÷ 35 module watts per second
= 4 megawatts per module watt per 1/35 second (A)

The quantity of energy generated by a module watt:

≈ 1825 kilowatt hours annual sunlight per square meter
× 0.15 efficiency
× 0.70 after losses without solar tracking
÷ 150 module watts per square meter
= 1.28 kilowatt hours per year per module watt

The rate of energy generated by a module watt:

≈ 1.28 kilowatt hours per module watt per year
× 3.6 million watt-seconds per kilowatt hour
÷ 31,536,000 seconds per year
= 0.146 watts per module watt (B)

The ratio of electric power consumed to make a module watt (A) to the power generated by a module watt (B):

≈ 4 megawatts per module watt
÷ 0.146 watt per module watt
= 27.4 million watts to 1 watt (C)

The final ratio of manufacturing power to solar collection power must account for the fraction of a second in which each module watt is made:

≈ 27.4 million watts
× 35 module watts per second
≈ 1 billion to 1 (D)

SOLAR INCIDENCE

1373 watts per square meter
at the edge of Earth's atmosphere

45 ° latitude

Outer atmosphere incident sunlight per square meter

26.4 MJ	per day
7.3 kWh	per day
2677 kWh	per year

Ground level incident sunlight per square meter

(includes atmosphere)

U.S. maximum (with tracking)

6.8 kWh	per day
2482 kWh	per year

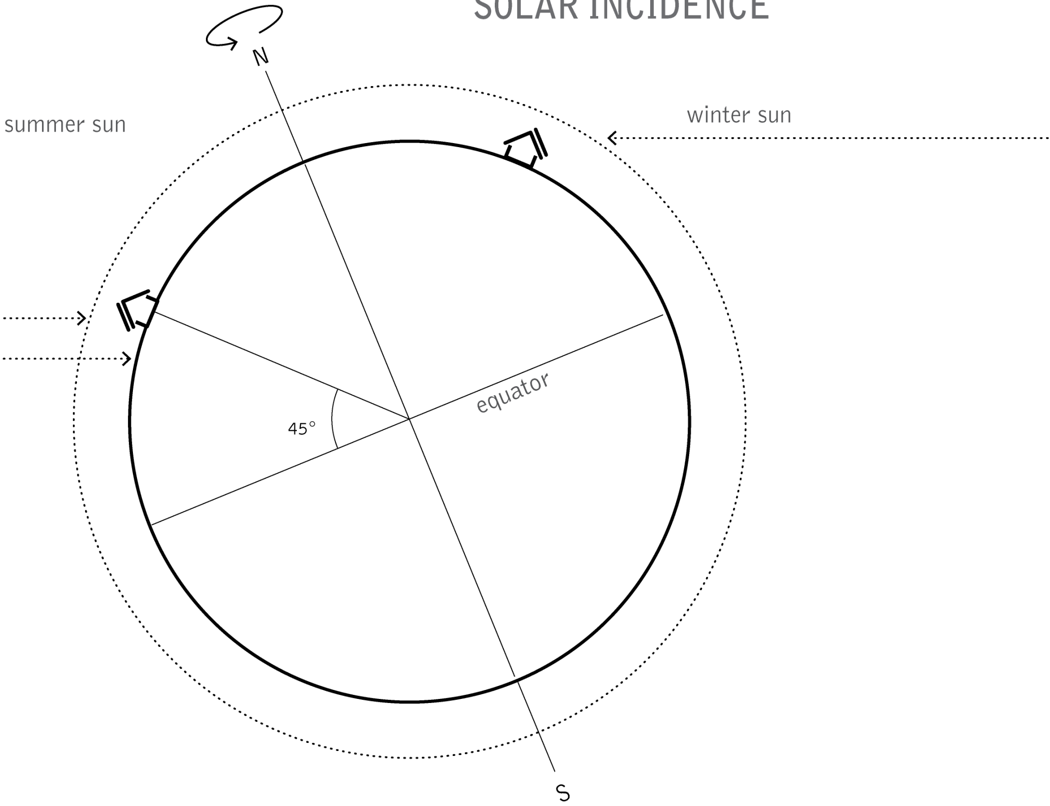
U.S. average (with tracking)

5 kWh	per day
1825 kWh	per year

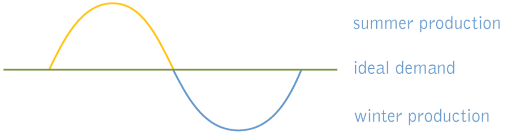
Solar module (sq. meter) 15% efficiency

(includes tracking but does not include system losses)

0.75 kWh	per day
274 kWh	per year



If excess power in summer is not stored for winter lows, two systems will be needed to fulfill demand.



RSW 2016 www.rswilson.net

A.1 ENERGY GENERATED (ROOFTOP)

≈ 21 kWh per peak watt per lifespan

system losses:
5 to 10% loss over lifetime guarantee
20 to 25% loss without solar tracking
5% loss from DC to AC grid
10% loss: (transmission 5%; voltage steps 5%)
3% loss to dust, condensation
7% loss to heat

= 110 to 137 kWh / m^2 year
= .73 to .91 kWh per year per module watt

x 20 year life (one maker's own depreciation)
= 15 to 18 kWh per module watt per lifespan
or
x 25 year life (PV industry claims)
= 18 to 23 kWh per PV watt per lifespan

A.2 ENERGY CONSUMED TO MANUFACTURE (ROOFTOP)

≈ more than 21 kWh per peak watt minimum

Finding the total energy used to manufacture and deliver energy from today's high-tech renewable systems is such a formidable task as to be nearly impossible. It involves determining the energy related to all relevant operations, resources, machinery, real estate, international labor rates, fluctuations of energy prices, inflated currencies, subsidies, investment, depreciation and histories thereof.

Another way to assess the manufacturing and delivery energy is to compare the production and consumption ends of the energy loop. Dividing the price of $2.15 per roofltop solar system peak watt* by a $0.10 kWh price of electricity consumption, **the apparent production energy spent per PV system watt is 22 kWh.** When module efficiency and all losses are counted, **each peak watt of a rooftop solar system will generate 18 to 23 kWh over its lifetime,** and the difference between the two ends of the loop is zero. That means as much energy OUT as energy IN, with no surplus energy after recycling most of the mechanism. It actually takes twice as much primary energy to make electricity when burning fossil fuels.

Applying an industrial-energy-per-capita factor of 10 to 16 (see graph on that topic) for overseas PV production, the PV module is well below sustainability. Many glass factories that make the tempered and coated glass of PVs operate in Southeast Asia where extremely low labor costs parallel extremely low per capita energy consumption. This doesn't mean however, that it takes any less energy to melt glass. The US Energy Information Agency estimates the energy consumed to make flat glass in the US is about 5 kWh per US dollar. Solar panel production is also a high energy-per-dollar industry, but even at a hypothetical 2 kWh per dollar of American-made solar panel, a price of $2.15 for overseas production, multiplied by an energy-per-capita factor of 10 to 15, comes to a manufacturing energy of **40 to 70 kWh per PV watt.**

* uninstalled rooftop PV system imported from China includes mounting hardware and DC-AC transformers for a grid tie-in (no battery storage) year 2016.

B.1 ENERGY GENERATED (PV SOLAR FARM)

≈ 54 kWh per peak watt per lifespan

$2.4 billion cost[1]
550 MW capacity[2]
Cadmium Telluride polycrystal silicon thin film [3]
9 million modules[2]
0 modules with tracking[2]
.72 square meter per module[2,3]
1.3 billion kWh per year generation[1]
mfg: US, Malaysia, subcontractors worldwide[2]
$4.36 per watt capacity (peak watt)
6.48 million square meters [2,3]
85 watts per square meter
200.6 kWh per square meter per year
2000 kWh annual incident light
10% system efficiency
2.35 kWh per module watt
2.1 kWh generated per year per rated watt
including up to 12% post generation
transmission losses
52–55 kWh lifetime yield per rated module watt

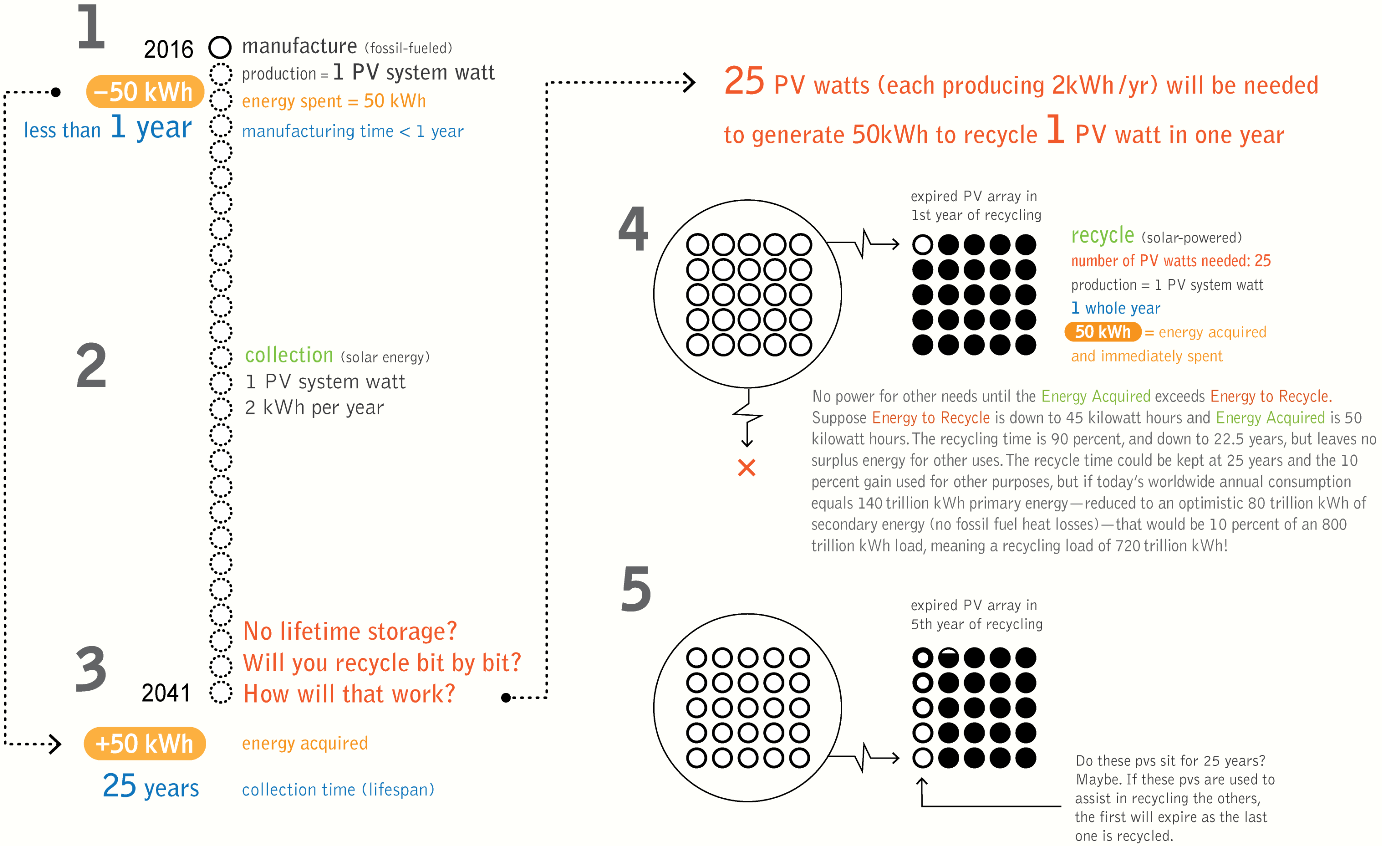
[1] stated or derived from a corporate website 2016
[2] stated or derived from a corporate 2015 annual report
[3] stated or derived from Wikipedia website 2016

B.2 ENERGY CONSUMED TO MANUFACTURE (SOLAR FARM)

≈ 55 kWh per peak watt minimum

More than half the mass of a solar panel is superior quality flat glass, mostly made in Southeast Asia where industry labor costs as low as $1.25 per hour reflect very low per-capita energy consumption—countries like Malaysia also offer subsidies for high energy industries. This does not mean that it takes that much less energy to melt and ship the glass. A major float glass manufacturer with continuous production lines around the world, estimates that just transporting glass overland reaches its economic limit at about 600 kilometers, the norm being about 200 kilometers.† The U.S. Energy Information Agency estimates the energy consumed to make flat glass in the US is about 5 kWh per U.S. dollar,‡. To account for overseas labor rates and the much higher industrial-energy-per-capita of overseas production, an adjustment by a factor of 10 to 15 (see separate graph on this subject) applied to the 5 kWh per dollar comes to 50 to 80 kWh per U.S. dollar. The $4.36 per PV farm peak watt (see figures at left) includes U.S. installation costs and what appears to be leased property for the operation. Assuming the overseas portion is reflected by half that price, at $2.18 per PV system watt, the adjusted production energy per system peak watt is like that in example A.1 and the production energy is equal to or greater than the energy return per lifetime.

† NSG corporation 2011 report
‡ USDOE EIA's MECS table 6.1



1

2016 manufacture (fossil-fueled)

production = 1 PV system watt

−50 kWh energy spent = 50 kWh

less than 1 year manufacturing time < 1 year

2

collection (solar energy)

1 PV system watt

2 kWh per year

3

No lifetime storage?

Will you recycle bit by bit?

2041 How will that work?

+50 kWh energy acquired

25 years collection time (lifespan)

25 PV watts (each producing 2kWh /yr) will be needed to generate 50kWh to recycle 1 PV watt in one year

4

expired PV array in 1st year of recycling

recycle (solar-powered)

number of PV watts needed: 25

production = 1 PV system watt

1 whole year

50 kWh = energy acquired and immediately spent

No power for other needs until the Energy Acquired exceeds Energy to Recycle. Suppose Energy to Recycle is down to 45 kilowatt hours and Energy Acquired is 50 kilowatt hours. The recycling time is 90 percent, and down to 22.5 years, but leaves no surplus energy for other uses. The recycle time could be kept at 25 years and the 10 percent gain used for other purposes, but if today's worldwide annual consumption equals 140 trillion kWh primary energy—reduced to an optimistic 80 trillion kWh of secondary energy (no fossil fuel heat losses)—that would be 10 percent of an 800 trillion kWh load, meaning a recycling load of 720 trillion kWh!

5

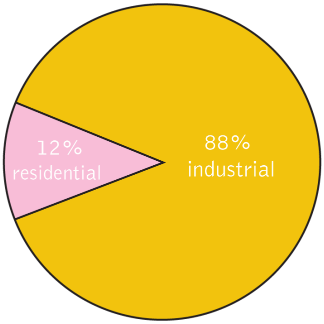
expired PV array in 5th year of recycling

Do these pvs sit for 25 years? Maybe. If these pvs are used to assist in recycling the others, the first will expire as the last one is recycled.

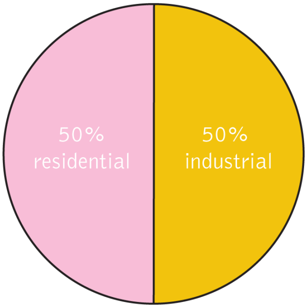
PHOTOVOLTAIC SYSTEM RECYCLING DIAGRAM

RATIO OF RESIDENTIAL ENERGY CONSUMPTION TO INDUSTRIAL ENERGY CONSUMPTION IN CHINA AND THE USA

(includes transportation but not commercial sectors)



CHINA
(assuming 2011 trends)
≈ 90 EXAJOULES

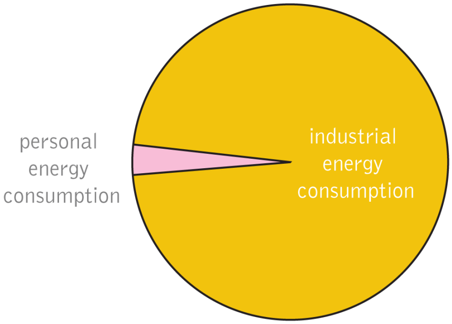


USA
(assuming 2011 trends)
≈ 80 EXAJOULES

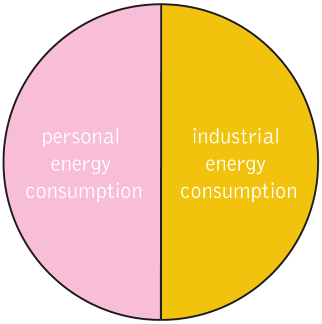
……

INDUSTRIAL ENERGY CONSUMPTION PER CAPITA IN CHINA AND THE USA

(includes transportation but not commercial sectors)



CHINA
(2011)



USA
(2011)

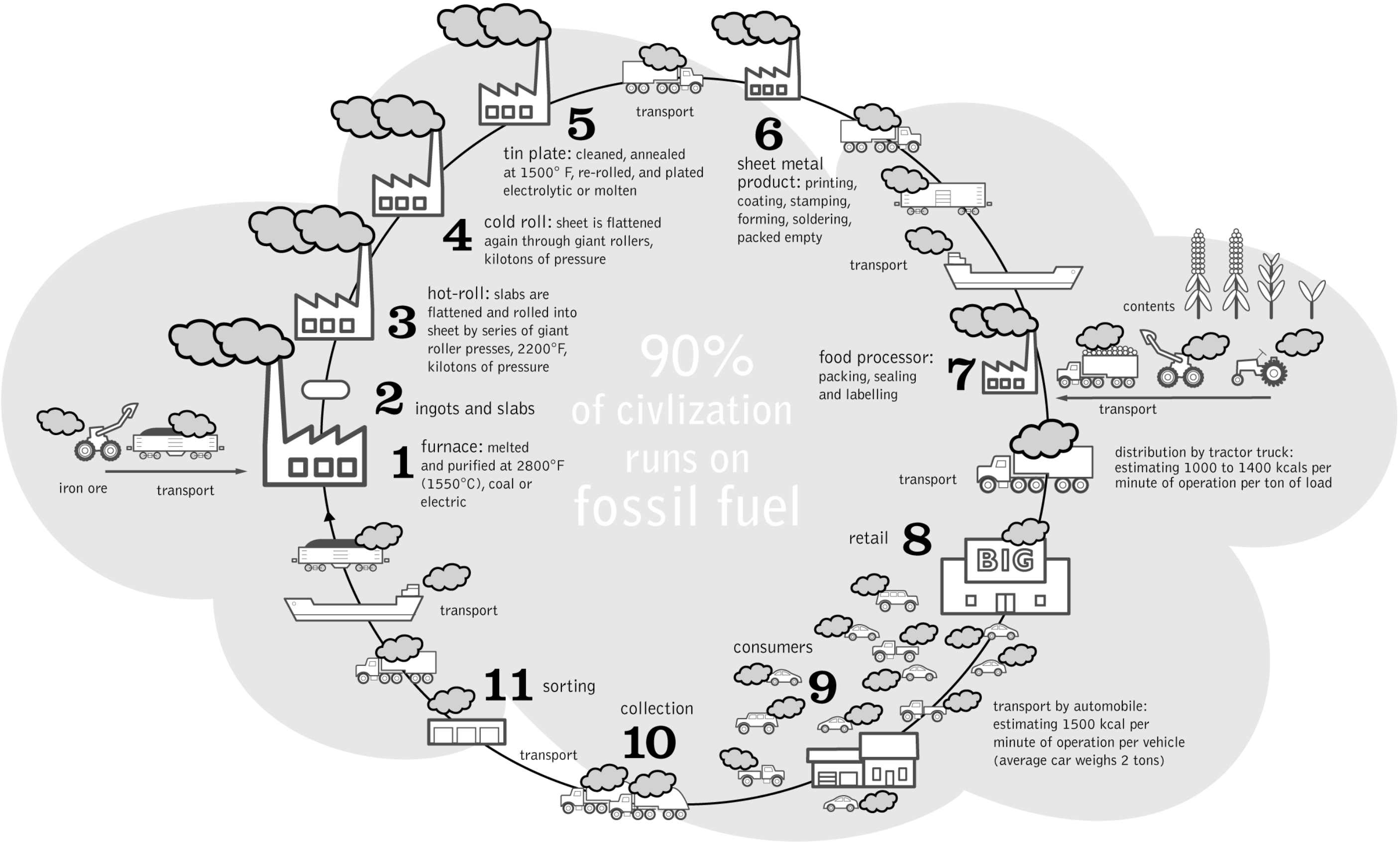
Notes: The graphs are roughly extrapolated from the following data: 1) Key China Energy Statistics, 2012, Lawrence Berkeley National Laboratory; 2) USDOE-EIA Annual Energy Review, 2011 (see fig. 1 Energy Flow graph); 3)DOE Transportation Energy Data Book #33 yr 2014

Chinese industrial energy per capita compared to US industrial energy per capita: 4 energy factor × 4 population factor = 16 total. These factors relate to monetary exchange rates and wage differences. According to data at the US BEA, the wage difference for industrial labor in the two countries is a factor of about 5 to 6. I use a conservative factor of 5 for other of my energy calculations (solar modules, plate glass), but that factor should probably be higher.

RSW 2017.05.27

Disposable Planet

Cycle of Tinplated Steel (tin cans, etcetera) (magnify 50,000x for automobiles)



iron ore

transport

1 furnace: melted and purified at 2800°F (1550°C), coal or electric

2 ingots and slabs

3 hot-roll: slabs are flattened and rolled into sheet by series of giant roller presses, 2200°F, kilotons of pressure

4 cold roll: sheet is flattened again through giant rollers, kilotons of pressure

5 tin plate: cleaned, annealed at 1500° F, re-rolled, and plated electrolytic or molten

transport

6 sheet metal product: printing, coating, stamping, forming, soldering, packed empty

transport

contents

transport

7 food processor: packing, sealing and labelling

transport

distribution by tractor truck: estimating 1000 to 1400 kcals per minute of operation per ton of load

8 retail

9 consumers

transport by automobile: estimating 1500 kcal per minute of operation per vehicle (average car weighs 2 tons)

10 collection

transport

11 sorting

transport

90% of civlization runs on fossil fuel

At some point I will acknowledge all those who have helped me in one way or another, but there's more to come. When it's all over, my generous supporters, lenders of time, and expertise may want nothing to do with me or my views.