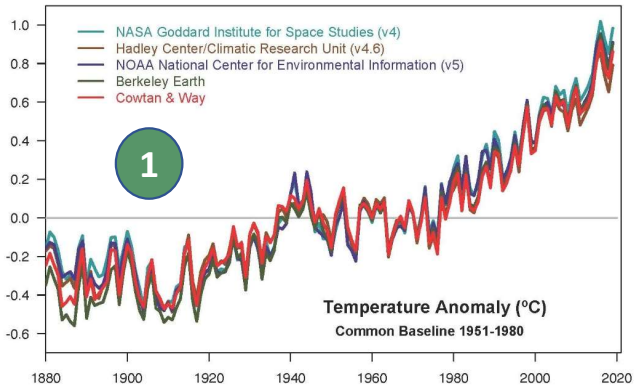
Sierra Club NJ Chapter Presentation

How to Plan the Electrification & GHG Reduction of Your Household

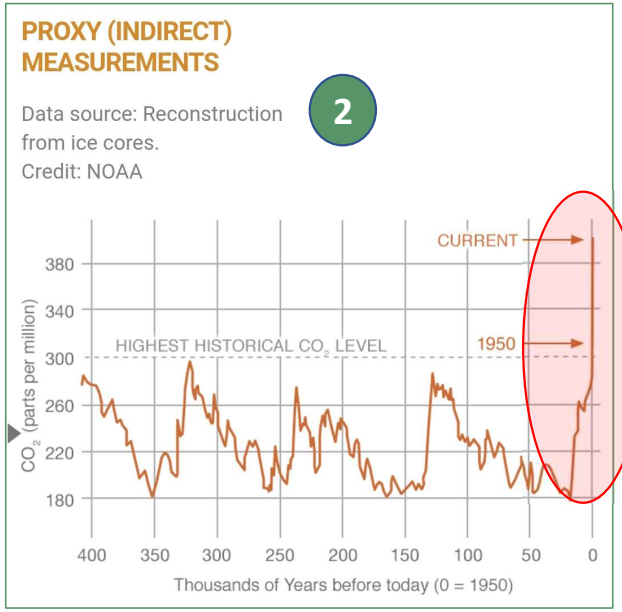
11.16.23
Matt Kavanagh
Founder Green Insight LLC
www.greeninsight.green
Matt.Kavanagh@greeninsight.green
(973) 379-0992

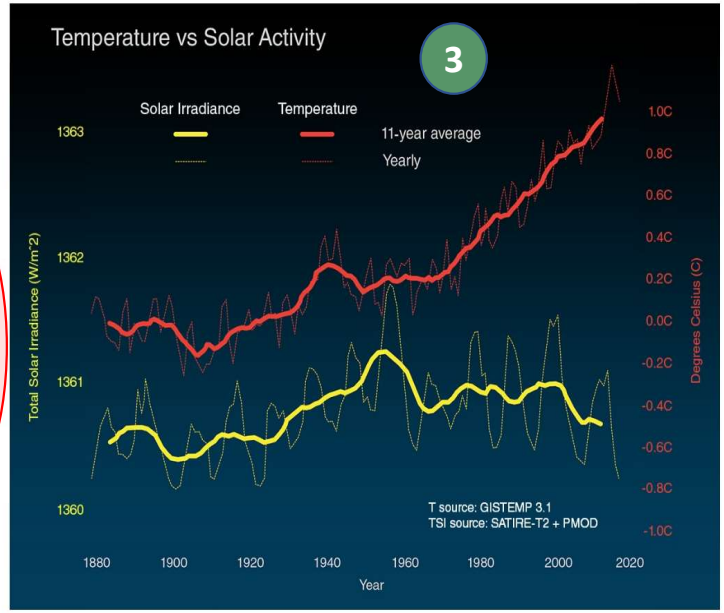
Why Decarbonize - Climate Change requires Everyone's Action Today

Green Insight



Temperature data showing rapid warming in the past few decades. According to NASA data, 2016 was the warmest year since 1880, continuing a long-term trend of rising global temperatures. The 10 warmest years in the 140-year record all have occurred since 2000, with the six warmest years being the six most recent years. Credit: NASA/NOAA.





1. Global mean temperatures continue to raise year over year (NASA) *(NJ 2x higher than average)*
2. Atmospheric CO2 is above 400 ppm (up from 280 ppm 1850s) (NOAA) *(May 2022 421ppm)*
3. Anthropogenic green house gas emissions are the cause (not sun activity) *(IPCC)*

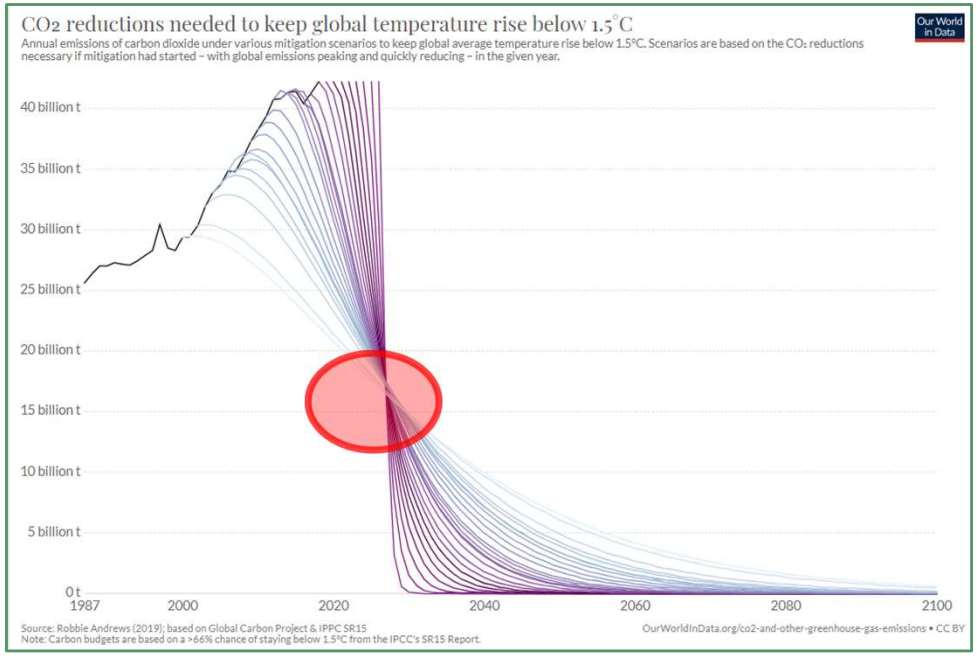
Why Decarbonize - Climate Change requires Everyone's Action Today

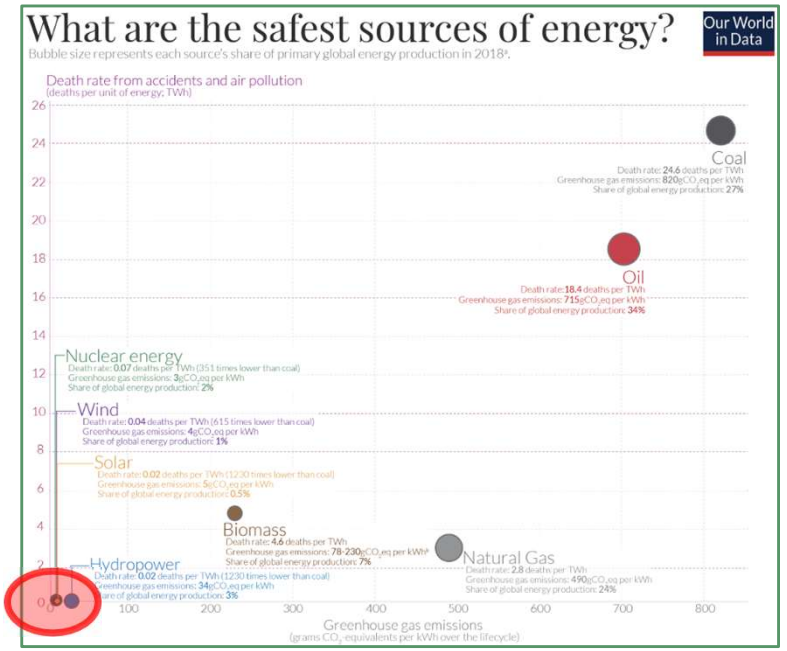
Green Insight

2027 Marks a year of inflection for the world where at least 50% C02 Reductions are needed to keep below 1.5 C warming

Solar PV, Geothermal and Wind are:

1. **Cheap** (levelized cost of energy winning)
2. **Safest energy sources** (see below)
3. **Abundant** (~40 min of sun = 1 Yr global electric)
4. **Requires very little water**
5. **Affords energy freedom and resiliency**





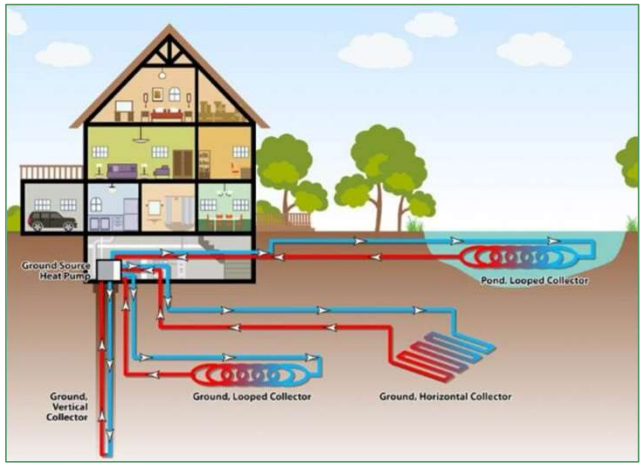
Carbon & Energy Reduction with Efficiency & Renewables

Path to Decarbonize Your Home

1. Reduce energy demand with home energy efficiency upgrades
2. Offset as much electric (kWh) and heating (therms)/cooling energy (kWh) demand for home with on premises solar PV & heat pumps (air source/ground source)
3. Offset balance with clean renewable electric energy purchased through an aggregation program, clean 3rd party or via community solar programs

Geothermal Ground Source Heat Pumps (GSHP)

Vertical or horizontal water loop wells act as a heat exchanger with the ground with the best thermal COP ~3-5



Solar Photovoltaic (PV) Systems

Ground Mount

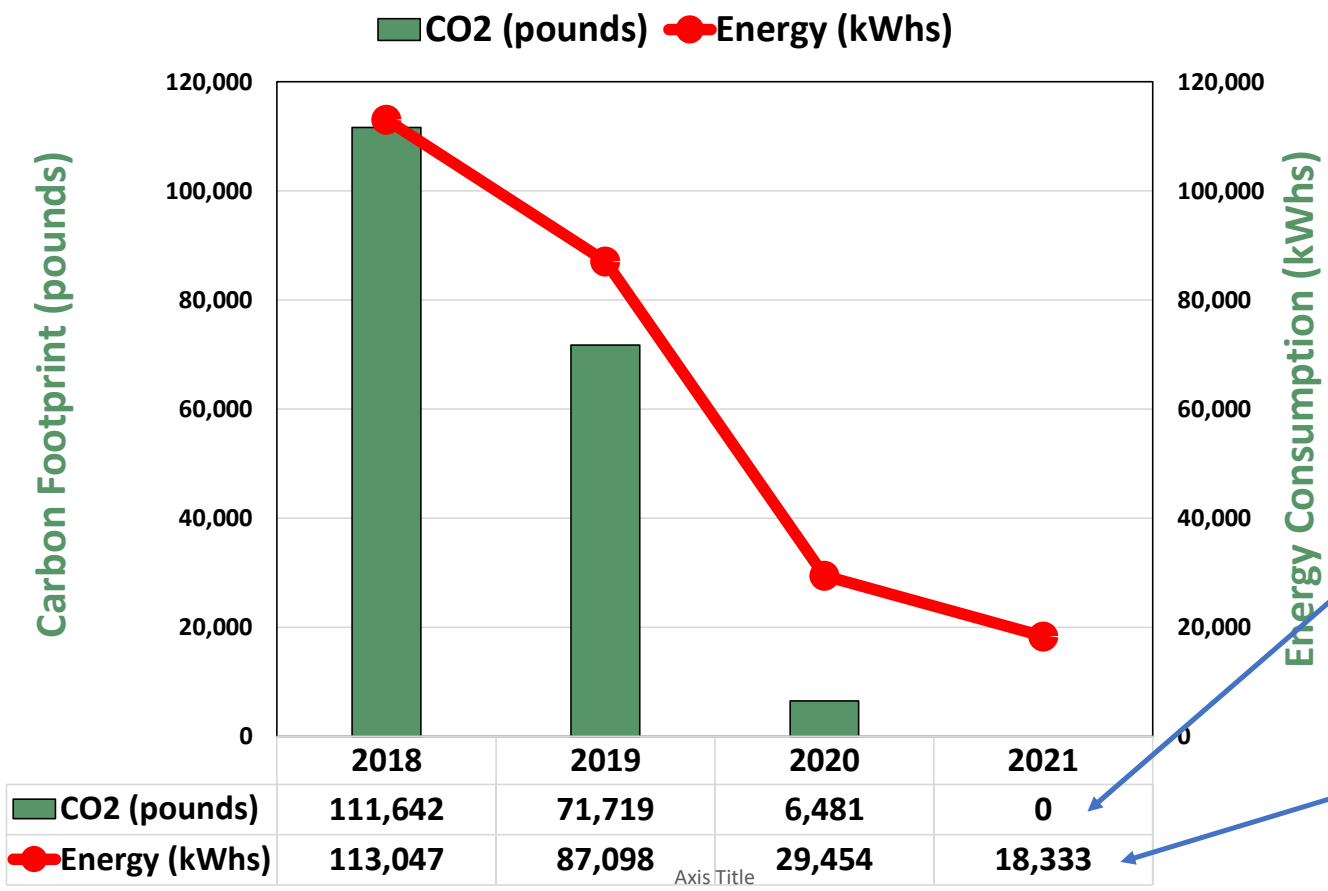
Carport

Rooftop

Residential Case Studies

Kavanagh Carbon Reduction Plan (New Jersey)
Johnson Carbon Reduction Plan (Maryland)

Kavanagh Energy Master Plan - Renewable Energy Transition (Energy and Carbon)



	2018	2019	2020	2021
CO2 (pounds)	111,642	71,719	6,481	0
Energy (kWhs)	113,047	87,098	29,454	18,333

Includes electric, heating/cooling, transportation and lawn care energy demands

- *2018-2019 drop = Solar PV installation*
- *2019-2020 drop = geothermal installation*

1 *Zero (0) energy carbon footprint within 3 years*

2 *>80% energy consumption reduction*

Renewable Transition Cash Flow Data

	Annual	Cummulative	Annual	Cummulative	Annual Savings	Cumulative	Carbon Savings (lbs)
2020	$ 6,417	$ 6,417	$ 8,822	$ 8,822	(2,405)	(2,405)	96,519
2021	$ 6,610	$ 13,027	$ 8,822	$ 17,644	(2,212)	(4,617)	96,519
2022	$ 6,808	$ 19,834	$ 8,835	$ 26,479	(2,027)	(6,644)	111,642
2023	$ 7,012	$ 26,846	$ 8,848	$ 35,327	(1,836)	(8,480)	111,642
2024	$ 7,222	$ 34,069	$ 8,861	$ 44,188	(1,639)	(10,119)	111,642
2025	$ 7,439	$ 41,508	$ 1,375	$ 45,563	6,064	(4,056)	111,642
2026	$ 7,662	$ 49,170	$ 1,390	$ 46,953	6,273	2,217	111,642
2027	$ 7,892	$ 57,062	$ (36)	$ 46,918	7,928	10,145	111,642
2028	$ 8,129	$ 65,191	$ (20)	$ 46,897	8,149	18,294	111,642
2029	$ 8,373	$ 73,564	$ (5)	$ 46,893	8,377	26,671	111,642
2030	$ 8,624	$ 82,188	$ 3,267	$ 50,159	5,357	32,028	111,642
2031	$ 8,883	$ 91,070	$ 3,283	$ 53,442	5,599	37,628	111,642
2032	$ 9,149	$ 100,219	$ 3,300	$ 56,743	5,849	43,477	111,642
2033	$ 9,424	$ 109,643	$ 3,318	$ 60,061	6,106	49,582	111,642
2034	$ 9,706	$ 119,349	$ 3,336	$ 63,397	6,370	55,953	111,642
2035	$ 9,997	$ 134,847	$ 3,355	$ 66,752	6,643	68,095	111,642
2036	$ 10,297	$ 145,144	$ 3,374	$ 70,126	6,923	75,018	111,642
2037	$ 10,606	$ 155,750	$ 3,394	$ 73,520	7,212	82,231	111,642
2038	$ 10,925	$ 166,675	$ 3,414	$ 76,934	7,510	89,741	111,642
2039	$ 11,252	$ 177,927	$ 3,436	$ 80,370	7,817	97,558	111,642
2040	$ 11,590	$ 189,517	$ -	$ 80,370	11,590	109,147	111,642
2041	$ 11,938	$ 201,455	$ -	$ 80,370	11,938	121,085	111,642
2042	$ 12,296	$ 213,750	$ -	$ 80,370	12,296	133,380	111,642
2043	$ 12,665	$ 226,415	$ -	$ 80,370	12,665	146,045	111,642
2044	$ 13,044	$ 239,459	$ -	$ 80,370	13,044	159,089	111,642
	$ 239,459		$ 80,370		Lbs CO2	Pound CO2	2,760,802
	$ 9,578		$ 3,215		Tons CO2	Tons CO2	1,380

Notes

- Positive cash by year 5.5
- $159k in net cash
- Hedged against inflation
- ~1400 Tons of lifetime carbon savings
- ROI ~8%
- 20 yr. solar loan
- 5 yr. geothermal loan
- Investment tax credits pay down loans

Assumptions

- 3% escalator on utilities
- $210/SREC (10 yrs.) (old program)
- Typical replace furnace at 15yrs

Kavanagh 25 Year Cash Flows for Renewable Transition

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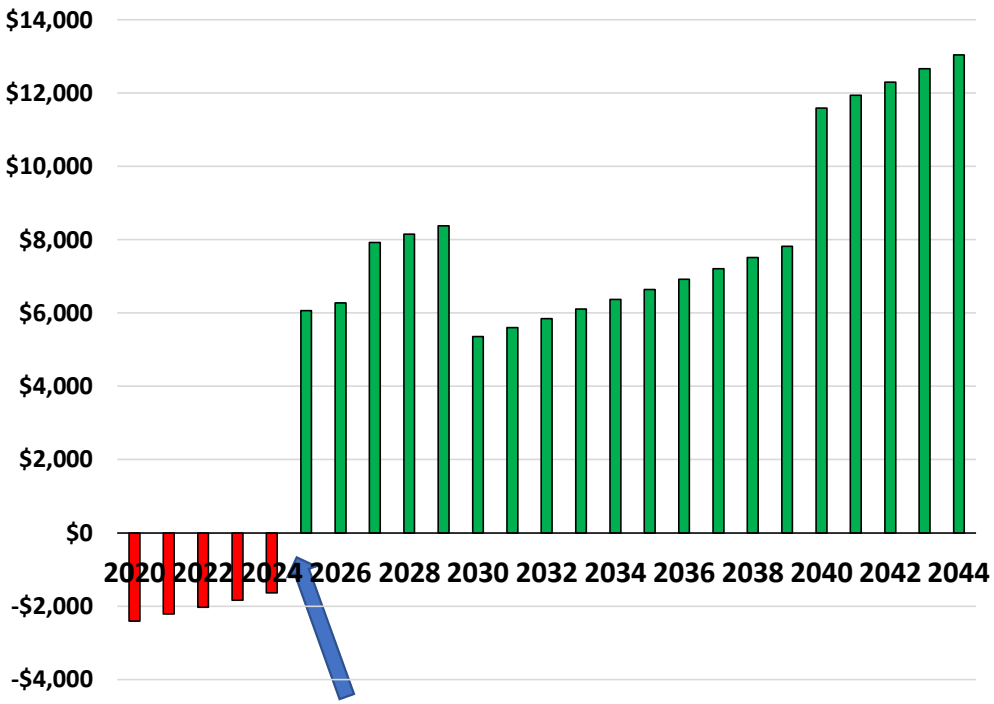
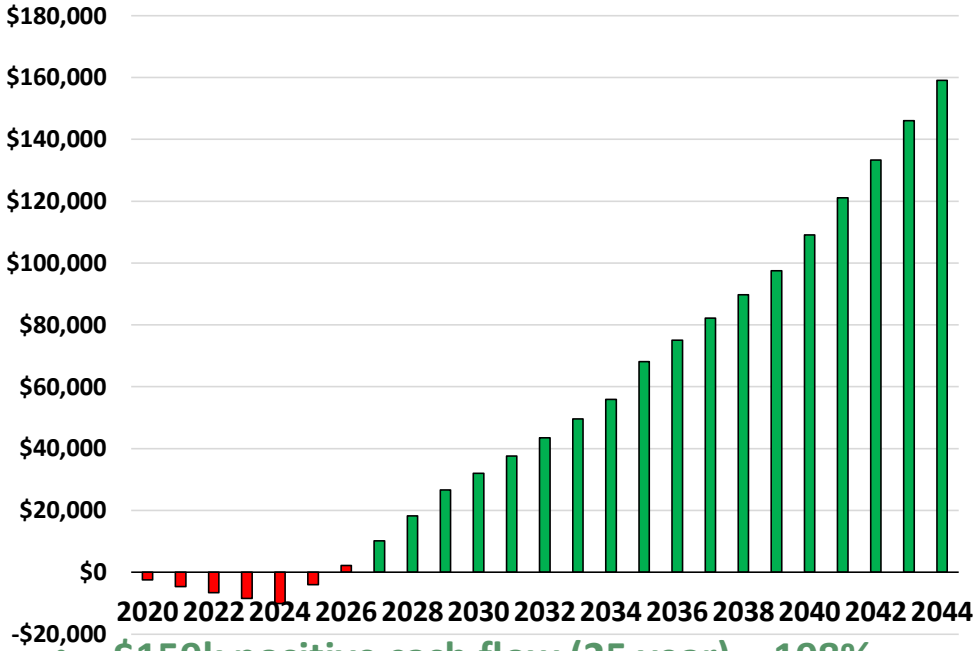
Annual Cash Flow _ Kavanagh Zero Carbon Energy Master Plan



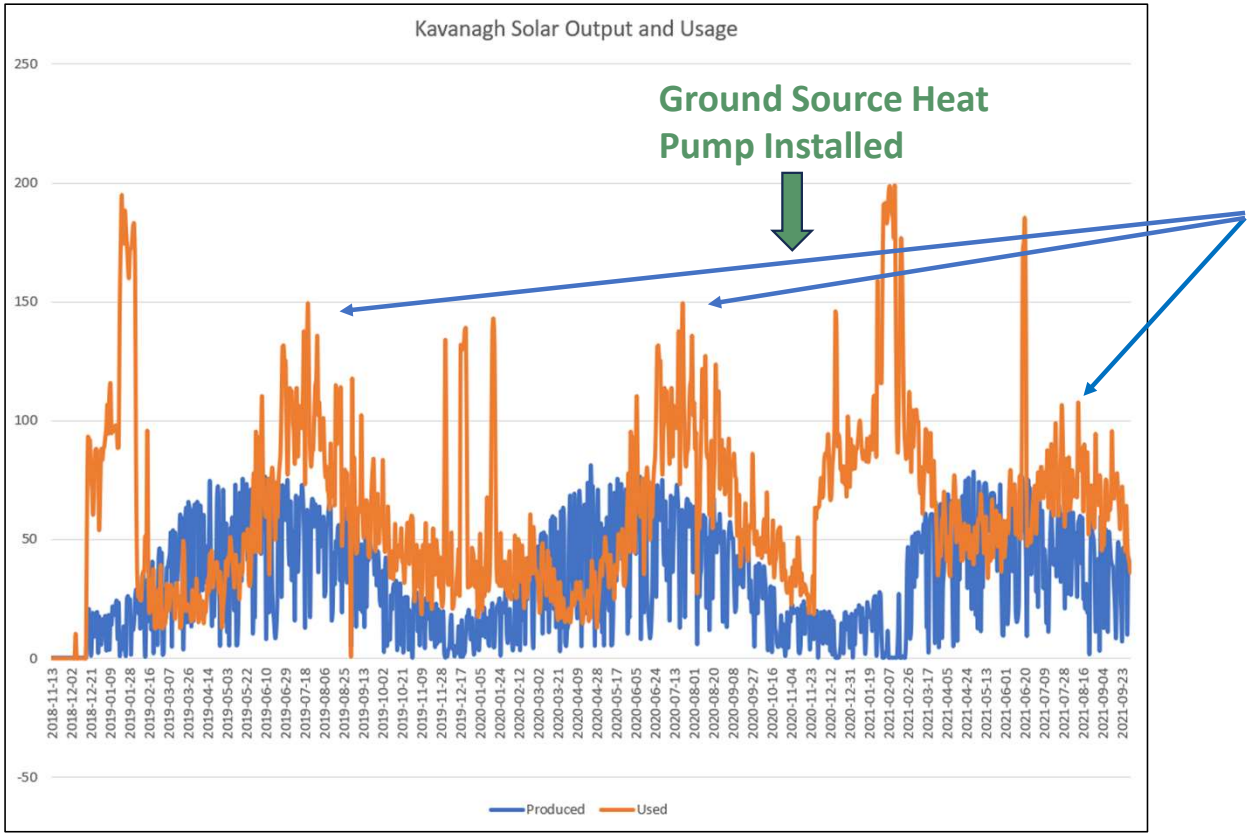
Positive Cash Flow after 5.5 years

Cumulative Cash Flow _ Kavanagh Zero Carbon Energy Master Plan



- **$159k positive cash flow (25 year) – 198% ROI/8% annual ROI**
- **~$15k additional rebates (cars)**
- **More savings beyond warranty & ground loop lifespan (50+yrs)**

Kavanagh Solar Production vs Usage (Electric)



- Summer peak electric demands lower after Geothermal installed
- Peak solar output ~75kWh/day in June/July
- December lowest solar output ~20kWh/day
- Spring usually has a surplus (lower energy usage and higher solar production)

Renewable Cash Flow Data & Carbon Impact

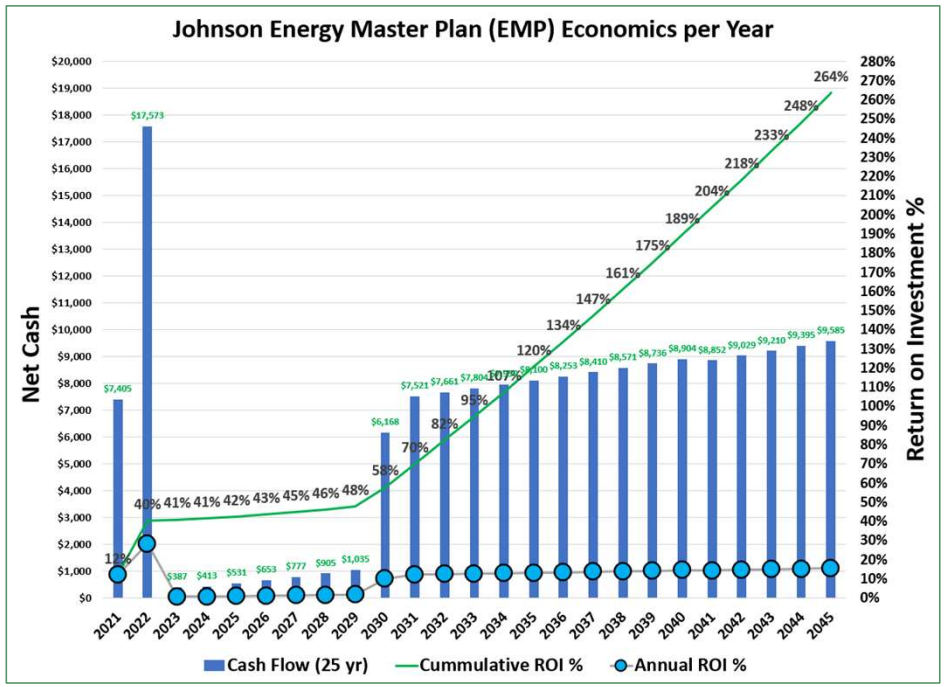
Maryland Case Study

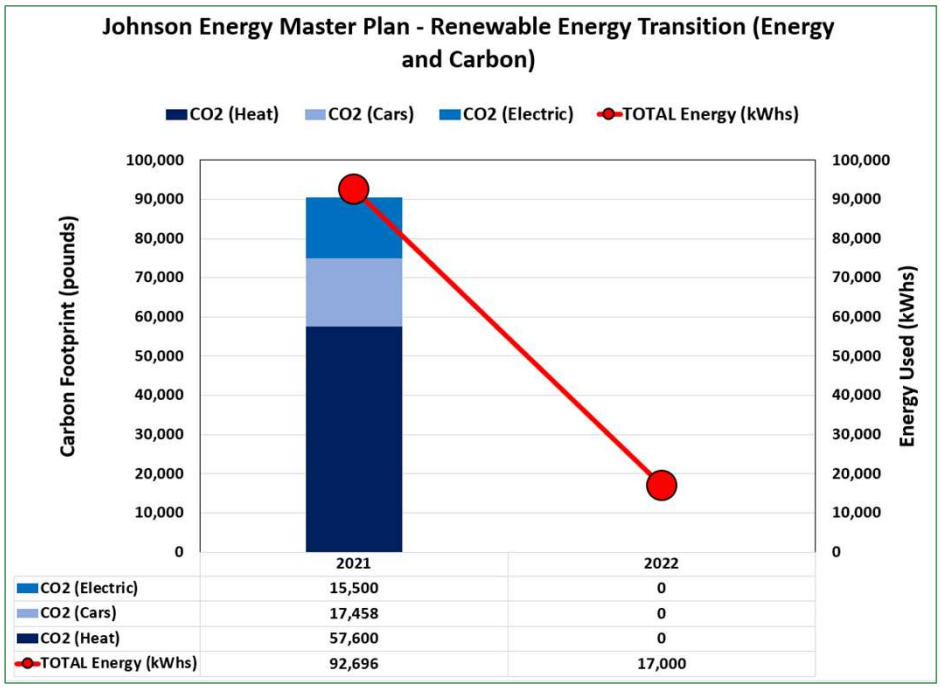
Includes electric, heating/cooling, and transportation energy demands.

Payback by year 7. Positive cash flow from year 1

1. Zero (0) energy carbon footprint within 1 years

2. >75% energy consumption reduction

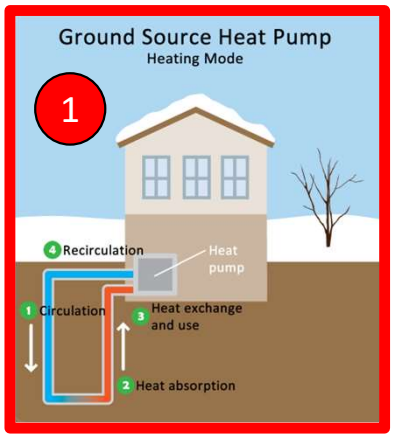




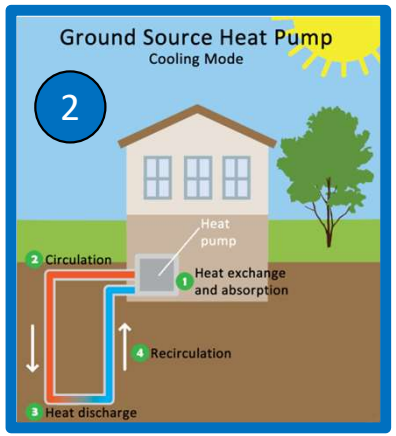
Ground Source Heat Pump – What is it?

- A geothermal heat pump (GHP) or ground source heat pump (GSHP) is a central heating and/or cooling system that transfers heat to or from the ground, often through a vapor-compression refrigeration cycle. Commercial and residential applications. [1]
- Also known as a “geoexchange, earth-coupled, or earth energy system” (different from pure geothermal). [1]
- A ground source heat pump extracts ground heat in the winter (for heating 1) and transfers heat back into the ground in the summer (for cooling 2).[1]
- Takes advantage of near constant temperature in the upper 20ft of the Earth’s surface due to the sun’s energy [2]

Heating Mode – Extracting heat from home



Cooling Mode – Moving heat to the ground



Our Install (2020)

- **Drilling** (1 week)
  - (3) ~250’ deep vertical ground exchange wells
  - Single underground loop
- **Install** connection and equipment install (6 days)
  - Attic (heat/cool air handler + insulation)
  - Basement (water heater, pumps, storage tank, WaterFurnace, remove outside AC condenser


Well cap

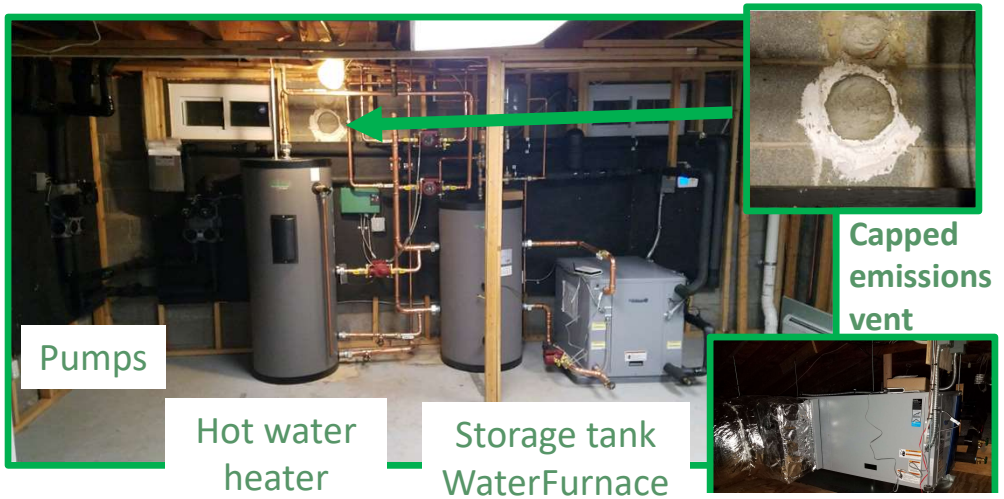

Drill rig

Before (natural gas furnace and hot water heater)


Removed

Removed

After (GSHP heating, air conditioning and water heater)


Pumps

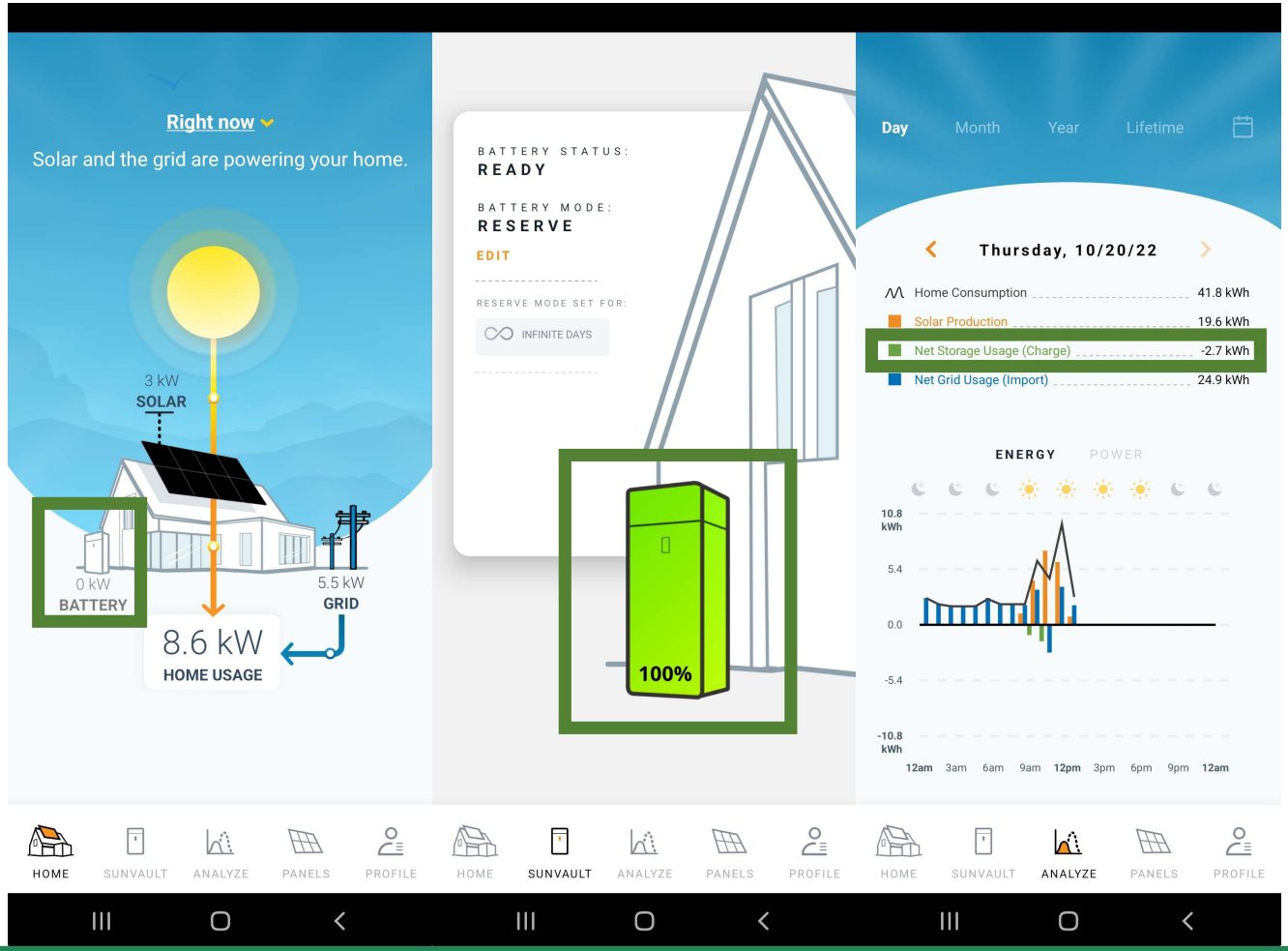
Hot water heater

Storage tank WaterFurnace

Capped emissions vent

Attic air handler

SunPower SunVault© Energy Storage System (ESS)



- 2022 installed 52-kilowatt hour energy storage system
- Whole house back up in event of outage
- Pairs with solar system and recharges during the day
- Indefinite back up at reduced load
- 10-year warranty on battery capacity

[Mega SunVault™ Storage Install – YouTube]

[SunVault the Solar Battery Storage System for Homeowners | SunPower]

Volt Plug in Hybrid Savings Analysis

Green Insight

#/Gallon	$/kWh
$ 3.00	$ 0.15

	Fuel Economy:	Electric Consumption (kWh/100mi):	Mi/kWh	Electric Miles:	kWh used (estimated)	Gas Miles:	Total Miles:	Percentage on Electric:	Percentage on Gas:	Estimated Gallons of Fuel Saved:	East Coast Cost per Gal Per US EIA	Gas Savings	Gallons Burned	$ Spent on Gas	Estimated CO2 Avoided (lbs):	(lbs) CO2 per Gallon of Fuel	
March	123 mpg	41	2.4	462	189	132	593	78%	22%	21	$ 2.55	$ 53.47	4	$ 11.20	407	19.4	
April	250+ mpg	31	3.2	539	167	48	588	92%	8%	24	$ 2.77	$ 66.48	2	$ 4.43	473	19.7	
May	74 mpg	32	3.1	810	259	865	1,675	48%	52%	50	$ 2.81	$140.70	29	$ 81.14	973	19.5	
June	200 mpg	33	3.0	659	217	147	805	82%	18%	31	$ 2.67	$ 82.80	5	$ 13.09	601	19.4	
July	101 mpg	36	2.8	687	247	356	1,043	66%	34%	35	$ 2.73	$ 95.41	12	$ 32.35	680	19.4	
August	108 mpg	35	2.9	956	335	529	1,485	64%	36%	51	$ 2.61	$133.31	18	$ 46.09	986	19.3	
September	250+ mpg	31	3.2	1,041	323	132	1,173	89%	11%	48	$ 2.57	$123.12	4	$ 11.29	923	19.2	
October	74 mpg	37	2.7	702	260	833	1,535	46%	54%	46	$ 2.55	$117.25	28	$ 70.78	894	19.4	
November	151	38	2.6	664	252	176	840	79%	21%	31	$ 2.54	$ 78.83	6	$ 14.92	601	19.4	
December	73	39	2.6	347	135	251	840	58%	42%	18	$ 2.55	$ 45.94	8	$ 21.35	346	19.2	
TOTAL		35.3	2.9	6,867	2,385	3,469	10,577	65%	35%	355		$937.31	116	$306.64	6884	19.4	Net Savings $ 580

Electric Costs	$ 358	Gas Costs Saved	$ 937
Electric Cost/Mile	$ 0.052	Gas Costs / Mile	$ 0.136
Estimated Total kWhs	3674		
Full Electric			

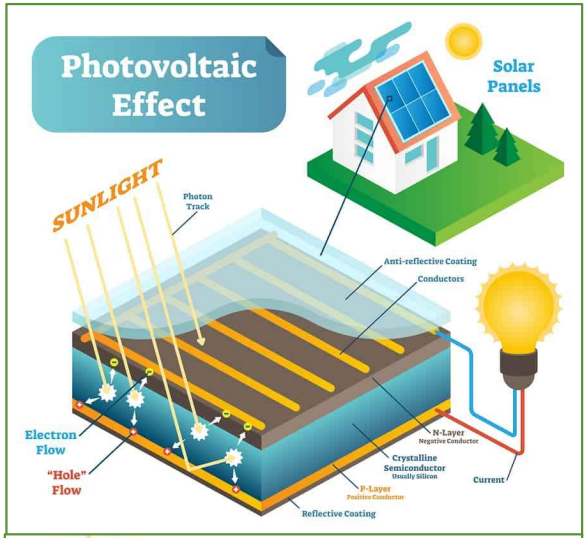
Cost per mile is 3X lower for EVs - **~$750 savings / yr** + maintenance savings

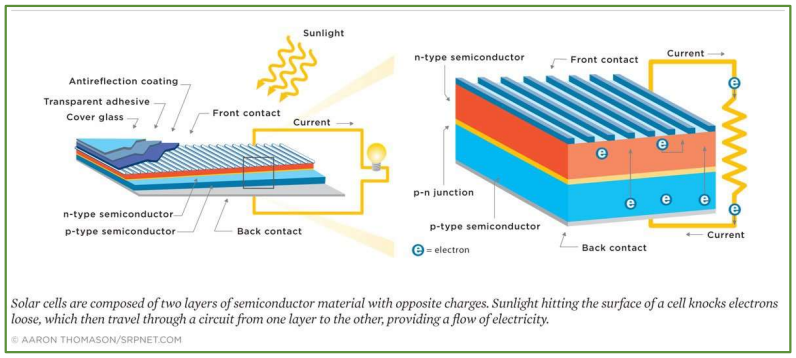
*Savings even higher with increasing gas prices 2021>>

Appendix

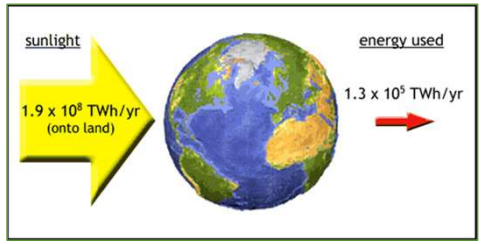
How Does Solar Works - Science

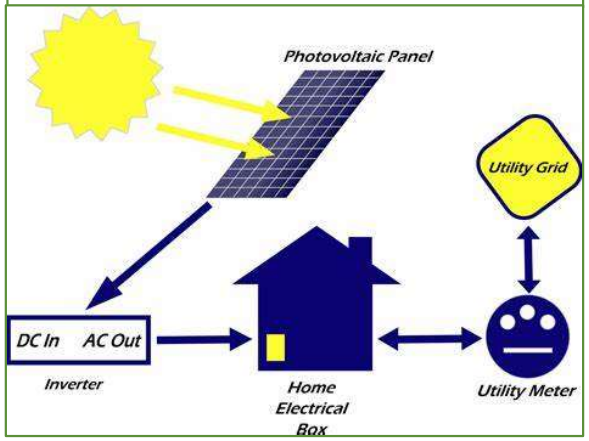
1. Photos of light hit the solar cells or PV material and dislodge electrons which creates a voltage across the gap (~0.5V).
2. Multiple cells create a voltage per PV module, and these are strung together like lights to form “strings”.
3. Each string produces power and current which is then converted to AC power for use in your home and tied to your electric panel (before = line side) or (after = load side) the grid connection.
4. Anything extra power (instantaneously unused) is returned to the grid via a bidirectional meter (net metering)





Solar cells are composed of two layers of semiconductor material with opposite charges. Sunlight hitting the surface of a cell knocks electrons loose, which then travel through a circuit from one layer to the other, providing a flow of electricity.

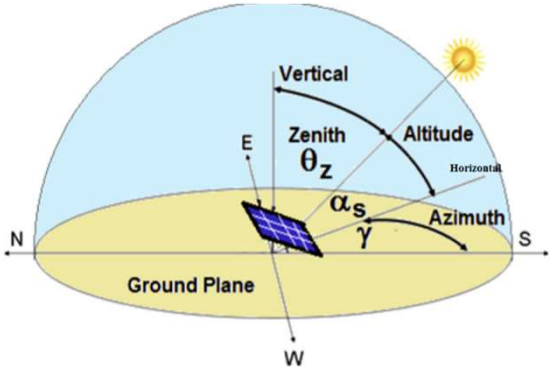




How Does Solar Work – Performance Factors

kWh per Watt in our area is 1 – 1.4 kWh/Watt/year

1) Orientation to the Sun (south is best)



UK Solar Orientation Chart (orientation and tilt)

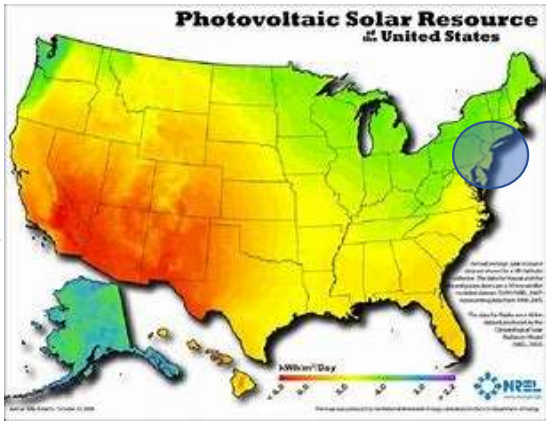
Orientation Chart showing output for different orientation and tilt angles (% of maximum)																			
Tilt (°)	West							South						East					
	90	80	70	60	50	40	30	20	10	0	10	20	30	40	50	60	70	80	90
0	87	88	90	91	92	92	93	93	93	93	93	93	92	92	91	90	89	87	86
10	84	87	90	92	94	95	95	96	96	97	97	96	95	94	93	91	89	87	84
20	82	85	90	93	94	96	97	98	99	99	98	97	96	95	93	91	88	84	81
30	78	83	87	91	93	96	97	98	99	100	98	97	96	95	93	89	85	81	78
40	75	79	84	87	92	94	95	96	96	96	96	95	94	92	90	86	82	77	72
50	70	74	79	83	87	90	91	93	94	94	94	93	91	88	83	80	76	73	70
60	65	69	73	77	80	83	86	87	87	87	88	87	85	82	78	74	71	67	63
70	59	63	66	70	72	75	78	79	79	79	79	79	78	75	72	68	64	61	56
80	50	56	60	64	66	68	69	70	71	72	72	71	70	67	66	60	57	54	50
90	41	49	54	58	59	60	61	61	63	65	65	63	62	59	60	52	50	47	44

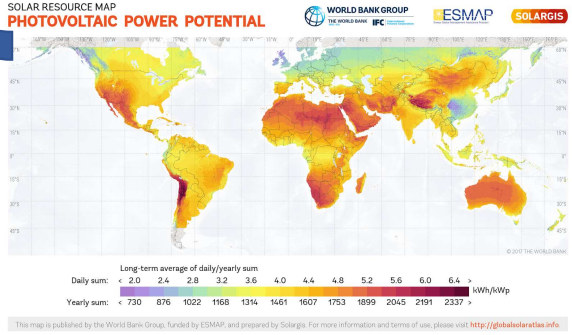
Source: PVNI.org.uk

2) Shade (no/low shade is best)

[Project Sunroof (google.com)]

3) Location on Earth (high sun, high altitude areas are best)

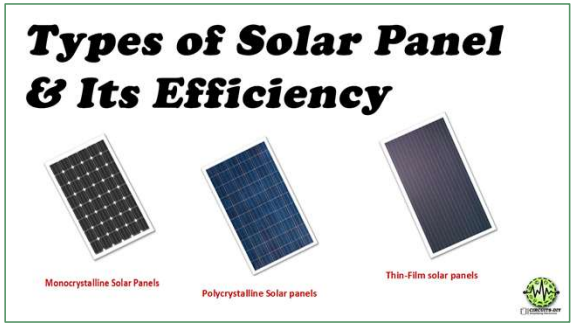


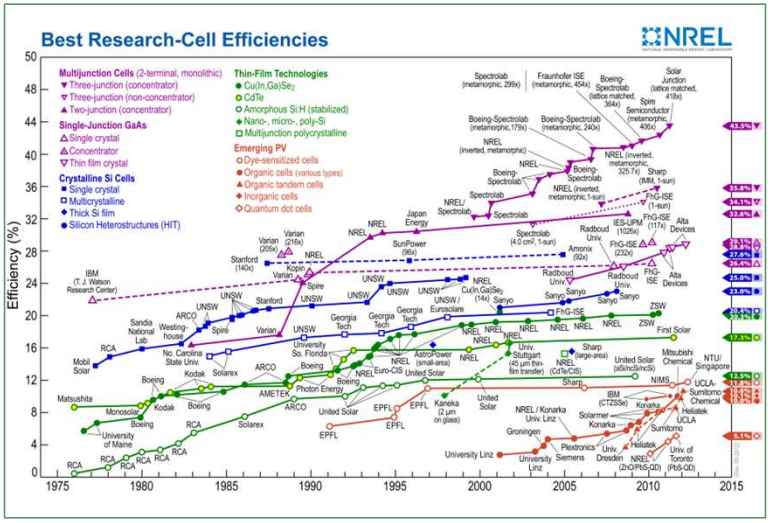


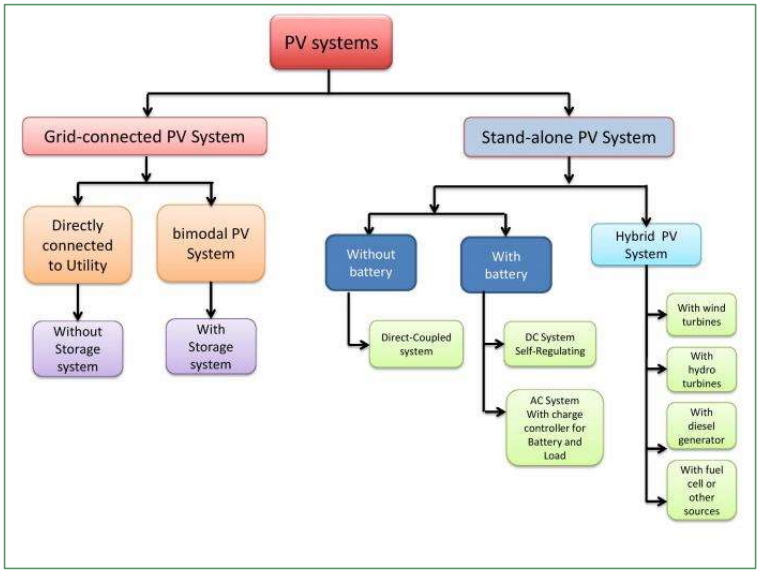
Types of Solar

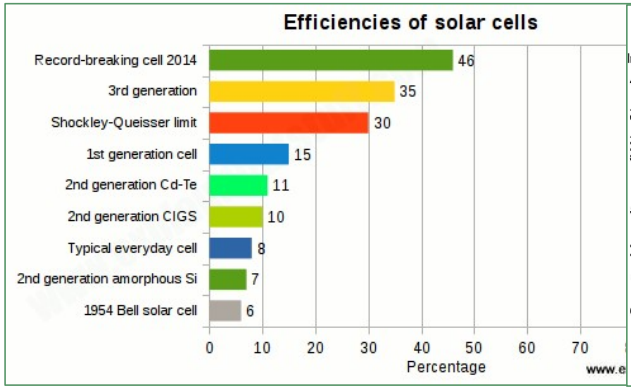
Systems:
(grid connected, stand alone)

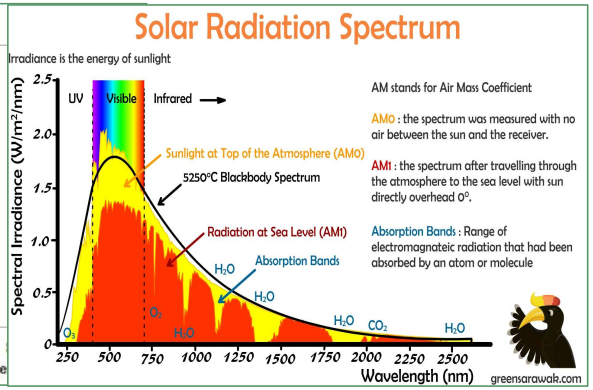
PV Types (efficiencies vary & efficiency matters)





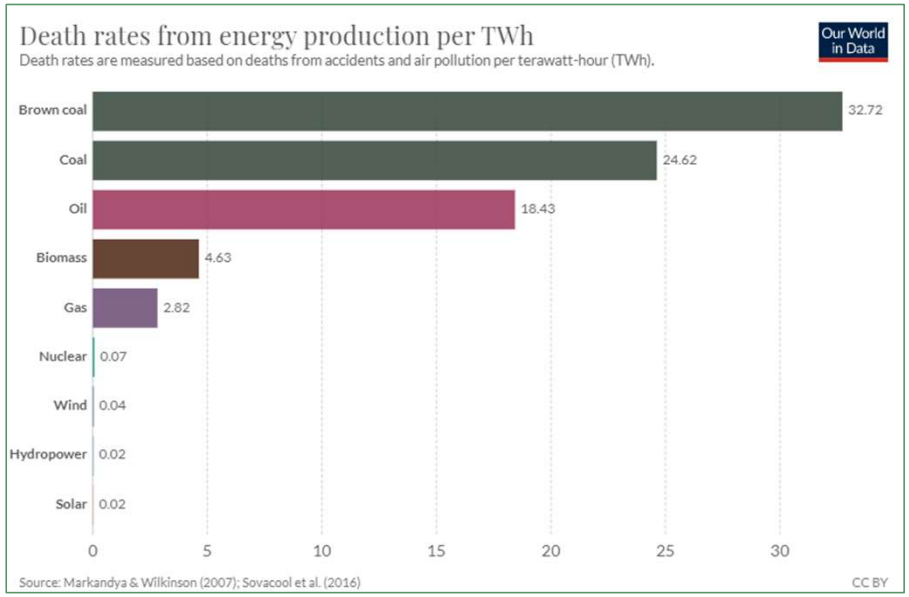


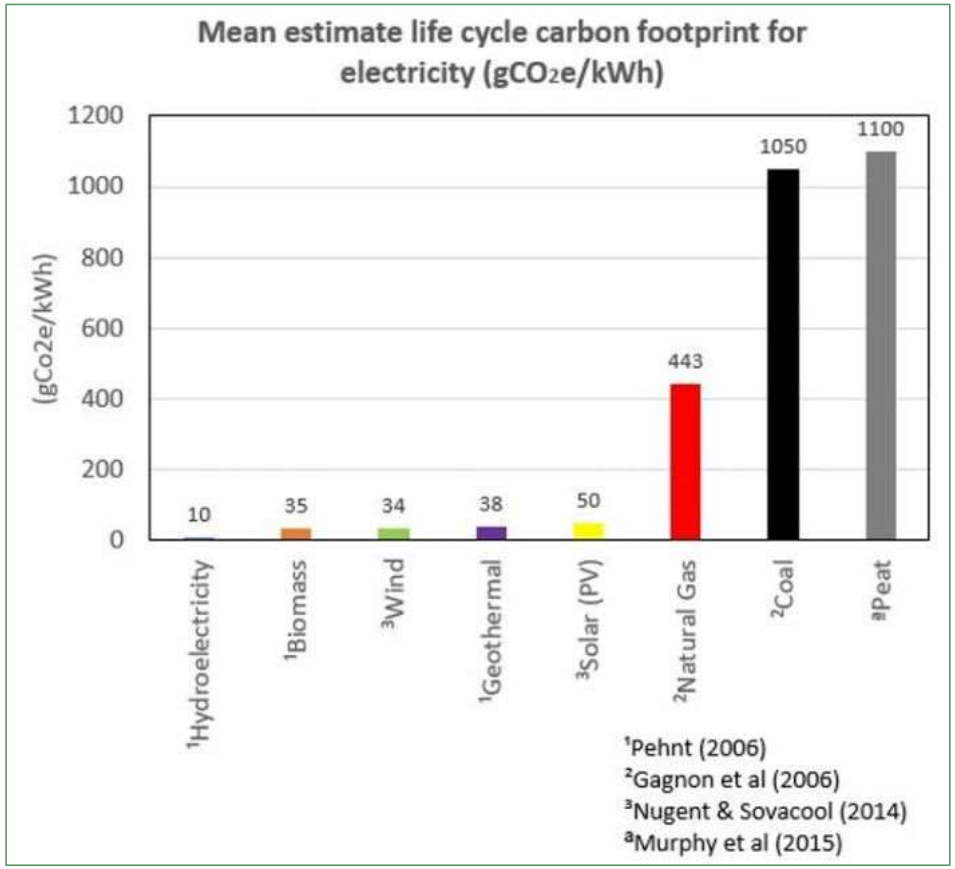




Benefits of Solar – Clean / Safe

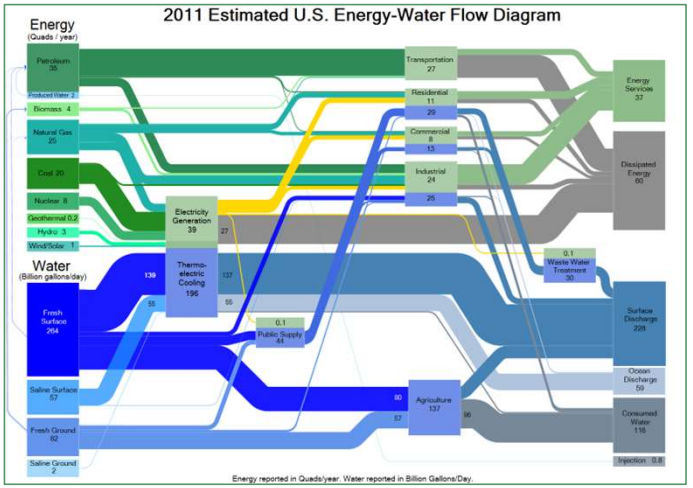
- Carbon savings due to not burring fossil fuels and due to reduced supply chains
- Reduced societal impacts comparted to the alternate

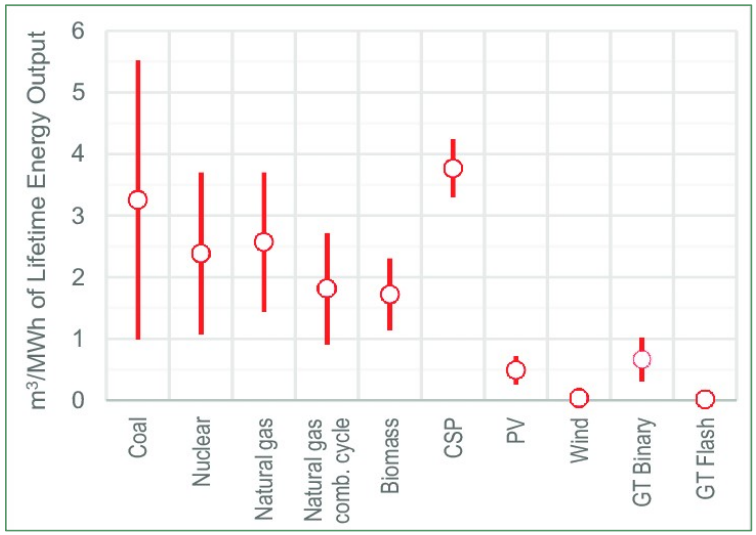


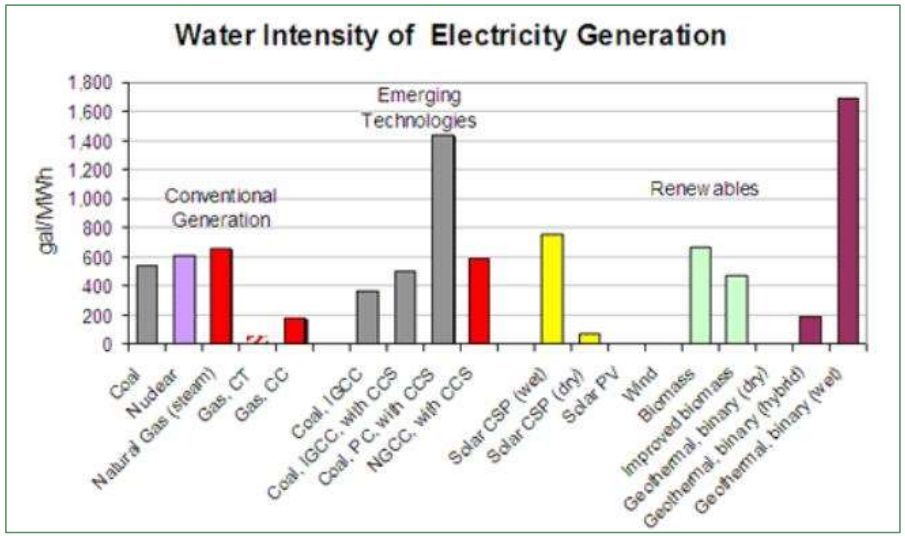


Benefits of Solar – Low Water Usage

- Some generation means use large amounts of water to cool thermal cycles (law of thermodynamics)
- Solar PV has no thermal cycle

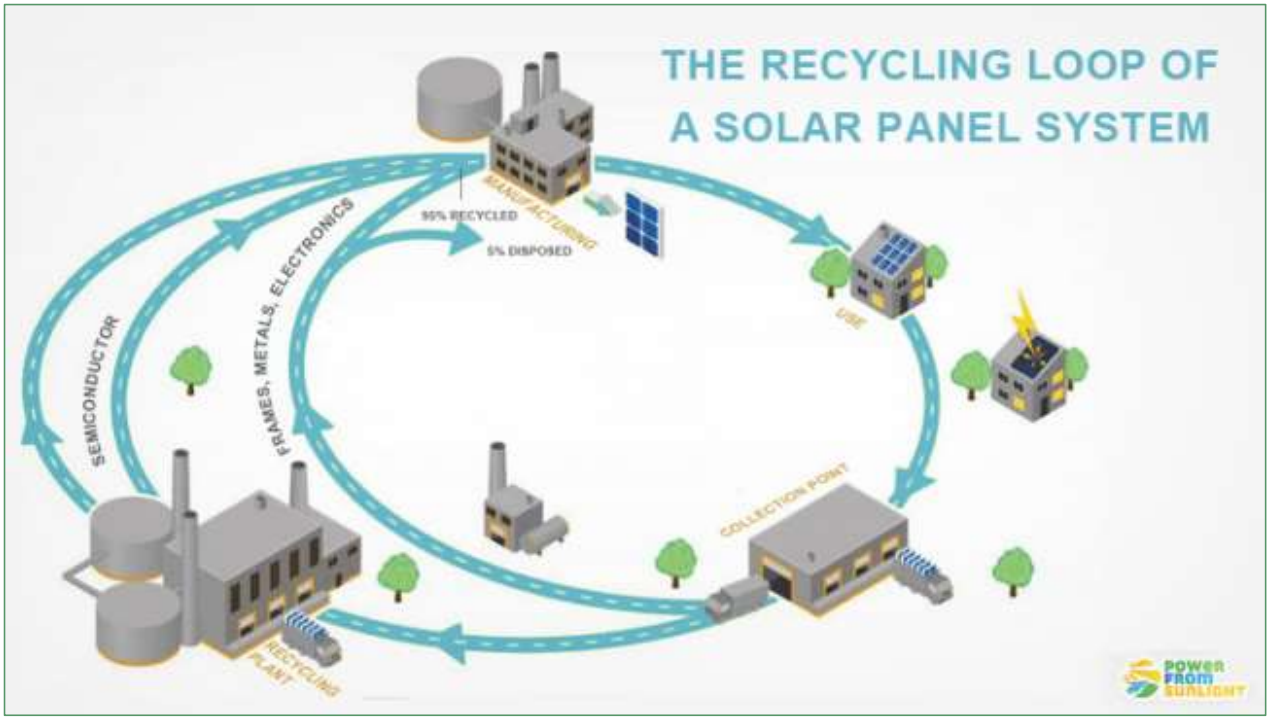






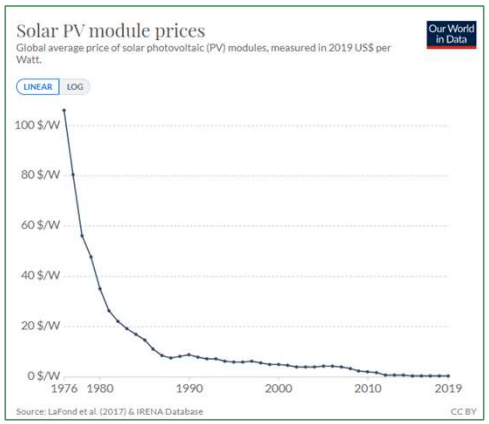
Benefits of Solar – Circular / Sustainable

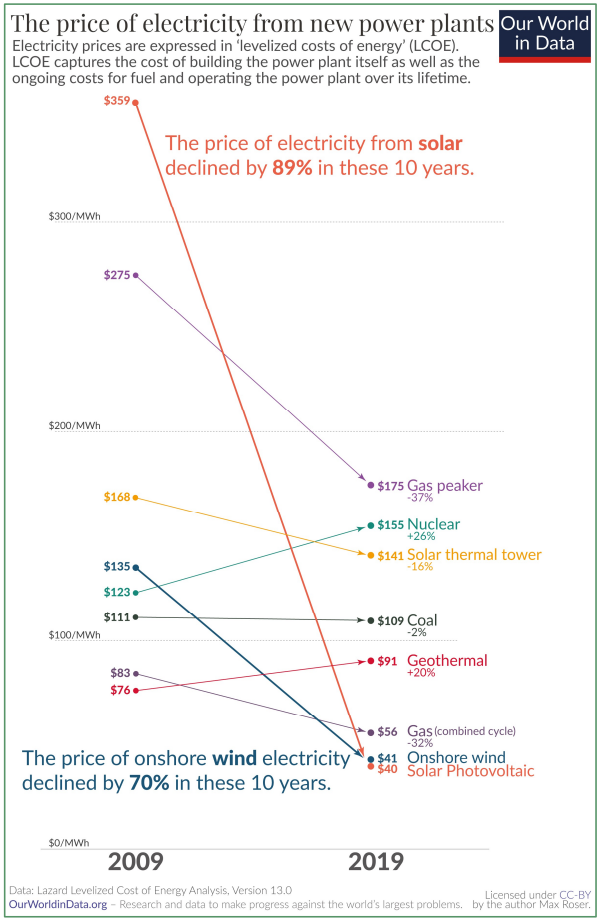
- Solar modules can be recycled
- Mostly glass and aluminum
- 95-98% recyclable
- More innovation to come
- You can't recycle fossil fuels

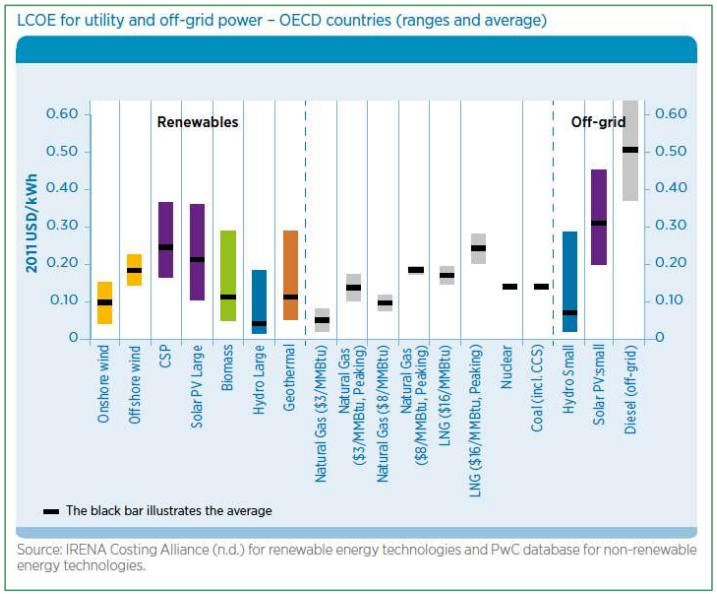


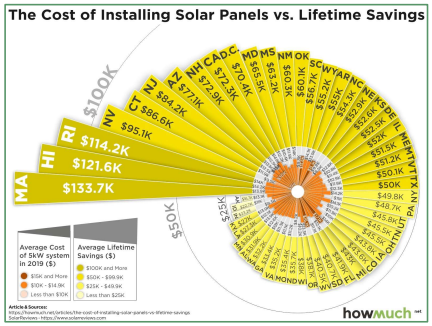
Benefits of Solar – Cheap (now)

- True measure is called Levelized Cost of Electricity (LCOE)
- Fossil fuel costs do not include environmental costs
- Solar follows a learning curve reduction
- Savings come from no / low electric costs



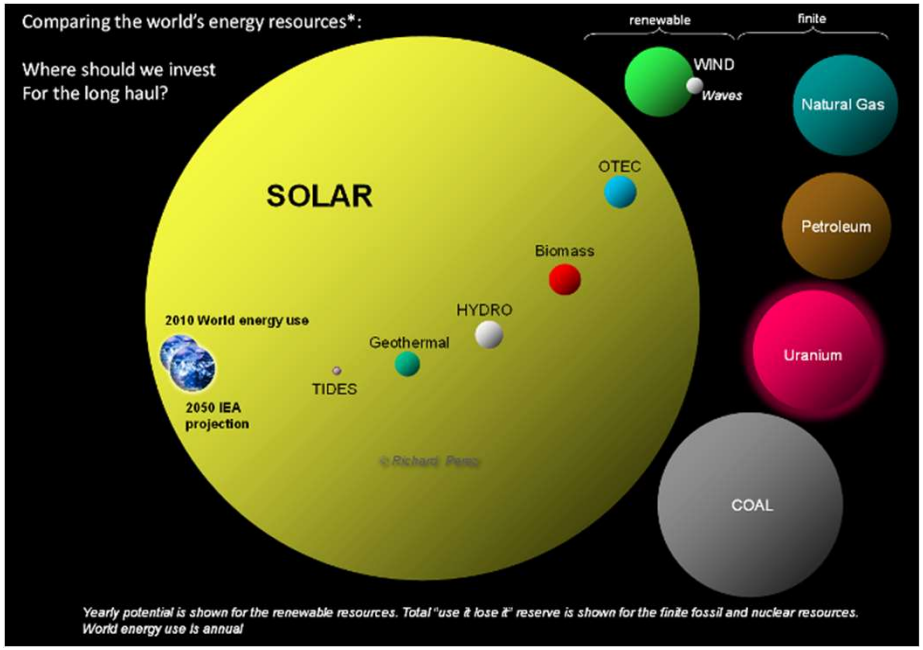






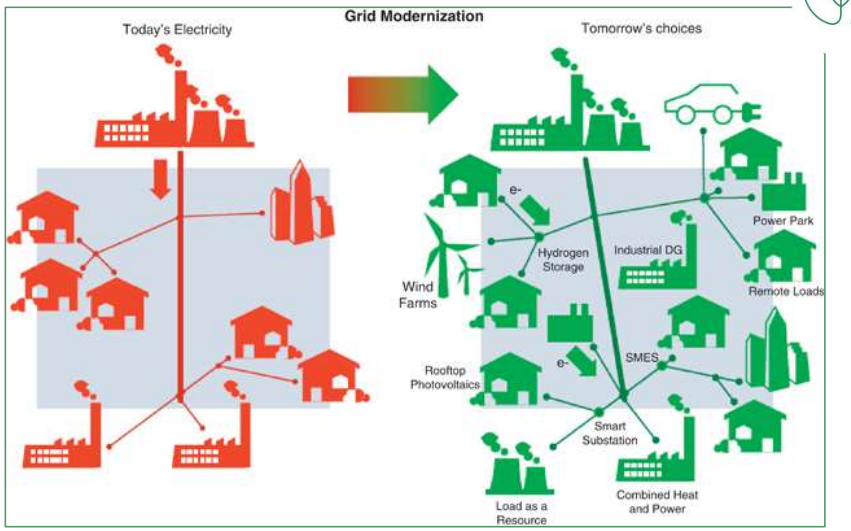
Benefits of Solar – Abundant

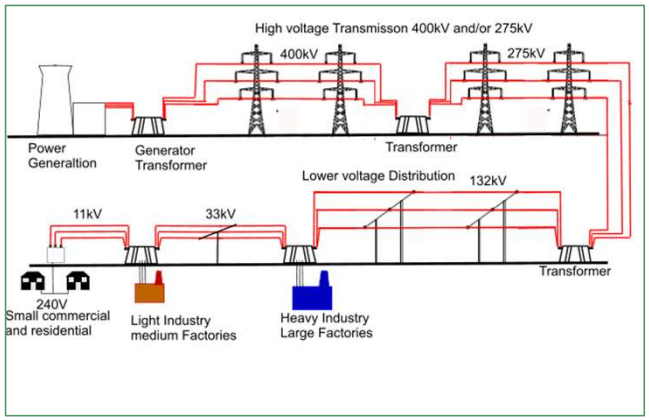
- The sun is the most abundant resource we have
- The sun is available almost anywhere
- No fuel supply chains required (e.g., coal, natural gas)
- 1 hour of sun could power humanity for a year

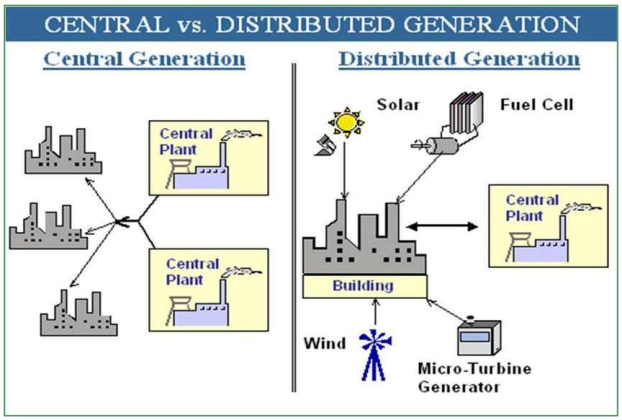


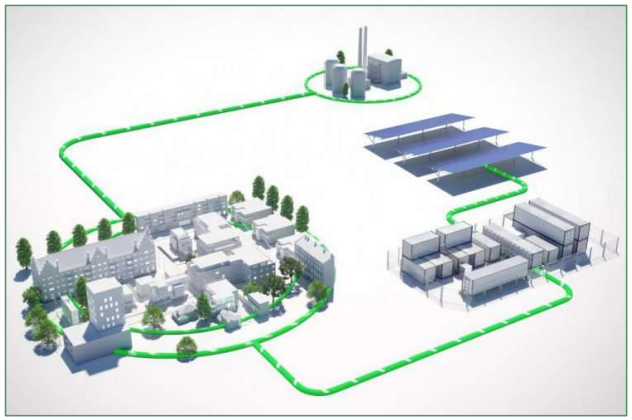
Benefits of Solar – Distributed

- Grid network consists of central power plants supplying electricity of miles of power lines
- Renewable energy + storage offers micro-grid capabilities (off grid cities).
- Grid modernization is a key priority as solar increases
- Provides resiliency during power outages



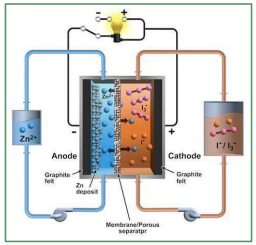


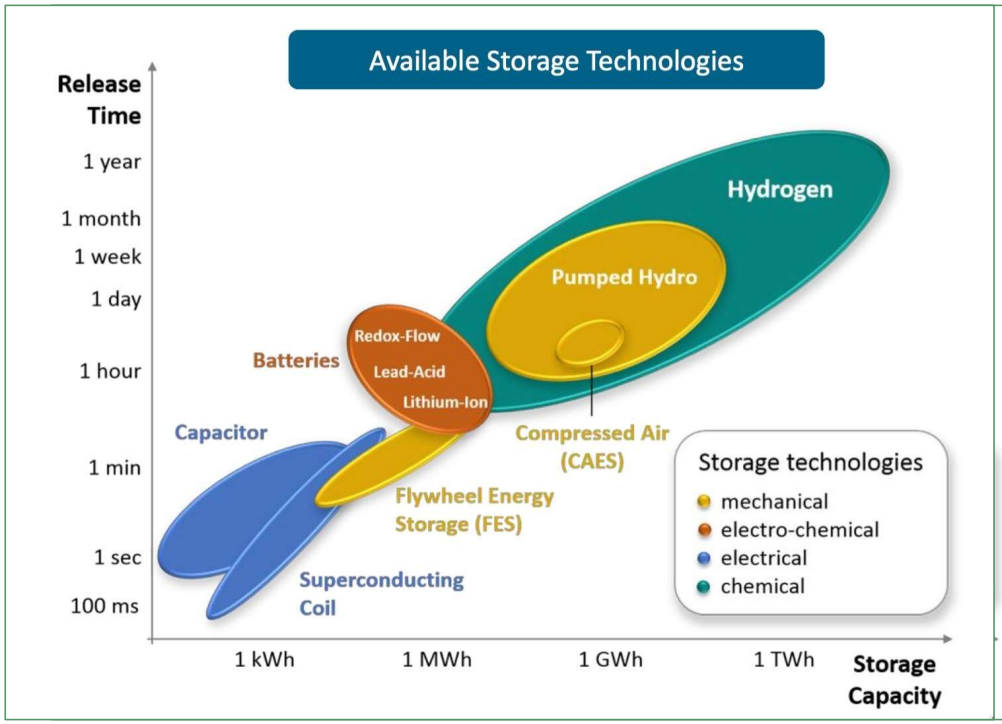


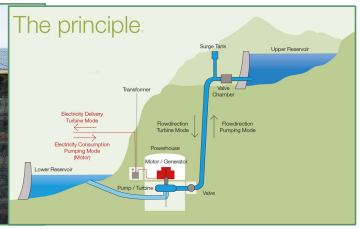


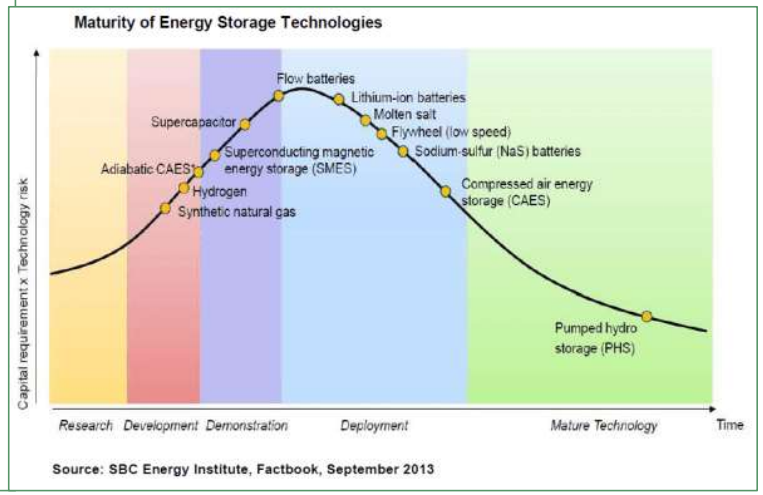
Renewable Energy Storage Systems (ESS)

- Intermittency problem - when the sun doesn't shine, we still need energy. Solution = store it for later.
- Incredible spectrum of energy storage options
- (electrical, mechanical, chemical, gravity, kinetic, thermal)



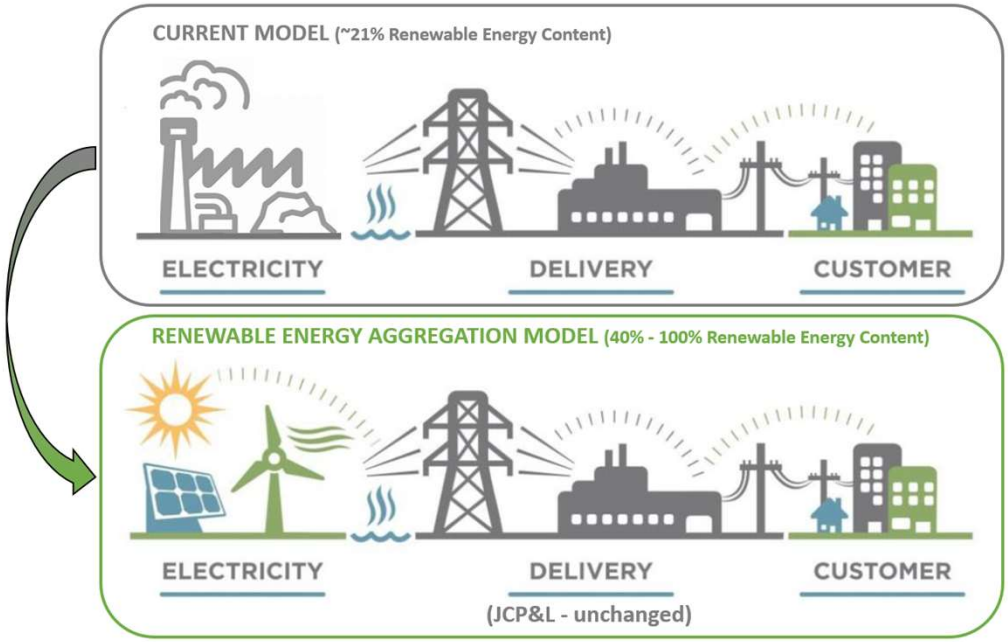






3rd Party Clean Energy Providers

- If you can't do solar, 3rd party suppliers is an option to go renewable/green
- 3rd party suppliers for the energy portion of your bill can be swapped in for JCP&L with higher content of renewable energy (wind or solar) up to 100%
- Process is a paper transaction change, JCP&L remains your supply side provider. Your bill remains through JCP&L
- Renewable energy is not always produced locally but the fees subsidize a specific installation



Towns can entertain a state program called renewable government energy aggregation (R-GEA)

This is a way to team up with the buying power of the town/neighbors to get the best price and avoid any complexity of doing a 3rd party contact individually

Sustainable Jersey has a specific action for this and Parsippany is working on this option

Ground Source Heat Pump – Benefits [3]

- Low Energy Use (25-50% less energy, ~500% COP)
- Free or Reduced-Cost Hot Water (uses excess)
- Year-Round Comfort (quieter, lower humidity)
- Design Flexibility (new or retrofit)
- Improved Aesthetics (no external heat exchangers)
- Low Environmental Impact (~44% reduction)*
- Durability (no exposed parts, 25-50yr warranty)
- Reduced Vandalism (no outdoor parts)
- Low Maintenance (1/3 of cost)
- Zone Heating/Cooling
- No fossil fuel supply chains (natural gas, oil)
- Commercial and Residential Applications

Select a Technology ▾ | Geothermal vs. Natural Gas

	Geothermal	Natural Gas
Efficiency Rating	500%	98%
Capable of Zoning	✓	✓
Does Not Use Fossil Fuels or Release Harmful Emmissions	✓	×
No Combustion	✓	×
No Carbon Monoxide or Oil Leaks	✓	×
Not Impacted by Volatile Operating/Fuel Costs	✓	×
Heating and Cooling in One Unit (and hot water capabilities)	✓	×
Most environmentally friendly (According to the EPA)	✓	×
No Outdoor Equipment	✓	×
Uses the Earth's Free Heat (For every 1 unit of electricity used, you get 4 units free)	✓	×

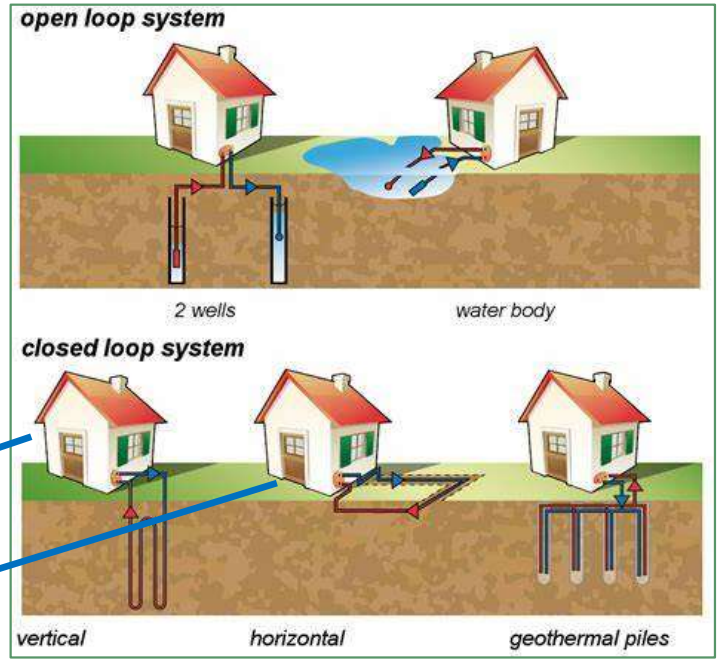
[5]

- A GSHP system can be installed in virtually any area of the country and will save energy and money. [3]
- According to the Environmental Protection Agency (EPA), GeoExchange systems are the most energy efficiency, environmentally clean and cost-effective space conditioning systems available [4]
- A GSHP is up to 5 times more efficient than a gas boiler. This combined with the low carbon intensity of the grid, means that installing a GSHP instead of a gas boiler, will reduce emissions by 87%. [6]

*Environmental impact is reduced even more when paired with renewable energy electric sources like solar PV or clean energy purchasing ~ 0

Ground Source Heat Pumps – Types [1]

1. **Open Loop**
   1. Well, groundwater heat pump
   2. Heat exchange with a direct water source (well or pond)
2. **Closed Loop**
   A. Drilled or buried ground heat exchanger depending upon space and geology
   B. Vertical
   C. Horizontal
   D. Pond



(B) Vertical Drilled Borehole

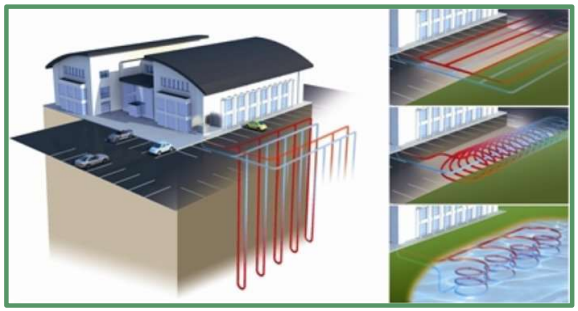
(C) Horizontal Trench

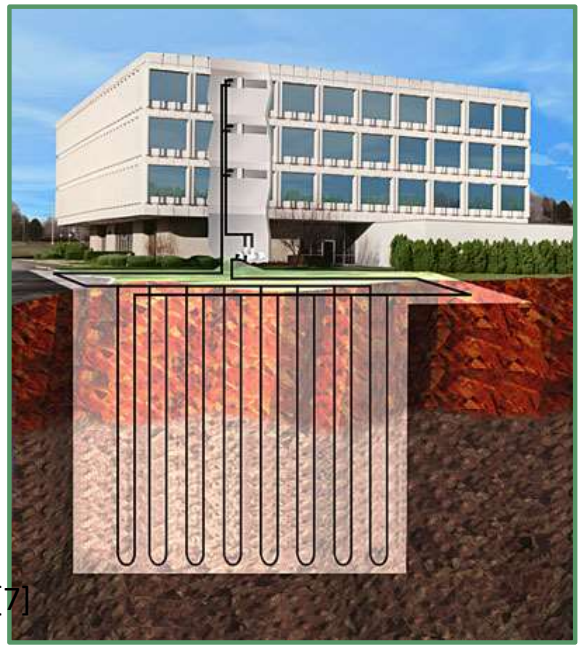
(D) Submerged Pond Loop

Green Insight

Ground Source Heat Pump – Commercial

- GSHPs can be used for commercial buildings for space conditioning
- Retrofit or new construction
- Heat exchanger under parking lot makes use of wasted space

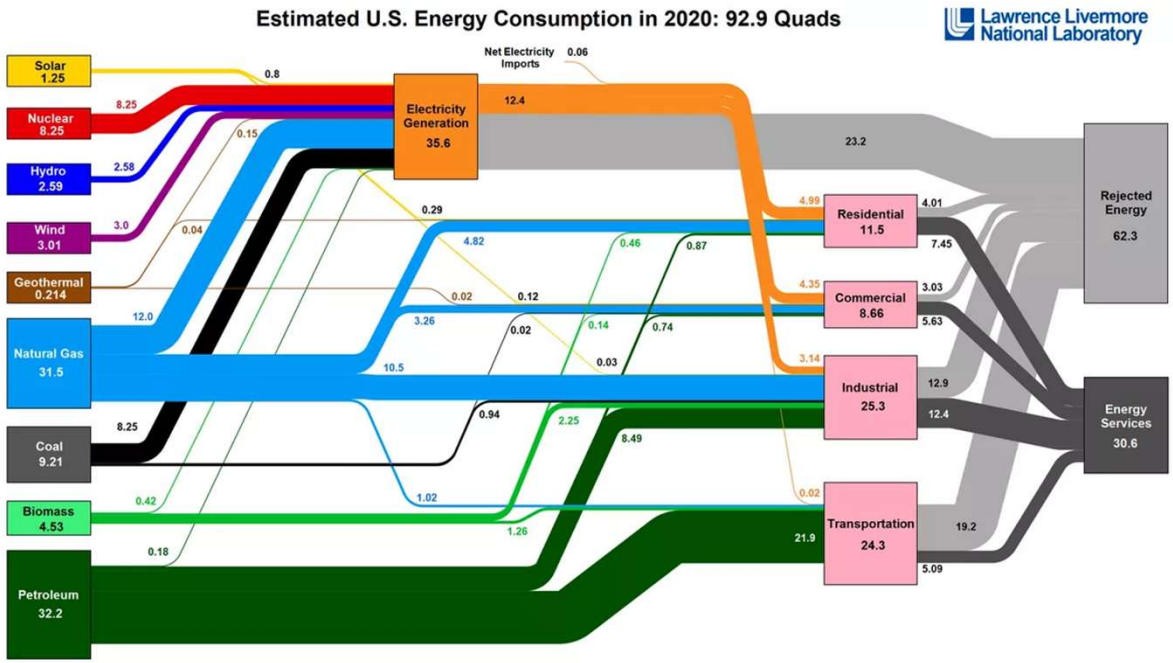




[7]

US Energy Consumption in 2020

- 92.9 gross Quads of energy (27.3 Petawatt hours) - >*50% energy consumption reduction possible*
- Ground source heat pumps can reduce gross residential and commercial heating demand by >~15 Quads
- Electric vehicles can reduce transportation gross demand by >~10 Quads
- Renewable energy can reduce electric generation demand by >~25 Quads



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

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- [1] “Geothermal Heat Pump” (2020) Geothermal heat pump - Wikipedia
- [2] "Groundwater temperature's measurement and significance - National Groundwater Association". National Groundwater Association. 23 August 2015.
- [3] “Geothermal Heat Pumps,” DOE/GO-10098-652 FS 105, September 1998. Geothermal Heat Pumps | Department of Energy
- [4] “Space Conditioning: The Next Frontier,” EPA 430-R-93-004, April 1993. Document Display | NEPIS | US EPA
- [5] “The Advantages of Geothermal” (2020), GeoComfort.com. Geothermal Benefits (geocomfort.com)
- [6] “Energy Infrastructure of the Future: Ground Source Heat Pumps” (2020), NIBE. NIBE GSHP PAPER.pdf
- [7] “Community Builder” (2018), MattamyHomes. PowerPoint Presentation (escribemeetings.com)