Learning about solar power, the life and death of an electron.

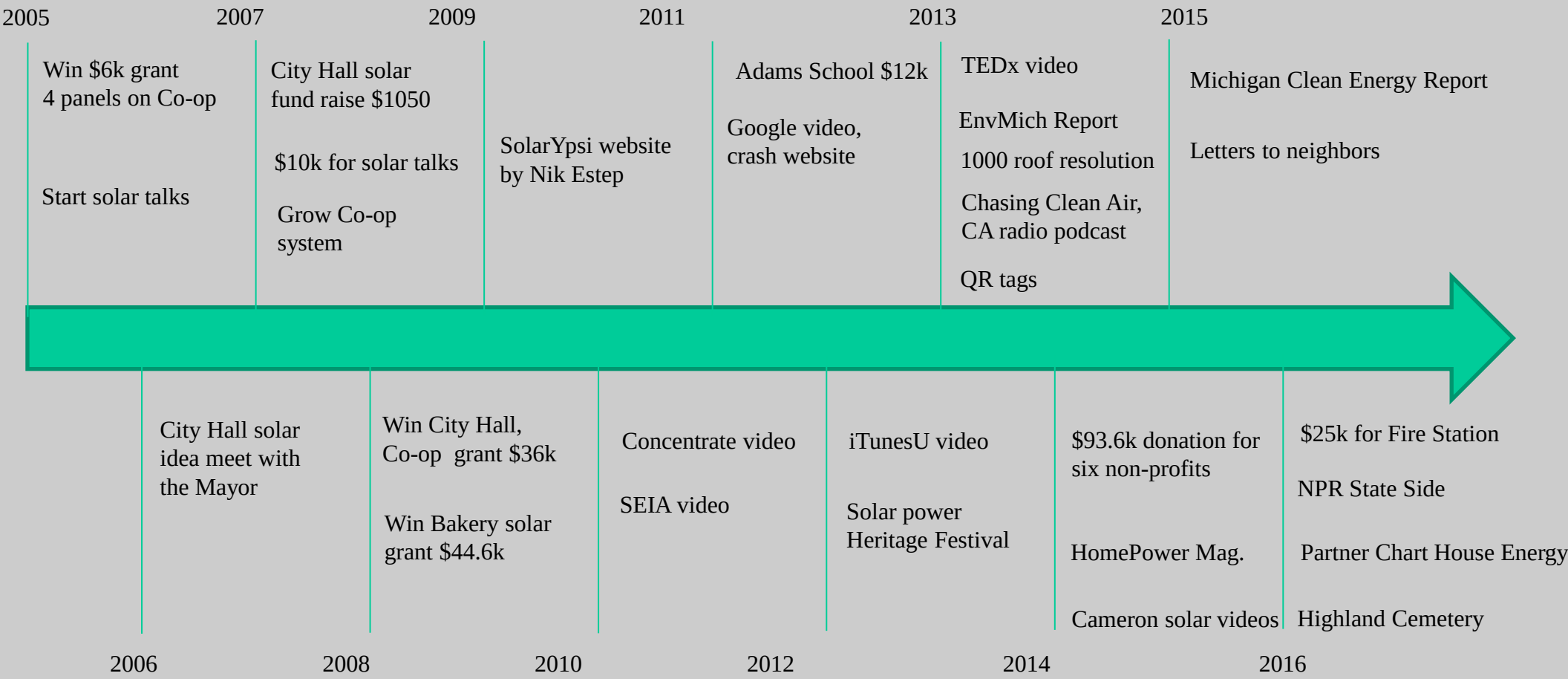
Baby Minus

SOLAR YPSI.org

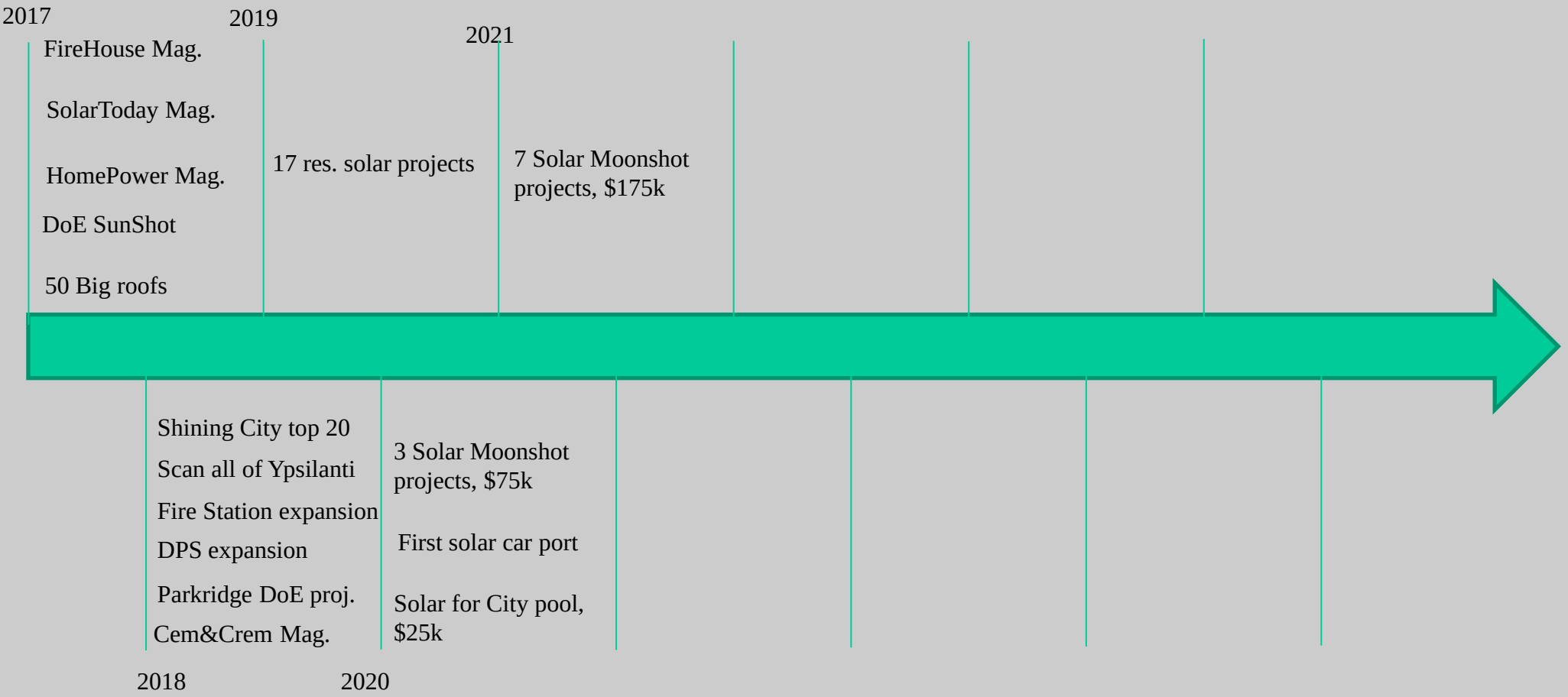
Dave Strenski

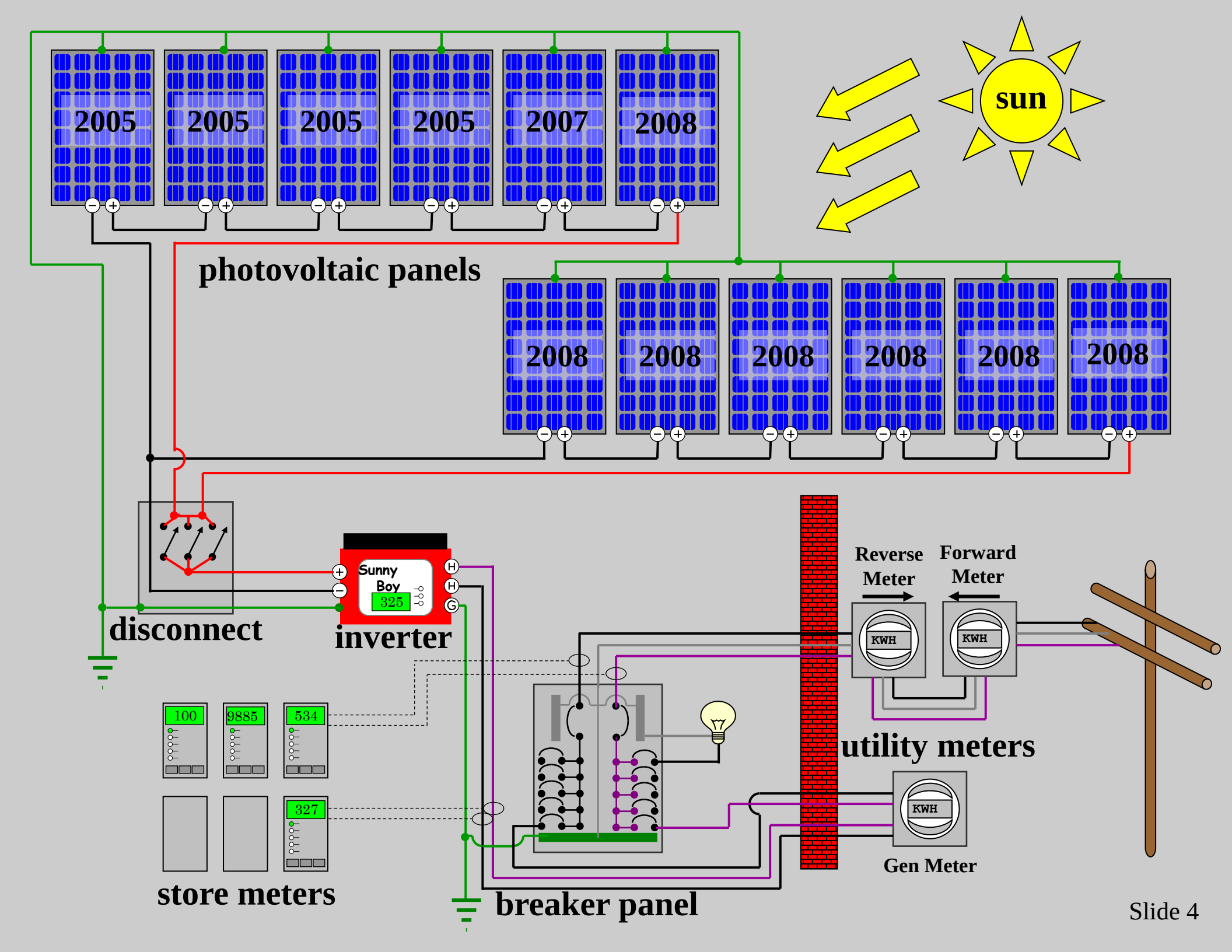
March 2023

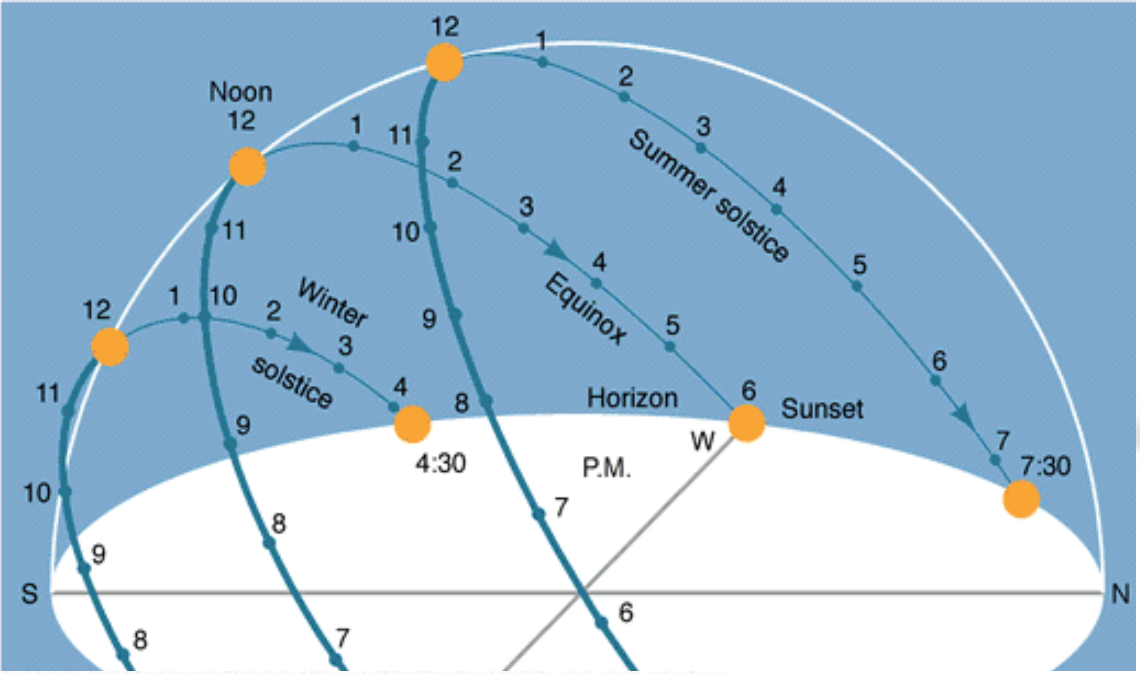
SolarYpsi History

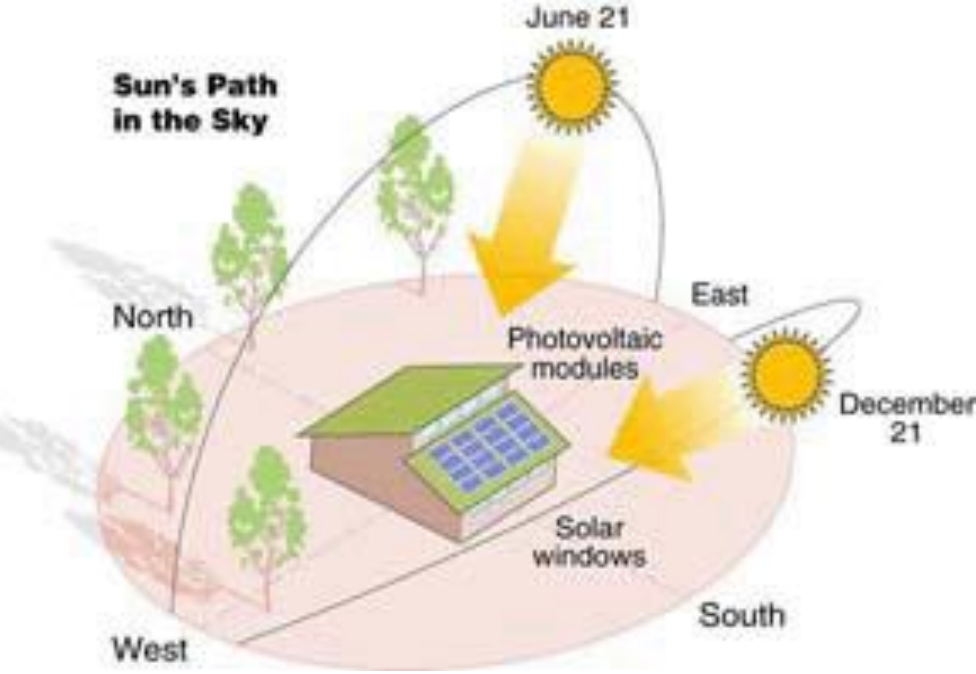


SolarYpsi History

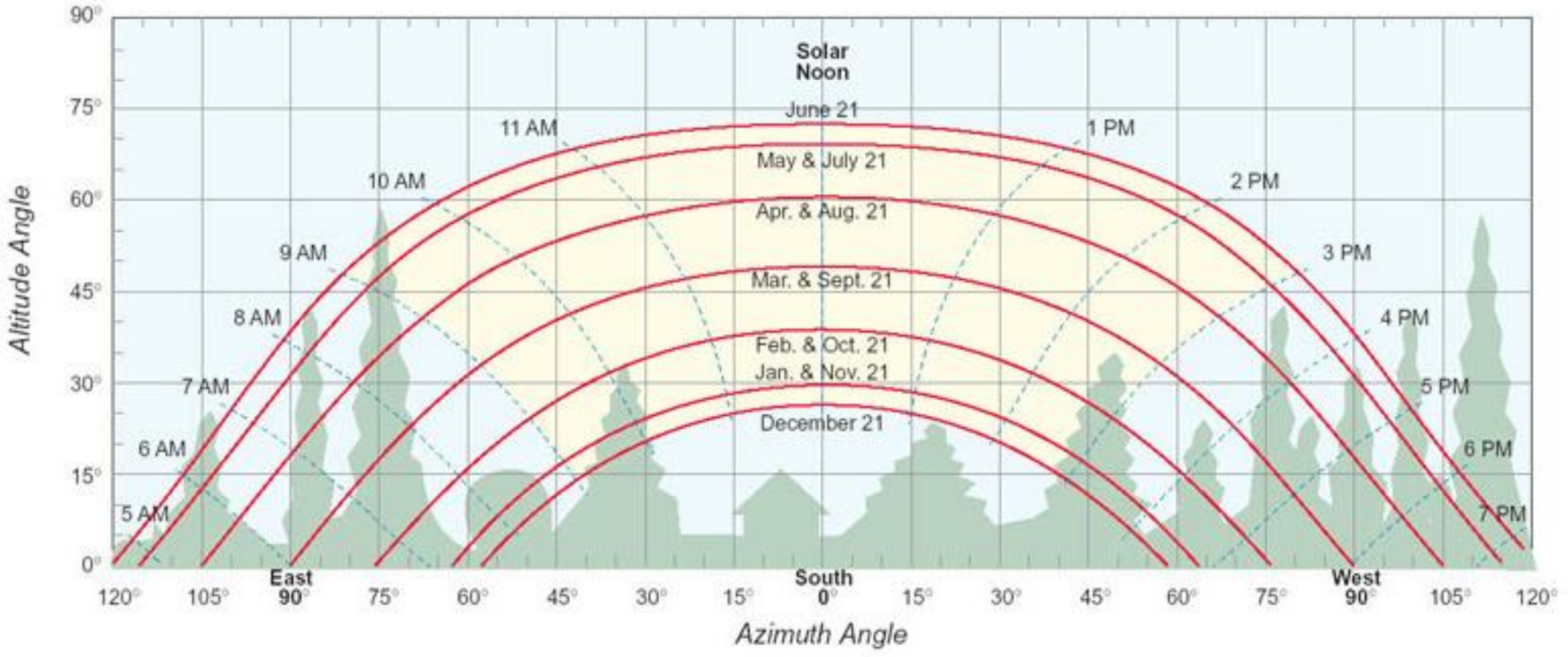



2005
2005
2005
2005
2007
2008
sun
photovoltaic panels
2008
2008
2008
2008
2008
2008
disconnect
Sunny Boy 325
inverter
Reverse Meter
Forward Meter
KWH
KWH
utility meters
100
9885
534
327
store meters
breaker panel
KWH
Gen Meter



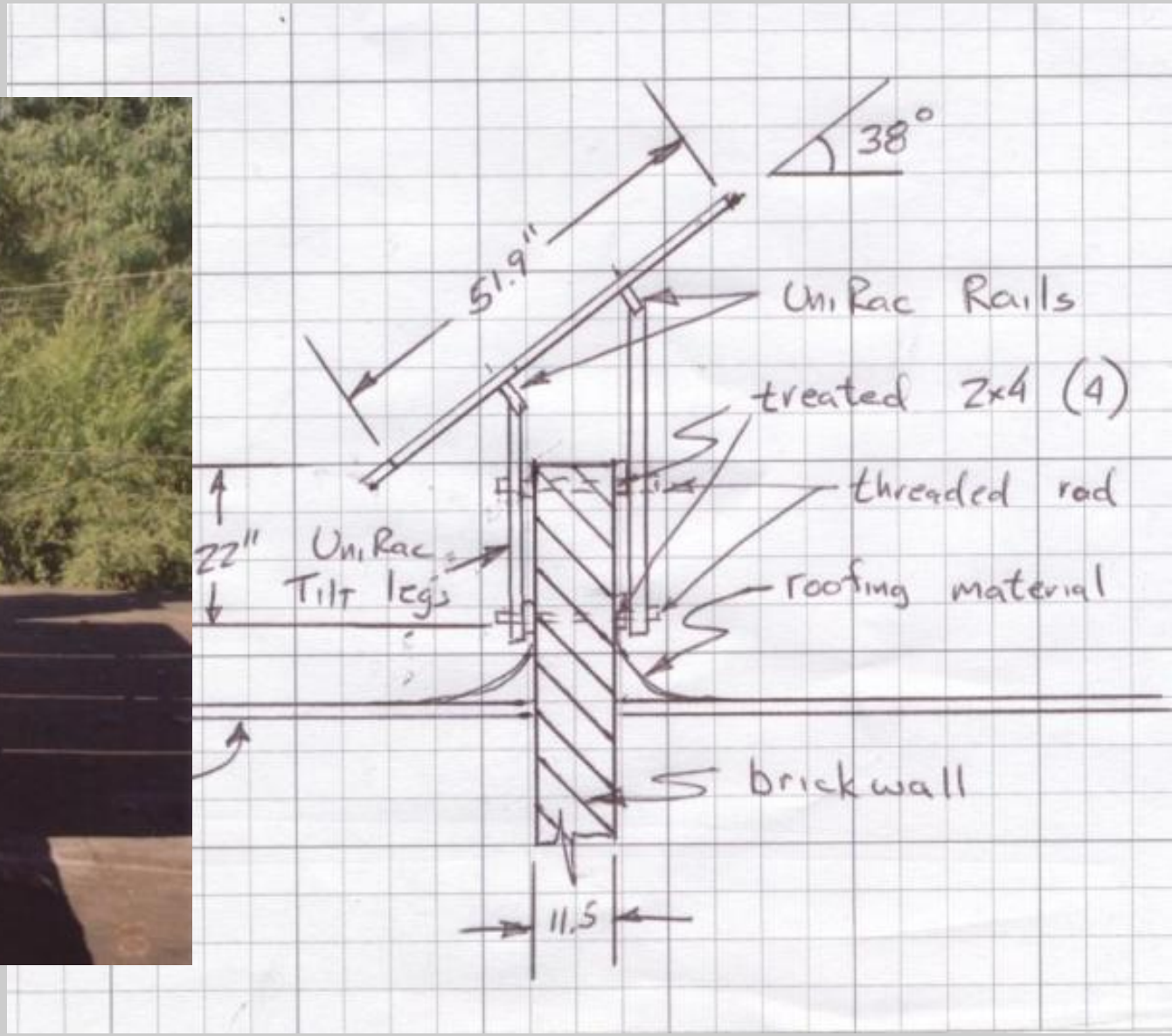


Sun Path Chart for 40° North Latitude

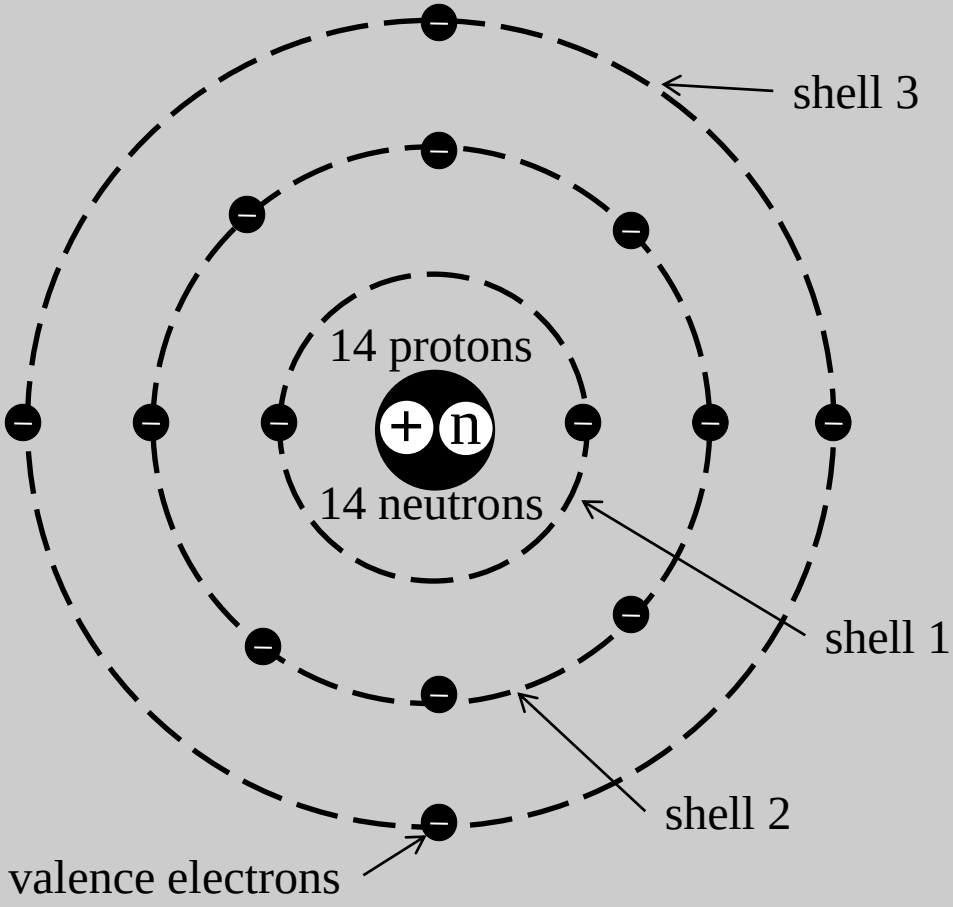


Steeper for more uniform annual power
Flatter for maximum annual power

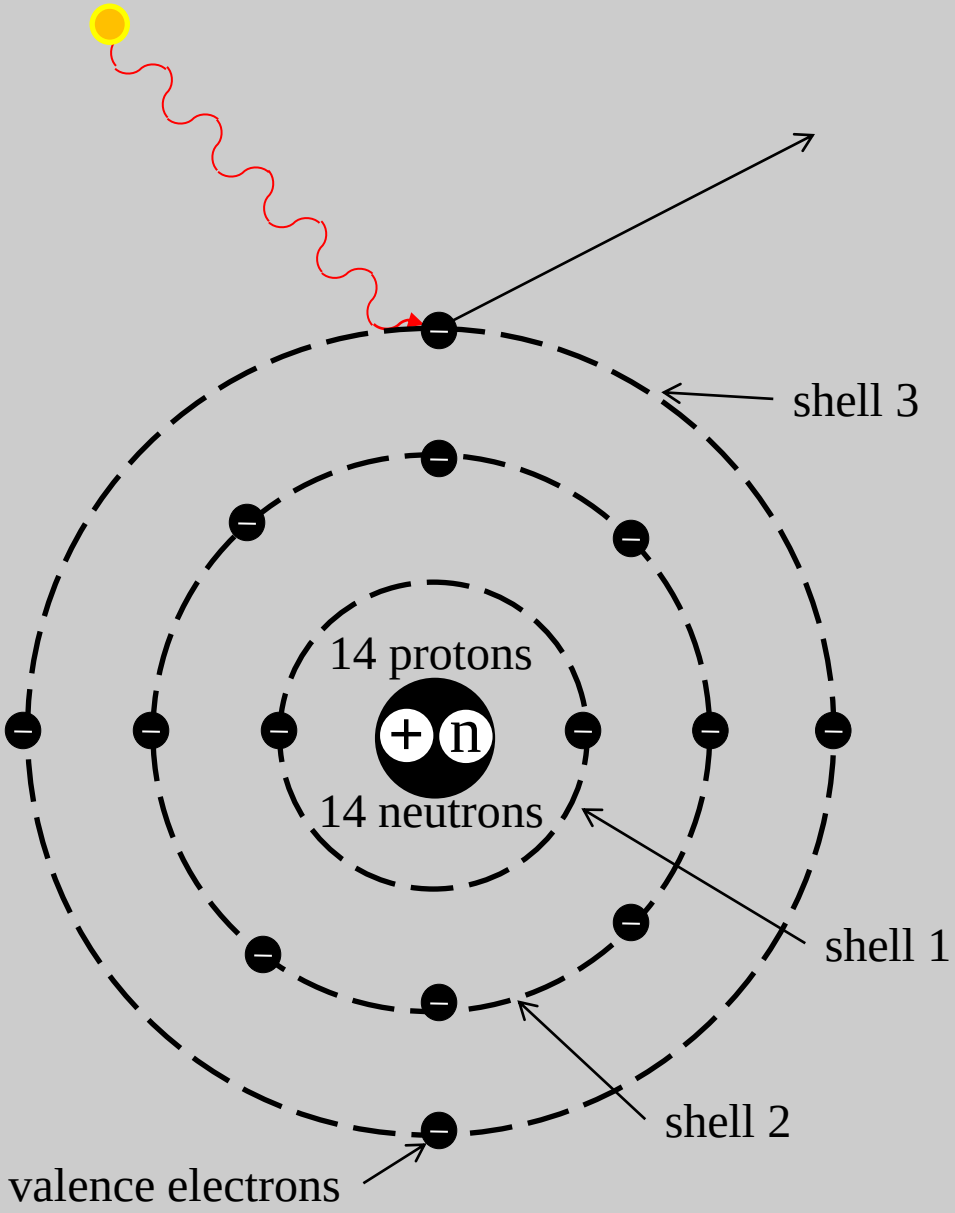
Tracking systems
Seasonal fixed panels
Fixed panels



Silicon [Si]


shell 3
14 protons
n
14 neutrons
shell 1
shell 2
valence electrons

Silicon [Si]


shell 3
14 protons
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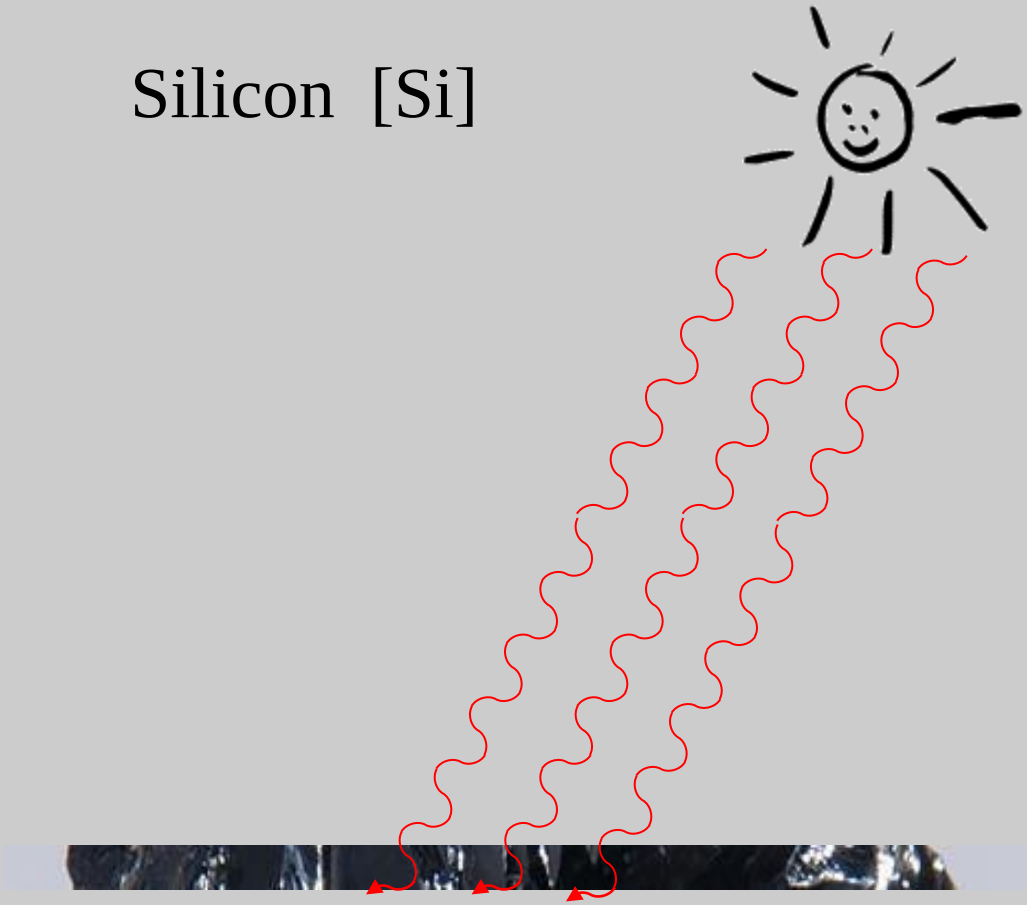
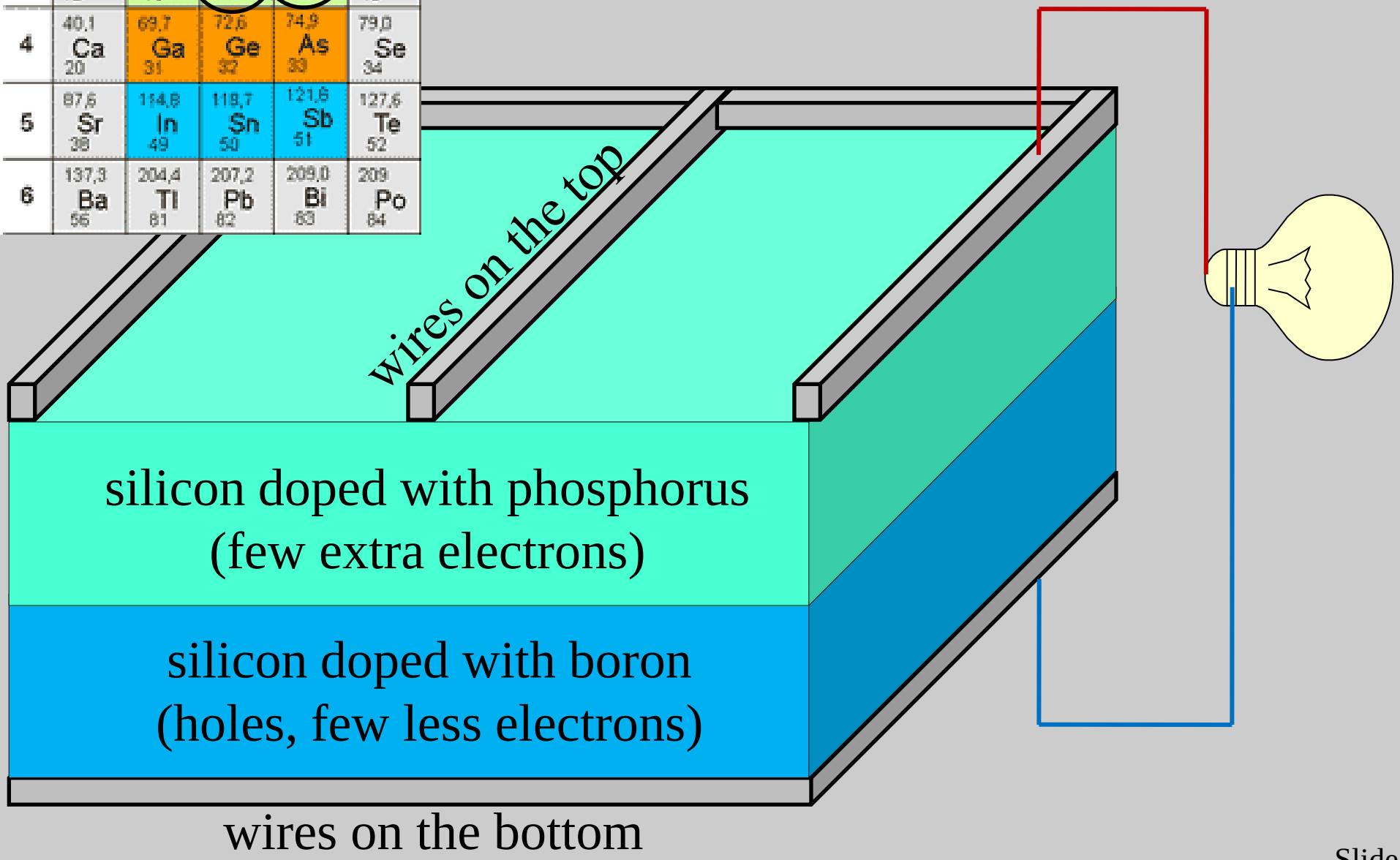
valence electrons

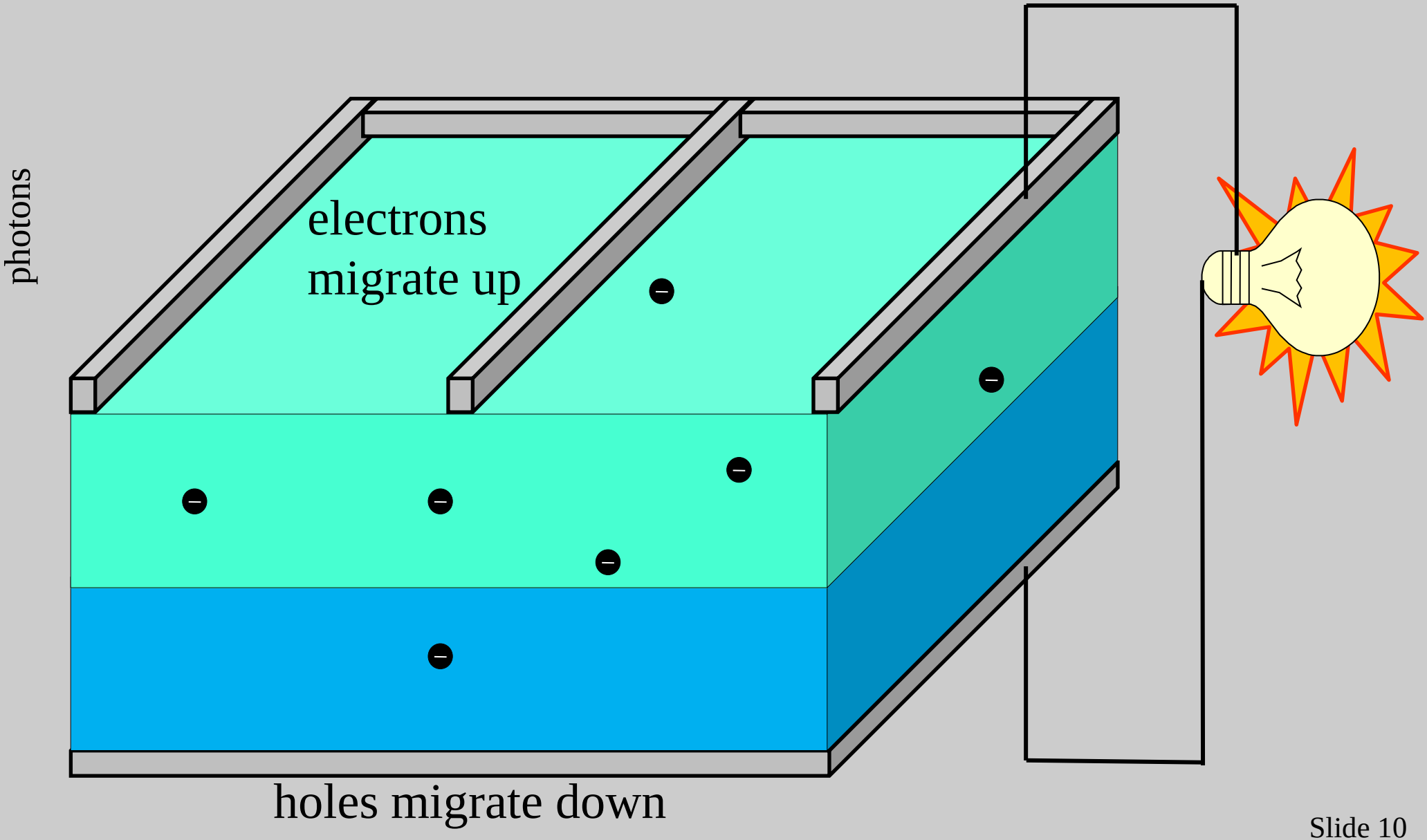


Building a Solar Cell

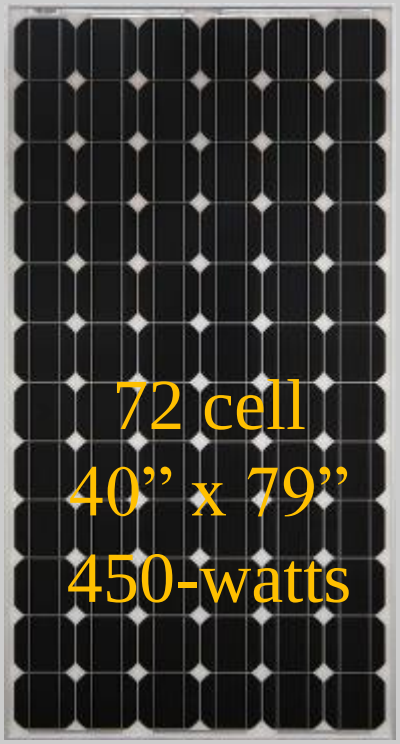
Periode	II	III	IV	V	VI
2	9,0 Be 4	10,8 B 5	12,0 C 6	14,0 N 7	16,0 O 8
3	24,3 Mg 12	27,0 Al 13	28,1 Si 14	31,0 P 15	32,1 S 16
4	40,1 Ca 20	69,7 Ga 31	72,6 Ge 32	74,9 As 33	79,0 Se 34
5	87,6 Sr 38	114,8 In 49	118,7 Sn 50	121,6 Sb 51	127,6 Te 52
6	137,3 Ba 56	204,4 Tl 81	207,2 Pb 82	209,0 Bi 83	209 Po 84

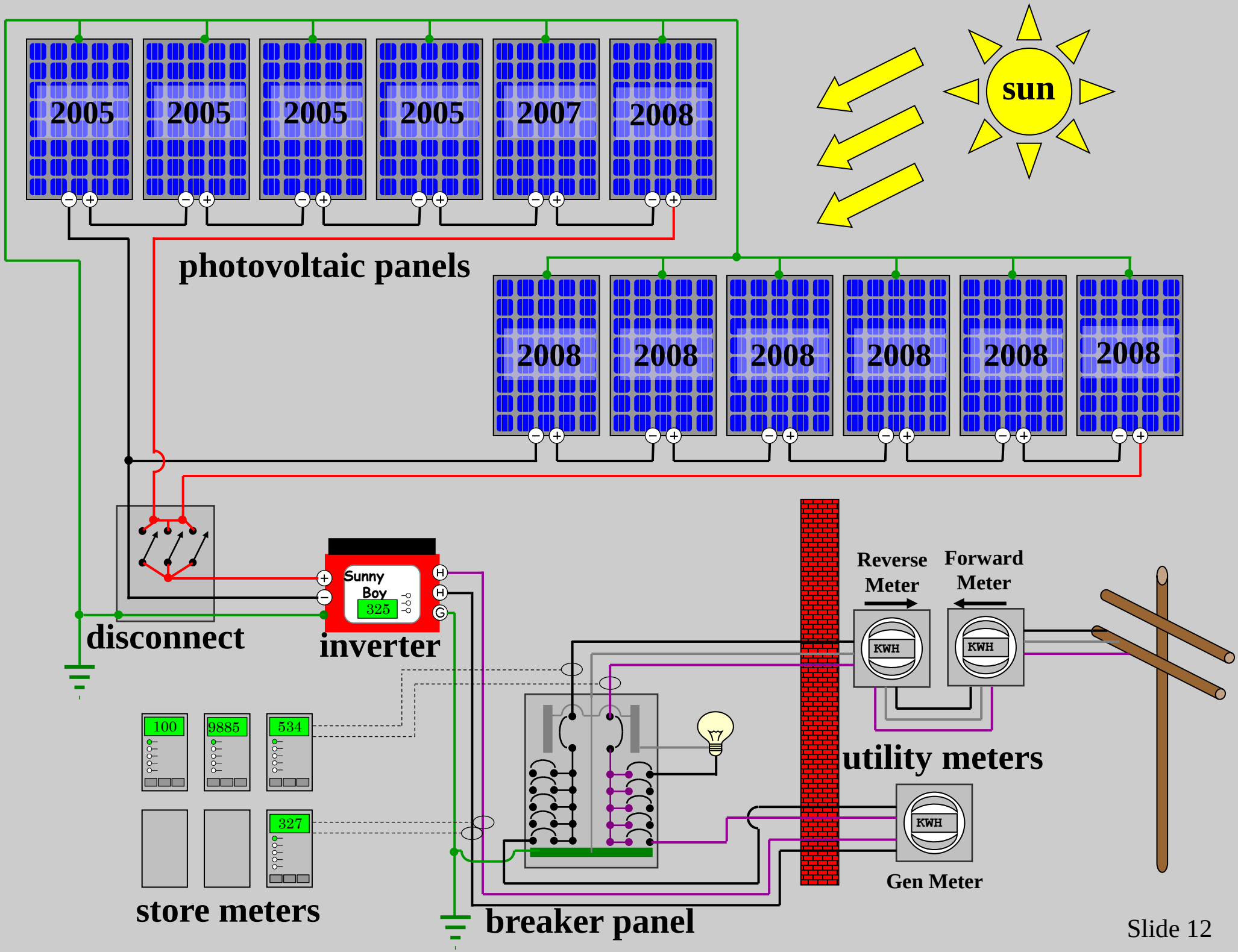
Hauptgruppen




photons
electrons
migrate up
holes migrate down

Mono and Polycrystalline Silicon




2005
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sun
photovoltaic panels
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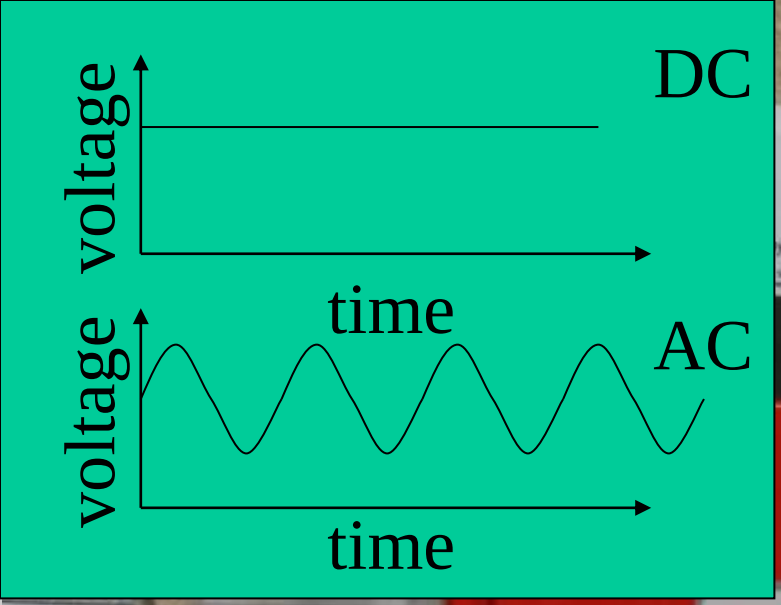
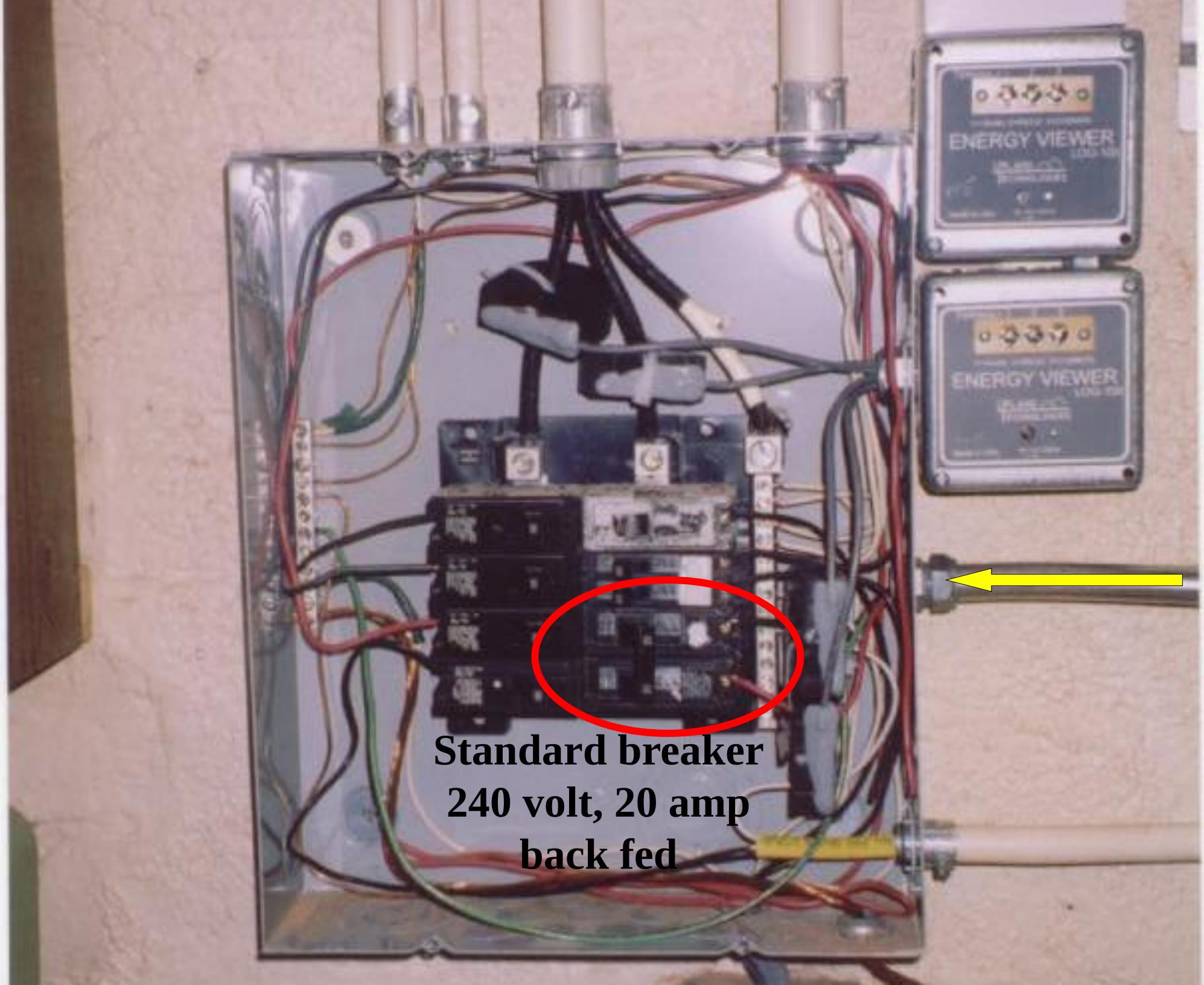


UL listed
Clean power
Shuts offs if grid is down
Powered by solar
Quite and Cool
Displays power generated

Sunny Boy

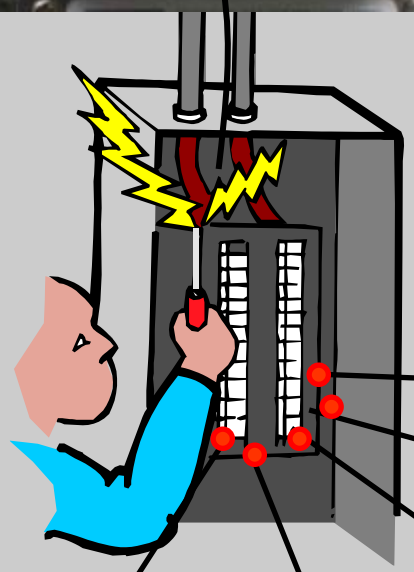
AC out

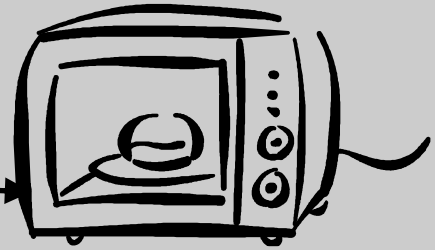
DC in

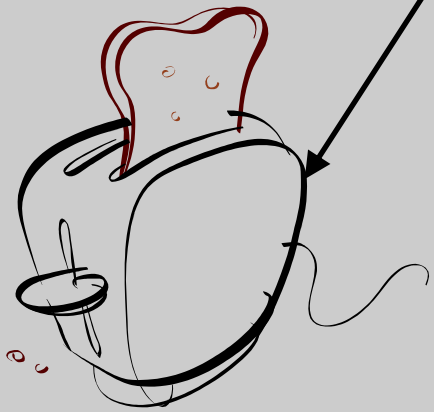

ENERGY VIEWER
ENERGY VIEWER
Standard breaker
240 volt, 20 amp
back fed

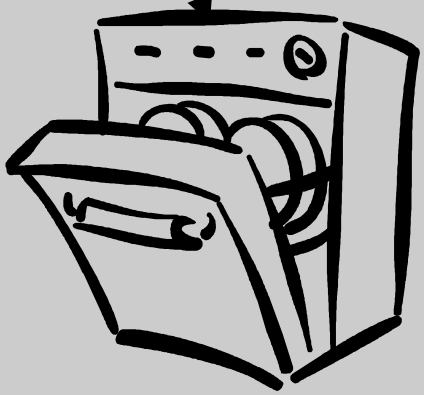
4:00 am

forwards









8:00 am

forwards

direct current

alternating current

Slide 16

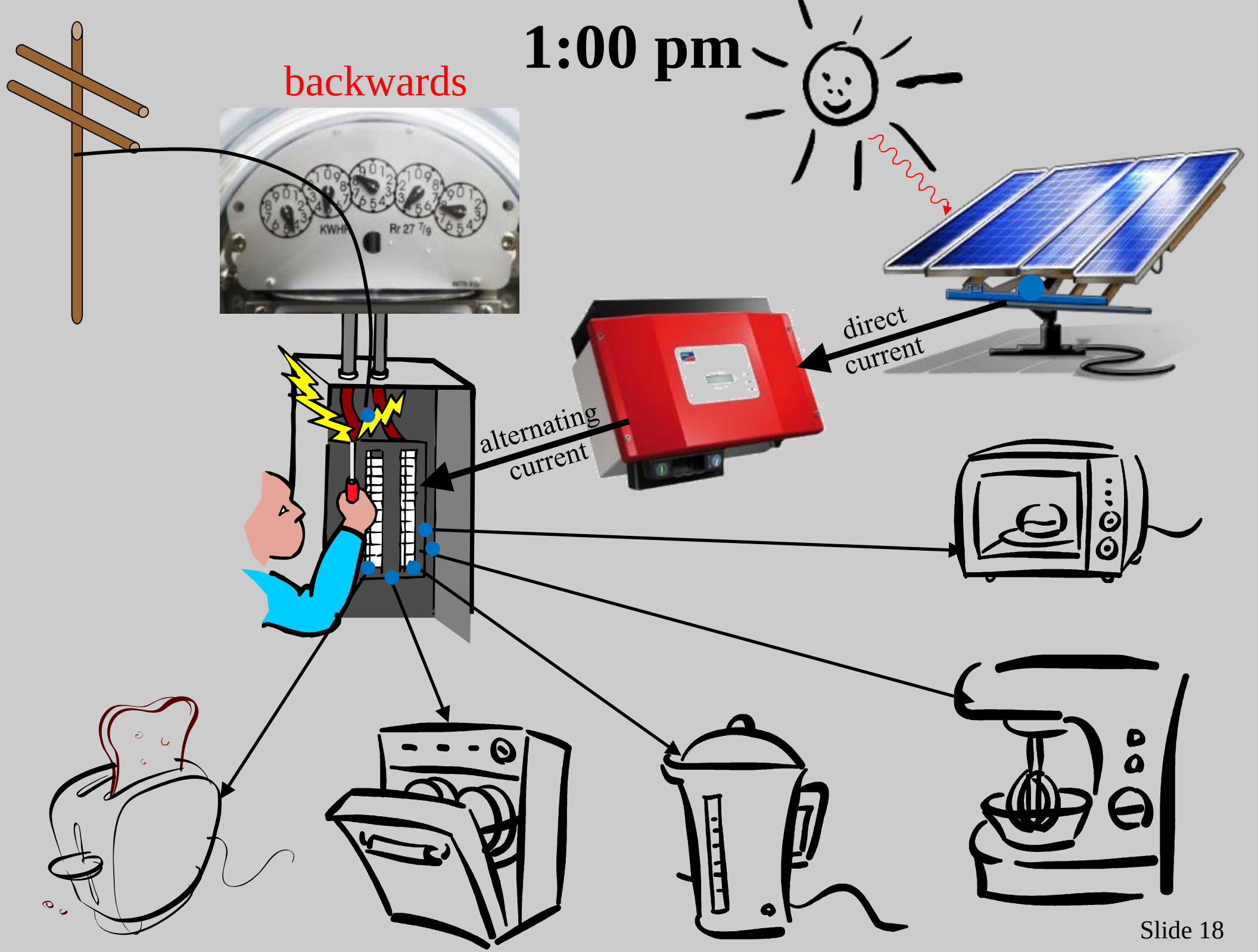
11:00 am

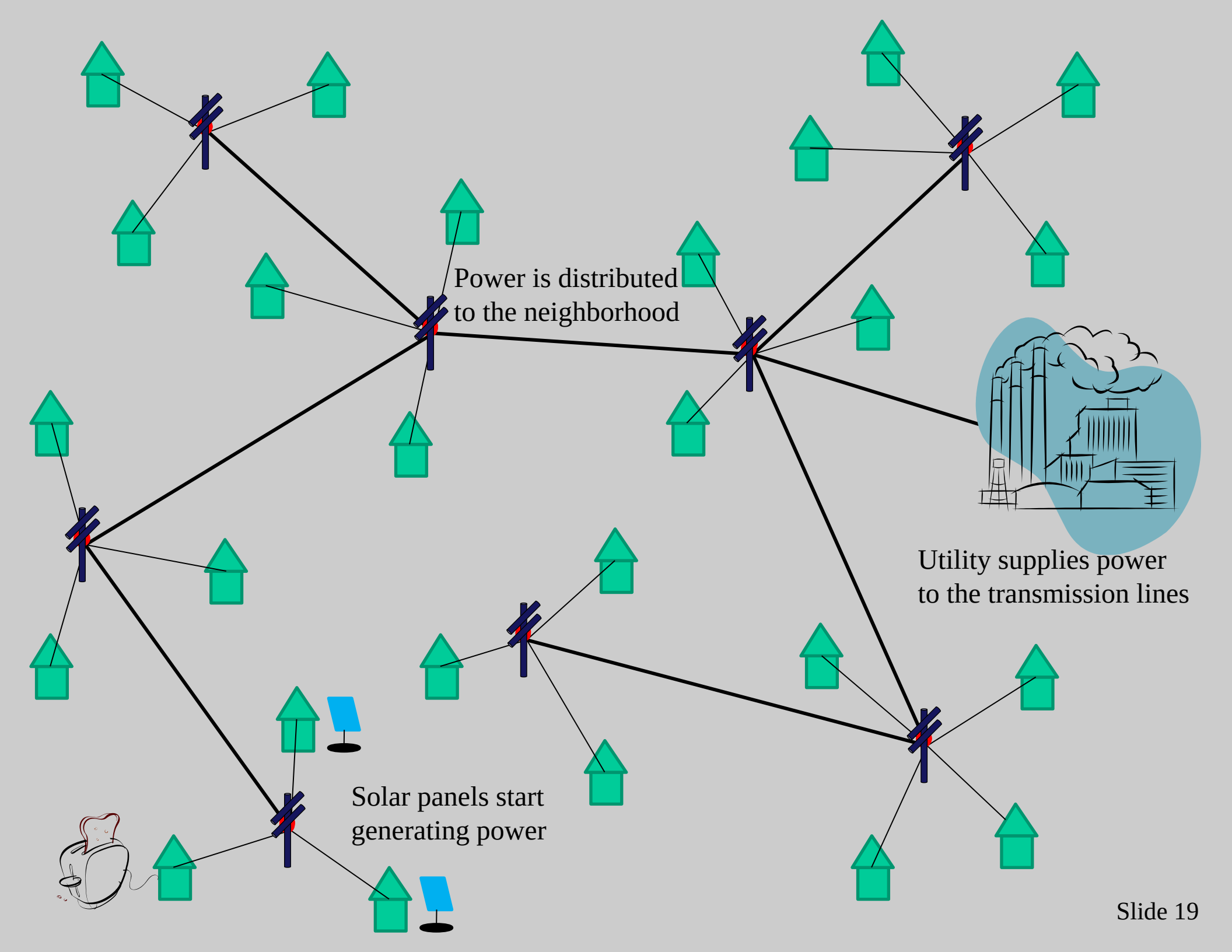
forwards

direct current

alternating current

Slide 17


1:00 pm
backwards
direct
current
alternating
current

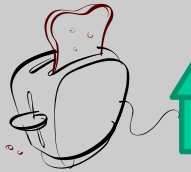

Power is distributed
to the neighborhood
Utility supplies power
to the transmission lines
Solar panels start
generating power

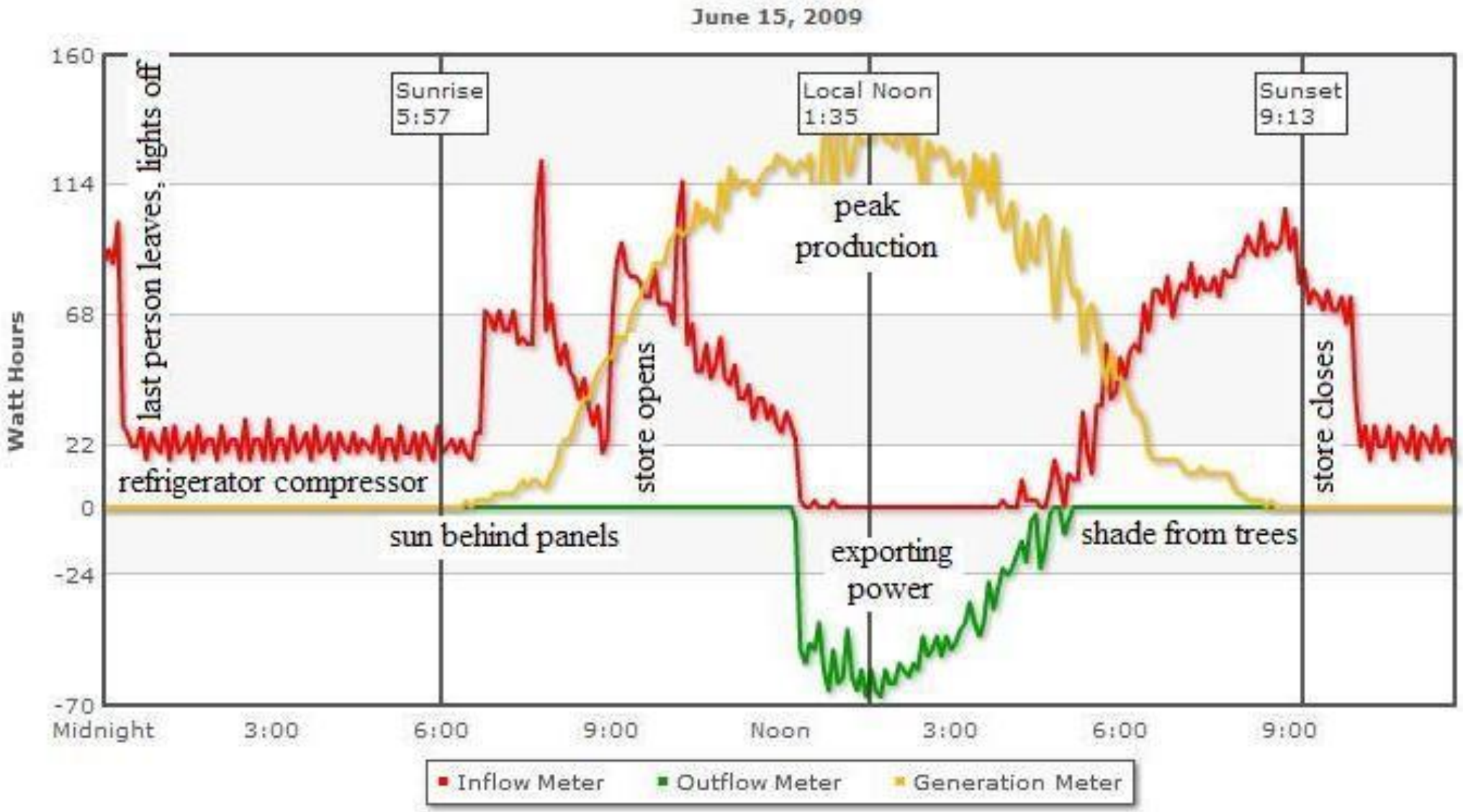
One less shovelful of coal is needed at the utility power plant

Power is distributed to the neighborhood

Utility supplies power to the transmission lines

Solar panels start generating power




June 15, 2009
Watt Hours
160
114
68
22
0
-24
-70
Midnight
3:00
6:00
9:00
Noon
3:00
6:00
9:00
Sunrise 5:57
Local Noon 1:35
Sunset 9:13
last person leaves, lights off
refrigerator compressor
store opens
peak production
sun behind panels
exporting power
shade from trees
store closes
Inflow Meter
Outflow Meter
Generation Meter

Solar Economics

Average Michigan home
668 kWh/month (average month)
18.11c per kWh, $121/month (2023)
668 kWh / 30 days = 22 kWh (average day)
https://www.michigan.gov/-/media/Project/Websites/mpsc/consumer/electric/rates1.pdf?rev=959038e92dbd465a9293dd7152009d4f

Summary of Charges

Account Number 1111 111 0002 7

Your Payment Plan Summary

Last Month's Amount Due	129.00
Payment Received Dec 21, 2015	- 129.00
Prior Period Balance	0.00
Current Payment Plan Amount	129.00
Payment Due By January 29, 2016	**129.00**

Actual Balance Information

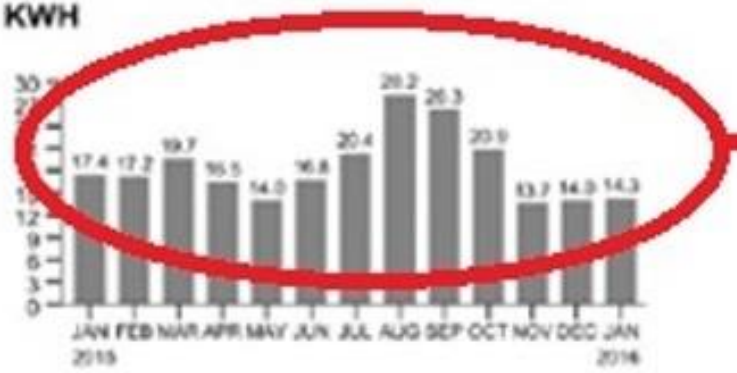
Account Balance as of Dec 07, 2015	58.44
Payment Received Dec 21, 2015. Thank You!	- 129.00
Balance Prior to Current Charges	- 70.56
Total Current Charges	154.69
Account Balance as of January 07, 2016	$84.13

Your Monthly Energy Usage

For ways to save energy and save money, go to dteenergy.com/saveenergy

ELECTRIC

KWH



Your usage is based on an ACTUAL meter reading

Average Usage per day

	Current Month	Last Month	Year Ago
KWH Usage	14.3	14.0	17.4
Change		2%	-17%

GAS

CCF

these 13 numbers

Your usage is based on an ACTUAL meter reading

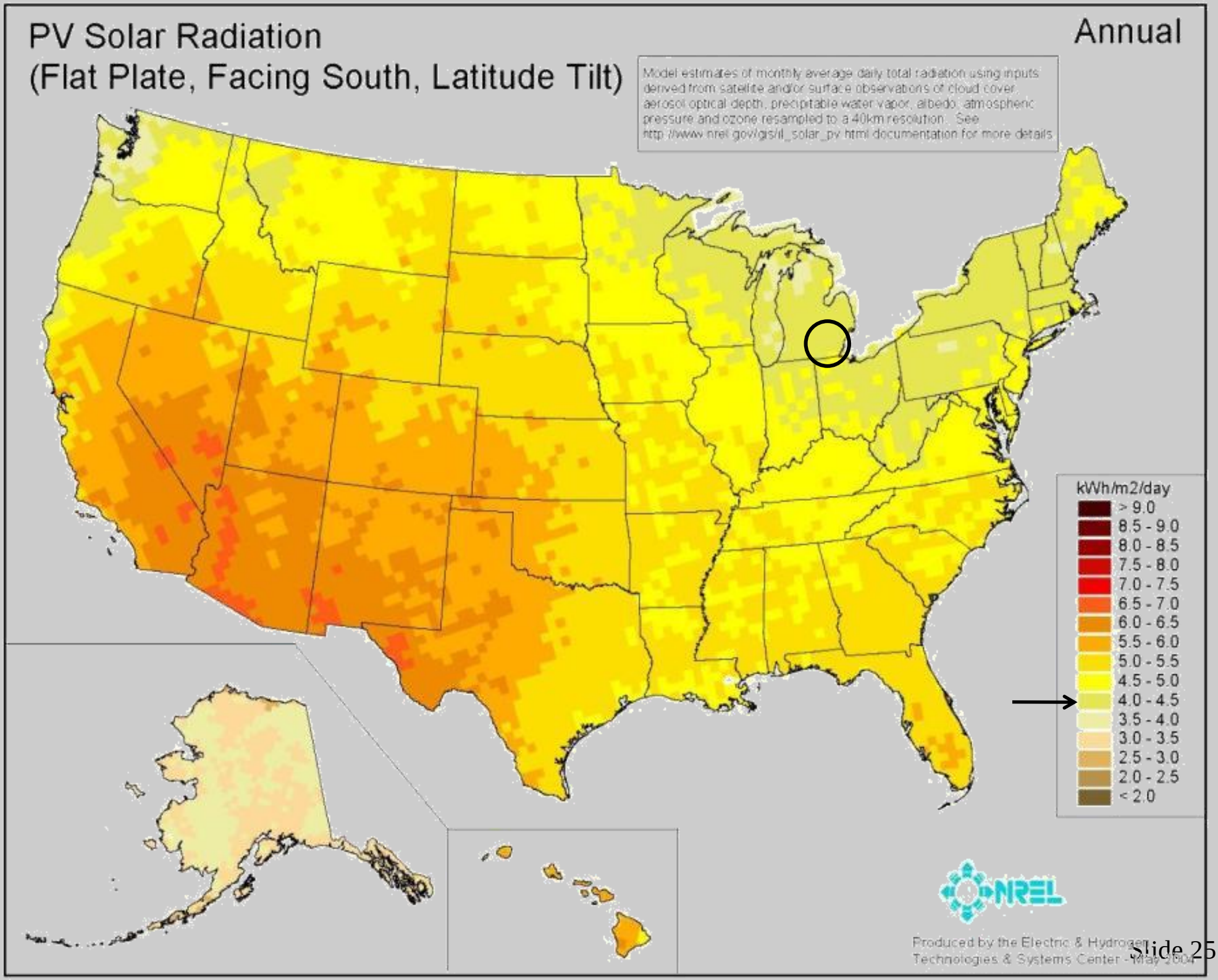
Average Usage per day

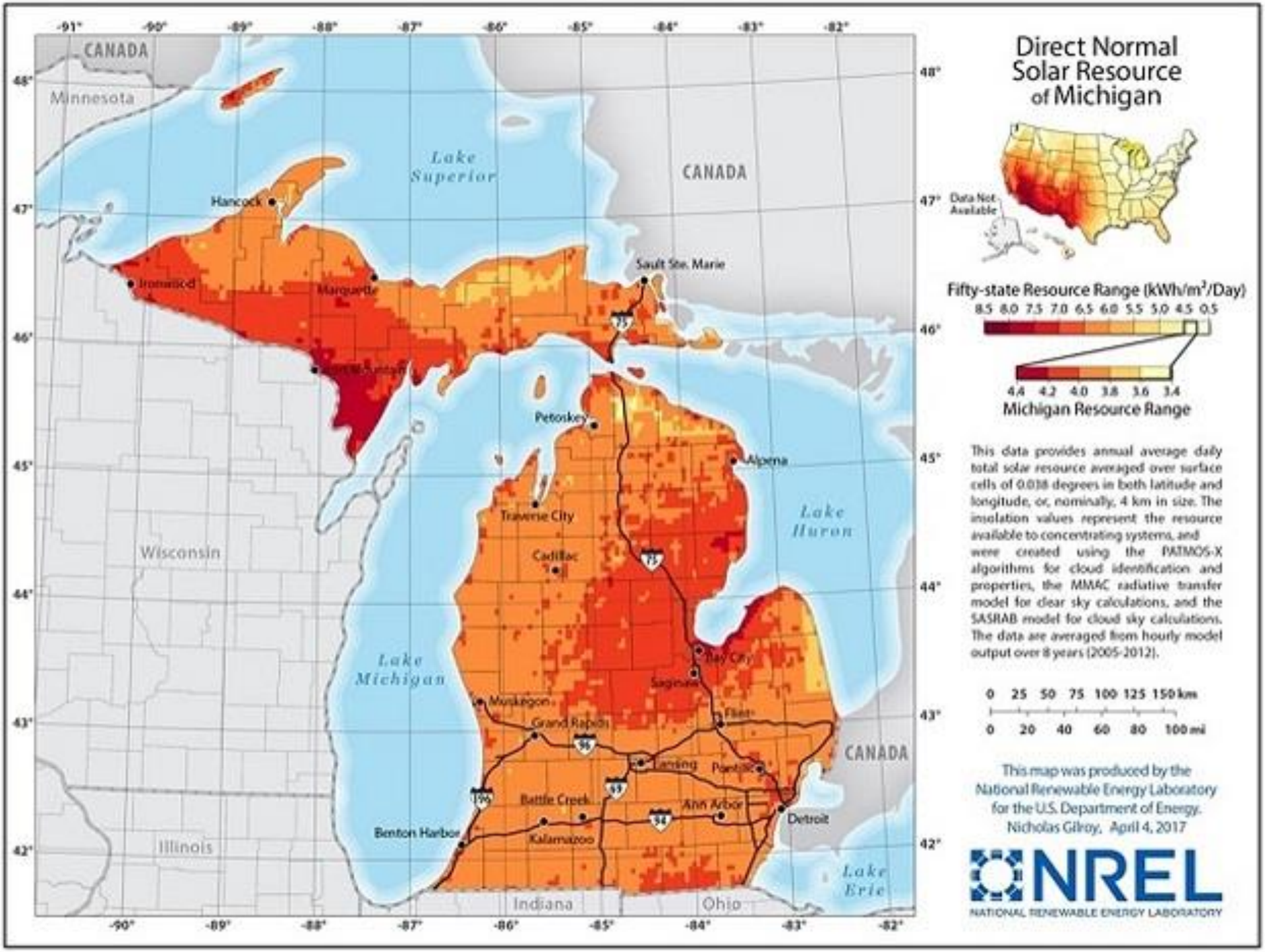
	Current Month	Last Month	Year Ago
CCF Usage	2.9	2.0	3.5
Change		45%	-17%

Solar Economics

Average Michigan home
668 kWh/month (average month)
18.11c per kWh, $121/month (2023)
668 kWh / 30 days = 22 kWh (average day)

4 hour of sun per day, assuming panels are facing south tilted at your latitude.
Assume 20% loss for system efficiency and some shading
22 kWh / 4 hr * 1.2 = 6.6 KW
6600 watts would be about 16 solar panels at 410W per panel. (2 x 8 array, 13’ x 27’)


PV Solar Radiation
(Flat Plate, Facing South, Latitude Tilt)
Annual
Model estimates of monthly average daily total radiation using inputs derived from satellite and/or surface observations of cloud cover, aerosol optical depth, precipitable water vapor, albedo, atmospheric pressure and ozone resampled to a 40km resolution. See http://www.nrel.gov/gis/rl_solar_pv.html documentation for more details
kWh/m2/day
> 9.0
8.5 - 9.0
8.0 - 8.5
7.5 - 8.0
7.0 - 7.5
6.5 - 7.0
6.0 - 6.5
5.5 - 6.0
5.0 - 5.5
4.5 - 5.0
4.0 - 4.5
3.5 - 4.0
3.0 - 3.5
2.5 - 3.0
2.0 - 2.5
< 2.0
NREL
Produced by the Electric & Hydrogen Technologies & Systems Center - May 2004


Direct Normal Solar Resource of Michigan
Data Not Available
Fifty-state Resource Range (kWh/m²/Day)
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 0.5
4.4 4.2 4.0 3.8 3.6 3.4
Michigan Resource Range
This data provides annual average daily total solar resource averaged over surface cells of 0.038 degrees in both latitude and longitude, or, nominally, 4 km in size. The insolation values represent the resource available to concentrating systems, and were created using the PATMOS-X algorithms for cloud identification and properties, the MMAC radiative transfer model for clear sky calculations, and the SASRAB model for cloud sky calculations. The data are averaged from hourly model output over 8 years (2005-2012).
0 25 50 75 100 125 150 km
0 20 40 60 80 100 mi
This map was produced by the National Renewable Energy Laboratory for the U.S. Department of Energy.
Nicholas Gilroy, April 4, 2017
NREL
NATIONAL RENEWABLE ENERGY LABORATORY
CANADA
Minnesota
Lake Superior
Hancock
Ironwood
Marquette
Sault Ste. Marie
Petoskey
Alpena
Traverse City
Cadillac
Lake Huron
Wisconsin
Lake Michigan
Bay City
Saginaw
Muskegon
Grand Rapids
Flint
Lansing
Pontiac
Battle Creek
Ann Arbor
Detroit
Benton Harbor
Kalamazoo
Illinois
Indiana
Ohio
Lake Erie

Solar Economics

Average Michigan home
668 kWh/month (average month)
18.11c per kWh, $121/month (2023)
668 kWh / 30 days = 22 kWh (day)

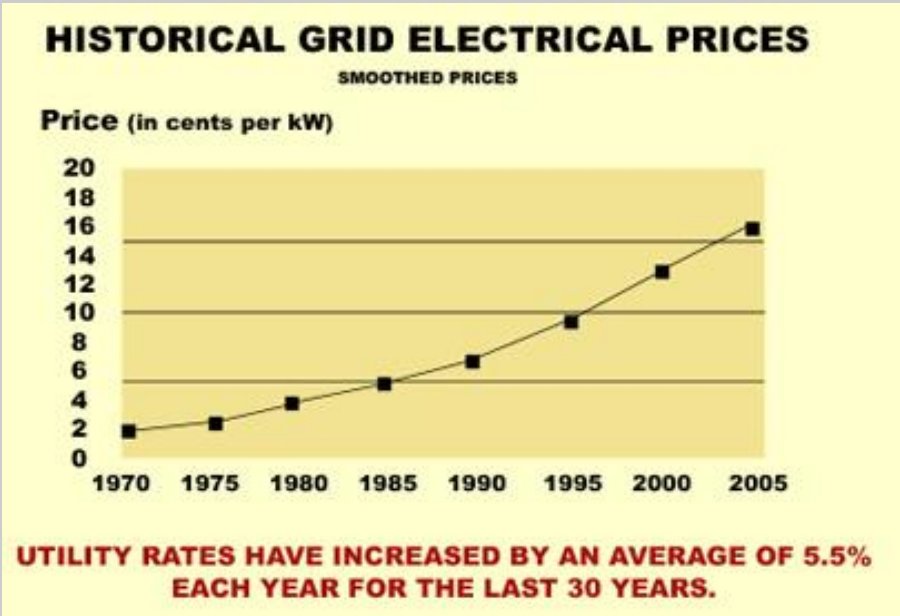
4 hour of sun per day, assuming panels are facing south tilted at your latitude.
Assume 20% loss for system efficiency and some shading
22 kWh / 4 hr * 1.2 = 6.6 kW
6600 watts would be about 16 solar panels at 410W per panel. (2 x 8 array, 13' x 27')

Solar installation cost = $3.0 per watt	$3.5 per watt
6600W x $3/W = $19,800	6600W x $3.5/W = $23,100
$19,800 x 0.30 = -$5,940	$23,100 x 0.30 = -$6,930
$13,860	$16,170

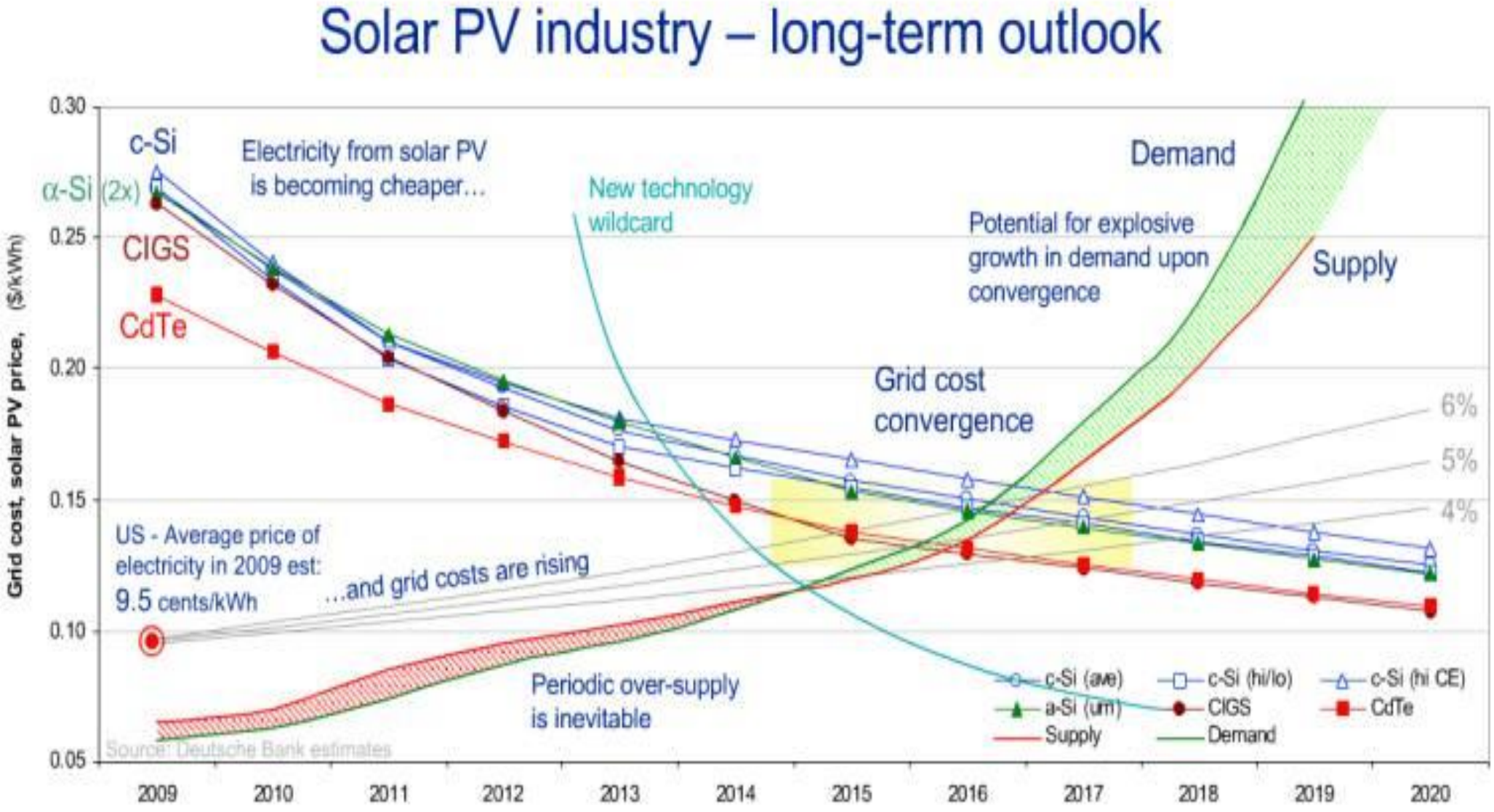
6.6 kW x 4 hr x $0.1811 = $4.78/day
$4.78 x 365 days = $1,745/year

@ $3.0/watt $13,860 / $1,745 = ~8 years ROI
@ $3.5/watt $16,170 / $1,745 = ~9 years ROI

City of Ypsilanti
@ $3.0/watt ($13,860-$2000) / $1,745 = ~7 years
@ $3.5/watt ($16,170-$2000) / $1,745 = ~8 years



Solar Economics



Economics of Scale

Intel 80486 PC

Purchased in **1990** for $2000

16 MB of Memory, 50 MHz clock

50 pounds and BIG.

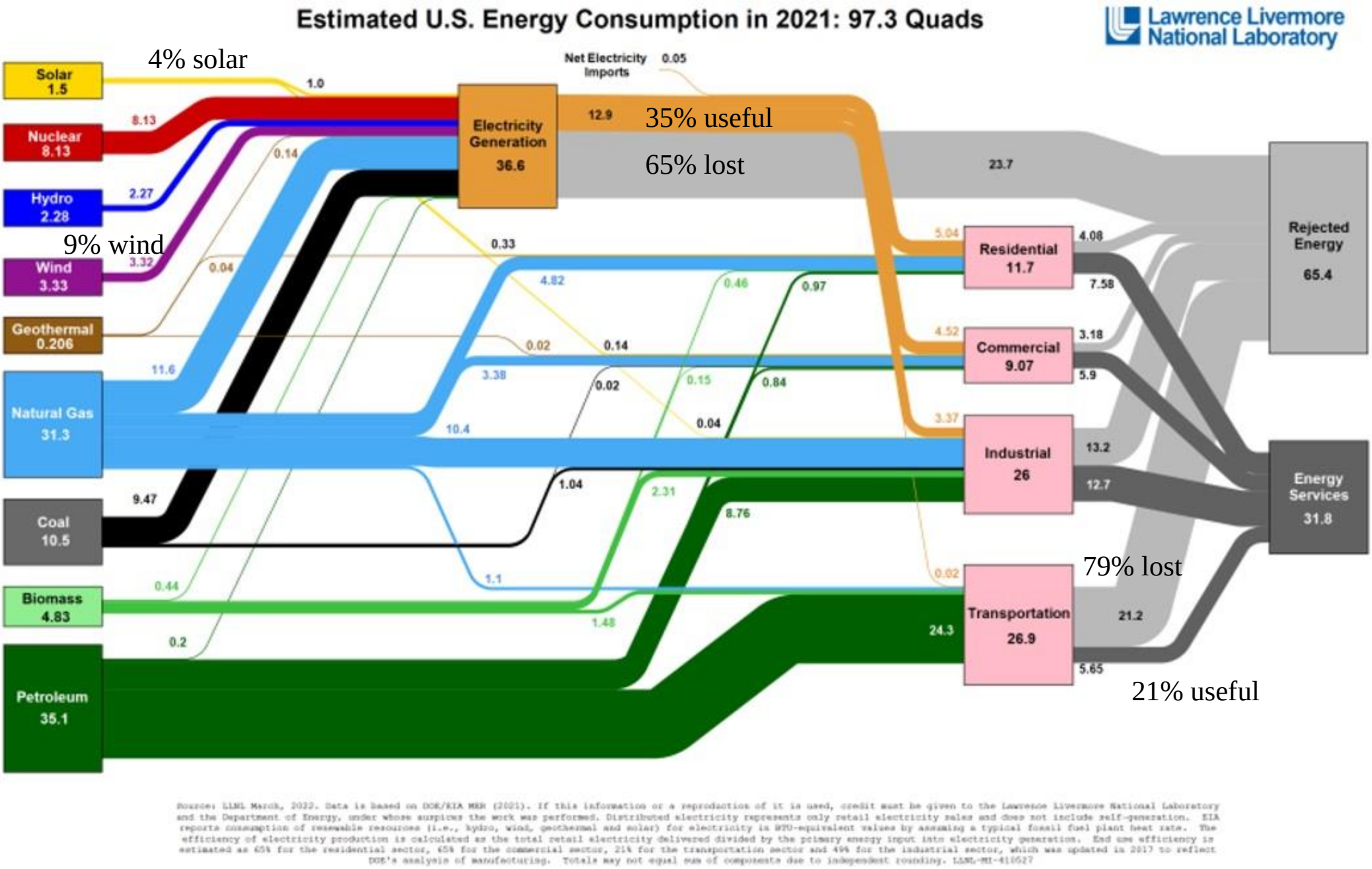
Samsung Galaxy Nexus

2013 for $200

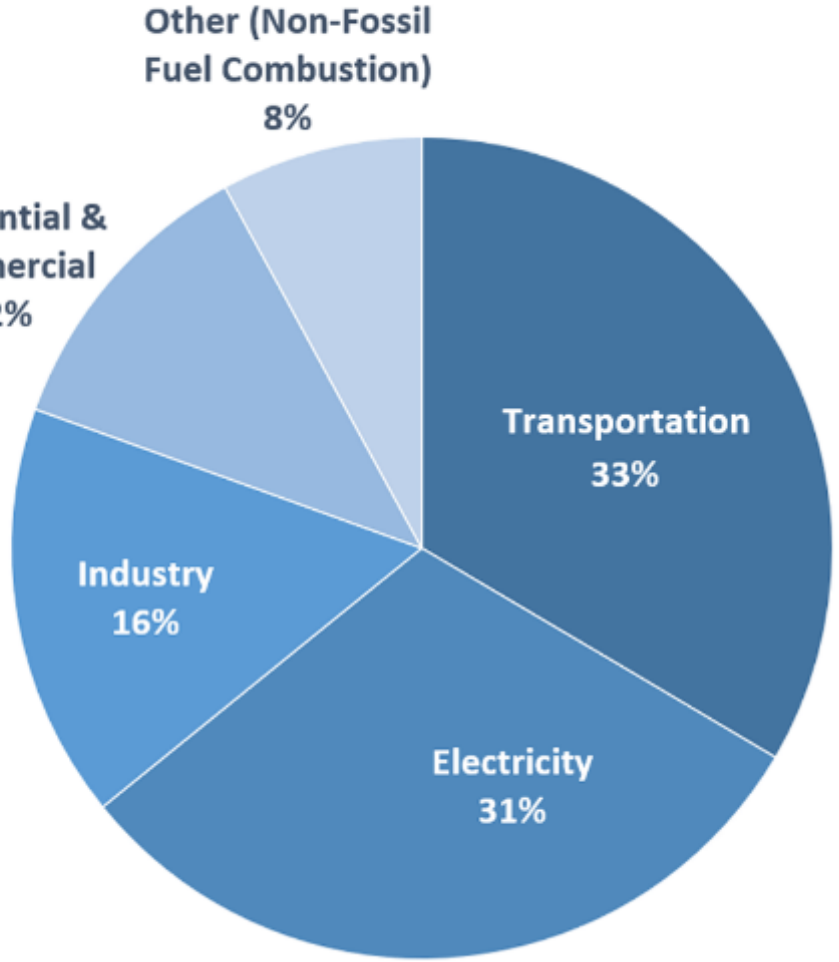
32 GB , 1.2 GHz clock, dual-core

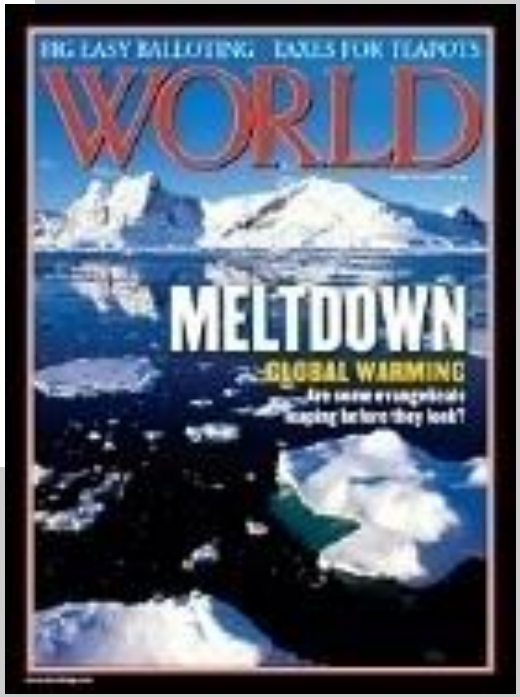
5 ounces and fits in your pocket

23 years = 10x cheaper, 2000x memory, 48x faster, 160x lighter


Estimated U.S. Energy Consumption in 2021: 97.3 Quads
Lawrence Livermore National Laboratory
4% solar
9% wind
35% useful
65% lost
79% lost
21% useful
Solar 1.5
Nuclear 8.13
Hydro 2.28
Wind 3.33
Geothermal 0.206
Natural Gas 31.3
Coal 10.5
Biomass 4.83
Petroleum 35.1
Net Electricity Imports 0.05
Electricity Generation 36.6
Residential 11.7
Commercial 9.07
Industrial 26
Transportation 26.9
Rejected Energy 65.4
Energy Services 31.8
1.0
8.13
2.27
3.32
0.04
0.14
11.6
9.47
0.44
0.2
0.33
4.82
0.02
0.14
3.38
0.02
10.4
1.04
1.1
1.48
0.46
0.97
0.15
0.84
0.04
2.31
8.76
12.9
23.7
5.04
4.52
3.37
0.02
24.3
4.08
7.58
3.18
5.9
13.2
12.7
21.2
5.65
Source: LLNL March, 2022. Data is based on DOE/EIA MER (2021). 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

2020 U.S. Carbon Dioxide Emissions, By Source



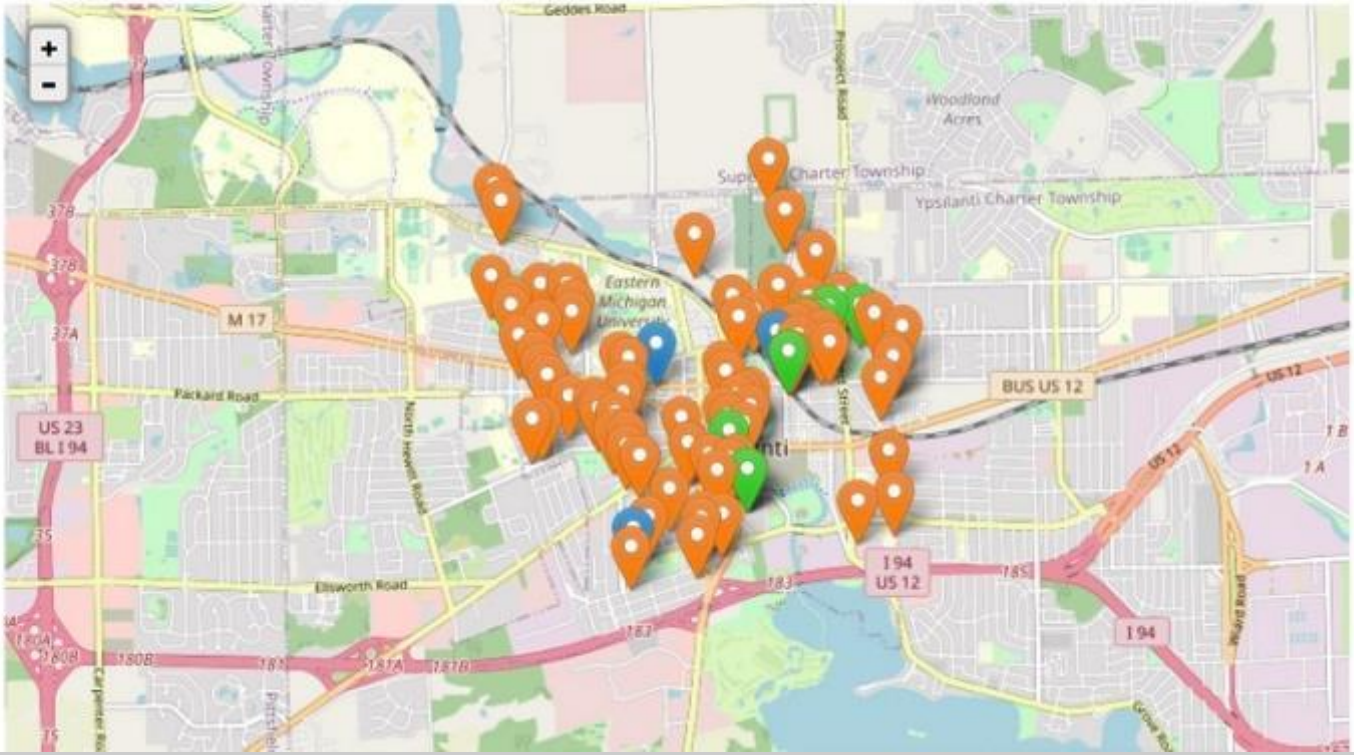


https://www.solarypsi.org

SolarYpsi | Home | Installations | Links | Presentations | Events | About | Contact | Blog | SolarYpsi.org

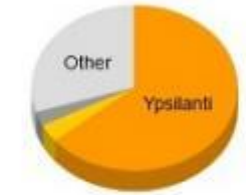
SOLAR YPSI | For a Sustainable YPSILANTI

SolarYpsi is a grass-roots effort in Ypsilanti, MI dedicated to the use of renewable energy sources and this website demonstrates our efforts in real time reporting of electrical production from solar panels. The panels are located in and around Ypsilanti and have been funded through a variety of sources. Selecting a site on the right will take you to the detail page for that site. On the map, a green marker indicates a site that has panels installed and is being monitored from this website while an orange marker is for sites that have panels installed but no monitoring. Blue markers are proposed or otherwise inactive sites.



49 °F - Ypsilanti, MI

144 Sites



Ypsilanti 1/4

2.05 MW Potential

Ypsilanti 1/4